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AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR

1894.

INCORPORATED 1881.

VOL. XXVIII.

EDITED BY

THE HONORARY SECRETARIES.

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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 the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

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The Honorary Secretaries request that authors of papers (to be read before the Royal Society of New South Wales) requiring illustrations by photo-lithography, will, before preparing such drawings, make application to the Assistant Secretary for patterns of the standard sizes of diagrams &c. to suit the Society's Journal.

ERRATA.

Corrections to Paper on "Aboriginal Bora held at Gundabloui in 1894."

Page 100, line 8, for "365 – 374," read "565 – 574."
,, 101, line 10, for "was" read "*were.*"
,, 101, line 11, for "affect" read "*effect.*"
,, 106, line 3, after the word "close" add the following paragraph:—
"From additional information furnished by my valued correspondent in answer to further enquiries made by me while this paper was in the press, I have found that some slight errors, incidental to information obtained through a correspondent five hundred miles distant, have been made in describing the equipment of the messengers, and in the details of the formalities observed on their arrival at a camp when bearing the summons to attend a Bora, (p. 107); in the particulars of the preliminary daily performances of the women and boys at the larger circle, (p. 115); and in the account of the ceremonies immediately preceding the departure from the larger circle of the novices with their guardians, (pp. 117 – 118). The amended information will be offered by me to the Society in another paper dealing with initiation ceremonies."

Page 111, note † second line from bottom, for "turf" read "*trees.*"
,, 121, note * line 2, for "huuting" read "*hunting.*"

Page 62, line 13 from top, for "1892" read "1894."
,, 254, line 4 from top, for "rember" read "*remember.*"
,, 322, line 5 from bottom for "an aprophyte" read "*a saprophyte.*"

PUBLICATIONS.

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

Vol.	I.	Transactions of the Royal Society, N.S.W.,				1867,	pp. 83,	,,		
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1888	Mullins, George Lane, M.A., M.D. Trin. Coll. *Dub.*, M.D. *Syd.*, F.R.M.S. *Lond.*, 'Murong,' Albion-street, Waverley.
1894	Symonds, John, 'Craigton,' Parramatta Park.

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OF THE

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P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

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1885		Allworth, Joseph Witter, District Surveyor, East Maitland.
1881		Amos, Robert, 'Kinneil,' Elizabeth Bay.
1877		Anderson, H. C. L., M.A., 161 Macquarie-street.
1890		Anderson, William.
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1894		Baker, Richard Thomas, F.L.S., Assistant Curator, Technological Museum.
1894		‡Balsille, George, Sandymount, Dunedin, New Zealand.
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1889		Berney, George Augustus, 74 Alberto Terrace, Darlinghurst Road.
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1859		Goodlet, John H., 'Canterbury House,' Ashfield.
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1874		Jones, James, 'Miltonia,' Randwick.
1879		Jones, John Trevor, C.E., 'Tremayne,' North Shore.
1884		Jones, Llewellyn Charles Russell, M.L.A., Solicitor, 130 Pitt-st.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College-street, Hyde Park, p.r. 'Llandilo,' Boulevard, Strathfield.
1876		Jones, Richard Theophilus, M.D. *Syd.*, L.R.C.P. *Edin.*, 'Caer Idris,' Ashfield.
1891		Jones, Robert E., Assoc. M. Inst. C.E., Roads Department, Muswellbrook.
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., George-st., Dulwich Hill.
1878		Joubert, Numa, Hunter's Hill.

Elected.		
1883		Kater, The Hon. H. E., M.L.C., 'Cheverells,' Elizabeth Bay Rd.
1873		Keele, Thomas William, M. Inst. C.E., District Engineer, Harbours and Rivers Department, Ballina, Richmond River.
1877		Keep, John, 'Broughton Hall,' Leichhardt.
1884		Kendall, Theodore M., B.A., L.R.C.P., L.R.C.S. *Lond.*, L.M., 28 College-street, Hyde Park.
1887		Kent, Harry C., Bell's Chambers, 129 Pitt-street.
1892	P 1	Kiddle, Hugh Charles, Public School, Walbundrie.
1891		King, Christopher Watkins, L.S., Roads and Bridges Branch, Public Works Department, Sydney.
1874		King, The Hon. Philip G., M.L.C., 'Banksia,' William-street, Double Bay.
1892		Kirkaldie, David, Chief Traffic Manager, New South Wales Government Railways, Sydney.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 16 College-street, Hyde Park.
1881	P 2	Knibbs, G. H., Lecturer in Surveying, University of Sydney, 'Avoca House,' Denison Road, Petersham.
1877		Knox, Edward W., J.P., 'Rona,' Bellevue Hill, Double Bay.
1875		Knox, The Hon. Edward, M.L.C., O'Connell-street.
1877		Kopsch, G., 33 Boulevard, Petersham.
1878		Kyngdon, F. B., F.R.M.S. *Lond.*, Deanery Cottage, Bowral. *Vice-President.*
1878		Kyngdon, Frederick H., M.D., C.M. *Aberdeen*, L.S.A. *Lond.*, M.R.C.S. *Eng.*, 'Bon Accord,' North Shore.
1874		Lenehan, Henry Alfred, F.R.A.S., Sydney Observatory.
1883		Lingen, J. T., M.A. *Cantab.*, 109 Elizabeth-street.
1872	P 42	Liversidge, Archibald, M.A. *Cantab.*, F.R.S.; Assoc. Roy. Sch. Mines *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chemistry of Gt. Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineral Society, *France;* Cor. Mem. Edin. Geol. Soc.; Roy. Soc. *Tas.*; Roy. Soc. *Queensland;* Senckenberg Institute, *Frankfurt;* Soc. d' Acclimat. *Mauritius;* Hon. Mem. Roy. Soc. *Vict.*; N. Z. Institute; K. Leop. Carol. Acad. *Halle a/s;* Professor of Chemistry and Mineralogy in the University of Sydney, The University, Glebe; p.r. 'The Octagon,' St. Mark's Road, Darling Point.
1881		Lloyd, Lancelot T., 'Eurotah,' William-street East.
1874		Lloyd, The Hon. George Alfred, M.L.C., F.R.G.S., 'Scottforth,' Elizabeth Bay.
1890	P 2	Loir, Adrien.
1887		Long, Alfred Parry, Land Titles' Office, Elizabeth-street.
1878		Low, Hamilton, H.M. Customs, Sydney.
1887		MacAllister, John F., M.B., B.S. *Melb.*, 'Ewhurst,' Stanmore Road, Stanmore.
1892		MacCarthy, Charles W., M.D., F.R.C.S. *Irel.*, 223 Elizabeth-street, Hyde Park.

Elected.		
1884		MacCormick, Alexander, M.D., M.B., C.M. *Edin.*, M.R.C.S. *Eng.*, 125 Macquarie-street North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1892		McDonagh, John M., B.A., M.D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*, 173 Macquarie-street North.
1878		MacDonald, Ebenezer, 'Kamilaroi,' Darling Point.
1886		MacDonald, John A., M. Inst. C.E., M. Inst. M.E., M. Am. Soc. C.E.
1868		MacDonnell, William J., F.R.A.S., Bank of New South Wales, Port Macquarie.
1877		MacDonnell, Samuel, Norwich Chambers, Hunter and Bligh-, streets.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* Hospital for Insane, Gladesville.
1882		MacGillivray, P. H., M.A., LL.D., M.R.C.S., F.L.S., Bendigo, Victoria.
1876		McKay, Charles, M.D. Univ. *St. Andrews*, L.R.C.S. *Edin.*, 20 Carrington-street, Wynyard Square.
1891		McKay, Robert Thomas, L.S.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch. M., 'Glengower,' Fraser-street, Petersham.
1876		Mackellar, The Hon. Charles Kinnard, M.L.C., M.B., C.M. *Glas.*, 183 Liverpool-street, Hyde Park.
1872		Mackenzie, John, F.G.S., Athenæum Club, Sydney.
1876		Mackenzie, Rev. P. F., The Manse, Johnston-st., Annandale.
1880	P 4	M'Kinney, Hugh Giffin, M.E. Roy. Univ. *Irel.*, M. Inst. C.E., Chief Engineer for Water Conservation, Athenæum Club, Castlereagh-street.
1876		MacLaurin, The Hon. Henry Norman, M.L.C., M.A., M.D. *Edin.*, L.R.C.S. *Edin.*, LL.D. Univ. *St. Andrews*, 155 Macquarie-st.
1894		McMillan, William, M.L.A., 'St. Albans,' Allison-st., Randwick.
1882	P 1	Madsen, Hans. F.' 'Hesselmed House,' Queen-st., Newtown.
1883	P 2	Maiden, Joseph H., F.L.S., F.C.S., Corr. Memb. Pharm. Soc. Great Britain, and of Roy. Soc., South Australia, Curator, Technological Museum, Sydney. *Hon. Secretary.*
1878		Maitland, Duncan Mearns, Department of Lands, Sydney.
1873		Makin, G. E., Market Square, Berrima.
1880	P 1	Manfred, Edmund C., Montague-street., Goulburn.
1877		Mann, John F., 'Kerepunu,' Neutral Bay.
1876		Manning, Frederic Norton, M.D. Univ. *St. And.*, M.R.C.S. *Eng.*, L.S.A. *Lond.*, Hunter's Hill.
1880		Marano, G. V., M.D. Univ. *Naples*, Clarendon Terrace, Elizabeth-street.
1890		Marshall, Hezlett Hamilton, L.R.C.P., L.R.C.S. *Edin.*, Lic. Fac. Phys. and Surg. *Glas.*, 2 Lyons' Terrace, Liverpool-st.
1893	P 1	Martin, Charles J., B.Sc., M.B. *Lond.*, M.R.C.S. *Eng.*, Demonstrator of Physiology, Sydney University.
1879		Matthews, Robert Chr., Sheridan-street, Gundagai.
1875	P 3	Mathews, R. H., J.P., L.S., 'Carcuron,' Parramatta.
1888		Megginson, A. M., M.B., C.M. *Edin.*, 147 Elizabeth-street.
1889		Mestayer, R. L., M. Inst. C.E., F.R.M.S., Drainage Engineer, Wellington, New Zealand.
1893		Millard, Reginald Jeffery, M.B., Ch.M., *Syd.*, Hospital for Insane Parramatta.

Elected.		
1887		Miles, George E., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, Hospital for Insane, Callan Park.
1873		Milford, F., M.D. *Heidelberg*, M.R.C.S. *Eng.*, 3 Clarendon Terrace, 265 Elizabeth-street.
1882		Milson, James, 'Elamang,' North Shore.
1889	P 3	Mingaye, John C. H., F.C.S., M.A.I.M.E., Assayer and Analyst to the Department of Mines, Sydney.
1892		Mollison, James Smith, Assoc. M. Inst. C.E., Roads, Bridges and Sewerage Branch, Department of Public Works, Sydney.
1856	P 7	Moore, Charles, F.L.S., Director of the Botanic Gardens, Sydney.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street.
1875		Moir, James, 58 Margaret-street.
1893		Money, Angel, M.D., F.R.C.P. *Lond.*, 75 Hunter-street.
1877	P 1	Morris, William, Fel. Fac. Phys. and Surg. *Glas.*, F.R.M.S. *Lond.*, 5 Bligh-street.
1883		Morley, Frederick, 334 Victoria-street, Darlinghurst.
1882		Moss, Sydney, 'Kaloola,' Kiribilli Point, North Shore.
1877		‡Mullens, Josiah. F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1887		Munro, William John, M.B., C.M. *Edin.*, M.R.C.S. *Eng.*, 112 Glebe Road, Glebe.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.
1893		Nangle, James, Architect, 13 Wellington-street, Newtown.
1890		Neill, Leopold Edward Flood, M.B., Ch. M., Univ. *Syd.*, No. 3 Bayswater Houses, Double Bay.
1891		Noble, Ewald George, 60 Louisa Road, Longnose Point, Balmain.
1873		Norton, The Hon. James, M.L.C., LL.D., Solicitor, 2 O'Connell-street, p.r. 'Ecclesbourne,' Double Bay.
1893		Noyes, Edward, C.E., 'Waima,' Wentworth Road, Point Piper, Sydney.
1878		Nowlan, John, 'Eelah,' West Maitland.
1878		Ogilvy, James L., Melbourne Club, Melbourne.
1890		Olliff, Arthur Sidney, Government Entomologist, Department of Agriculture, Macquarie-street.
1888		O'Neill, G. Lamb, M.B., C.M. *Edin.*, 175 Liverpool-street.
1883		Oram, Arthur Murray, M.D. Univ. *Edin.*, 213 Macquarie-st. North.
1875		O'Reilly, W. W. J., M.D., M. Ch. Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Roads and Bridges Office, Cowra.
1893		Owen, Lieut. Percy Thomas, Assistant Engineer Military Works, Australian Club.

Elected.		
1875		Palmer, J. H., 'Hinton,' Queen-street, Burwood.
1880		Palmer, Joseph, 133 Pitt-st., p.r. Kenneth-st., Willoughby.
1885		Park, Archibald John, Chairman Local Land Board, Grafton.
1891		Parkinson, Henry W., 55 Market-street, Melbourne.
1878		Paterson, Alexander, M.D., M.A. *Edin.*, 146 Crystal-street, Petersham.
1878		Paterson, Hugh, 197 Liverpool-street, Hyde Park.
1877		Pedley, Perceval R., 227 Macquarie-street.
1877		Perkins, Henry A., 'Barangah,' Coventry Road, Homebush.
1881		Philip, Alex., L.K.Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 574 Crown-street, Surry Hills.
1876		Pickburn, Thomas, M.D., C.M. *Aberdeen*, M.R.C.S. *Eng.*, 22 College-street.
1879	P 2	Pittman, Edward F., Assoc. R.S.M., F.G.S., L.S., Government Geologist, Department of Mines, Phillip-street.
1881		Poate, Frederic, District Surveyor, Tamworth.
1890		Pockley, Francis Antill, M.B., M.C. Univ. *Edin.*, M.R.C.S. *Eng.*, 227 Macquarie-street.
1879		Pockley, Thomas F. G., Commercial Bank, Singleton.
1887		Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B.Sc., *Syd.*, 'The Towers,' Neutral Bay.
1891		Poole, William Jr., Water Conservation Branch, Department of Public Works, Sydney.
1882	P 4	Porter, Donald, Tamworth.
1891		Pringle, Adam Thompson, Government Inspector of Vineyards, 'Albma Villa,' Parramatta Road, Concord.
1893		Purser, Cecil, B.A., M.B., Ch. M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1876		Quaife, Frederick H., M.A., M.D., Master of Surgery *Glas.*, 'Hughenden,' 19 Queen-street, Woollahra.
1865	P 1	‡Ramsay, Edward P., LL.D. Univ. St. And. *Aberdeen*, F.R.S.E., F.L.S.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Elizabeth-street, Hyde Park, p.r. Fullerton-street, Woollahra.
1888		Reading, Richard Fairfax, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.D.S. *Eng.*, 151 Macquarie-street.
1881	P 3	Rennie, Edward H., M.A. *Syd.*, D.Sc. *Lond.*, Professor of Chemistry, University, Adelaide.
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 16 College-street, Hyde Park.
1870		Renwick, The Hon. Arthur, M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 295 Elizabeth-street.
1868	P 4	Roberts, Sir Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. *Vienna*, 125 Macquarie-street North.
1893	P 1	Roberts, W. S. de Lisle, C.E., Sewerage Branch, Public Works Department, Phillip-street.
1891		Robjohns, Rev. Henry Thomas, B.A. *Lond.*, M.A. *Syd.*, 'Eton,' Waverley-street, Waverley.
1885		Rolleston, John C., C.E., Harbours and Rivers Branch, Dept. of Public Works.

Elected.		
1892		Rossbach, William, Assoc. M. Inst. C.E., Chief Draftsman, Harbours and Rivers Branch, Public Works Department.
1887		Ross, Andrew, M.D., Mast. Surg. Univ. *Glas.*, M.L.A., Molong.
1884		Ross, Chisholm, M.B., C.M. *Edin.*, Hospital for the Insane, Newcastle.
1865		Ross, J. Grafton, O'Connell-street.
1882		Rothe, W. H., Union Club, Colonial Sugar Co., O'Connell-st.
1894		Rowney, George Henry, A.M.I.C.E., Sewerage Construction Branch, Public Works Department, p.r. 12 Kellet-street, Darlinghurst.
1864	P 55	Russell, Henry C., B.A. *Syd.*, C.M.G., F.R.S., F.R.A.S., F.R. Met.Soc., Hon. Memb. Roy. Soc., South Australia, Government Astronomer, Sydney Observatory. *Vice-President.*
1893		Rygate, Phillip W., M.A., B.E. *Syd.*, c/o Messrs. Walter Bradley & Co., 322 George-street.
1886		Sager, Edmund E., Secretary to the Board of Health, 127 Macquarie-street North.
1875		Sahl, Charles L., German Consulate, 42 Pitt-street.
1892		Schofield, James Alexander, Sydney University, Glebe.
1887	P 1	Schwarzbach, B., M.D. *Würzburg*, L.F.P. & S. *Glas.*, 28 College-st.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1886		Scott, Walter, M.A. *Oxon.*, Professor of Greek, University, Sydney.
1891		Seaver, Thomas Whitchurch, B.C.E. Roy. Univ. *Irel.*, Water Conservation Branch, Public Works Department, p.r. Alma-street, North Shore.
1876		Sedgwick, William Gillett, M.R.C.S. *Eng.*, 178 King-street, Newtown.
1877		Selfe, Norman, M. Inst. C.E., M. Inst. M.E., Victoria Chambers, 279 George-street.
1890	P 1	Sellors, R. P., B.A. *Syd.*, 'Winster,' Boyce-street, Glebe Point.
1891		Sellman, D. Codrington, Wh. Sc., St. James' Chambers, King-street, City.
1876		Sharp, Henry, Green Hills, Adelong.
1891		Shaw, Percy William, C.E., Tramway Construction Branch, Beresford Chambers, Castlereagh-street.
1883	P 3	Shellshear, Walter, M. Inst. C.E., Divisional Engineer, Railway Department, Goulburn.
1879		Shepard, A. D., Box 728 G.P.O. Sydney.
1875		Sheppard, Rev. G., B.A. *Syd.*, Berrima.
1882		Shewen, Alfred, M.D. Univ. *Lond.*, M.R.C.S. *Eng.*, 6 Lyons' Terrace, Hyde Park.
1894		Simpson, Benjamin Crispin, C.E., 113 Phillip-street.
1882		Sinclair, Eric, M.D., C.M. Univ. *Glas.*, Hospital for the Insane, Gladesville.
1893		Sinclair, Russell, M.I.M.E. &c., Consulting Engineer, 97 Pitt-street.
1884		Skirving, Robert Scot, M.B., C.M. *Edin.*, Elizabeth-street, Hyde Park.
1877		Sloper, Frederick Evans, 94 Oxford-street, Paddington.
1891	P 1	Smail, J. M., M. Inst. C.E., Engineer for Sewerage, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.

Elected.		
1893	P 2	Smeeth, William Fredrick, M.A., B.E., F.G.S., A.R.S.M., Demonstrator in Geology, Sydney University.
1893	P 4	Smith, Henry G., Laboratory Assistant, Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, Denison-street, Woollahra.
1875		Smith, Robert, M.A. *Sydney*, Marlborough Chambers, 2 O'Connell-street.
1886		Smith, Walter Alexander, M. Inst. C.E., Roads, Bridges and Sewerage Branch, Public Works Department.
1892		Speak, Savannah J.
1893		Spencer, Thomas William Loraine, Resident Engineer, Roads and Bridges, Muswellbrook.
1879		Spry, James Monsell, Union Club.
1892	P 1	Statham, Edwyn Joseph, Assoc. Inst. C.E., 'Hillside,' Herbert-street, Rockdale.
1892		Statham, Hugh Worthington, Roads Office, Blayney.
1882		Steel, John, L.R.C.P., L.R.C.S. *Edin.*, Ch.M., B.S. Univ. *Melb.*, 3 Lyons' Terrace, Hyde Park.
1889		Stephen, Arthur Winbourn, L.S., Mulgoa.
1879		‡Stephen, The Hon. Septimus A., M.L.C., 12—14 O'Connell-st.
1891		Stilwell, A. W., C.E., Box 37 G.P.O. Sydney, Roads and Bridges Department, Bathurst.
1892		Stuart, Charles McDonnell, B.E. Queen's Univ. *Irel.*, 'Dunsevirick,' Pymble.
1883	P 2	Stuart, T. P. Anderson, M.D. Univ. *Edin.*, Professor of Physiology, University of Sydney. *Vice-President.*
1892		Sturt, Clifton, L.R.C.P., L.R.C.S. *Edin.*, L.F.P.S. *Glas.*, 'Wistaria,' Bulli.
1883		Styles, George Mildinhall, Commercial Bank, George-street.
1887		Sulman, John, F.R.I.B.A., 339 George-street.
1876	P 1	Suttor, The Hon. W. H., M.L.C., No. 6 Wenlock, Rockwall Crescent, Pott's Point.
1891		Sutherland, George W., M.D. *Lond.*, M.C. *Edin.*, Liverpool-st., Hyde Park.
1862	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1878		Thomas, F. J., Hunter River N.S.N. Co., Sussex-street.
1879		Thomson, Dugald, M.L.A., c/o R. Harper & Co., Empire Chambers, York-street.
1893		Taylor, James, B.Sc., A.R.S.M., Government Metallurgist, 'Shirecliffe,' Double Bay.
1875		Thompson, Joseph, 159 Brougham-street, Woolloomooloo.
1877		Thompson, Thomas James, Eldon Chambers, 92 Pitt-street.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, Health Department, 127 Macquarie-street.
1892		Thow, William, Locomotive Department, Eveleigh.
1886	P 2	Threlfall, Richard, M.A. *Cantab.*, Professor of Physics, University of Sydney. *President.*
1888		Thring, Edward T., F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.

Elected.		
1876		Tibbits, Walter Hugh, M.R.C.S. *Eng.*, 'Belchester,' Liverpool Road, Enfield.
1894		Tidswell, Frank, M.B., M.Ch., Randwick.
1876		Toohey, The Hon. J. T., M.L.C., 'Moira,' Burwood.
1891		Tooth, Alfred Erasmus, Abbotsford Road, Homebush.
1894		Tooth, Arthur W., 'Ilfracombe,' Burwood.
1893		Townsend, George W., C.E.
1882		Traill, Mark W., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Coolabah,' Belmore-street, Burwood.
1873	P 1	Trebeck, Prosper N., 2 O'Connell-street.
1879		Trebeck, P. C., 2 O'Connell-street.
1877		‡Tucker, G. A., Ph. D., c/o Perpetual Trustee Company, 14 O'Connell-street.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1884		Verde, Capitaine Felice, Villa Borracchia, Spezia, Italy.
1890		Vicars, James, B.C.E., City Surveyor, Adelaide.
1892		Vickery, George B., 78 Pitt-street.
1876		Voss, Houlton H., J.P., c/o Perpetual Trustee Company, 14 O'Connell-street.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-st.
1891		Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C.E., Supervising Engineer, Harbours and Rivers Department, Newcastle.
1867		Ward, R. D., M.R.C.S. *Eng.*, West-street, St. Leonards.
1891		Ward, Thomas William Chapman, B.A., B.C.E. *Syd.*, Roads and Bridges Branch, Department of Public Works, p.r. 'Roslyn,' Toxteth Road, Glebe Point.
1883		Wardell, W. W., F.R.I.B.A., M. Inst. C.E., 'Upton Grange,' St. Leonards.
1877		Warren, William Edward, M.D., M.Ch., Queen's University *Irel.*, 265 Elizabeth-street, Sydney.
1883	P 4	Warren, W. H., Wh. Sc., M. Inst. C.E., Professor of Engineering, University of Sydney, p.r. 'Undoona,' Albert Road, Strathfield. *Vice-President.*
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, 47 Phillip-street.
1891		Watkins, Sydney C., M.R.C.S. *Eng.*, Manly.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown.
1859		Watt, Charles, Parramatta.
1876		Waugh, Isaac, M.B., M.C. *Dub.*, T.C.D., Parramatta.
1876		Webster, A. S., c/o Permanent Trustee Co., 16 O'Connell-st.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S. *New Zealand*, Borough Engineer, Town Hall, Marrickville.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1891		Wells, Frederick, M. Inst. C.E., 'Cleves,' Ryde.
1881		‡Wesley, W. H.
1878		Westgarth, G. C., Pitt-street, p.r. 59 Elizabeth Bay Road.

Elected		
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Oaklands,' Edgecliff Road, Woollahra.
1892		White, Harold Pogson, Assistant Assayer and Analyst, Dept. of Mines, p.r. Brown's Road, Kogarah.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1874		White, Rev. James S., M.A., LL.D. *Syd.*, 'Gowrie,' Singleton.
1888		White, The Hon. Robert Hoddle Driberg, M.L.C., Union Club, p.r. 'Tahlee,' Port Stephens.
1884		Wiesener, T. F., 334 George-street.
1878		Wilkinson, Rev. Samuel, 'Regent House,' Regent-street, Petersham.
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Kiora,' Ocean-street, Woollahra.
1876		Williams, Percy Edward, The Treasury.
1878		Wilshire, James Thompson, J.P., 'Coolooli,' off Ranger's Road, Shell Cove, Neutral Bay.
1879		Wilshire, F. R., P.M., Berrima.
1891		Wilson, Robert Archibald, M.D. *Glas.*, Mast. Surg. *Glas.*, 2 Booth-street, Balmain.
1890		Wilson, James T., M.B., Mast. Surg. Univ. *Edin.*, Professor of Anatomy, University of Sydney.
1876		Windeyer, The Hon. Sir William, Knt., M.A. *Syd.*, LL.D. *Cantab.*, Judges' Chambers, Supreme Court.
1873		Wood, Harrie, J.P., Under Secretary for Mines and Agriculture, Department of Mines and Agriculture, Phillip-st.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Esher,' Holden-street, Ashfield.
1876		Woolrych, F. B. W., 'Verner,' Grosvenor-street, Croydon.
1881	P 1	Wright, Frederick, M.P.S., c/o Messrs. Elliott Bros., Limited, O'Connell-street, p.r. Harnett-street.
1872		Wright, Horatio G. A., M.R.C.S. *Eng.*, L.S.A. *Lond.*, 4 York-street, Wynyard Square. *Hon. Treasurer.*
1893		Wright, John, C.E., Toxteth-street, Glebe Point.
1879		Young, John, 'Kentville,' Johnston-street, Leichhardt.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1878		Agnew, Sir James, M.D., Hon. Secretary, Royal Society of Tasmania, Hobart.
1875		Bernays, Lewis A., C.M.G., F.L.S., F.R.G.S., Brisbane.
1875	M	Ellery, Robert L. J., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.
1887		Foster, Michael, M.D., F.R.S., Professor of Physiology, University of Cambridge.
1875		Gregory, The Hon. Augustus Charles, C.M.G., M.L.C., F.R.G.S., Brisbane.
1875	P 1 M	Hector, Sir James, K.C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z.

Elected		
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., late Director of the Royal Gardens, Kew.
1892		Huggins, William, D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1888	P 1 M	Hutton, Captain Frederick Wollaston, F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.
1879	M	Huxley, Professor, F.R.S., LL.D., F.G.S., F.Z.S., F.L.S., &c., &c., Professor of Natural History in the Royal School of Mines, South Kensington, London.
1875	M	M'Coy, Frederick, C.M.G., D.Sc., F.R.S., F.G.S., Hon. M.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of National Museum, Melbourne.
1875	P 6 M	Mueller, Baron Ferdinand von, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S., Government Botanist, Melbourne.
1883		Pasteur, Louis, M.D., Paris.
1894		Spencer, W. Baldwin, M.A., Professor of Biology, University of Melbourne.
1888	P 2 M	Tate, Ralph, F.G.S., F.L.S., Professor of Natural Science, University, Adelaide, South Australia.
1875		Waterhouse, F. G., F.G.S., C.M.Z.S., Adelaide, South Australia.

Corresponding Members.

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1886	Marcou, Professor Jules, F.G.S., Cambridge, Mass., United States of America.

Obituary.

1893.

Ordinary Members.

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1865	Cracknell, E. C.
1874	Fischer, Carl F.
1877	Henry, James
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1887	Mitchell, J. Sutherland.
1876	Saliniere, Rev. E. M.

Honorary Member.

1884	Tyndall, Professor John.

1894.

Ordinary Members.

1883	Dixson, Dr. Craig.
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1879	Hills, Robert.
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1880		Low, Andrew S.
1875		Montefiore, E. L.
1865		Murnin, M. E.
1876		Quodling, W. H.
1886		Redfearn, William
1879		Wilson, F. A. A.

1895.

Hon. President.

His Excellency Sir R. W. Duff, P.C., G.C.M.G.

Honorary Member.

1876		Cockle, Sir James, F.R.S.

Corresponding Member.

1880		Clarke, Hyde, V.P. Anthrop. Inst.

Ordinary Members.

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1878		Nowlan, John.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE LATE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

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.

1878 Professor Sir Richard Owen, K.C.B., F.R.S., Hampton Court.
1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.
1880 Professor Huxley, F.R.S., The Royal School of Mines, London, 4 Marlborough Place, Abbey Road, N.W.
1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne.
1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.
1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S., Government Botanist, Melbourne.
1884 Alfred R. C. Selwyn. LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada, Ottawa.
1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.
1886 Professor L. G. De Koninck, M.D., University of Liége, Belgium.
1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.
1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.
1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.
1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William Street, Sydney.
1891 Captain Frederick Wollaston Hutton, F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.

1892 Professor William Turner Thiselton Dyer, C.M.G., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.

1893 Professor Ralph Tate, F.L.S., F.G.S., University, Adelaide, S.A.

1895 Robert Logan Jack, F.G.S., F.R.G.S., Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Department of Mines, Sydney.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

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

1882 Andrew Ross, M.D., Molong, for paper on the '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 on 'Water supply in the Interior of New South Wales.'

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

1887 Jonathan Seaver, F.G.S., Sydney, for paper on '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 on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

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

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

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

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

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

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

ANNIVERSARY ADDRESS.

By T. P. Anderson Stuart, M.D.,

Professor of Physiology in the University of Sydney.

[*Delivered to the Royal Society of N. S. Wales, May 2, 1894.*]

In determining what sort of an address I should deliver, I had the excellent example of my two predecessors, who each in his turn reviewed the progress the Colony had made during their period of office in the departments of knowledge of which the work of the Royal Society takes cognisance, and I was somewhat constrained to follow in their footsteps. It occurred to me, however, that I might perhaps do wisely if on this occasion I directed your attention to matters of interest or importance to us in New South Wales at the present time or in the near future, rather than so entirely to contemplate and record what had already been achieved in the near past. And then, too, *ne sutor ultra crepidam.* In a general review I felt that I should have either to touch upon matters with which I have no special acquaintance or to depend upon others who should write up each his own department. The first alternative was not agreeable to me, and for the second I had left myself rather little time, and so I come to speak of matters which fall more or less within my own sphere of activity. Possibly the next anniversary address will be a fitting opportunity for reviewing the work of the preceding two years.

THE SUPPLY OF ARTESIAN WATER IN AUSTRALIA.

Two of the most important meetings of the past Session were those at which the question of Artesian Water in Australia was discussed, on the papers by Professor David and the Hon. W. H. Suttor. It is apparent that the supply is by no means inexhaustible, and, though of course our information is even now by no means complete, still that there are data to estimate the possible yield in New South Wales as being perhaps twenty times the present output of forty-one million gallons *per diem*, or eight hundred and twenty million gallons daily. Taking the figures of Mr. McKinney as a basis, this quantity of water would irrigate two and a quarter million acres with average circumstances and high class management. This is $\frac{1}{89}$th of the whole area of the Colony, and about twice as much as is under cultivation now. It thus appears, that though it has its limits, yet irrigation by artesian water may play a great part in the development of the Colony, and the magnificent specimens of many vegetables and plants submitted to the Society amply proved what can be done by these waters.

Happily a suggestion that these waters might be found to be medicinally valuable has not been sustained. It would appear that in the neighbourhood of some of the bores the people esteem the waters highly for the treatment of various diseases—perhaps the mere copious use of the water in these water-scarce regions may be the real beneficial agent—at all events analyses which I had made do not disclose saline contents in such quantities as to make them on that account medicinally valuable. And very fortunate it is too, for a water useful as medicine is scarcely likely to be good as the daily supply of man or beast or vegetable.

One of the most urgent and most important questions in this connection is that of the origin of this water, for if we knew this we might then ascertain the intake and therefore estimate the output. It must be gratifying to you to learn, that the appeal which I made to the Under Secretary for Mines and Agriculture, to have proper gauges attached to all bores systematically, has borne fruit, for Mr. Wood is now having the gauges fixed and the flow measured and recorded systematically. Doubtless we shall soon have most valuable data, throwing a flood of light on the origin of artesian water, not in New South Wales only but in Australia generally.

EXPEDITION TO BORE AN ATOLL IN ORDER TO DETERMINE THE FORMATION OF CORAL.

As most of you are aware, one of the greatest works of the illustrious Darwin was his book on corals and their formation.

The leading ideas of his theory were thought of during his voyage in the *Beagle*, in which he visited our own Colony, and they were published in 1842 in his "The Structure and Distribution of Coral Reefs." So beautiful is his theory, so completely did it seem to explain all the phenomena, that it remained unchallenged till about the year 1863, when Semper published his paper on the Pelew Islands, which he made out to show elevation instead of the subsidence required by Darwin's theory. But neither this, nor the objections subsequently raised by others, succeeded in shaking the belief of Darwin, who died in 1882, still convinced that his was the true theory. In 1880, Murray, the naturalist on the *Challenger*, published the most formidable attack which has yet been made upon the theory of Darwin, and from that time till the present a keen controversy has been carried on. Murray's theory is, in some measure, a revival and development of the early theory of Chamisso, the poet-naturalist, who visited the South Seas in 1815-1818. It is not for me here to enter into the details of the argument on either side, nor indeed to express any opinion on the merits of a subject which is somewhat outside my own line of work, and is the subject of much discussion by the masters of geology of the day.

It appears, however, that the controversy, in the opinion of Darwin himself and of those who should be well qualified to judge, will be as good as settled if one could put a drill down to the bed of the coral formation of a typical atoll and bring up a core to be examined by competent geologists. Darwin himself it was who conceived the idea, for in his letter of May 5th, 1881, to Alexander Agassiz, in which he spoke of Murray's theory, he says—

"I wish that some doubly rich millionaire would take it into his head to have borings made in some of the Pacific and Indian atolls, and bring home cores for slicing from a depth of five hundred to six hundred feet."

The purpose of my reference to these matters here is to tell you, that this is about to be carried out by a Committee of the British Association for the Advancement of Science, for which I have the honour to be acting in Australia.

When I was in Europe three years ago, I was consulted as to the possibility of Sydney being the starting point for a expedition to one of the South Sea Atolls, and having for its object the realisation of Darwin's idea of boring and bringing up a core. The Chairman of the Committee is Prof. Bonney, F.R.S., and the Secretary Prof. Sollas, F.R.S., and the members of the Committee* include the most distinguished British Geologists and others interested in the work and two of the sons of Darwin. As the matter seemed to me to hardly come within the range of physiology, I proposed to pass it on to somebody else, but it was urged that as my share of the work would be entirely administrative, I determined to take it in hand myself and now I am glad that I did so, for it has given me great satisfaction to help in bringing the project to its present favourable outlook.

On my return to Sydney I sent out a circular to such as I thought might help me, giving the salient points of the scheme, and requesting information. In answer to this I received some replies, and thus, with the copious information derived by my personal enquiries amongst missionaries, sailors, and traders in Sydney, I was able to send a very satisfactory report to the Committee. The greatest material help was given by the enlightened action of the Minister of Mines and Agriculture, the Hon. T. M. Slattery, who under suitable conditions, so that the Colony shall be put to no direct expense and so that its property will be duly protected, has granted the use of a diamond drill in charge of one of the department's officers, who will be paid by the Committee.

The suitability of numerous islands has been carefully considered by the Committee and my latest advices tell me that now the choice is narrowed down to Funafuti in the Ellice Group or to

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* Sir Archibald Geikie, F.R.S., Professors A. H. Green, F.R.S., J. W. Judd, F.R.S., C. Lapworth, F.R.S., A. C. Haddon, Boyd Dawkins, F.R.S., G. H. Darwin, F.R.S., Anderson Stuart, Captain Wharton, F.R.S., (Hydrographer to Admiralty), Drs. H. Hicks, F.R.S., J. Murray, H. B. Guppy, Messrs. F. Darwin, F.R.S., H. O. Forbes, G. C. Bowne, S. Hickson, A. R. Binnie, J. D. Gregory, P. Fawcett.

one of the Northern Maldives; that the Admiralty will provide a ship, and that everything seems in train for settling matters at the forthcoming meeting of the Association at Oxford. The results cannot fail to be of the deepest interest, may be of great importance, and in any case will be creditable to the Colony of New South Wales for the share which it is taking in the work.

NAMING SOME PART OF THE BLUE MOUNTAINS AFTER DARWIN.

The mention of the name of Darwin leads me to commend the suggestion that some noteworthy feature in the mountains which he visited, should bear his name. I have had a talk with the Hon. P. G. King, M.L.C., a shipmate of Darwin in the *Beagle*, and who rode with him as far as Penrith, and Mr. King has promised to help in the matter. It must be some feature worthy of the name, and it is not easy to find such now. Still, perhaps, someone may make a suggestion—preferably of some place which Darwin actually visited or saw, for Port Darwin he never was near.

POISON OF THE PLATYPUS.

The action of the secretion of the gland connected with the spur of the *Ornithorhynchus*, or platypus, offers a tempting subject for investigation, and unless the research be undertaken before long it will not be an easy if indeed a possible matter, for the animals are getting scarcer, and at all times, even if plentiful, are not easy to get at under circumstances permitting a satisfactory examination of the effects of the poison. The poisonous action of the secretion has been alternately asserted and denied, but I have no doubt whatever that it is, at least at certain seasons, a powerful poison. I have from time to time made enquiry, and have also advertised for information, and I have two good accounts from very intelligent hunters of the animal, in widely separated parts of the Colony, which coincide perfectly, so that I have no doubt myself that they accurately represent the main features of the action of the poison in dogs and as observable by laymen.

One account shows that the males fight very fiercely while in the water during the pairing season, mostly applying themselves to each other belly to belly. The scratches are mostly on the under surface of the tail. The females are very seldom found scratched. One of the hunters tells of a dog he had which was "stung" on three different occasions—each time both spurs were employed, and the wounds were always on the dog's cheeks. The wounds are always described as on the head or face somewhere, because they are inflicted while the dog is retrieving the wounded animal. The effects followed very quickly, like the sting of a bee, within a couple of minutes the head began to swell, and on the first occasion had reached a "tremendous" size within a quarter of an hour. This swelling gradually disappeared, and was gone in thirty-six, ten, and three hours on the first, second, and third occasions respectively. The swelling and all the other symptoms were less marked the second than they were the first time, and the third than the second time. The swollen head was tender to the touch, for the dog "sang out" when it was touched there. The eyes were at first closed up by the swelling, and when again visible were "wild looking." The dog became sleepy, as if under the influence of a strong narcotic, so that he had to be carried to the camp, and he moaned from time to time. The dog would neither eat nor drink, but there was no salivation, vomiting, diarrhœa, tremor, convulsions, nor staggering. Breathing was difficult, but not very. This dog quite recovered.

My other account is from one of two brothers who were both great hunters of platypus, and he confesses to having been wicked enough to have shot many thousands during his thirty-two years of work. He had four valuable water dogs that died from the "stings." On one occasion he actually saw the platypus strike, heard the dog whine, saw the wound, and the train of symptoms ending in death. These were comparatively large dogs. He knew that after he himself gave up hunting, his brother, who went on with it, lost dogs too. The drowsiness was so intense that he has had to carry the dogs on horseback with him for as long as three hours.

The first of the two accounts of the action of the poison in the human subject which I have found, was that communicated in

1816 by Sir John Jamison to the Linnæan Society of London (*vide* Trans. Linn. Soc., March 18th, 1817). This account is so very interesting in the light of what I have to tell you on the same subject, and has been so much discredited or so completely overlooked and forgotten that I take leave to copy it here :—

"I wounded one with small shot; and on my overseer taking it out of the water, it stuck its spurs into the palm and back of his right hand with such force, and retained them in with such strength, that they could not be withdrawn until it was killed. The hand instantly swelled to a prodigious bulk; and the inflammation having rapidly spread to his shoulder, he was in a few minutes threatened with locked-jaw, and exhibited all the symptoms of a person bitten by a venomous snake. The pain from the first was insupportable, and cold sweats and sickness afterward took place so alarmingly, that I found it necessary, besides the external application of oil and vinegar, to administer large quantities of the volatile alkali with opium, which I really think preserved his life. He was obliged to keep to his bed for several days, and did not recover the perfect use of his hand for nine weeks. This unexpected and extraordinary occurrence induced me to examine the spur of the animal; and on pressing it down on the leg the fluid squirted through the tube: but for what purpose Nature has so armed these animals is as yet unknown to me."

Jamison's description was quite unknown to the Rev. W. W. Spicer who wrote the other account of the effects of the poison on man, which I have found, (*vide* Papers and Proceedings and Report, Roy. Soc. of Tasmania, 1876), and who says—"First, both in date and value, are the observations of the veteran naturalist Dr. Bennett," whose loss we in Sydney have so recently had to mourn. Yet Dr. Bennett's writings on the subject were not published for many years after Jamison's and they were negative, for he could not get any evidence that the spur was a weapon of offence or defence, since the animals never attempted to use it on himself. These animals, however, were in captivity, and most people know how difficult it sometimes is in such circumstances to get some animals to use their weapons, while the description given by Jamison and by Spicer were from animals in their natural state and greatly irritated, the one by being shot and handled, the other by being twice captured by the hand.

Spicer's account is really that written by Mr. Stephens, Inspector of Schools, and whom I know as an extremely intelligent man. Mr. A. Simson was the victim. Here are Mr. Stephens' words:—

"After an exciting chase platypus was recaptured; but this time he revenged himself by giving my friend a severe wound on the hand, one spur slightly tearing the palm, and the other the back of the hand, making a deep puncture between the knuckles of (I think) the first and second fingers. The pain from this was intense and almost paralysing. But for the administration of small doses of brandy, he would have fainted on the spot: as it was, it was half an hour before he could stand without support: by that time the arm was swollen to the shoulder, and quite useless, and the pain in the hand very severe. No ammonia was to be had; no medical assistance was available; and the only treatment that could be adopted was to keep the whole arm for a night and day in wet bandages, which seemed to alleviate the pain a little, and to reduce the inflammation. A week later I was informed by letter that the swelling had subsided, the hand was still very tender, with a sensation as of a severe bruise. From this time there was a slow but gradual improvement."

As regards the convalescence, the victim himself writes:—

"There must be some kind of poison in them I fancy, as, though the wounds healed up quickly, I still have a queer feeling in the hand and fore-arm, and cannot bear any pressure on the hand; the flesh, especially in the morning when I wash, feels as if it were with the skin grazed off, quite sore, and the hand is still rather cramped, and incapable of grasping anything, though I can use the fingers now again. The foregoing sensations extended right up the arm at first, which was everywhere tender to the touch, and all the joints and bones of the fingers also. Some natives told me they would rather lay hold of a snake than a platypus."

Spicer goes on to say:—

"I may mention that on Mr. Stephens attempting to seize the animal, it attacked him in a similar manner; fortunately his hand was protected by a glove, and the spurs only left a deep indentation without piercing the covering. And Mr. Stephens himself wrote, 'The mode of attack is not by scratching, but (as I know from experience) by a powerful lateral and inward movement of the hind legs, the spurs being brought together like the points of a pair of calipers.' It is worth noticing that the animal was in a state of considerable irritation when recaptured; and also that the object of his attack was a strong man, in the prime of life and in perfect health."

Mr. Spicer did not know of Jamison's description nor of any account whatever of the symptoms of the poison, other than the one case reported to him by Mr. Stephens, and consulting what literature was available to him, he found so much against the spur apparatus being really a poison apparatus, and so much in favour of its being something else, such as useful in the sexual object, etc., that he concluded thus :—

"The question is surrounded with difficulties, and cannot be determined in our present state of knowledge," and that "it was a decided and unsolvable mystery."

Now if we review these four accounts, we note that—

1. They are all absolutely independent, not one writer knowing anything of the other three, three hailing from different parts of the colony of New South Wales, and one from Tasmania, and all from different periods of time.
2. Two were in the human subject and the rest in dogs.
3. The train of symptoms, *mutatis mutandis*, agree most perfectly.
4. In all cases the poison was allowed to follow its natural course, nothing but external applications, if anything at all, being ever employed by way of treatment.
5. The symptoms were specific and differed entirely from the ordinary surgical effects of lacerated wounds.

We may, I think, conclude that the poison is powerful enough, at all events at certain seasons, but at what seasons, the accounts do not permit me to say, though I think it is the pairing season. I have set down these new accounts because I believe them worthy of record, and perhaps this allusion may lead to something more being done.

POISON OF SPIDERS.

We hear many stories of the poisonous effects of the red-backed spider, *Lathrodectus*, and some time ago I began an investigation of the variety not uncommon around Sydney, and which Mr. H. H. B. Bradley tells me is either *Lathrodectus Thorelli* or *Hasellii*, though he thinks these are only varieties. I have accounts of the results of the bite of this spider from medical men, which agree so well with those described as following the bite of the New Zealand species, the "Katipo," that I am bound to believe that the Sydney varieties are poisonous, at all events in certain seasons, though I got no results from hypodermic injection in dogs except profuse vomiting. I could not induce the spiders to "bite," and so I had to make extracts of the glands or rather of the entire body. Just at this stage, my friend Professor Kobert, of Dorpat, wrote to me, telling me that he had been investigating *Lathrodectus tredecempunctatus*, which he said was the most poisonous spider in the world, and that he had obtained therefrom the most powerful poison up till that time known, for 0·00003 gramme per kilogramme weight of animal injected into the blood was fatal. A better idea of what this really means will be conveyed if I tell you that at this rate one twenty-eighth part of a grain injected into the blood of a man twelve stone weight would be fatal. Brieger has also found in the "Caracurt," or "Black Wolf," a poison making up twenty-five *per cent.* of the body weight, and of about the same power as the poison of the *Lathrodectus*. I collected and sent to Dr. Kobert some *Lathrodecti* from St. Leonards, near Sydney, but these yielded negative results. I am therefore inclined to think that this insect is not always in a poisonous state, but what are the conditions I do not know, for in a poisonous state a single spider should be able to kill many dogs. The records of cases of the bite in man are neither numerous nor complete in the medical literature of Australasia, while the stories of the spiders are well known to everyone. Such is the "Katipo" *(Lathrodectus lugubris)* of New Zealand, which is, as it appears to me justly, credited with fatal results to human adults, though, on the other hand, it, too, has been found in a not very poisonous condition. An interesting account of the poisonous and fatal results of the bite of the Katipo may be read in Dr. F. W. Wright's paper in the Transactions of the New Zealand Institute for 1869. From these particulars, then, it will be seen that there is quite a field open as regards Australasian spiders alone.

POISON OF THE AUSTRALIAN BUSH-TICK.

The question of the poisonousness of ticks is an interesting one, for on the one hand dogs, cats, small marsupials, and snakes are found in the neighbourhood of Sydney and near the coast literally covered with them, and yet show not a symptom. On the other hand it is a common belief, which is I think, well founded, for I have collected a number of accounts by competent and trustworthy medical men who agree in their observations, that frequently grave symptoms, often ending in death, result from the insect's bite. The train of symptoms in dogs which seems to summarise the observations on about one hundred cases, according to the letters of my correspondents are as follows: Young animals are specially susceptible. There is first moping, hot-nose, and gradually advancing muscular weakness first noted in hind-limbs from the staggering gait, then in fore-limbs, neck and muscles of respiration. Probably owing to the last mainly is a great diminution of the animal's activity and alteration of its bark, which becomes rather a gruff cough. Obstinate constipation, troubles of micturition or retention. Epileptiform attacks or prolonged convulsions may usher in a fatal issue, or there may be no convulsive sign and death ensue from failure of heart, the pulse having been flickering, or from failure of respiration, there having perhaps been Cheyne-Stokes breathing. Peripheral nerve paralyses have been seen during convalescence—such as Bell's paralysis. The tick when filled with blood falls off and leaves a hard lump which does not disappear for two to three weeks. One attack confers immunity from the evil effects upon subsequent atacks, and in some districts where the ticks abound, dogs are regularly made immune by letting the tick remain till the first symptoms appear, which may be in a few hours, and then removing it. Upon complete recovery this is repeated one or two times. The second time the symptoms are longer in appearing than the first time, and are longer still the third time. After this the dog is protected.* There are apparently, different kinds of ticks, some comparatively harmless, some, such as the large "bottle tick," a single one of which killed a dog of forty pounds weight, very venomous, the effects of the two sexes may differ

* I have to acknowledge valuable information on this matter from various correspondents, and particularly Drs. H. A. Ellis and G. W. Taylor.

and the different seasons may have their influence. There is a good subject here, and I hope that the offer of the prize by the Council may lead to some one taking it up.

THE POISON OF THE AUSTRALIAN SNAKES.

The investigation of the action of the poison of the Australian snakes has been continued by Dr. Martin in the Physiological Laboratory at the Medical School, and towards the expenses of the work the New South Wales Branch of the British Medical Association gave a grant of money. The subject is a very big one, and, from the nature of it, results come very slowly. The work is being done in a systematic manner, beginning with the changes induced in the blood of the victim—and from these it appears, that the blood is so profoundly altered as to become for the time being unfitted for carrying on its functions, and the changes affect both the corpuscular and liquid parts of the blood. These results have been already published. The changes in the heart, and blood-vessels, the nervous system, and the various cell elements of the body are now under examination. The results so far obtained make the Australian snake venom resemble that of the American viperine snakes, though with marked differences in some respects. Such researches always open up side issues, requiring to be followed out in order to throw light on the main line of work. This method, though perhaps slow, is the only sure one. It is only by ascertaining the physiological action of the venom as it affects the different organs and parts of the body, that a rational method of treatment will be definitely arrived at. And this knowledge of the physiological action must be thorough—as thorough as the present state of the science of physiology permits. It is not enough to cause a snake to bite an animal, and merely stand by and observe what happens. The experimental method must be invoked in all its variations, so as to elucidate the precise action of the venom on the separate mechanisms or organs of the body, for only when in possession of this knowledge can we hope to meet the evil effects of the poison by appropriate remedial measures. There is room for many workers in this field, and I may therefore be permitted to refer to the prize offered by the Council for the best Essay containing the results of original research on the physiological action of the poison of any Australian snake, spider, or tick—to be sent in not later than May, 1895.

A NEW VACCINE TO PROTECT AGAINST ANTHRAX.

In these times anything which increases the productive power of the land is of interest, and such virtually is the protection of our flocks in certain districts from anthrax. This was the first infectious disease proved to be due to the presence of microbes, and it is now the best understood of them all. As far back as 1880 and 1881, Toussaint and Pasteur announced that they could produce a modification of this microbe, inoculation of which produced the disease in a milder form, that protected the animal against the more virulent form. It is true that the immunity produced is only temporary and somewhat uncertain, but there is now, of course, no doubt that it is real. The method of Pasteur has been largely employed in this Colony, but quite recently a correspondent, a station manager (who from the specimens of his work submitted to me appears to be an excellent worker), writes that he has succeeded in producing a vaccine, of which he gives the following amongst other particulars. He arrived at the fixed standard of the attenuated virus in October, 1892, and experiments, at first on smaller numbers of sheep, during 1893 gave such uniformly good results, that all the young sheep, twelve thousand, on the station were then inoculated. Without the inoculation a mortality of twenty to thirty *per cent.* was practically certain, while none of these have died from anthrax, and that this is due to their being really "protected" is proved by the direct hypodermic injection of virulent material, when absolute immunity was shown. During the current year forty thousand sheep have been inoculated, with similar results. On all the stations where these sheep were treated they were dying rapidly, but within ten days after the inoculations began the mortality absolutely ceased, except in a small flock of one thousand two hundred, in Victoria, where a suspicious death or two occurred. It is anticipated that at least two hundred thousand sheep will be inoculated during the ensuing season. These splendid results are of the highest importance, for the loss sustained in the infected districts has hitherto been tremendous. Hereafter, according to these results, it need be no more than insignificant. But, further than that, we may in this way hope to very greatly diminish, if not eradicate, the disease, even should at some future time the inoculations be discontinued, for one of the most important circumstances keeping it persistently in a district is allowing the dead animals to rot where they die. The ground near the carcass becomes saturated with the organisms, and in the soil these have been proved to live for many years. This, of course, could be met by burning the dead bodies, and that should invariably be done where it can be done. Unfortunately in these colonies it is rarely possible. If, then, by inoculation the deaths from anthrax are either entirely prevented or very greatly limited, it is clear that the absence of rotting bodies, dead of this disease, will tend to let it die out in the district; and *a fortiori* prevent its spread to other districts.

THE SPREADING OF ANTHRAX.

In connection with the spread of anthrax from infected to uninfected country, I may mention that I am at present engaged in investigating the cause of a certain green colour which appears at times in wool, and which we have traced to the presence of a chromogenic organism—the results will be laid before this Society at an early date. In the course of the work we have, unexpectedly, obtained an abundant growth of the anthrax bacillus from wool sent to me quite unconnected with the subject of anthrax. It is thus easy to see how sheep, in themselves perfectly healthy, from an infected country may carry the organism to clean country and so spread the disease. There is, of course, nothing really new in this, but meeting it in the way I did, it rather impressed me. The practice of some cautious pastoralists who will have nothing to do with animals from an anthrax country is absolutely justified, for even while themselves perfectly healthy they may carry the organism in abundance in their fleeces.

PREVALENCE OF HYDATIDS AND THE REMEDY.

In 1888, I drew attention in the press to the prevalence of the dire disease hydatids, and urged that steps should be at once taken to lessen the number of ownerless dogs which infest the city and suburbs. Something was done at the time, and occasionally and spasmodically since, but for a long time these dogs have apparently been as numerous as ever. The disease arises from the egg of a tape-worm of the dog being swallowed in drinking water, or in food, or perhaps ingested as dust. The egg gives rise to an organism which may find its way into the blood, and so may be carried by the circulation into any part of the body producing the insidious and dangerous disease. The only way to entirely rid ourselves of the disease would be to get rid of all dogs. That is not possible, but it is possible to keep down the disease by adopting the suggestions which I made, and to which I still adhere viz., to make the registration of every dog absolutely compulsory, to issue annually a distinguishing badge to be attached to the collar, and then to impound every collarless dog or dog without the badge of the year, and dispose of it unless claimed within a reasonable time. And these regulations should be really enforced, not left as dead letters. To this end their execution should not be imposed upon the police, with whose essential duties this dog catching is quite incompatible. A few dog catchers with veritable dog carts perambulating the streets would do all that is needed, and the extra revenue derived from the better collection of the dog tax would, I am sure, meet all the extra expenditure entailed. To reinforce what I have already said, I might add that from the æsthetic point of view the removal of the wretched creatures, which meet us at every turn, would be a boon to us and a blessing in disguise to the animals themselves, for it is not the dogs with homes that would be removed, but only those that having no owner remain uncared for, pick up a living anyhow, and drag out a miserable existence to a miserable end. What I propose is less than is carried on successfully in some places, but I think it would suffice for us here, and I have gone a little out of my way to speak of it, because it appears to me something which should be done, and that a little agitation is needed. I may point out our curious inconsistency in imposing a prolonged quarantine on imported dogs lest they should bring disease into the Colony, while we so utterly neglect the transmission of disease from dogs already here. I might here incidentally draw attention to the prize offered by the Council of this Society for the best results of original research on the subject of the origin of multiple hydatids in man, and as the competition is open to all comers, I trust that some of our younger colonial graduates may find the time and have the inclination, as they unquestionably have the opportunity, to do something towards the settlement of the question.

DISPOSAL OF SEWAGE—SEWAGE FARMS.

One of the greatest difficulties one has to encounter in these colonies is the collection and disposal of sewage, for there are special difficulties in the way of both. The collection of it is comparatively costly, because owing to the semi-tropical character of the rainfall, either the wholly or partially separate system has to be adopted in order to carry off the storm waters, or the sewers must be made large enough to do so, and these are then much too large for the ordinary sewage. This undue size of the sewer, too, brings its own troubles, because the difficulty of proper flushing and ventilation is immensely increased.

Our notions as to the disposal of sewage have of late years been much affected by the discovery of the precise manner in which nature goes about its business in this respect. A little reflection will show one that, seeing how tolerably constant is the sum of living organisms on the earth's surface at any given time, a marvellous process of disposal of the dead bodies of plants and animals must constantly be going on. Formerly it was supposed that principally chemical processes, and mainly direct oxidation by the oxygen of the air, effected the decomposition of the organic remains. Now we know that the change in buried remains is mainly due to the vital activity of the omnipresent microbes.

An examination of the soil from any part of the earth's surface discloses the presence of organisms, in the form of *cocci*, *bacteria*, and *bacilli*, which have the common property of converting the nitrogenous constituents common to all dead organic matter into harmless bodies, such as nitrites and nitrates of whatever base may be present, and so are removed, dissolved in water, and perhaps taken up by the roots of plants, the materials, the decomposition of which is otherwise offensive to the senses and injurious to the health of the living. Moreover, these organisms are mainly in the uppermost layers of the soil, diminishing in number downwards, so that at a depth of five or six feet there are comparatively few—this is why it is mainly in the surface layers that, on the one hand, the greatest amount of decomposition of organic matter takes place, and, on the other, the rootlets of plants are mainly found, for it is now clear that plants are largely dependent upon these nitrifying organisms for their food. This is proved inferentially by the fact that these organisms are distributed everywhere co-extensively with plants, and directly by the fact that if fertile soil be heated to a temperature sufficient to destroy the vitality of the organisms, that soil is no longer fertile, it has become sterile, plants will not grow in it, and it will no longer purify sewage as it did before. The term "living earth" has been most happily applied to the natural soil, and a curious experiment is to chloroform such soil and see, that when the activity of its living organisms is thus suspended, it is powerless to decompose organic matter, in short, to dispose of sewage matters as it did before. If now the chloroform is allowed to evaporate, the active properties of the soil as regards purifying sewage return.

The discovery of these nitrifying organisms and our knowledge of their conditions of activity, have given us much more definite notions of what goes on in sewage farms, and to my mind point to such farms, where the proper soil in sufficient area, in a convenient locality, and at a reasonable price can be had, as at once the most natural and most efficient mode of disposing of sewage. At the Botany Farm, according to the latest figures, each acre in use disposes, in a perfectly satisfactory manner, of the sewage from 1,024 persons, and I do not doubt, could deal with the sewage from a very much larger number. And when one says it disposes of the sewage one means absolute destruction, for on analysis the uppermost layers of the soil at the Botany Farm showed an increase in the amount of organic matter *after five years continuous use* of only ·02 *per cent.* There is under proper management, and even with very considerable mismanagement, no chance of any "clogging" with organic matter, and there is no reason why the same soil should not go on doing its work practically for ever. Another consequence of this newer knowledge of the precise manner in which organic matter is destroyed, is to largely remove the question of the disposal of sewage from the domain of the sewerage engineer to that of the biologist, and now one may say that it is the business of the engineer to collect and distribute the sewage, but that it is mainly that of the biologist or of the chemist to say how it should be disposed of or destroyed. I am aware that the engineers do not as yet quite like such an assertion, but it is nevertheless, in my opinion, true.

These matters have their importance to us now on account of the schemes which had been devised for the sewerage of Parramatta and Granville. I believe that this scheme might have been much less costly, simply by having the sewage farm much nearer the town, and so avoiding or lessening the cost of pumping and delivery mains. But I look farther ahead than this even, for on the shores of the harbour are plenty of low lying lands, the reclamation of which with suitable material, would at once provide means of disposing of sewage of suburbs, would yield cultivated lands, reclaim unhealthy areas and improve the remaining waters of the harbour. It is true that the great Western Suburbs scheme now in course of construction provides, I believe, most satisfactorily for these suburbs, but there are still other suburbs to be provided for near Sydney, and there are unfortunately numbers of other towns in the Colony still innocent of sewerage arrangements.

But, it may be asked, is it right and safe to bring a sewage farm so near the town—was not the costly pumping plant and main sewers of the Parramatta scheme, for instance, specially designed in order to get it away from the town. Herein lies the inconsistency of some such schemes—on the one hand copious evidence is brought forward to prove that no nuisance is likely to arise, and on the other hand great trouble is taken, and much money proposed to be spent, in order to remove the farm to a distance. If no nuisance is to arise, clearly there is no need to go so far afield with the farm, there is no reason to put it in any special locality, other than for reasons of convenience and general suitability of the site. I know of no evidence to show that the vicinity of such a farm is necessarily injurious to health. The sewage applied to the land in a fresh condition, in a properly intermittent manner, is destroyed without causing a nuisance. If the farm be properly managed, the vegetables grown on the farm are safe articles of food. No disease results to the workers on the farm, nor to the cattle fed on its produce, for no special disease is generated there, and the disease particles from men and animals carried to the farm by the sewage, if not already dead, meet there conditions so adverse to their existence that they probably speedily die. Almost any sort of soil will do, the end result will be the same, but the more suitable the soil the greater the quantity of sewage it will deal with. I have seen figures up to five thousand persons per acre.

With these remarks, then, I recommend this most natural system of sewage disposal for consideration in all future sewage schemes in this Colony, where land is often comparatively cheap, where water available for irrigation is always valuable, where there are no frosts to suspend the action of the organisms, nor very low temperature, short of frost, to notably diminish their activity in winter. And one of the most interesting places to visit near Sydney is the Sewage Farm at Botany, where thirty-three and a half acres actually in use dispose of the sewage (including storm water) from thirty-five thousand souls, and where a total area of seven hundred acres is available, enough at this rate to provide for a population of the very least three-quarters of a million.

In saying what I have as to sewage farms, I do not forget the immense progress which the chemical modes of treating sewage have made in recent years, but where the conditions laid down for sewage farms are found together, then such farms should be preferred. In other circumstances, other methods. Each case requires to be considered on its merits.

DISPOSAL OF THE DEAD.

The disposal of the dead deserves some notice here, for precisely the same prime conditions control the destruction of all buried organic remains whatever be their source. The cemetery at Rookwood is not a suitable soil—a stiff clay is one of the worst that could have been chosen, while a light, porous, well-drained site such as at Waverley is the best, for there the decomposition proceeds rapidly and with the least danger to the living. When the time comes to extend the cemetery accommodation, the authorities should try to find a sandy valley draining into the ocean—just as at Waverley in fact, and this opinion is supported by enquiries I have caused to be made at the Waverley Cemetery, where the grave diggers tell of the rapid disappearance of all the soft parts of the body. At Rookwood, on the other hand, my enquiries show that decomposition proceeds very slowly and very imperfectly. This might be inferred from the impermeable nature of the soil—wedges have sometimes to be used to get out the hard rock at the bottom, and in wet weather, as I was told, the open graves sometimes need to be baled out before the funeral.

SEWER AIR—ITS CHARACTERS.

This subject has lately been the cause of much discussion and controversy in Sydney, and it might perhaps be fitting for me to say something on the matter here, speaking in very general terms, and without particular reference to the sewers of Sydney, seeing that these will be specially dealt with by the Board of Health, of which I have the honour to be President.

Sewer air is not always offensive to the sense of smell, and it is a fact that sometimes when most evil smelling it is really least poisonous, because when putrefactive decomposition is marked, while the smell may be very bad, the chemical products of putrefaction are so inimical to the lower forms of life, the microbes, some of which may be the injurious or poisonous elements in the sewer air, that these microbes are killed. It is then important to note, that there is no necessary relationship between the offensiveness and noxiousness of sewer air : the one is not a measure of the other.

The evil odour sometimes arises from highly odorous materials of a chemical nature poured into the sewers, as, for instance, the contents of tan pits. Here, clearly, however disagreeable it may be, the odour is not particularly poisonous. But even where the odours are due to the chemical bodies arising by decomposition of the sewage matter themselves, Haldane found that they are probably not necessarily poisonous, however offensive they may be, for when considerable quantities of sewer air were drawn through weak sulphuric acid no injurious results followed the injection of the neutralised liquid under the skin of animals. Again, sewer air, as already said, even the most offensive, is not always injurious when inhaled. Haldane records that he and many others, who were not "used to it," as might be said of sewer-workmen, never suffered any evil consequences during all their work. On the other hand, there are cases where the evidence is very strong in support of its having been the cause of diseases, although in most cases ascribed to sewer gas, an examination of the evidence shows, that they were probably more coincidences than examples of cause and effect. We have thus a set of extremely variable conditions to deal with, and altogether a very complex problem to solve.

The absolute number *per litre* of organisms in the sewer air of Sydney, as it would appear from the recently published results, is greater than is commonly found in England, but less than was found in Calcutta. Obviously, the warmer and moister air being favourable conditions, the organisms multiply rapidly. The absolute number, however, is no criterion of the evil they may do: the only way to estimate this is to ascertain what manner of organisms they are. For instance, an hundred pigeons would be less dangerous to their fellow birds than a solitary hawk. The whole question then depends, not on the quantity but on the quality, not on the number but on the nature of the organisms. In illustration of this I may mention that Haldane states, that the number of microbes he found in the air of a room in which a common door-mat had been shaken, compared very unfavourably with the number found in any sewer air!

The nature of the organisms may, in a measure, be inferred by ascertaining where they came from. It is obvious that they may come from the air that enters the sewer, or from the sewage. These organisms are distributed throughout all the lower regions of the external atmosphere, but, heavier than air, they are continually tending to subside on to the earth's surface, and so the nearer the earth's surface, the greater the number in a given volume of the outer air. But the air which enters the sewers is precisely this lowest layer of the outer air, containing the most organisms. What wonder, then, that sewer air contains at least as many organisms as the worst air outside, and, moreover, the same kind of organisms as in that outside air. It is what one would *a priori* expect, and what has been proved by experiment to be the case; for it has been shown in the case of the sewers of London, Bristol and Dundee, that the numbers and kinds of organisms observed in the sewer air were not those observed in the sewage, but those observed in the outside air at the same time.

Sometimes, however, the numbers in the sewer air are greater than in the outside air, sometimes they are fewer. These exceptions, as it were, only prove the rule; for it is clear that in very dry weather the air containing the organisms, when it enters the sewer, becomes moister and it may be warmer, and thus more favourable to the organisms. It may also be that volatile products of decomposition saturate the now moist particles to which the organisms cling, so that they may have a food supply while yet floating in the sewer air. In these circumstances, then, it is not difficult to understand an increase in number of the organisms in the air after entering the sewer, altogether apart from any contributions from the walls of the sewer or from the sewage. Then, again, the organisms tend to subside within the sewer just as they did outside, so that when the conditions already referred to as favourable to their increase are not dominant, the longer the air resides in the sewer, the more the organisms have fallen into the sewage. Thus, when the ventilation is not enough to obliterate the effects of the subsidence, and apart from other conditions, the air, when it enters the sewer, may actually lose many of its microbes there.

As to the other possible source of the organisms, the sewage itself, it follows for what has already been said, that it is the less important. For the following reasons sewer air ought not to contain so very many more organisms than the ordinary outer air. Experiments have conclusively shown that, when organisms are contained in a liquid, the only probable ways in which they can find their way into the air above that liquid, are splashing of the liquid and the bursting of bubbles of gas. In properly constructed sewers there is not necessarily any splashing, nor are there many gas bubbles, for the sewage is disposed of before it has time to decompose so as to produce much gas, and even if there were gas, the diminutions of barometric pressure leading to disengagement of the gas are not so very frequent. In the case of sewage, the deposits on the walls may dry, become pulverulent and get carried away by air draughts, but drying does not often take place in sewers, and when it does, the mere drying kills many organisms, and the air draughts are not always there at the same time. Taking into account all that has just been said against the sewage origin of the microbes in the sewer air, and all already said in favour of their origin mainly from the outer air, the greater importance of this latter source is obvious. In a word far and away most of the microbes in sewer air are derived from the external atmosphere, not from the sewage.

Now, if we bear in mind that we live every day and all day in the most microbe laden lowest stratum of the outer air, or what is worse, in closed spaces, close rooms etc., in the air of which the microbes are usually more numerous than in the air outside, we at once must admit that, apart from their numbers, the nature of the microbes, thus common to the outer air and the sewer air, can not be so poisonous after all. As a matter of fact there are microbes and microbes, harmless or friendly, and injurious or unfriendly, those that never prey upon the healthy animal body, but always on dead or non-living organic matter, those that never are found except as parasites preying upon the living, and intermediate kinds that vary according to the conditions. The vast majority of the microbes in ordinary air and in sewer-air belong to the group of harmless or friendlies, and the questions to be answered are, whether there are any of the second kind, the pathogenic or disease-producing organisms, and if there are any, what is their nature and how many are there of them? In this last connection the number is of importance, because the healthy animal body has means of combating the attacks of disease-producing organisms, a struggle ensues between the body and the microbes—if the latter be few they are overcome and destroyed, if too many they overcome the body's natural protectors (phagocytes?), and so obtain a footing, grow, multiply and produce their specific disease. These three questions constitute the problem of the sewer air, and the answers are by no means easy. It is not enough to say that any particular organism belongs to this or that group, for to a single group belong both harmless and harmful individual sorts. The answers to these three questions can only be given by a laborious separation of the different kinds, and an investigation of the nature and properties of the separate kinds, a task which so far as I know, has never yet been fully undertaken, and certainly has not as yet been accomplished.

We have yet the important question to consider—What likelihood is there of there being disease-producing organisms in the sewers? There can be no doubt that such organisms do reach the sewers by the dejecta, etc., of persons and animals, especially during epidemics. But, even then, the numbers of the harmless microbes are immensely greater than the numbers of the harmful; and we have no reason to suppose that the harmful organisms rise into the sewer air more easily than the harmless. Thus even in epidemics, the proportion of harmful microbes in the sewer air would be small. But all who have tried to make pure cultures of pathogenic organisms, have found how difficult it is to satisfy all the necessary conditions as to temperature and medium, and can understand how unlikely it is that the sewage will offer favourable conditions for their growth and multiplication. Lastly, they will have to compete in the struggle for existence, for food, with the vast numbers of the harmless sorts. Altogether it does not seem likely that the pathogenic organisms will readily thrive, or even survive, in their new surroundings in the sewage.

Finally, let us assume that the sewer air really does contain disease-producing organisms, and actually reaches the outer air. They are here in a usually much drier medium than while still in the sewer, and many are killed by the mere drying. They are also exposed to sunlight, and this alone kills many more. Lastly, the survivors are distributed through so large a quantity of air that the chances are more and more against any one ingesting them in such numbers that they overcome the body's protectors, as already described, and really produce their specific disease.

SANITARY LEGISLATION IN NEW SOUTH WALES.

A review of the Acts in force in New South Wales relating to the public health unfortunately does not take long. They are as follows, viz. :—

The Quarantine Act and its Amendments, 1832 – 53.

These Acts deal only with maritime quarantine and the segregation of introduced disease. They do not even apply equally fully to all the ports of the Colony.

Cattle Slaughtering Act and its Amendments, 1834 – 51.

Mainly for police, though they contain a few clauses for sanitary purposes. These, however, are so obsolete in their machinery, &c., as to be ineffective now.

Towns Police Act, 1838.

Contains some sanitary sections, though mainly police, but is largely out of date, and its sanitary sections, for many reasons, largely inoperative or inadequate to the needs of the present day.

Municipalities Act, 1867.

Gives power to municipalities to make sanitary regulations. This has been unevenly and imperfectly done, and the regulations, such as they are, are not enforced. One of the most heart-breaking tasks I have ever had is trying to induce municipalities to carry into effect their own sanitary by-laws. The indifference of municipal councils in this Colony to sanitary measures is nothing less than shocking, nor do I anticipate that it will be any better until power is taken by the central authorities to compel negligent local authorities to do their duty in these respects.

Nuisances Prevention Acts, 1875 – 92.

Deal largely with the removal of nightsoil.

Sale of Poisons Act, 1876.

This requires no remark—its purpose is a limited one.

Adulteration of Food Act, 1879

Is practically a dead letter. It is unworkable.

Metropolitan Water and Sewerage Acts, 1888 – 89.

The scope and purposes of these Acts is indicated by the title.

Infectious Disease Supervision Act, 1881.

Deals with small pox only, but that most efficiently.

Dairies Supervision Act, 1886.

A most efficient Act, though defective in certain minor respects.

Animals Infectious Disease Act, 1888.

Provides for handling or dealing with the microbes of infectious diseases, inoculation, &c. An Act of limited application and doubtful necessity.

Leprosy Act, 1890.

Provides for the segregation of lepers. Most efficient.

Diseased Animals and Meat Act, 1892.

A most useful and successful measure now meeting the approbation even of those at first opposed.

From this review it is plain that—

1. The really efficient acts are the work of the last ten years or so.
2. The acts are piecemeal. A comprehensive Public Health Bill was drafted in 1885 by the Hon. Dr. Mackellar, and was read a first time in the Legislative Council, but it has not got any further.
3. The only infectious diseases with which there is power to deal are Small Pox and Leprosy, though with regard to these two diseases the powers are most ample.

The results of the absence in New South Wales of such sanitary legislation for infectious diseases other than small pox and leprosy, may be illustrated by the following examples, all occurring during the past twelve months or so.

Diphtheria.—At Cowra, the town having some nine hundred and fifty inhabitants, the town and neighbourhood two thousand one hundred, and the district seven thousand five hundred, from November, 1892, till May 16th, 1893, there were no less than two hundred and seventy-three cases of diphtheria, and thirty-six were fatal. The town gets its drinking water from the river below the town: there is no sewerage, almost no drainage; half the houses have cesspits, and these are not properly constructed, the other half have the objectionable single-pan system. In the surrounding district the cesspits were foul and the excreta of the sick were simply thrown into them: the general surroundings of the houses were such as to encourage the introduction and prevalence of disease. The first known case was that of a girl attending the public school, and from her it probably spread. Even while sick, this girl was permitted to nurse a child, and it developed the disease. In every instance investigated, infection, direct or indirect, was proved. Further, these two hundred and seventy-three cases were only those which came under medical cognisance, and certainly here, as in every outbreak of the sort, there were a very large number of cases which appeared so slight as not to come under medical care, though they were undoubtedly diphtheria, and fully capable of communicating the disease in a virulent form. In the State of Michigan (population, 1890, a little over two millions), on the other hand, and I take the figures from the diagram exhibited by the State Board of Health at the Chicago Fair, and a copy of which has just been sent to me, before isolation and disinfection in diphtheria were enforced, the averages in three hundred and seventeen outbreaks, were—

13·57 cases with 2·67 deaths,

and after enforcement 2·04 cases with ·48 deaths.

This represents a saving of 15,302 cases, and a saving of 2,722 lives, during the period 1886 – 90 in this one State. Think of the wretchedness and misery of parents thus saved, for it is children that have mainly thus been spared.

Measles and Scarlet Fever.—With regard to these diseases, I cannot do better than quote from the report of the Board of Health on the recent very general outbreak, which has practically overrun the whole Colony :—" Thirteen deaths from measles occurred among the three hundred and eleven cases admitted to hospital, being equal to a death-rate of 4·18 per cent. ; the deaths registered in the metropolitan district from the same disease, excluding deaths occurring in hospital, were three hundred and eighty-eight, and assuming that the rate of mortality of cases treated in their homes was the same as that of the cases treated in hospital, it is estimated that *there must have been some nine to ten thousand persons attacked with measles in the metropolitan district during the epidemic in 1893.* Most probably the numbers were much larger, as only those cases which suffered from the disease in a more or less severe form were removed to hospital, and consequently it may be expected that the death-rate among such cases was higher than among those who were treated at their own homes. Seventeen deaths occurred among the two hundred and seventeen cases of scarlet fever removed to hospital, or at the rate of 7·83 per cent. and an estimate formed on the same basis as previously stated, shows that *at least some two* *thousand persons must have been attacked with scarlet fever in the metropolitan district during the epidemic of 1893."* These figures it will be noticed, refer to the metropolitan district only, with its population of four hundred and sixteen thousand three hundred and seventy. If these same ratios are extended to the entire colony, there have been thirty thousand cases of measles, and six thousand cases of scarlet fever. The report goes on to say :— "The suffering and misery caused by these two epidemics, happening as they did at the same time, cannot be estimated, and it is to be regretted that, owing to the absence of an act for the compulsory notification and registration of infectious diseases, this Board had not sufficient power to deal with the epidemics. There can be no doubt that had some of the earlier cases been reported, and proper means taken for their isolation, many lives might have been saved." In the State of Michigan already referred to and during the same period referred to, isolation and disinfection have saved thirteen thousand three hundred and sixty-eight cases and six hundred and ninety lives from scarlet fever alone.

Typhoid Fever.—The present outbreak at Aberdeen is very much to the point. The township had from six hundred to seven hundred inhabitants, and up to date at least one hundred cases have come under medical cognisance—and the outbreak is not over yet. The sanitary condition of the place is most foul, and that largely in a way that I will not particularise here. Suffice it to say, that so long as no specifically infectious matters got into the filth, which owing to the nature of the soil and the manner in which it was deposited, remained on or near the surface and was not destroyed as it would have been had it been properly buried, and thanks to the delightful locality, the fresh air and abundant sunlight, the people did fairly well in spite of their dirty surroundings. But in November last a person, whose name is known, brought the specific infection into the township, and immediately, in such, to them, congenial circumstances, the organisms, the bacilli, throve and multiplied, and the disease began to spread-until it has reached the now notorious proportions I have mentioned. Owing to the absence of any provision for notification, the authorities here in Sydney knew nothing of its ravages until it already had a strong hold on the district.

It is to be hoped that one of the first measures introduced by the Government in the next Parliament will be one for the compulsory notification and the prevention of infectious diseases—such as the Act now in force in the United Kingdom. At present except with regard to small pox and leprosy, there is nothing of the sort in New South Wales. Should cholera, for instance, be brought here, the authorities have not power sufficient to deal with it promptly and efficiently. Unless the first cases of infectious disease are made known, the Sanitary authorities cannot take steps to prevent the spread of the malady.

This is not the place to bring forward all the arguments in favour of the legislation asked for, since I do not suppose there is a man in the room who does not assent, but it is fitting enough that I should here draw attention to the subject. It is distinctly a poor man's question—the rich can and do, in a measure, protect themselves, and the results of infectious sickness in their families are not so terrible. What we have to contend with is not any real opposition, so much as apathy and ignorance.

As shown by the voluntary vaccination returns, a single case of small pox in the harbour dispels apathy, and causes a rush of people who desire the protection afforded by vaccination, and apathy and ignorance combined sat opposite to me in a public vehicle the other day. An old lady and her grandchild were there; presently the child coughed and whooped. I looked at the old lady and suggested "whoop?" She nodded quite unconcernedly as if it were quite a matter of course. And whooping cough is a very infectious disease.

But I could go on in this strain indefinitely. The whole subject must be taken in hand and dealt with thoroughly. As an encouragement we need only read the Hon. Dr. MacLaurin's most able Report on Sanitary Legislation in England, where we read that "the number of lives preserved to the country which would have been lost if the old high death-rate had been maintained" was in 1889, the last year given, no less than one hundred and forty-two thousand four hundred and forty-six. The reduction of the fever (typhus, typhoid and simple) mortality alone is immense—from nine hundred and ninety-four per million before 1871 to one hundred and ninety-seven per million in 1890, or a total saving in the whole population of twenty-two thousand nine hundred lives in that one year alone from this one cause. As Dr. MacLaurin remarks, "This is truly a result of which the English sanitarians may be proud." In that same year in Sydney it was four hundred per million.

NOXIOUS AND OFFENSIVE TRADES.

There is at present no law efficiently controlling such trades, but there is before the Legislature a Bill which it is hoped will be speedily passed into law.* The principal object of the Bill is to support the local authorities, which are charged with the immediate supervision of the trades (including slaughter-houses), and in order to recoup the local authorities for necessary expenditure, they are to retain the fees for licenses, &c. The central authority held in reserve behind the local authorities to help them, if need be, in performing their duties and carrying their powers into effect, is the Board of Health.

This has been a burning question in Sydney for the last twenty years, and has formed the subject of enquiry by two Royal Commissions, each of which recommended a particular site, removed from population, where the traders should be free, or practically so, to carry on their trade as they liked. To this, there is every objection, and the present Bill aims at regulating the trades so that they shall be carried on without causing a nuisance, and therefore obviates the necessity of their removal to inconvenient and unsuitable localities. If a particular site were set apart it

* This Bill became law, as the "Noxious Trades and Cattle Slaughtering Act," a few days after the address was delivered.

would soon become intolerable, population would gradually gather around it, and the old condition of things arise anew. Further, the cost of carriage and, in the case of establishments concerned in the working up of surplus live stock, offal, hides, etc., etc. etc., deterioration of material in transit, would greatly diminish the value of the raw material, lower the price of stock, lower the price of stations, and so would tell back upon every important interest of the Colony.

The Bill gives no details of the measures to be employed—these are to be set out, as far as need be, by regulations made under the Act. The principle, however, is simple enough,—prevent decomposition of organic matter, and prevent the discharge of malodorous vapours into the atmosphere. There can be no reasonable doubt that the traders will soon here, as has so often happened elsewhere, recognise the benefits conferred by the Bill, in forcing them, and all alike, to conduct their business in sanitary and therefore in profitable ways, for smells cost a deal of money. At the same time the surrounding population will be relieved from the burden of an intolerable nuisance.

SUGAR AS FOOD-STUFF IN AUSTRALIA.

An interesting circumstance worthy of mention here has been emphasised by the financial panic in Australia and the depression following upon it. In conversation with the manager of a large sugar business in Australia, he mentioned that the consumption of sugar had not diminished notably, certainly not to the extent one might have thought it would, considering what we have been passing through, and that while there has been some small reduction in the total consumption of sugar per head here, he thought that such reduction has been only in the quantity used for brewing, and not in that used for food. Even now the consumption per head in Australasia is very largely above that of any other country, notwithstanding the enormous import of confectionery, etc., from England, which is all included in the British consumption, and although the people here are supplied with other articles of diet in infinitely larger quantity and of better quality than any other community can obtain. This statement interested me greatly because so accurately in accord with the teachings of modern physiology, which show that sugar is no longer a mere sweetening agent or condiment, but that it is really a food-stuff of high value. This fact people seem to have found out for themselves, because when all sorts of economies have had to be made, sugar has not been given up, apparently because experience has shown that it is no longer a mere luxury. Owing to the insular position of Australia and to the general distribution of the present distress throughout all the Colonies, this continent is peculiarly adapted for observations of this sort, and experimental physiology, working in the laboratory, confirms the apparent experience of the people by showing, that four times as much sugar disappears in the muscle during its activity than does while it is at rest, and Vaughan Harley has just shown, by experiments upon himself, that sugar taken as a food is a muscle-food. The apparatus he employed is the "ergograph" of Professor Mosso of Turin, and Harley performed his experiments in Professor Mosso's laboratory. By this instrument a definite group of muscles can be brought into play, and, as any one group is like all the other muscles of the body so far as the experiments are concerned, what is found to be true for a part, is true for the whole. Thus an accurate record can be obtained of the effect of any given set of conditions on the muscular work of the body generally. In his own case, seventeen and a-half ounces of sugar taken on a fasting day, increased the work done by 61 – 76%; seven ounces added to a small meal increased the muscle work by 6 – 30%; with eight and a-half ounces added to a full meal the increase of work was 8 – 16%, and the same amount of sugar increased the total work done in eight hours by 22 – 36%. Finally, he found that sugar, taken as a food about 3·30 in the afternoon, obliterates that daily fall in the muscular power common to us all, and usually happening about 5·30 p.m. These are interesting results, and, taken with the present prices of meat, bread and sugar, important, for assuming that one hundred and thirty-six pounds of bread contain seventy pounds of carbohydrates and that bread is one penny farthing per pound, carbohydrate foods, which are absolutely indispensable in some form or other, are now as cheap in the form of sugar as in that of bread. It is true that bread contains also the nitrogenous elements of food, but these in Australia are generally preferred in the form of butcher's meat, which is cheap enough and copiously indulged in. This new position of sugar in the dietary of the people is of far reaching importance and quite a thing of our own times. My recollections do not go back so very far, yet only thirty years ago as a boy I was permitted to have either milk or sugar to my porridge, but not both, for the then costly sugar was regarded as a pure condiment and therefore a luxury, to be sparingly administered, so as not to spoil the child. This, I may add, was in Scotland.

The difference between sugar as a sweetener and sugar as a food has been much emphasised by the discovery of "saccharin," a complex derivative of the coal tar products, and which is some three hundred times as sweet as sugar, but of no value as a food stuff, if its continuous use, indeed, be not positively injurious. Some time ago it was stated that the German authorities had prepared large quantities of "saccharin" tablets for issue to the soldiers instead of sugar: if this were done the blunder was a curious one for a people who claimed that their soldiers' diet was prepared on scientific principles. They substituted for a valuable food a sweetening substance not only with no sustaining power, but which may have serious effects when taken continuously.

SUMMARY OF THE SOCIETY'S PROGRESS DURING THE PAST YEAR.

I have now to summarise the principal events connected with the Society's position and progress during the year. At the end of a period of twelve months during the whole of which there has existed an unexampled depression in trade, leading to universally diminished incomes, it would be indeed strange if this Society had alone escaped the general fate. And it has not escaped. The income of the Society has been smaller, but then expenditure has been curtailed so that the Council has had to do, what everybody else has had to do, to cut its garments according to its cloth. When we reflect on the beneficent purposes on account of which all the funds of this Society are expended, you will unite with me in a fervent hope, that the coming year will show a turn of the tide.

Roll of Members.—The number of members on the roll on the 30th April, 1893, was four hundred and seventy-seven. Thirty-one new members have been elected during the past year. We have, however, lost by death nine Ordinary and one Honorary member, and thirty-one by resignation. Twenty have been struck off the Roll for non-payment of their subscription, and three have failed to take up their membership under Rule IXA. There is thus left a total of four hundred and forty-five on April 30th 1894; this number however, does not include the Honorary and Corresponding members. A comparison of these figures with those of previous years shows, that the loss on the total membership during the year is practically entirely due to resignation and to failure to pay the annual subscription,—due therefore to the causes already alluded to, and not to any diminished interest in the Society or its work.

The losses by death were :—

Honorary Member :

Tyndall, Prof., D.C.L., LL.D., F.R.S., Elected 1884.

Ordinary Members :

Bayley, G. W. A., Elected 1878.
Bell, Walter F., M.I.C.E. *Irel.*, Elected 1892.
Fischer, C. F., M.D., M.R.C.S. *Eng.*, Elected 1874.
Henry, James, Elected 1877.
Leibius, Adolph, Ph. D., M.A., F.C.S., Elected 1859.
Mitchell, J. S., Elected 1887.
Redfearn, W., Elected 1886.
Saliniere, Rev. E. M., Elected 1876.
Wilson, F. A. A., Elected 1879.

Professor JOHN TYNDALL was seventy-three years of age when he passed away, and had been a teacher of physics for some forty-seven years. To him the word teacher was peculiarly fitted, for it was as a lucid expositor, a brilliant lecturer, that he made his way to fame. To him is due much of that general interest in science which is a feature of our times.

Dr. LEIBIUS was a familiar figure in this hall, for during twelve years he did yeoman service as joint honorary secretary, in 1891 he filled the Presidential Chair, and at the time of his death was Honorary Treasurer. We have thus a continuous service of some fifteen years, and to him for his careful and assiduous work in its early days much of the present success of the Society is owing. At the time of his death he had been Senior Assayer at the Sydney Branch of the Royal Mint for thirty-four years, and this position together with his genial manner and the enthusiastic thoroughness with which Dr. Leibius set about everything he undertook, contributed to make him what he must ever remain to us—one of the founders of the Society. It was indeed a sad coincidence—was it merely a coincidence?—that took Dr. Leibius from us so soon after we had lost his respected chief, the Deputy Master, Mr. Robert Hunt, who also must be regarded as a founder of the Society. Dr. Leibius really never was himself after Mr. Hunt's death, so greatly did he feel the loss of one who was more friend than master. I cannot speak of the one without thinking of the other, and of both I have personally the most grateful recollections on account of the kindly relations maintained between us from my first days in the Colony to the last days of their lives. And I am not the only one here who can say the same.

Meetings.—There have been eight general meetings at which no less than thirty-six papers were read, by far the largest number ever read in a session, the nearest to it being the preceding year, when, however, only twenty-two papers were read. The average attendance of members was forty-two, and of visitors four. This likewise was a great increase, for the highest average of attendance before this year was in 1890, when the average was a little over thirty-six members and five visitors. Thus both in the number of papers read and persons present the past year has shown a considerable advance on any previous year.

In addition to the general meetings there have been three meetings of the Medical Section, and eight meetings of the Engineering Section, at which valuable contributions to their respective branches of knowledge have been made.

The library has been duly cared for at an expenditure in money of £138, and the Society has exchanged publications with no less than three hundred and ninety-five institutions, so that in this way as many as one thousand eight hundred and sixteen publications have been received and added to the library.

Original Research.—In continuation of the practice commenced in 1881, of publishing yearly a list of subjects more or less peculiar to Australia, the investigation of which would be of interest and value, the Council invited original contributions, and offered its medal together with a grant of £25 for the best original paper on the following subjects, viz.:

Series XII.—*To be sent in not later than 1st May, 1893.*

No. 40—Upon the Weapons, Utensils, and Manufactures of the Aborigines of Australia and Tasmania.

No. 41—On the Effect of the Australian Climate upon the Physical Development of the Australian-born Population.

No. 42—On the Injuries occasioned by Insect Pests upon Introduced Trees.

No papers however were received on any of these subjects.

Series XIII.—*To be sent in not later than 1st May, 1894.*

No. 43—On the Timbers of New South Wales, with special reference to their fitness for use in construction, manufactures, and other similar purposes.

No. 44—On the Raised Sea-beaches and Kitchen Middens on the Coast of New South Wales.

No. 45—On the Aboriginal Rock Carvings and Paintings in New South Wales.

Series XIV.—*To be sent in not later than 1st May, 1895.*

No. 46—On the Silver Ore Deposits of New South Wales.

No. 47—On the Physiological Action of the Poison of any Australian Snake, Spider, or Tick.

No. 48—On the Chemistry of the Australian Gums and Resins.

Series XV.—*To be sent in not later than 1st May, 1896.*

No. 49—On the origin of Multiple Hydatids in man.

No. 50—On the Occurrence of Precious Stones in New South Wales, with a description of the deposits in which they are found.

No. 51—On the effect of the Australian Climate on the Physical Development of the Australian-born Population.

The competitions are in no way confined to members of the Society, nor to residents in Australia, but are open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor. The Society is fully sensible that the money value of the prize will not repay an investigator for the expenditure of his time and labour, but it is hoped that the honour will be regarded as a sufficient inducement and reward. The successful papers will be published in the Society's annual volume. Fifty reprint copies will be furnished to the author free of expense. Competitors are requested to write upon foolscap paper—on one side only. A motto must be used instead of the writer's name, and each paper must be accompanied by a sealed envelope bearing the motto outside, and containing the writer's name and address inside. All communications are to be adressed to the Honorary Secretaries.

NOTES ON SOME MINERALS AND MINERAL LOCALITIES IN THE NORTHERN DISTRICTS OF N. S. WALES.

By D. A. PORTER, Tamworth.

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

TOURMALINE.

Tourmaline occurs very abundantly at Wallangra, on the McIntyre River, some forty miles from Inverell, where veins of quartz containing this mineral, are common over a large area ; it exists in the greatest abundance on a ridge opposite to the Post Office, and extending to the Wallangra homestead. This ridge is about three-quarters of a mile in its longest extension and half a mile in width, and the whole of this area is plentifully strewn with broken prisms and masses of the mineral.

The tourmaline occurs here under three different conditions :—

1. In veins of milky quartz.
2. In nodular segregations in the granites of the locality.
3. In immense masses (rocks) of aggregated crystals, with which little, if any, quartz or other mineral is associated.

The veins of quartz occur in great number on the ridge before mentioned, and vary from a few inches, to many feet in thickness, They do not appear to have any definite strike, but seem to be all radiating from a very large mass or "blow" of quartz, which caps the apex of the ridge. The whole of these quartz veins are thickly impregnated with prismatic masses of the mineral, which usually exhibit a radiated structure. The crystals of tourmaline are without pyramidal terminations, or at least, none were observed. Some of the quartz matrix is translucent, but most of it is opaque, and varies from bluish-white to a milky-white in colour. A measurement of convergence of prisms, taken from part of a radiated mass, showed that some of the prisms had been originally eighteen inches in length.

The crystals exhibit innumerable cross-fractures, and when removed from the matrix usually break up in short pieces; none of the prisms exceed $\frac{3}{16}$ inches in diameter, while some are as thin as horse-hairs. The thin crystals transmit light, and appear of a clove-colour, with a slight tinge of green. The larger crystals are quite black and opaque.

In the granite rocks in river-bed close by, are exhibited sections of globular segregations, in which the tourmaline occurs in minute prisms associated with crystalline grains and plates of quartz and orthoclase. The nodules are rendered conspicuous through being much darker in colour than the containing rock. The sections of nodules are seldom more than four or five inches in diameter.

The schorl rocks before mentioned, are outcropping on the flat ground at the base of the tourmaline ridge, some of these masses would exceed half a ton in weight.

Garnet.

Garnets occur loose in the surface soil of a small isolated ridge of basalt, which is close to the main road from Tamworth to Bingara, and is distant about fifteen miles from the latter named place. Several parties have at various times been prospecting the ground, and collecting the stones, under the impression that they were spinels, and of considerable value. In a parcel of about two hundred of these stones which I was shown, I found one that I estimated at four carats, some few others would be about two carats, while the general average of the whole parcel would be about one-quarter carat.

No trace of crystalline form was observed on any of the stones. The surfaces have a pitted or corroded appearance, and many of them are evidently *not* waterworn, so that they are probably amorphous, and, I believe, are of the iron-alumina variety (almandite), although none of the stones show any trace of the purple colour which is so noticeable in the almandine garnets lately discovered in Western Australia at Alice Springs.

The Bingara stones are of a pale to deep wine colour, passing to clear bright red in some specimens. When cut and polished they exhibit great brilliancy, and as they are remarkably clear, and free from flaws and imperfections, they make very handsome gems. B. B. easily fusible, and in solution they give strong iron reaction.

SPESSARTITE.

Spessartite has been met with in the argentiferous lodes of Broken Hill, but only occurs in small quantity. A sample which I recently received from that locality, consisted of about a dozen broken crystals, which had the appearance of having been originally very perfect crystallisations.

One portion of a crystal showed faces of the rhombic dodecahedron without modification, and another presented planes of the same kind, in combination with faces of the tetragonal tris-octahedron, the latter planes being much reduced. The colour of the stones is a reddish-sherry tint, passing into brownish-red, and in greater part they are perfectly transparent.

No cleavage was observed, but some of the dodecahedral faces viewed on the edge exhibited a lamellar or platy structure. No striæ were noticed on crystalline faces. The hardness was slightly over 7, the mineral scratching quartz, but not readily. The Sp. G., as a result of the mean of several trials, was found to be 4·18. B. B. fuses readily if in small splinters or fragments, and the colour of the fused mineral becomes much darker, but is not in any degree magnetic. With fluxes gives strong reaction for manganese. One of the broken crystals in the sample weighed eighteen and a half grains troy.

HYALITE.

Hyalite is found on 'Mount Cora,' a conical hill of basalt, which is situated about twelve miles due east from Yalaroi Station in the Warialda district. The mineral exists in large quantities filling in crevices and cavities on the top of the mount, and large and fine specimens are readily obtainable. Also at Elsmore, one and a half miles from the Elsmore Public School, at the junction of the Elsmore and Glen Innes roads; it occurs here lining amygdaloidal cavities in basalt; rare.

Hyalite is found at Cockburn Creek (Moonbi), and at Bowling-Alley Point, near Nundle, in serpentine, and has been observed on chromite, at Beadles' Conditional Purchase on Cockburn Creek.

Lepidomelane.

A mineral from Torrington near Emmaville, has been identified by Professor Liversidge, as lepidomelane. It is of a greenish-black colour *en masse.* Thin laminæ transmit a dull greenish light. Laminæ rather brittle, very slightly elastic, streak greyish-white. B. B. to black magnetic globule, re-acts for iron and manganese.

Chalcedony.

Bluish-white chalcedony occurs abundantly in nodules in basalt on a ridge about two miles north-west by west from Boggabri, some pieces three inches in diameter, compact, sub-translucent. Also in the gravel beds of the Peel River, at Nundle. Colour bluish-white to milky-white; some specimens show zonal stricture often hollow. The cavities usually lined with quartz crystals.

Small, but fine coloured agates, carnelians and chalcedonies occur at 'Dobbikin,' near Millie in the Moree district. They appear to have been liberated by the disintegration of conglomerate rocks in the vicinity, but were probably derived, originally from the trap rocks of the Nandewar Range some few miles to the eastward.

Axinite.

Axinite is found associated with epidote, forming small veins in altered slate boulders in Hall's Creek near Bingara, and about two miles north-east from the Hall's Creek Public School.

Olivine.

Fine specimens of olivine exist in basalt near the 'Gum-flat' road, four miles from Inverell. Some pieces an inch in diameter.

Pleonaste.

At about eight miles from Glen Innes on the top of the 'pinch,' Inverell road, a good locality for pleonaste exists. Broken crystals are common on the surface, and specimens of the mineral embedded in the rock (basalt) are readily obtainable. Crystals approaching perfection in regard to crystalline form are rare.

Tachylite.

Tachylite is quite a common mineral on Mathers' Hill at Inverell, where it occurs encrusting basalt and in loose pieces in the surface soil. Colour black, brown, breaks into irregular fragments with vitreous lustre on newly broken surfaces. Some specimems shew spherulitic structure, and others are coated with a dull bluish film. Also in basalt in road cutting at about seven miles from Warialda on road to Yetman. At Kangaroo Flat, near Emmaville, an immense boulder in the creek bed appears to be entirely of tachylite.

Zoisite.

Zoisite occurs at upper Bingara at an old copper mine in Cooringra Creek. The mineral is found in veins in a magnesian rock. Crystallized in slender prisms which are massed together transversely to direction of containing vein ; crystals all parallel, not divergent, and without free terminations. Colour pale sulphur-yellow ; silky lustre. Plentiful.

Nantokite (Cu_2Cl_2).

Found forming small veins in hæmatite in the silver lodes of Broken Hill. Colourless, transparent, lustre vitreous, crystalline, showing brilliant cleavage planes where broken ; also disseminated through the ferruginous material, and accompanied by much silica in the form of minute quartz crystals. The small amount of mineral available prevented the Sp. G. or hardness being determined. B. B. gives the characteristic flame of cuprous chloride and on charcoal is reduced to metallic copper. Oxidises rapidly on exposure.

Dyscrasite (Antimonial Silver Ore).

Dyscrasite has been found in considerable quantities, accompanying sternbergite, stromeyerite, and other silver ores in the Consols' Mine at Broken Hill, in fact by far the greater portion of the so called 'native silver' taken out of that mine has been dyscrasite. One large mass weighed upwards of twenty-two hundred weight, and another discovered in 1891 weighed sixteen hundred weight. This latter slug gave when smelted a return of fine silver at the rate of 77·9%. Three other pieces weighing collectively four hundred weight, and many smaller samples were obtained in 1891, the total amount of this mineral raised, between January and September of the year referred to, totalling six tons seven hundred weight one quarter and eighteen pounds, and which gave a silver return of 142·554 ounces troy.

A specimen of dyscrasite from Broken Hill, examined by me, was found to have a Sp. G. of 9·70; lustre bright metallic; colour silver-white on newly broken parts, but tarnishing to yellowish-white on exposure. The containing gangue was calcite in which the mineral occurred in beautiful arborescent forms. B. B. on charcoal gives coating of oxide of antimony and a remaining globule of silver. Dyscrasite is said also to occur in beautifully perfect crystals, in calcite in the mine before referred to.

NOTE.—A most interesting paper on the occurrence of dyscrasite at Broken Hill, was read by Geo. Smith Esq., of Broken Hill, at the inauguration of the Australian Institute of Mining Engineers at Adelaide in 1893, and the statistical information quoted in these notes has been gathered from the paper referred to.

PRELIMINARY NOTES ON THE PHARMACOLOGY OF *CARISSA OVATA*, VAR. *STOLONIFERA*, *Bail.*

By THOS. L. BANCROFT, M.B. *Edin.*

(Communicated by J. H. MAIDEN, F.L.S., F.C.S.)

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

WHILST in search of bitter plants (with the object of ascertaining if any possessed pharmacological activity) in a scrub near Dalby, Queensland, September 1893, a *Carissa* was noticed to come under this category.

The plant proved to be sufficiently distinctive from the normal or coast form of *Carissa ovata*, R. Br., to warrant the Colonial Botanist, Mr. F. M. Bailey, in describing it as a variety, viz., *stolonifera.** The normal form of *Carissa ovata* is a common plant about Brisbane; observations and experiment show that it very rarely develops the bitter poison of the western variety, and if so, only in small amount.

An alcoholic extract of the bark was made, and solutions in water of this when injected into frogs rapidly killed them. The muscles were pale and paralysed, and the heart stopped in systole. Applied to the exposed hearts of frogs, pithed or under the influence of Curara, it slowed and finally brought them to a standstill in systole. It was then seen that the substance resembled closely in its action *Strophanthin* and *Ouabin*, glucosides from allied genera of the Apocynaceæ.

A solution of the extract in water gave the following reactions: copious precipitates with chloride of gold, acetate of lead and sulphate of copper. Slight precipitates with acetic acid, dilute sulphuric acid, tannic acid, mercuric chloride and ferric chloride (black). No precipitate with ammonia, carbonate of soda, or iodide of potassio-mercury.

Referring to numerous works on Botany and Materia Medica, I found the following mention of the medicinal use of a *Carissa*: Under the heading *Carissa* in the "Treasury of Botany" there is the following:—"Some of the species have medicinal properties, being as bitter as Gentian. The bark of *C. xylopicron*, a native of Mauritius and Bourbon, is used by the Creoles in diseases of the urinary organs, while the wood, there called Bois amère, has a like reputation. Small cups are made of it, in which water or wine is allowed to stand till it acquires the flavour of the wood, as in the bitter cups now so frequently used in this country."—[M.T.M.]

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* Botany Bulletin, No. 9.

In a work by Louis Bouton entitled "Medicinal Plants of Mauritius," is the following account of the medicinal use of *Carissa xylopicron*:—"The Bois amère is according to Pellicot, a physician, who long resided in the Mauritius, a sovereign remedy in gonorrhœa. Cossigny observes that it might be useful in other diseases, such as ulceration of the bladder, uterus, and in the whites or fluor albus. Possesses, according to Du Petit Thouars, a bitter flavour, which it communicates to the water when infused and is considered at Bourbon as very tonic. The bark is frequently used by the creoles in diseases of the urinary organs, nephritic calcules."

I wish here to suggest the advisability of investigations in Europe being made of this Mauritius species, for if the active principle of the genus be considered of value therapeutically, as appears to me very probable, it is to such a plant that recourse would have to be made as the subject of this paper is a small plant and not plentiful. The genus *Carissa* being so closely allied to *Acokanthera*, led me to suspect that the active principle might be the same, viz.: the glucoside *Ouabin*, but as far as I have been able to ascertain without the assistance of chemists, it would appear that it is quite distinct. In the Pharmaceutical Journal, May 13, 1893, there is a reprint of Professor Fraser's paper on the "Way Nyika Arrow-poison," which is derived from an *Acokanthera;* the active principle is there described as a glucoside crystallising from a watery solution in quadrangular plates and in needle-shaped crystals from alcohol; it is stated also that a saturated solution of the substance in water is tasteless.

Now the active principle under observation separates out in minute globular specks extremely like white blood corpuscles, not only from a watery, but from alcoholic solution, and moreover is very bitter. It neither agreed with the appearances and reactions of *Strophanthin* as given by Professor Fraser.*

It is a curious circumstance that so many of the Apocynaceæ are poisonous, and of these so many are cardiac poisons of the

* On the Chemistry of Strophanthin—British Medical Journal, July 23, 1887.

Digitalis type ; in addition to the genera already mentioned viz.: *Strophanthus*, *Acokanthera* and *Carissa*, there are at least two others, viz., *Tanginia* and *Nerium*.

To prepare the active principle, the following method proved the best in my hands, although there is no doubt a certain amount of decomposition of the glucoside from the use of sulphuretted hydrogen. Boil the bark in water, decant the decoction, add some lead acetate, boil for a minute and allow to stand for several hours, filter, remove excess of lead with sulphuretted hydrogen, evaporate at a gentle heat over a water bath to a honey consistence. The material is thus left as a sticky yellow mass, which upon standing some days becomes a magma of peculiar crystals. It can be purified further by solution in absolute alcohol. Exposed to the air for a few days in a thin layer it becomes green in colour ; it is deliquescent, does not polarise light and reduces an alkaline solution of cupric oxide. Fungi of various kinds readily grow in it. It is very soluble in water, less so in aqueous alcohol, slightly soluble in absolute alcohol, and insoluble in ether and chloroform. It gives no coloration with strong sulphuric acid, strikes a yellow colour with ammonia. Gives slight precipitates with auric chloride and tannic acid, none with mercuric chloride.

On ALMANDINE GARNETS from the HAWKESBURY SANDSTONE at SYDNEY.

By Henry G. Smith, Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

A short time back I had submitted to me for determination, some small reddish particles contained in a conglomerate taken from a quarry at Pyrmont. They were found to be garnets, and the presence of gem-stones in so unlikely a locality as the neighbourhood of Sydney, induced me to make this investigation. The exact locality from which these garnets were taken, is about half way between Miller Street and the Glebe Island Bridge, on the right hand side. A small amount of work has been done there, but has apparently been stopped.

The conglomerate consists of a thin layer covering the bed of sandstone, which is nearly horizontal, having but a slight dip towards the north. The garnets are very minute, and do not consist of perfect crystals, being principally fragments; in fact, I could only detect traces of faces on one or two of them. The colour is light in most instances, although some are deep red, and others inclining to purple, having all the characteristics of stones of this group known as "precious garnets." The lustre is good, and there are little signs of decomposition.

It was found advisable to crush the conglomerate and wash it to obtain the garnets, which can be readily picked out of this material when dried, better with the aid of a lens; the remaining portion being largely composed of water worn quartz pebbles, some mica, and a few jasperoid stones mostly of a green colour. The reason these garnets are in fragments is apparent when placed under the microscope, the cleavage being beautifully marked and quite distinct; in some instances the apparent cubical cleavage is so striking, that the resemblance to that of galena is at once suggested.

The conglomerate from which these garnets were obtained was most probably derived from the decomposition of granite, as the gravel has all the appearance of coming from that source, and there can be little doubt but that the garnets were derived from this granite also. A specimen from Albury, New South Wales, is before you, of a granite containing garnets, very much resembling those obtained in Sydney, being almandine garnets, small, and of much the same colour.

It is not probable that these garnets were obtained from the basaltic rocks common in the Hawkesbury deposit, because when heated before the blowpipe they readily fuse, become quite black and magnetic, and had they originated from that source we might have expected to have found them black or dark brown in colour, as for instance the variety Melanite from Vesuvius. The evidence already obtained, points to the fact that granite was the principal rock from which the Hawkesbury Sandstone was derived, and it shows the persistent nature of these garnets that they should have withstood decomposition in such fragments, when so readily cleaved, a property not of common occurrence in garnets.

The most prolific sources of the garnet, however, are the metamorphic rocks, these crystals being found plentifully in mica-schist, chlorite-schist, gneiss, limestone, &c. When writing on the Hawkesbury Sandstone, the Rev. J. E. Tenison-Woods* inclined to the opinion that considerable masses of the sandstone had been subjected to metamorphic action, basing this suggestion upon the presence of the glistening particles of crystalline quartz, and mentioning the millstone grit of England as an example. Even if this opinion is acceptable, there is nothing to show that these garnets are the effect of this metamorphism ; they are simply an accidental constituent of the conglomerate in which they are found, they are not in crystals, and had been submitted to fracture before they became stationary. There is nothing to denote that they are of more recent date than the surrounding rocks.

The specific gravity of the garnets is 3·902. Hardness, just above 7, being just hard enough to scratch quartz with difficulty, they were mounted in lead for this test.

Before the blowpipe they fuse readily, the bead being magnetic. With borax they give an iron reaction ; with soda show presence of trace of manganese. When examined in thin sections they are seen to be isotropic, no light passing during an entire revolution. For this investigation the small stones were placed in a glass tube closed at one end, heated and pressed flat between two pieces of wood ; when cold, they can be ground down and mounted in the usual way for rock sections.

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* Proceedings Royal Society, N. S. Wales, Vol. XVI., p. 53.

For observing their perfect cleavage they were mounted in balsam under a cover-glass, and both reflected and transmitted light used. For analysis they were decomposed by fusion with the carbonates of potash and soda. The protoxide of iron was estimated from a portion decomposed by heating in a closed tube with sulphuric acid, and determining with potassium bichromate. The following are the results obtained :—

		Oxygen.		
Silica (SiO_2)	= 38·704	= 20·642		20·642
Alumina (Al_2O_3)	= 21·795	= 10·256	10·906	20·963
Ferric oxide (Fe_2O_3)	= 2·168	= ·650		
Ferrous oxide (FeO)	= 27·750	= 6·167	10·057	
Magnesia (MgO)	= 9·725	= 3·890		
Manganese	trace			
	100·142			

From which the formula may be written as,
$(\frac{1}{2}(\ddot{F}e, \ddot{M}g)^3 + \frac{1}{2}\ddot{\ddot{A}}l)^2 \ddot{\ddot{S}}i^3$ or $6\left\{\begin{matrix}FeO\\MgO\end{matrix}\right., 3\,SiO_2 + 2\,Al_2O_3, 3\,SiO_2$

The sesquioxides are a little high, although they balance with the protoxides fairly well. If the whole of the sesquioxide of iron found is calculated into the protoxide, the amount is 29·7012 per cent., containing oxygen equal to 6·6, and this added to the oxygen of the magnesia equals 10·490, an amount nearly that of the alumina. The ratio is that of an unisilicate belonging to the garnet group. The presence of such a large percentage of magnesia is not usual in almandine garnets, and approaches the "pyrope" or Bohemian garnets, although the large quantity of protoxide of iron retains them in the iron-alumina group.

I am indebted to Mr. C. Wooller, of Harris Street, Ultimo, for directing my attention to the existence of this garnet bearing conglomerate, and its locality.

ON THE MAGNETIC SUSCEPTIBILITIES OF SPECIMENS OF AUSTRALIAN BASALTS.

By A. W. RÜCKER, M.A., F.R.S.,
Professor of Physics in the Royal College of Science, London.
(Communicated by Professor THRELFALL, M.A.)

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

IN a paper recently published in the Proceedings of the Royal Society of London (Vol. XLVIII., pp. 505 – 535, 1890), I described a simple method of measuring the magnetic susceptibility of irregular fragments of bodies which were nonconductors of electricity and of low magnetic permeability. Mixtures of magnetic oxide and glycerine in various proportions were first made, and their permeabilities were determined by the magnetometric method. Approximately equal volumes of one of these mixtures were introduced in test tubes into the two cups of a Hughes' Induction Balance, and silence was obtained by means of a compensator.

A fragment of the rock under experiment was then placed in one of the test tubes, and liquid was removed until the total volume was the same as before. In general, the balance was disturbed as the permeability of the rock was different from that of the liquid it displaced. Finally two liquids were found, to the permeabilities of which that of the rock was intermediate, and by observing the displacement of the compensator necessary to produce silence in each case when the rock was introduced, the susceptibility of the fragment was calculated from the known susceptibilities of the liquids.

As a full account of the experiment has been published, it is unnecessary to describe here the precautions taken and the various tests to which the results were subjected. It was found that the method applied to susceptibilities between 0·0001 and 0·008, and it was also proved that in the specimens studied, the magnetic force and the induction were proportional for forces between 5·0 and 0·9 C.G.S. units.

Since the publication of the above results I have (through the good offices of Professor Threlfall), received from Mr. C. S. Wilkinson of the New South Wales Geological Survey, specimens of a number of Australian basalts. The same apparatus was used. The liquids were tested by means of some of the specimens previously studied and were found to be unaltered. The experiments were made by Messrs. J. W. Pickles, and W. E. Harrison, students in the Physical Laboratory of the Royal College of Science, London. The following table contains the results. The susceptibilities are expressed in C.G.S. units.

No. of specimen.	Locality &c.	Reference number on specimens in the Geological Museum.	Magnetic susceptibility 0 00001 ×
1	Grand Junction Shaft near Forest Reef	(m. 6 C. S. W.)	20·7
2	Ditto	(m. 7 C.S.W.)	31·0
3	Ditto	(m. 8 C.S.W.)	25·3
4	25 chs. S.E. of Dalwood crossing	(m. 27)	105·0
5	Road Metal Quarry opposite Dalwood	(m. 26)	118·2
6	From Penningtons' Raymond Terrace		86·4
7	Ditto	(m. 29)	23·4
8	Ditto	(m. $\frac{29}{2}$)	14·2
9	Irrawang, Raymond Terrace	(m. $\frac{28}{3}$)	472·0
10	Lochinvar	(m. 55)	25·3
11	Narrigo	(m. 12)	14·1
12	Narrigo	(m. 12)	8·0
13	2 miles W. of Armidale	(m. 1)	94·4
14	North of Armidale	(m. 65)	90·1
15	Euroka Creek	(m. $\frac{9}{2}$)	10·5
16	Euroka Creek	(m. 9)	0
17	Near Molong	(m. 62)	73·4
18	Ditto	(m. $\frac{62}{2}$)	59·8
19	Ditto	(m. $\frac{62}{3}$)	49·4
20	Near Herbert Road station E. of Armidale	(m. 66)	6·8

No. of specimen.	Locality &c.	Reference number on specimens in the Geological Museum.	Magnetic susceptibility 0·00001 ×
21	Moree Road, N. Bingara	(m. 60)	84·0
22	3 miles N. of Narrabri	($\frac{\text{C.S.W.}}{2}$ 16)	19·1
23	Murrurundi Tunnel	(m. 11)	119·1
24	Werris Creek	(m. 48)	18·5
25	Parish Anderson, Co. Gough	(m. 42)	19·1
26	Doherty's Hill, Uralla	(m. 43)	3·0
27	Parish of Uralla, Co. Devon	(m. 44)	15·4
28	Near Bathurst	(m. 15)	22·2
29	Ditto	(m. $\frac{15}{2}$)	31·0
30	Five Island Point, Wollongong	(m. 18)	154·8
31	10 miles E. of Dubbo	(m. 67)	154·2
32	Brown's shaft, Two Mile Flat, Gulgong Dist.	($\frac{\text{C.S.W.}}{2}$ 34)	26·5
33	The Battery, Lachlan R.	(m. 35)	6·2
34	Wayo, Crookwell	(m. 11, C.S.W.)	185·7
35	Near Milton	($\frac{\text{C.S.W.}}{2}$ 13)	117·2
36*	$\frac{3}{4}$ mile S.W. Flemington Railway Station, Homebush	($\frac{\text{C.S.W.}}{2}$ 3)	140·7
37	Corral Gap, Southern-rd	(m. 17)	126·5
38	Leucite basalt from El Capitan, near Cobar	(m. $\frac{57}{2}$)	24·1

These results are in close accord with those obtained from European basalts, as the following table will show.

Specimen of	Locality.	K.
Porphyritic basalt ...	Schemnitz, Hungary ...	0·00109
Basalt	Faroe Islands	116
Basalt	Unkel-on-Rhine ...	45
Basalt	Rowley Regis	118
Basalt	Giant's Causeway ...	27
Basalt	Giant's Causeway ...	21
Porphyritic basalt ...	Tobesmorey Skull ...	231
Basalt	Tobesmorey Harbour ..	209
Porphyritic basalt ...	Fishguard	61
Basalt	Dumfries	114
Basalt	Staffa	48
Basalt	Staffa	77
Mean of twelve European Basalts		0·00099
Mean of thirty-eight Australian Basalts... ...		0·00068

* Subsequent information shows that this rock was probably an argillaceous limestone.

Specimen 9, from Irrawang has a higher susceptibility than any rock described as a basalt in our list of European rocks. It is however less susceptible than several samples of gabbro or olivine gabbro from Skye.

On a NATURAL MINERAL SPRING at BUNGONIA.

By Rev. J. Milne Curran.

[With Plate I.]

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

Mineral springs are so few in this Colony that no apology is needed for bringing forward the following notes. The existence of the Bungonia spring has been known to Mr. James Armstrong and the writer for some few years past, but it is only recently I had an opportunity to revisit and make a detailed examination of the locality. A chemical examination of the water has become almost a necessity in the public interest. It is now customary for numbers of persons to resort to the spring, and very favourable opinions are generally expressed to the therapeutic properties of the water.

The spring is situated on the Bungonia Creek, a short distance above Bungonia. The locality is part of a district known to Rev. W. B. Clarke and Dr. A. M. Thompson as Lumley Creek.*

Near the spring the first feature to attract attention is the presence of beds of fresh-water limestone, as well as the free escape of bubbles of carbonic acid gas from the water. This limestone calls to mind a similar tufa that I saw surrounding the well known mineral spring at Cooma. In both instances the calcareous tufa has been deposited by the mineral water and is

* Trans. Roy. Soc. N. S. Wales for year 1869, p. 67.

still forming. Near the Bungonia spring there are three separate patches of the limestone marked on the accompanying map A, B, and C. The C deposit is nearly half-a-mile up the creek from the spring. At one time the waters reached the surface at this point. At present I could detect neither water nor gas escaping.

Referring to the tufa generally, many varieties can be distinguished. The more compact kinds might at first sight be easily mistaken for Silurian limestone, particularly on weathered surfaces, but its dull sound under the hammer reveals its true nature. One interesting variety is a granular limestone and crystallised calcite in alternate layers, the calcite being stained a bright red colour by iron oxide. Much of the rock is spongy in texture, the cavities being filled with black mud. Near the spring the tufa is in the bed of the creek as seen in the foreground of the photograph I exhibit. At the point marked C, it is somewhat above the present water level, and is honeycombed in a more or less vertical direction by holes like annelid bores. These I take to be cavities caused by escaping gases while the rock was yet forming.

I have found the following shells as fossils in the limestone or tufa :—*Endodonta funerea*, Cox, *Sphœrium macgillivrayi*, Smith, *Bulinus carinatus*, H. Adams, var. *cumingii*, H. Adams, *Limnea lessoni*, Deshayes, *Bulinus gibbosus*, Gould. The shells were identified for me by Mr. Charles Hedley of the Australian Museum. They are all living species, as we should expect to find in a rock now forming. The *Limnea* and *Bulinus* can be found in great numbers, in calcareous nodules embedded in a black clay on the "point" formed by the junction of Abel's Gully and Lumley Creek.

Silurian fossils are found at many places in the sandstones, chiefly casts of a coral near *Cyathophyllum*. The limestone shown contains spirifers, but I could find no specimens of the coral or the brachiopod perfect enough for specific identification.

The accompanying map will give a general idea of the geology of the district. The rocks chiefly represented are granite, porphyry, clay-slate, sandstones, and limestones, the latter as freshwater and recent, and Silurian. There is nothing in the geology of the neighbourhood to explain the origin of the spring. It rises through sandstones, but none of these are calcareous. There is no basalt nearer than a few miles, and the point of eruption must be still further away. A Silurian limestone crops out about half-a-mile to the south-east, but it has no apparent connection with the spring. The fact of the outlet being so close to the junction of porphyry and sedimentary rocks demands some attention. The igneous rock has been intruded amongst the stratified rocks, and no doubt the water finds its way to the surface along one of the many rents and fissures formed by the intruding mass. The spring is however, of comparatively recent origin, while the porphyry is to say the least pre-tertiary.

The following analysis was made in duplicate in my own laboratory and on samples of the water collected by myself :—

	Grains per Gallon.
Total solids at 100°	103·04
Silica	1·47
Ferrous oxide	·19
Lime	35·00
Magnesia	5·18
Soda	5·53
Potash	4·27
Chlorine...	5·88
Sulphur trioxide	1·16
Carbon dioxide (fixed)	34·86
Combined water	10·75
	104·29
Less "oxygen equiv." to Cl. found ...	1·25
	103·04

Solids soluble	21·00	per gall.
Solids insoluble...	71·29	
Water	10·75	
	103·04	

The probable combination of the above works out as follows :

	Grains per Gallon.
Calcium carbonate	61·100
Magnesium carbonate	10·835
Ferrous carbonate	·300
Silica	1·470
Calcium sulphate...	1·972
Sodium chloride	9·688
Sodium carbonate	·805
Potassium carbonate	6·264
Water, combined	10·750
	103·184

In a three foot tube the water is colourless. It is agreeable to the taste, and its continued use is followed by no ill effects. An attempt was made to estimate the free carbonic acid by filling some bottles completely at the spring, but in every instance I believe some "free acid" escaped. When the water reached the laboratory it contained two hundred and eighty-nine cubic inches of gas to the gallon. As the water rises in the spring it has a temperature of 53° F., the temperature of the air at the same time being 60° F.

The following represents the composition of the fresh water limestone :—

Insoluble in HCl, organic matter ...	7·9	
Silica	3·6	11·5
Iron and alumina		·9
Calcium carbonate		79·4
Magnesium carbonate		2·3
Na_2CO_3 and K_2CO_3		1·0
Water, combined		4·9
		100·0

The specific gravity of the more compact variety of the tufa is 2·58, the specific gravity of an average sample of Silurian limestone being 2·6—2·8.

I have made enquiries from many who have used this water as to its effects. It is generally agreed that it promotes the appetite and assists digestion. This I give as a matter of opinion. Exact knowledge on this head must be left to others skilled in the medicinal value of mineral waters. I may add too, that many who feel the loss of calcium and magnesium salts in Sydney water, are agreed that as an aerated table water the Bungonia spring is excellent.

For convenience in comparing with the well known Cooma water the following table is added :—

	Bungonia Spring.	Cooma Soda Spring *
	Grs. per Gall.	Grs. per Gall.
Calcium carbonate... ...	61·10	40·10
Magnesium carbonate ...	10·84	22·35
Ferrous carbonate... ...	·30	1·40
Calcium sulphate	1·97	
Sodium chloride	9·69	3·98
Sodium carbonate	·81	42·95
Potassium carbonate ...	6·26	3·50
Lithium carbonate ...	...	·21
Silica	1·47	1·03
Combined water	10·75	
Organic matter and water...	...	13·40
Total solids ...	103·19	128·92

Since writing the above I find that the Bungonia water is selling in Sydney as an ærated table water, but modified in the relative quantity of its solid constituents. The commercial article contains approximately :

Calcium carbonate	30	grains per gallon.
Magnesia carbonate	10	,, ,,
Sodium carbonate	20	,, ,,
Sodium chloride	5	,, ,,

* Dixon, Ann. Report Dept. Mines, N.S.W., 1879, p. 48.

Explanation of the Plate.

The two tufa deposits A, B, will probably prove to be a single bed. In the section thin bedded sandstones crop out at A. A coarse grained grit overlies the limestone at C. The limestone C is at most twenty feet in thickness. The coarse grit above the limestone contains abundant casts of corals allied to *Cyathophyllum*.

NEW ORBIT OF THE DOUBLE STAR β416 = SCORPII 185.

By Prof. S. Glasenapp, Imperial Observatory, St. Petersburg.

(Communicated by H. C. Russell, B.A., C.M.G., F.R.S.)

[Read before the Royal Society of N. S. Wales, June 6, 1894.]

Since I published in the No. 115 of the journal "Astronomy and Astrophysics" the elements of the true orbit of β 416, I have received from Mr. H. C. Russell, Government Astronomer for New South Wales, a set of measures of this star made by Mr. R. P. Sellors during the year 1893. With the kind permission of Mr. H. C. Russell, I here reprint these observations :—

Observations of β 416 made by Mr. R. P. Sellors.

Epoch.	θ	Weight.	ρ	Weight.	
1893·493	349°·9	10	0″·65	10	Star East of Meridian
·528	348·6	6	0·82	6	,, ,,
·531	347·7	7	0·73	7	,, ,,
·597	347·7	6	0·57	4	Star West of Meridian
·608	347·5	5	0·77	5	,, ,,

Mean : 1893·55 $\theta = 348°·3$ $\rho = 0''·71$ 5 nights.

These measures are of great value for the investigation of the orbit ; and make it possible to obtain a new set of elements. If we take into consideration these observations we obtain the following elements :—

T = 1892·15	ι = 59·77
u = 27·66 years	ϵ = 0·442
n = 13°0177	Ψ = 26°228
☊ = 153°30	a = 2″·04
λ = 255·80	

The comparison of these elements with the observations is given in the following table :—

t	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
	°	°	°	″	″	″
1876·52	240±	235·4	+4·6	1·80	1·47	+0·33
77·58	223·5	223·9	—0·4	1·78	1·54	+0·24
88·72	147·5	148·5	—1·0	1·89	1·69	+0·20
89·55	133·0	140·1	—7·1	1·16	1·41	—0·25
90·60	122·0	121·3	+0·7	0·81	0·96	—0·15
91·53	82·3	80·1	+2·2	0·51	0·61	—0·10
92·38	24·4	24·0	+0·4	0·58	0·69	—0·11
93·55	348·5	347·8	+0·7	0·71	1·17	—0·46

The differences $\theta_o - \theta_c$ are very small, but the differences $\rho_o - \rho_c$ are considerable, and present a systematical rate; the three first residuals are positive, the others are negative.

To verify the results obtained I have determined the corrections of the elements of Mr. T. E. Gore (Monthly Notices, 1892), and have obtained :—

Elements of T. E. Gore.	Their Corrections.	New Elements.
T = 1891·85	—0·05	1891·80
u = 34·48 years	—2·25	32·23 years
n = —10°·4413	—0°·7276	—11°·1689
☊ = 139°·43	+ 9°·09	148°·52
λ = 278°·25	—5°·43	272°·82
ι = 56°·72	+ 4°·12	60°·84
ϵ = 0·5562	—0·0645	0·4917
Ψ = 33°·7934	—3°·8485	29·9449
a = 2″·13	+ 0″·06	2″·19

The obtained corrections approach the elements of Mr. T. E. Gore to those which I have determined; we may consider this circumstance as an indication that our elements are near the truth. The comparison of the corrected T. E. Gore's elements with the observations is given in the following table :—

t	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
	°	°	°	″	″	″
1876·52	240±	236·8	+3·2	1·8±	1·59	+0·21
77·58	223·5	227·3	−3·8	1·78	1·60	+0·18
88·72	147·5	148·7	−1·2	1·89	1·63	+0·26
89·55	133·0	140·4	−7·4	1·16	1·39	−0·23
90·60	122·0	122·8	−0·8	1·81	0·96	−0·15
91·53	82·3	82·3	−1·5	0·51	0·59	−0·08
92·32	24·4	23·8	+0·6	0·58	0·64	−0·06
93·55	348·5	346·9	+1·6	0·71	1·15	−0·44

It is to be seen that the systematical rate in the distances is not eliminated.

I have also compared the elements which are determined by Mr. S. W. Burnham in the No. 119 of the "Astronomy and Astrophysics," by the graphical way, namely :—

T =	1892·26	ι =	44°·0
u =	24·7 years	ϵ =	0·56
n =	−14°·57	Ψ =	34°·056
Ω =	122°.0	a =	1″·46
λ =	273°·5*		

This comparison is given in the following table :—

t	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
	°	°	°	″	″	″
1876·52	240·±	240·2	−0·2	1·8±	1·63	+0·17
77·58	223·5	232·9	−9·4	1·78	1·64	+0·14
88·72	147·5	146·0	+1·5	1 89	1·27	+0·62
89·55	133·0	135·6	−2·6	1·16	1·14	+0·02
90·60	122·0	117·4	+4·6	0·81	0·91	−0·10
91·53	82·3	87·4	−5·1	0·51	0·62	−0·11
92·38	24·4	26·5	−2·1	0·58	0·47	+0·11
93·55	348·5	321·3	+27·2	0·71	0·78	−0·07

Although the elements of Mr. S. W. Burnham present a very good agreement (except 0″·62 for 1888) between the calculated and observed distances, and the residuals $\rho_o - \rho_c$ have not a

* S. W. Burnham gives $\lambda = 93°·5$; we have added 180°.

systematical rate, yet the calculated angle of position for the last observation differs so much from the observed that we cannot admit such an error, and must suppose that his elements are not the most probable ones.

New observations made during the current year will make it possible to decide the question with certainty.

On the VALUE of GRAVITY at the SYDNEY OBSERVATORY.

By E. F. J. Love, M.A., Fellow of Queen's College,

Demonstrator and Assistant Lecturer in Natural Philosophy in the University of Melbourne.

(Communicated by H. C. Russell, B.A., C.M.G., F.R.S.)

[*Read before the Royal Society of N. S. Wales, June 6, 1892.*]

Some years ago the Royal Society of Victoria—acting on a suggestion made by the present writer—appointed a Committee* to superintend the carrying out of a gravity Survey of Australasia. This committee obtained from the Royal Society of London the loan of three pendulums which had already been swung in many parts of the world, notably in the operations of the Great Trigonometrical Survey of India; a number of observations have been taken with these pendulums† in order to determine the relative values of the acceleration due to gravity at Melbourne and Sydney, and to compare them with the observations made with the same pendulums at Kew and Greenwich.

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* Proc. Roy. Soc. Vic. (New Series), Vol. II., p. 163; and the Reports of the Gravity Survey Committee in subsequent volumes.

† See Barracchi, Proc. Roy. Soc. Vic. (New Series) Vol. VI., p. 162; and Love, Proc. Roy. Soc. Vic. (New Series), Vol. VII., p. 1.

The Sydney observations, details of which are given in a paper communicated by the present writer to the Royal Society of Victoria,* have a special interest, inasmuch as they allow the value of gravity at Sydney to be determined by comparison with *three independent* absolute determinations; one of these—probably the most reliable—was executed at Kew by the officers of the Indian Survey;† another at Greenwich by Sabine;‡ and the third at Melbourne by Neumayer. The full details of the Melbourne determination have not yet been published, but the result is known.

In order to obtain from these observations the value of gravity in Sydney we require to know the daily number of vibrations—executed *in vacuo* and under a uniform temperature (62° F.), and reduced to sea level—of the three invariable pendulums at each of the four above mentioned stations: these are given in the following table:

TABLE I.

Station ...	SYDNEY.	GREENWICH.*	MELBOURNE.	KEW.*
Observer ...	Love.	Hollis	Baracchi.	Constable.
Pendulum No. 4	86095·95	86165·19	86107·89	86165·84
Pendulum No. 6	85995·97	86065·09	86008·05	86066·37
Pendulum No. 11	86047·25	86116·83	86059·69	86116·61

* These values for Greenwich and Kew are quoted from the recalculation in Baracchi's paper. (*Loc. cit.*)

If we subtract the Sydney values from those given for the other three stations we obtain the following table of differences:—

TABLE II.

Pendulum	G—S.	M.—S.	K.—S.
No. 4	69·24	11·94	69·89
No. 6	69·12	12·08	70·40
No. 11	69·58	12·43	69.36

This table sufficiently demonstrates the degree of consistency of the observations.

* *Loc. cit.*
† Report of the Great Trigonometrical Survey of India, Vol. v., p. 267.
‡ Phil. Trans., 1831, Art. xxv.

The calculations required are very simple. Let g_1 and g_2 be the values of gravity at any two places, V_1 and V_2 the vibration numbers of an invariable pendulum at the same places: then

$$\frac{g_1}{g_2} = \frac{V_1^2}{V_2^2}$$

$$\text{or } g_1 = g_2 \frac{V_1^2}{V_2^2}$$

hence if V_1, V_2, and g_2 be known, g_1 is determined.

The values of gravity for the three places at which the absolute determinations have been made are as follows :—

For Greenwich : $g = 981{\cdot}05$ cm. sec. ^{2}
,, Melbourne: $g = 979{\cdot}961$,, ,,
,, Kew : $g = 981{\cdot}197$,, ,,

From these we obtain the following table of values of g for Sydney :

TABLE III.

Pendulum.	Calculated from		
	Greenwich.	Melbourne.	Kew.
No. 4	979·551	979·671	979·606
No. 6	979·531	979·686	979·593
No. 11	979·521	979·678	979·622
Mean ...	979·534	979·678	979·607

Mean 979·606 cm. sec.$^{-2}$

The greatest difference from the mean is about 1 in 14,000; while the mean itself differs by about 1 in 600,000 from the value obtained by comparison with Kew, for which station—as already mentioned—the value of g is known with very great exactness, the determinations executed there with two entirely different sets of apparatus agreeing within 1 part in 3,000,000. We are therefore warranted in adopting 979·606 cm. sec.$^{-2}$ —at any rate provisionally—as a very fair approximation to the value of g at the sea-level in Sydney; the possible alteration can scarcely exceed a few units in the second decimal place.

In English units, assuming 1 metre = 39·37000 inches—as determined by the U.S. Coast and Geodetic Survey—this quantity becomes 32·1392 ft. sec.$^{-2}$

FROM NUMBER TO QUATERNION

By G. Fleuri, Licencié ès-sciences mathématiques and Licencié ès-sciences physiques, Sydney, N. S. Wales.

[With Sixteen Diagrams.]

(Communicated by H. C. Russell, B.A., C.M.G., F.R.S.)

[*Read before the Royal Society of N. S. Wales, June 6, 1894.*]

Preliminaries.—I propose to show in the present paper how mathematicians impelled by that spirit of generalization which predominates the whole of mathematical science may pass quite naturally from the idea of number to that of quaternion.

First of all, I will establish in a precise manner what it is that distinguishes algebra from arithmetic, and that part of my paper up to the introduction of quaternion may be considered as an elementary exposition of the fundamental principles of algebra after Grassman's* and Hankel's† ideas.

It is a pity that these fundamental principles of algebra should be always taught in the same awkward manner as they were several hundred years ago.‡ I am a believer in quaternions, and

* Grassman—"Ausdehnungslehre," Stettin 1862.

† Grassman's ideas would not yet perhaps be understood if it were not for Hankel's "Vorlesungen über complexe Zahlen und ihre functionen," Leipzig, 1867.

‡ Nay, I may say even in a more awkward manner, for if I trust an historical information given in P. Kelland and Tait's "Introduction to Quaternions," "Diophantus in his treatise on arithmetic boldly lays it down as a definition or first principle of his science that *minus into minus makes plus,*" and a professor of mathematics to whom I was speaking of the impossibility of the demonstration of that fact by old methods, told me that "having first shown the students that minus into plus makes minus he concludes that minus changed the signs and therefore changed minus into plus," a reasoning equivalent to the following :—"a blue liquid into a yellow liquid gives a green liquid and therefore changes the color, so that a b'u ͻ liquid into a blue liquid must give a color different from blue.

I think that this is one of the principal causes why the calculus of quaternions has not yet been more extensively studied. Moreover, a wrong idea, according to me, seems to prevail even amongst those who are best acquainted with the methods of quaternions, as to what direction should be given to that study. In Mr. P. G. Tait's and in Mr. A. McAulay's papers for instance, quaternion methods are proposed to replace Cartesian methods, and comparison is continually made between quaternions and Cartesian geometry. This is equivalent to proposing complex quantities to replace Cartesian plane geometry. That quaternions and complex quantities give ready solutions for certain classes of elementary questions of geometry the works of Bellavitis (method of equipollences) and Tait (quaternions) sufficiently prove. They furnish also very often for that purpose what is really a method of abridged notation. But I do not see very well how we could easily manage with them when we have to introduce elliptic and in general Abelian functions (see for instance, Clebsh Analytical Geometry, 3rd part).*

If quaternionic methods were only useful for the purpose of replacing Cartesian geometry, I should consider Mr. Heaviside perfectly right in adopting some different hypothesis for the establishment of a quaternion calculus. For, why are Hamilton's hypotheses more natural than those of Mr. Heaviside? And here we find one of the main reasons why I have undertaken the present work. Quaternions are already fifty years old, and to-day a physicist proposes to replace their calculus by a different one! And why?

When we come to examine the thing, we easily see that Mr. Heaviside has been completely mistaken as to the real nature of complex quantities of ordinary algebra; $\sqrt{-1}$ is for him a symbol without existence arising from consideration of equations of second degree and at any price he wants to get rid of it.† Unfortunately

* Of course it may be simply a want of custom on my part, but even so, I do not see the use of working with quaternions in that direction.

† I do not speak about his separation of the scalar and vector products of two vectors whose reunion forms the quaternion, for it does not in reality change anything in the theory of Hamilton.

those ideas are shared by many, and it is not rare to see even professors of mathematics working under that delusion that complex quantities are properly without existence.

Complex or so called imaginary quantities are, truly speaking, no more imaginary than the real quantities. A negative quantity may be an *imaginary* solution for a certain problem whilst on the other hand a complex quantity may be a *real* solution for some kinds of questions treated in an appropriate manner.*

I trust that the present paper will help a few persons to understand clearly the real nature of complex quantities in general, and will clearly show that the calculus of quaternions is a new algebra, a generalization of the old one.

Historical.—A short historical account of the question we are about to treat may prove interesting, and at any rate may serve to rectify certain historical errors in Tait's *quaternions.*†

It is in a remarkable pamphlet printed at Paris in 1806: "Essai sur une manière de representer les quantités imaginaires dans les constructions géométriques," that an otherwise unknown Genevese mathematician *Argand*, gave the representation of the so called imaginary quantities.‡

The geometrical constructions, now in general use, which have thrown such a light on the operations of complex quantities, are all found in that pamphlet for the first time; so that it is inexact to say, as Tait does in his treatise on quaternions:—"In the present century Argand, Warren and others extended the results of Wallis and de Moire. They attempted to express as a line the product of two lines each represented by a symbol such as $a + b\sqrt{-1}$. To a certain extent they succeeded, but simplicity was not gained

* I shall always remember the exclamation of a bachelor of science—a clever physicist—to whom I was explaining the theory of elliptic functions when I came to speak of functions of a complex argument, "You do not mean it has any physical application!" He holds a very different idea just now.

† Being unable to get the third edition, I can only speak about the second edition.

‡ However according to a recent work: "A History of Mathematics" by F. Cajori, New York, 1894, the first one to represent quantities of form $b\sqrt{-1}$ was H. Kühn, a teacher of Dantzig, in a publication of 1750-1751. Unfortunately no exact reference is given.

by their methods as the terrible array of radicals in Warren's treatise sufficiently proves."

Argand did succeed, and so far nothing has been changed in his representation* by a line of a product of two lines, each represented by a symbol $a+bi$. But where Argand failed was in his attempt to represent by similar methods the points of a space of three dimensions. The matter was much more difficult, and it was only thirty-seven years afterwards that *Hamilton* succeeded in that representation.

Argand's work was not sold but only distributed to a few friends, so that his ideas were but little spread when seven years afterwards a young artillery officer named Français, sent to the "Annales" of Gergonne the sketch of a theory whose first ieda—as he mentioned—was found by him in a letter from Legendre to his brother. In that letter, Legendre stated that the idea had not come from him, but from another mathematician, whose name he did not give. The paper of Français fell into Argand's hands, who sent immediately a note to Gergonne making himself known as the author of the work spoken of by Legendre and giving a pretty complete account of his pamphlet of 1806.

Français and Argand's papers gave rise in Gergonne's Annales to a discussion between Français, Gergonne and Servois, which was finally settled by a remarkable paper of Argand, where he explained in a more satisfactory manner several parts of his theory amongst which we notice the demonstration of the fundamental proposition of algebraical equations:

"Any algebraical equation has, at least, a root of form $a+bi$," a demonstration since reproduced by Cauchy (twenty-two years afterwards) under an analytical but certainly less striking form than Argand's. Fourteen years afterwards, Warren in England and Mourey in France were still working at the same question of calculus of complex quantities without seeming to have any knowledge of Argand's work. But they were soon forgotten—

* The algebraical expression was already known.

although Warren published in the Phil. Trans. two papers as a sequel to his treatise, and a short account of Mourey's work was given in the "Leçons d'Algèbre" of Lefébure de Fourcy, a then, well known French standard book. It was not till Gauss treated the same question again twenty-five years after Argand, that these ideas began to be known—principally in Germany—and for a long time Gauss was considered as having discovered them. However, justice was done to Argand, first by Cauchy (Exercices d'Analyse et de Physique mathematique, Vol. IV., p. 157), then by Hamilton (Preface to his Lectures on Quaternions) and Hankel (Gauss Werke, t. II., p. 174—Anzeige zur "Theoria residuorum biquadraticorum. Commentatio secunda").

But as late as 1874, although Argand was generally considered as the inventor of calculus of complex quantities, his work was not yet more extensively known owing to the great scarcity of the copies of his pamphlet. Under those circumstances, Honël, my learned professor of mathematics, thought it would be useful to give a second edition of that work. Through Chasle's kindness he was able to get the only available copy of Argand's pamphlet—that offered to Gergonne—and he published it with a very remarkable, although short historical notice, adding as appendix the two papers of Argand given in Gergonne's Annales. As a bibliographical curiosity, the first page of the second edition is the autographic reproduction of the first page of that copy of Argand's pamphlet dedicated to Gergonne.

In this historical notice I have purposely almost left aside the great personality of Hamilton, simply because the history of his invention of quaternions (16th October 1843*) and of his first paper on it (read before the Royal Irish Academy, of which he was the president, the 13th November 1843) is so well known that nothing can be added on the subject.†

* He discovered that very day the fundamental equations, basis of all calculations in quaternions: $i^2 = j^2 = k^2 = ijk = -1$

$$ij = -ji = k \quad jk = -kj = i \quad ki = -ik = j$$

† See for instance, "Life of Sir W. R. Hamilton by R. P. Graves, M.A.," Vol. II., pages 434 and following.

Number—Arithmetic.

Amongst the magnitudes considered in science, some, such as a volume, a weight, an atmospheric pressure, etc., are completely known when the number which measures them is known.

Those magnitudes are called *absolute magnitudes*, and the numbers which measure them are called their *moduli* or *tensors.**

Fig. 1.

Any of these magnitudes has same tensor as a certain straight line AB and therefore the line AB can be considered as representing that magnitude. Consequently, any question on absolute magnitudes of any kind can be transformed into a similar question on straight lines representing these magnitudes.

For simplicity in this representation we will agree to take these straight lines—in the same plane, always horizontal and moreover of *same direction*, the direction of the arrow, from left to right. (Fig. 1.)

This idea of direction may be made quite clear in the following manner: Let us suppose that a point moves along our line from A to B, the straight line AB can then be considered as the result of that motion (translation) and even as representing that motion or in other words as the *symbol of that motion.*

It is this way of considering a straight line which we choose—(and I may point out here that it is the way which tends to prevail in modern geometry). *A straight line AB is therefore the symbol of the translation of a point moving along the line from A to B.* Please notice the order of the letters AB. *A is the starting point, B the terminal point* and in denoting our lines we will always carefully put the starting point first and then the terminal point.

The properties of operations on absolute magnitudes are the properties of operations on their tensors, *i.e.*, on numbers and are

* We adopt the word tensor preferably to 'modulus,' as the latter word is used in quite a different acceptation in the theory of Elliptic and in general Abelian functions.

found in arithmetic. We will now exhibit those of the properties which are fundamental.

Addition (indicated by sign +)

First, operation *uniform* or single valued, *i.e.*, having one result only; this property may be expressed in the following manner:

If $a = a'$ and $b = b'$ $\quad a + b = a' + b'$

Second, *commutative*, *i.e.*, $a + b = b + a$

Third, *associative*, *i.e.*, $a + b + c = a + (b + c)$

Fourth, $a + o = a$ $\quad a, b, c, a', b'$ being numbers.

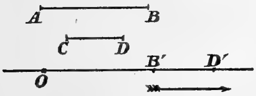

Fig. 2.

The geometrical operation on straight lines which corresponds to addition of their tensors can be defined as follows:

Let us propose to add AB and CD (Fig. 2).

From a point O on a straight line OX and in the standard direction take a length OB′ = AB and then, always in the same direction a length B′D′ = CD; or in other terms: let the point O move from O to the point B′ such that OB′ = AB and then from B′ to the point D′ such that B′D′ = CD; *OD′ is the sum AB + CD.*

And this definition is easily extended to any number of lines. From it one can see that all the fundamental properties of the addition are obvious.

Subtraction (indicated by sign —)

Definition.—It is the operation which, being given the sum of two tensors and one of them, consists in finding the other.

It is the inverse operation of addition*

Let OD′ = AB + CD

then by definition OD′—CD = AB

Geometrically it consists in displacing the movable point from O to D′ (Fig. 2) in the standard direction, and from D′ to B′ in the

* We call *inverse* operation with regard to another operation considered as the *direct* one, a second operation which—all the terms but one being given and the result of the first operation—consists in finding the missing term.

opposite direction and so that translation D′B′ be equal to translation CD ; OB′ is the result.

But if OD′ < CD the operation although possible geometrically does not correspond to any result, for 7 – 15 for instance has no signification in the case we are just considering.

Multiplication (indicated by sign × or by sign .)

First, *uniform* if $a = a'$ and $b = b'$ $ab = a'b'$

Second, *commutative* $a\,b = b\,a$

Third, *associative* $a\ b\ c = a\ (b\ c)$

Fourth, *distributive* with regard to addition and subtraction

$$(a + b - c)\ d = ab + bd - cd$$

Fifth, $a \times 1 = a$

Sixth, $a \times o = o$

a, b, c, d, a', b' being numbers.

Geometrically—Being given two lines AB and CD the operation consists in the construction of a fourth proportional OF

$$\frac{OF}{AB} = \frac{CD}{1}$$

By definition OF = AB × CD

and the definition is easily extended to any number of factors.

Division (indicated by sign ÷ or an horizontal bar between the numbers).

An operation which, the product of two tensors and one of them being given, consists in finding the other tensor. It is the inverse operation of multiplication.

By definition OF : AB = CD

Geometrically it comes to the construction of a fourth proportional CD

$$\frac{OF}{AB} = \frac{CD}{1}$$

as for multiplication so that there is in fact no difference between multiplication and division. Owing to the introduction of fractions in arithmetic we knew already that fact, for divisions by

7 and by $\frac{15}{101}$ for instance, come respectively to multiplications by $\frac{1}{7}$ and $\frac{101}{15}$.

Directive Quantities—Complex Quantities—Algebra.

So far we have only been dealing with arithmetic, for the study of absolute magnitudes comes to the study of their tensors, that is to say of numbers, which is precisely the aim of arithmetic.

But the absolute magnitudes are not the only ones to be considered in science, other magnitudes such as time, temperature etc., which can vary in two opposite directions, have also to be considered. Such magnitudes can be symbolised by straight lines or by translations as the preceding ones, but by *straight lines capable of two directions.*

Thus the notation AB will represent as before the translation of a movable point from A to B, but BA will represent a translation from B to A in the opposite direction to the first one.

The direction will be determined without ambiguity if we know the angle made by AB or BA with the standard direction from left to right in taking always our lines horizontal.

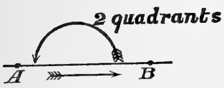

Fig. 3.

AB (Fig. 3) makes an angle zero or more generally 4 k quadrants (k being a whole number) measured by $2k\pi$, but BA makes an angle equal to 2 quadrants (measured by π) or more generally makes an angle equal to $(4k+2)$ quadrants measured by $(2k+1)\pi$.

If tensor AB $= a$ we can represent AB by a_0 or simply a, and BA by a_π.

That angle or its measure is called the argument* of the quantity considered.

* Another word is also wanted instead of argument as it is used for some other purposes, but the words norm and amplitude sometimes used respectively instead of square of modulus and argument are subject to the same objection.

Obviously the argument can be increased or diminished by an even number of π without altering the quantity under consideration.

$$a_0 = a_{2k\pi} \text{ and } a_\pi = a_{(2k+1)\pi}$$

Quantities with argument zero or $2k\pi$ are absolute quantities so that the directive quantities which we now consider are a generalization of absolute quantities or numbers. Our definitions of operations on directive quantities must therefore reproduce as particular cases the definitions already given in the case where the arguments are all equal to zero.

*But these definitions are only subject to that restriction and are otherwise arbitrary.**

Addition.—We will define the operation as follows for two directive quantities AB and CD. (Fig. 4.)

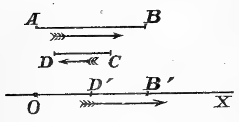

Fig. 4.

Let a point move on a straight line OX in the direction AB from O to B′ so that OB′ = AB, then let the point move in the direction CD from B′ to D′ so that B′D′ = CD.

OD′ will represent by definition the sum AB + CD.

And the definition is readily extended to any number of terms. The fundamental properties of addition resulting from this definition are easily found to be identical with the fundamental properties of the addition of tensors.

Subtraction.—It is, as already said, the inverse operation of addition, but now those two operations, addition and subtraction, are no more different but become essentially the same operation.

For let us consider two directive quantities

$$a_0 \text{ and } b_\pi$$

and suppose we have to subtract the latter from the former

$$a_0 - b_\pi$$

* We simply follow the general rule about generalization : As a particular case of the generalized thing we must be able to find the thing we intend to generalize.

the result must be such that added to b_π it gives $a_\circ$

But $a_\circ + b_\circ$ fulfils that condition for

$b_\pi + a_\circ + b_\circ = a_\circ + (b_\circ + b_\pi)$ (commutativity and associativity of addition)

and as $b_\circ + b_\pi = o$ (definition of addition)

therefore $b_\pi + a_\circ + b_\circ = a_\circ$

so that $a_\circ - b_\pi = a_\circ + b_\circ$

that is to say the subtraction of b_π comes to the same thing as the addition of $b_\circ$

In a similar manner we could prove that

$$a_\circ - b_\circ = a_\circ + b_\pi$$
$$a_\pi - b_\pi = a_\pi + b_\circ$$
$$a_\pi - b_\circ = a_\pi + b_\pi$$

so that we can say in a general manner that the subtraction of a directive quantity is the same as the addition of the directive quantity having same tensor and different argument.

Moreover the subtraction is now an operation having always a meaning.

Multiplication.—To multiply two directive quantities is to make the product of their tensors and the sum of their arguments or in other words:

We will call the product of two or more directive quantities, that quantity having as tensor the product of the tensors, and as argument the sum of the arguments of the quantities considered.

That is to say by definition

$$a_\circ \, . \, b_\circ = (a\,b)_\circ$$
$$a_\pi \, . \, b_\circ = (a\,b)_\pi$$
$$a_\circ \, . \, b_\pi = (a\,b)_\pi$$
$$a_\pi \, b_\pi = (a\,b)_{2\pi} = (a\,b)_\circ$$

The first equality shows that our definition includes as a particular case the muliplication of absolute quantities, therefore, without any further consideration our definition is a correct one as satisfying the only condition it must satisfy.

At first sight, however, that definition may be puzzling, and seems more arbitrary than it is in reality. For, there is a much greater difference between the definition given in arithmetic for the multiplication of whole numbers and that given for the multiplication of fractions. And the best proof that such is the case is that the definition given for the fractions properly understood is still sufficient for directive quantities.

To multiply a quantity (multiplicand) by an other (multiplier), is to determine a third quantity derived from the multiplicand by the same operation as was needed to derive the multiplier from unity.

Take for instance $a_o \times b_\pi$

multiplicand a_o — multiplier b_π — unit 1_o

b_π is formed from the unit by multiplying the tensor of the unit by b and turning the result through an angle π; then to obtain our product we must multiply the tensor of a_o by b—result $(ab)_o$ and then turn it of angle π—result $(ab)_\pi$

From our definition we see first that the multiplication of directive quantities is *uniform*, since addition and multiplication of absolute quantities are uniform.

Second, now denoting by α, β and γ any quantity o or π we can write $a_\alpha \cdot b_\beta = (ab)_{\alpha+\beta} = (ba)_{\beta+\alpha} = b_\beta \cdot a_\alpha$ from definition of multiplication, commutativity of addition and multiplication of absolute quantities and again definition of multiplication; therefore our operation is *commutative.*

Third,
$$a_\alpha (b_\beta\, c_\gamma) = a_\alpha\, ((b\,c)_{\beta+\gamma}) = (a\,b\,c)_{\alpha+\beta+\gamma} = a_\alpha \cdot b_\beta \cdot c_\gamma$$
so that the multiplication of directive quantities is associative.

Fourth,
$$a_\alpha (b_\beta + c_\gamma) = a_\alpha\, b_\beta + a_\alpha\, c_\gamma$$
for $b_\beta + c_\gamma$ being formed from unity by multiplying it by b_β then by c_γ and adding the results we must multiply a_α by b_β then by c_γ and add the results to get $a_\alpha\,(b_\beta + c_\gamma)$ therefore the multiplication is distributive.

Fifth, obviously $a_\alpha \cdot 1 = a_\alpha$
Sixth $a_\alpha \cdot o = o$

Division.—It is the inverse operation of multiplication and the quotient of two directive quantities is therefore obtained by making the quotient of the tensors and the difference of the arguments, a difference which can always be taken since an argument can always be increased by an even number of π.

The directive magnitudes we have considered varying in two directions only, are a particular case of more general magnitudes, such as forces and velocities (in a plane), vector radius of a conic, etc., which can take any position whatever in the plane. These magnitudes can be symbolised by straight lines capable of any direction in the plane or by translations and rotations combined.

Thus AB (Fig. 5) will represt a translation from A to B combined with a rotation α from a certain fixed direction OX to the direction AB.

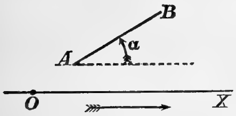

Fig. 5

Extending our notations of the directive quantities previously considered, we can represent AB without ambiguity by the notation

$$\overline{AB} \text{ or } a_\alpha \quad \text{where AB} = a$$

$\overline{AB} = a_\alpha$ is called a complex quantity a being the tensor and α the argument.

It results from our definition that any complex quantity can be transported to any position in its plane, subject only to the condition of keeping its direction, that is to say of remaining parallel to itself. And obviously

$$a_{\alpha+2k\pi} = a_\alpha \quad (k \text{ being a whole number})$$

that is to say the argument can be increased or diminished by an even number of π.

Addition.—To add two complex quantities is to bring the second one in its proper direction to the extremity of the first one, or in other words :

The sum of two complex quantities is the diagonal of the parallelogram constructed on those quantities; a definition which includes, as a particular case, the definition of the addition of two directive quantities and is easily extended to any number of complex quantities.

Let $\overline{AB} = a_\alpha$ $\overline{BC} = b_\beta$ (Fig. 6.)

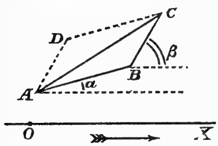

Fig. 6.

From our definition

$$\overline{AB} + \overline{BC} = \overline{AC}$$

First, the operation is *uniform*

Second, Completing the parallelogram on AC we see that

$$\overline{AB} + \overline{BC} = \overline{AD} + \overline{DC}$$

But $\overline{AB} = \overline{DC} = a_\alpha$ $\overline{BC} = \overline{AD} = b_\beta$

therefore:

$$a_\alpha + b_\beta = b_\beta + a_\alpha$$

the operation is *commutative.*

Third, Considering another complex quantity $\overline{CD} = C_\gamma$ we have: (Fig. 7.)

$$\overline{AD} = \overline{AB} + \overline{BC} + \overline{CD}$$

and $$\overline{AD} = \overline{AB} + \overline{BD}$$

whence

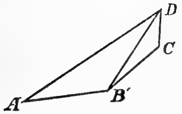

Fig. 7.

$$a_\alpha + b_\beta + c_\gamma = a_\alpha + (b_\beta + c_\gamma)$$

the addition of complex quantities is *associative.*

Fourth, $a_\alpha + o = a_\alpha$

Subtraction.—It is the inverse operation of addition.

$$a_\alpha - b_\beta = a_\alpha + b_{\beta+\pi}$$

for, from definition of subtraction and associativity of addition

$$a_\alpha + b_{\beta+\pi} + b_\beta = a_\alpha + (b_{\beta+\pi} + b_\beta) = a_\alpha$$

since

$$b_{\beta+\pi} + b_\beta = o \quad \text{(definition of addition)}$$

therefore the subtraction of a complex quantity b_β is the same as the addition of that quantity with the argument increased by π.

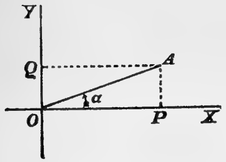

Fig. 8.

Decomposition of complex quantities.—Now draw a perpendicular OY to OX and let $\overline{OA}$ be any complex quantity a_α. Forming the rectangle OPAQ we have (Fig. 8)

$$\overline{OA} = \overline{OP} + \overline{PA} = \overline{OP} + \overline{OQ}$$

Let OP $= x$ and OQ $= y$ we can write it

$$a_\alpha = x + y_{\frac{\pi}{2}}$$

Multiplication.—We can keep the definition we have given for directive magnitudes or we can even keep the definition of multiplication of fractions in arithmetic.

From that definition we could give several representations of the multiplication of complex quantities from which we will choose the two following ones.

First, Let us describe a circle of radius 1 with O as centre (Fig. 9), and let OX be our fixed direction, a_α and b_β the two complex quantities to be multiplied.

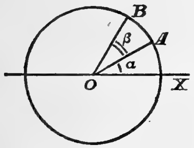

Fig. 9.

Draw $\overline{OA} = 1_\alpha$ and $\overline{OB}$ such that $\widehat{XOB} = \alpha + \beta$. The angle $\widehat{XOB}$ or rather the arc XB is the argument of the product. As arc XB = arc XA + arc AB we see that $a_\alpha \cdot b_\beta = (a\,b)_{\alpha+\beta}$ represents a multiplication of tensors ab combined with an addition of arcs of circle $\alpha + \beta$ and as both these operations are commutative the multiplication of complex quantities is commutative also.

Second, Otherwise let $\overline{OA} = a_\alpha$ $\quad \overline{OB} = b_\beta$ (Fig. 10)

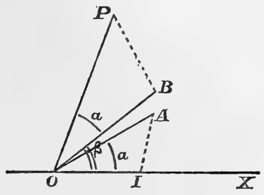

Fig. 10.

Draw OP making with OB the angle α and take OP = OA × OB $= a\,b$. Then on OX take OI = 1 ($\overline{OI} = 1_0$ is the unit).

It is easily seen that the triangles OIA — OBP are directly similar and that $\overline{OP} = (a\,b)_{\alpha+\beta}$

therefore to construct the product $\overline{OP}$ of two complex quantities $\overline{OA}$ and $\overline{OB}$ we have simply to construct on OB a triangle OBP directly similar to the triangle OIA formed with 1_o and $\overline{OA}$; the side OP of the triangle is the product in question.

We see at once, first, that the multiplication of complex quanti-ties is uniform and we have already seen, second, that it is com-mutative, *i.e.*, $a_\alpha \cdot b_\beta = \quad \beta \cdot a_\alpha$

Third, We have

$$a_\alpha \cdot b_\beta \cdot c_\gamma = (a\ b\ c)_{\ \alpha+\beta+\gamma} \quad \text{definition of multiplication}$$
$$= (a \cdot b\ c)_{\ \alpha+(\beta+\gamma)} \quad \text{associativity of multiplication and addition of scalar* quantities}$$
$$= a_\alpha \cdot (b\ c)_{\ \beta+\gamma} \quad \text{definition of multiplication}$$

that is to say the multiplication of complex quantities is associative.

Fourth, As for directive quantities we should easily see from the arithmetical definition of multiplication that the corresponding operation on complex quantities is distributive; but a geometrical demonstration is easily given.

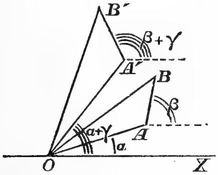

Fig. 11.

Consider $(a_\alpha + b_\beta) \cdot c_\gamma$

Let $\overline{OA} = a_\alpha$ $\overline{AB} = b_\beta$ $\overline{OA} + \overline{AB} = \overline{OB}$

Draw OA′ making an angle $\alpha + \gamma$ with OX and take OA′ $= a\,c =$ OA . c then draw A′B′ of argument $\beta + \gamma$ and such that A′B′ $= b\,c =$ AB . c; finally join OB′.

The two triangles OAB - OA′B′ being similar by construction give OB′ = OB . c and argument OB′ = argument OB $+ \gamma$

But $\overline{OB'} = \overline{OA'} + \overline{A'B'}$ therefore

$$(a_\alpha + b_\beta)\, c_\gamma = \overline{OB'} = a_\alpha \cdot c_\gamma + b_\beta \cdot c_\gamma$$

Fifth, $a_\alpha \cdot 1 = a_\alpha$

Sixth, $a_\alpha \cdot o = o$

Division.—The definition given remains always the same and can be expressed by the equality

$$a_\alpha \div b_\beta = \left[\frac{a}{b}\right]_{\alpha-\beta}$$

---

* Scalar, *i.e.*, quantities of index zero or π.

Negative quantities.—Now, if we remark that the subtraction of a_0 is replaced by the addition of a_π we see that—incorporating the sign with the quantity we consider—we have

$$-a_0 = a_\pi$$

so that a quantity of argument π may be replaced by the same quantity of argument zero but with sign minus. And we come then to the notion of *negative quantity* which may be developed at this stage of our study. As a natural result, tensor and argument can be considered as well positive as negative.

Any positive or negative quantity is called a scalar quantity.

Imaginary quantities.—Let us consider again a complex quantity under form

$$x + y_{\frac{\pi}{2}}$$

we see that it can be written also

$$x + 1_{\frac{\pi}{2}} \cdot y$$

and putting for shortness

$$1_{\frac{\pi}{2}} = i$$

we may write any complex quantity under the form

$$x + i\,y$$

From definition of quantity i

$$i^2 = 1_\pi = -1$$

$$i^3 = 1_\pi \cdot 1_{\frac{\pi}{2}} = -i \qquad i^4 = 1_{2\pi} = 1$$

or more generally denoting by n any whole number

$$i^{4n} = 1 \qquad i^{4n+2} = -1$$

$$i^{4n+1} = i \qquad i^{4n+3} = -i$$

and keeping the same definition of the square root as that used in arithmetic, *i.e.*, calling the square root of a complex quantity a second quantity such that squared it gives the first one, we see that

as $\quad i^2 = -1 \qquad i = \sqrt{-1}$

a quantity with a perfectly real signification, the symbol of a rotation by $\frac{\pi}{2}$.

Trigonometrical Expressions.

All that we have hitherto done till now supposes only a knowledge of arithmetic and of Euclid.* Adding to these mathematical

* We have only differed from Euclid in one respect, that is in considering a portion of a straight line as a symbol of translation and an angle as a symbol of rotation. I may point out here that Euclid's elements would gain a good deal by the introduction *at once* of these notions, which are universally recognised in modern mathematics.

elements the definitions of the trigonometrical ratios and the knowledge of the theorem on a rectangular triangle of sides a (hypotenuse), b and c

$$b = a \cos(a.b) = a \sin(c.a)$$
$$c = a \sin(a.b) = a \cos(c.a)$$

which is immediately demonstrated—we easily see that a complex quantity a_α can be put under the form

$$a(\cos \alpha + i \sin \alpha)$$

The definition of multiplication gives then almost at once the expression of de Moivre's theorem

$$\big(a(\cos \alpha + i \sin \alpha)\big)^n = a^n (\cos n\alpha + i \sin n\alpha)^*$$

Remark—By means of complex quantities introduced from the very beginning of Algebra, as we have done, many singularities can be explained, for instance the *finding of two values* in the extraction of a square root ceases to be a case of exception since the extraction of the nth root—as it is readily shown—is an operation n-form $\sqrt[n]{a_\alpha} = a^{\frac{1}{n}}\left(\cos \frac{\alpha + 2k\pi}{n} + i \sin \frac{\alpha + 2k\pi}{n}\right)$

A more extensive knowledge of Algebra including the study of series of an imaginary variable and of its condition of convergence shows that any complex quantity a_α can also be put under a fourth form $a\, e^{i\,\alpha}$
where e is the well known series.

Let us add that when a complex quantity a_α is written under the form $a_\alpha = a \,.\, 1_\alpha = a\, e^{i\,\alpha} = a(\cos \alpha + i \sin \alpha)$
a being the tensor,

$$1_\alpha = e^{i\,\alpha} = \cos \alpha + i \sin \alpha$$

is—according to Hamilton—the versor of the quantity, a fact expressed by $Ua_\alpha = e^{i\,\alpha}$ in Hamilton's notation.

* The ordinary demonstration given of that theorem is a survival from bygone ages. It is logically a vicious circle as it consists in applying to imaginary quantities rules of calculations only known for real quantities without showing them to be applicable.

Reflections on Algebra.

As the whole algebra is logically deduced from the fundamental properties of the operations which are verified for complex quantities generally, the process of algebraical calculation will not allow us to distinguish between positive, negative or imaginary quantities.

In other words, when we treat a question by Algebra—whatever be the real data—as soon as we translate our question into algebraical formulæ we transform it into a more general question on complex quantities. Therefore it is easily understood that the solution may be of a quite different nature from the data, for instance, imaginary although the data be real. But the ordinary way of dealing with natural questions is to consider only positive or negative quantities, *i.e.*, to consider quantities only in magnitude (within the sign) not in direction. In that case, the complex quantity which might be the solution of the corresponding algebraical question is not solution of the physical question.

We may remark nevertheless, that, as the sum and product of two scalar quantities does not give an imaginary quantity, as long as in our calculations we use only addition and multiplication, the nature of our quantities remains the same. Such is the case for instance for the questions which can be solved by equations of first degree. But if we have to extract roots, then we may introduce by so doing an imaginary quantity and therefore a solution which does not correspond to the physical problem.

In many questions however, quantities having direction as well as magnitude have to be considered and it might be possible to treat them directly.* In that case the complex solution furnishes the solution of the physical problem. But, as I will explain, it is not always possible to do so. The condition, necessary and

* Numerous examples of this nature will be found in the works of Giusto Bellavitis. and specially in its "Metodo delle equipollenze," Ann. Sci. Lomb. Veneto VII., 1837, pp. 243 . 261 ; VIII., pp. 17 . 37—85 . 121, translated in French, "Exposition de la méthode des équipollences" Nouv. Ann. Math. XII., 1873. See also C. A. Laisant, Theoric et application des equipollences, Paris, Gauthier Villars, 1887.

sufficient, to introduce a certain kind of magnitude into calculation is to be able to define in a precise manner the equality and the um of two magnitudes of that kind. For every kind of magnitude appropriate definitions are necessary which depend on the nature of the kind of magnitude considered.

With regard to absolute magnitudes first, the definitions are always given in such a manner, that, if two magnitudes are equal their tensors are equal and that the tensor of the sum equal the sum of the tensors, so that in that case the study of operations on absolute magnitudes come to the study of operations on numbers. This study is the aim of arithmetic.

With regard to directive plane magnitudes, the definitions are always given in such a manner that two equal magnitudes have equal tensors and arguments, and that the sum be obtained by the rule of the parallelogram. The study of operations on those magnitudes is therefore the aim of algebra.

We come now to a third series of magnitudes the one which can have any direction in space. As long as we consider their tensors only, we can operate on them with algebra, but when we come to consider those magnitudes in direction as well, other processes of calculation are necessary and we are then naturally introduced to the calculus of quaternions.

But before coming to the consideration of quaternions, an idea at first strikes one forcibly. Why could not algebra deal with space magnitudes? The reason of it is the *impossibility* of keeping in the multiplication of space quantities the property of commutativity which is, as we have explained above, fundamental in algebra.

However it may be a question whether it would not be possible to find another system of calculation of space quantities leaving untouched the commutativity of multiplication. We will try to demonstrate that "a priori" the thing is not possible, that is to say that algebraical calculations with its laws does not allow us to deal with any quantity but complex quantities.

For, let us suppose for a moment that quantities formed with three linearly irreducible imaginary units i, j, k could be introduced in algebra. We must be able to express as a quantity (i, j, k) the product of two of those quantities (i, j, k) and therefore we must have between i, j and k certain relations amongst which

$$(1) \quad \begin{cases} i^2 = a_0 + a_1\, i + a_2\, j + a_3\, k \\ ij = b_0 + b_1\, i + b_2\, j + b_3\, k \\ i\,k = c_0 + c_1\, i + c_2\, j + c_3\, k \end{cases}$$

a, b, c being scalar quantities.

The last two equalities can be written

$$(b_2 - i)\, j + b_3\, k = -b_0 - b_1\, i$$
$$c_2\, j + (c_3 - i)\, k = -c_0 - c_1\, i$$

Multiply the first relation by $(c_3 - i)$ the second by $-b_3$ and make the sum, we get

$$(2) \quad \Delta j = -(b_0 + b_1\, i)(c_3 - i) + (c_0 + c_1\, i)\, b_3$$

where Δ represents the determinant

$$\Delta = \begin{vmatrix} b_2 - i & b_3 \\ c_2 & c_3 - i \end{vmatrix}$$

Again, multiply the first equality by $-c_2$, the second by $b_2 - i$ and make the sum, we find

$$(3) \quad \Delta\, k = (b_0 + b_1\, i)\, c_2 - (c_0 + c_1\, i)(b_2 - i)$$

Now multiplying the first of relations (1) by Δ we obtain

$$\Delta\, i^2 = a_0\, \Delta + a_1\, \Delta i + a_2\, \Delta\, j + a_3\, \Delta\, k$$

whence by replacing Δj and Δk by their values from (2) and (3) we obtain an equation of fourth degree into i which therefore can be put under the form

$$A\,(i - \alpha_1)(i - \alpha_2)(i - \alpha_3)(i - \alpha_4) = o$$

where $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are ordinary complex quantities and A a constant. And as a product cannot be equal to nought unless one of the factors be equal to nought we must have

$$i = \text{ordinary complex quantity}$$

and in a similar manner we could demonstrate that

$$j = \text{complex quantity.} \qquad k = \text{complex quantity.}$$

Quaternions—Calculus of Quaternions.

Being now convinced of the impossibility of treating space quantities by algebra we will seek for some other method. The first method of generalization which presents itself to one's mind is to work with space vectors as we have worked with plane vectors or complex quantities. It is easily found that those vectors can be added by the rule of the parallelepiped—an obvious generalization of the rule of the parallelogram—and therefore that they can be represented by expressions

$$a\,i + b\,j + c\,k$$

where a, b, c are scalar and i, j, k three linear units along three rectangular axes, and Servois (thirty years before Hamilton) was successful so far. But when we come to try the combination of vectors by multiplication, we are soon stopped by difficulties which took Hamilton fifteen years to overcome. Since the difficulty comes from multiplication and since—after the general rule of generalization—we must find complex quantities as a particular case of space quantities, it is natural to look to multiplication of complex quantities to start our generalization from.*

We have seen that to multiply by a complex quantity $\overline{OA}$ (operating on $\overline{OB}$ for instance) we have only to construct (on $\overline{OB}$) a triangle OBP directly similar to triangle IOA where $OI = 1_0$ and $\overline{OP}$ being the product (see Fig. 10) we have $OP = OB \cdot OA$ or $OP = OB \cdot \dfrac{OA}{1} = OB \cdot \dfrac{OA}{OI}$

Therefore, to multiply by vector $\overline{OA}$ is a double operation composed first of a multiplication by $\dfrac{OA}{OI}$

† Another reflection may be suggested which will also induce one to examine the multiplication of plane vectors. When we operate on a scalar quantity by the extraction of root in algebra, a quantity of different nature may be obtained; why should it not be the case for the multiplication of vectors? Whether it is or not, the new kind of quantity must be a generalization of a complex quantity therefore it is natural to come to that kind of quantity again.

Second, of a rotation of an angle $\widehat{\mathrm{IOA}} = \alpha$

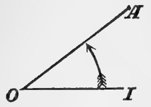

Fig. 12.

and we can denote by $\overline{\mathrm{IOA}}$ and represent geometrically (Fig. 12) by the figure IOA the operation of that multiplication. This operator applied to OI *i.e.*, to the absolute unit gives as result the vector whose tensor is $\mathrm{OI} \cdot \frac{\mathrm{OA}}{\mathrm{OI}} = \mathrm{OA}$ and which makes an angle α with OI that is to say gives $\overline{\mathrm{OA}}$.

Therefore the operator $\overline{\mathrm{IOA}}$ can be considered as representing the complex quantity $\overline{\mathrm{OA}}$.*

But with that meaning, any operator $\overline{\mathrm{BOP}}$ such that triangle BOP (Fig. 10) is directly similar to triangle IOA is equal to IOA for, the two operations

First multiplication by $\frac{\mathrm{OP}}{\mathrm{OB}} = \frac{\mathrm{AO}}{\mathrm{OI}}$

Second rotation of α

are identical respectively to the preceding ones.

Moreover, $\overline{\mathrm{BOP}}$ operating on $\overline{\mathrm{OB}}$ gives a vector of length $\mathrm{OB} \cdot \frac{\mathrm{OP}}{\mathrm{OB}} = \mathrm{OP}$ and making an angle α with OB that is to say gives OP; therefore the operator $\overline{\mathrm{BOP}}$ can also be considered as transforming by multiplication $\overline{\mathrm{OB}}$ into $\overline{\mathrm{OP}}$ (as operator $\overline{\mathrm{IOA}}$ transforms $\overline{\mathrm{OI}}$ into $\overline{\mathrm{OA}}$).

Extending now these notions to space we will give to a quantity (or operator) as above defined the name of quaternion.

Two quaternions are equal when the two triangles they determine are,

First, on same plane or on parallel planes (co-planar);

Second, directly similar.

Wherefore a quaternion may be transported in any way in its plane and may have one of its vectors of any given length.

---

* For, if multiplying the unit by a certain number we find as result 15, the number in question is 15.

Thus we see that a quaternion $\overline{BOP}$ is a natural generalization of a complex quantity and can be at the same time considered either as the symbol of a multiplication transforming its initial vector $\overline{OB}$ into its terminal one $\overline{OP}$;* or as a translation combined by multiplication with a rotation;† or as a magnitude.

But whilst two numbers were sufficient to determine an ordinary or plane complex quantity, four numbers are now necessary for the determination of a space complex quantity or quaternion since we have also to determine its plane.

But, obviously in our notion of a quaternion we must include the notion of space vector—a quantity depending only on three numbers. We are therefore naturally conduced to examine the particular cases when a quaternion depends on three numbers only. The simplest one is for the angle of the quaternion equal one right angle. In that case we can suppose that the quaternion represents a vector perpendicular to its plane (in a direction such that the rotation of the quaternion is from right to left for an observer standing up along the vector with his feet on the plane determined by the quaternion) and of length equal to its tensor. However arbitrary this definition may appear, it will be sufficiently justified if we obtain in the case of coplanar quadrantal quaternions the same results as before for complex quantities—and this is easily verified.‡

Fundamental operations on quaternions.

First of all, we will notice that we may easily bring any two quaternions to be collinear, that is to say to have their origins coinciding. For that purpose, we have simply to transport the

---

* The consideration of a quantity as a magnitude or as a symbol of operation is so familiar to us in mathematics that we are sometimes hardly able to distinguish between those ideas. A number is very often considered as a symbol of addition or of multiplication and it is according to those considerations that we may write $7 = \frac{35}{5}$, for 7 and $\frac{35}{5}$ are magnitudes of different kinds.

† Corresponding to a complex quantity a_α put under form $a \times 1_\alpha$.

‡ We may notice that a space vector becomes thus a generalization of a purely imaginary quantity.

quaternions—everyone in its plane—so that their origins shall be at the same point of the intersection of their two planes.

Addition.—Two quaternions being given and rendered collinear, turn them round their common origin O and alter, if necessary, the lengths of their initial vectors so that these initial vectors coincide. (Fig. 13.) Then the quaternions occupy the positions $\overline{AOB} \_ \overline{AOC}$. Constructing the parallelogram on $\overline{OB}$ and $\overline{OC}$, and drawing the diagonal $\overline{OD} \_ \overline{AOD}$ is said to be the sum of the quaternions $\overline{AOB} \_ \overline{AOC}$. That definition is extended easily to any number of terms and is justified by the fact that it coincides with the definition given for complex quantities when the quaternions are co-planar.

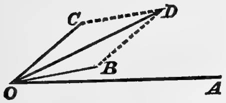

Fig. 13.

It is readily seen that the addition of quaternions has the same four fundamental properties as the addition of plane complex quantities *i.e.*, uniformity, commutativity, associativity and $\overline{AOB} + o = \overline{AOB}$.

From that definition, we are able to decompose any quaternion AOB into the sum of a scalar quantity and a quadrantal quaternion or vector. (Fig. 14.) Construct the rectangle OCBD having OB as diagonal and OA as direction for one of its sides.

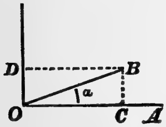

Fig. 14.

$$\overline{AOB} = \frac{OC}{OA} + \overline{AOD}$$

$$= a_0 + i\,a_1 + j\,a_2 + k\,a_3$$

Now let

$$T.\,\overline{AOB} = a = \frac{OB}{OA} \qquad \widehat{AOB} = a$$

and $\quad U.\,\overline{AOD} = A$*

We have OC = OB cos α whence $\frac{OC}{OA} = a \cos \alpha$ and similarly

$$T.\,\overline{AOD} = \frac{OD}{OA} = a \sin \alpha \text{ so that}$$

---

* T . AOB and U . AOD are the usual notations for tensor of AOB and versor of AOD.

$$\overline{AOB} = a(\cos\alpha + A\sin\alpha)$$

since $\overline{AOD} = T.\overline{AOD}\,.\,U.\overline{AOD}$

We have therefore for a quaternion the forms

$a_0 + ia_1 + ja_2 + ka_3$ analogous to $x + iy$ and

$a(\cos\alpha + A\sin\alpha)$ analogous to $a(\cos\alpha + i\sin\alpha)$

Subtraction—Inverse operation of addition.

Multiplication.—Two quaternions being given and rendered collinear, turn them round their common origin O and alter the lengths of their vectors, if necessary, so that the initial vector of the multiplier coincides with the terminal vector of the multiplicand. Then, they occupy the respective positions $\overline{BOC}$ _ $\overline{AOB}$ (Fig. 15)

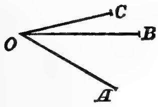

Fig. 15.

$\overline{AOC}$ is said to be the product $\overline{BOC}\cdot\overline{AOB}$ (the multiplier being first) and that definition is easily extended to any number of quaternions.

The operation is uniform but not commutative However it is associative and distributive and satisfies the equalities

$$\overline{AOB}\,.\,1 = \overline{AOB} \qquad \overline{AOB}\,.\,o = o$$

Demonstrations of those properties are found in any treatise on quaternions.*

Describing a sphere from O as centre with the unit as radius, we see that the multiplication of quaternions comes to

First, a multiplication of tensors

Second, a spherical addition of their argument.†

* One of the best demonstrations of the law of associativity is the one due to Möbius, and based on composition of rotations.

† A spherical addition, that is to say an addition of arcs of great circles on the sphere corresponds to a plane addition of vectors. Two arcs of circles are equal when they are of equal lengths, on the same great circle and of same direction. The sum of two arcs of circles $\alpha+\beta$ is obtained as follows: Take any of the two points of intersection of the circles on which the arcs α and β are situated; let us denote it by P. Displace α and β on their respective circles, the former so that its terminal point and the latter so that its starting point be at P. The arc of great circle joining the starting point of α to the terminal point of β in their new positions represents, by definition the sum $\alpha + \beta$.

Owing to the non-commutativity of spherical addition, quaternion multiplication is not generally commutative, as already seen. However when the quaternions are coplanar, the spherical addition becomes a circular addition and the multiplication of quaternions the multiplication of plane complex quantities which is commutative

The definition of multiplication applied to quadrantal versors shows immediately that

$$A^2 = -1$$

and generally

$$A^{4n} = 1$$
$$A^{4n+1} = A$$
$$A^{4n+2} = -1$$
$$A^{4n+3} = -A$$

and in particular

$$i^2 = j^2 = k^2 = -1$$

also $ijk = -1$

with

$$ij = k \qquad ji = -k$$
$$jk = i \qquad kj = -i$$
$$ki = j \qquad ik = -j$$

the fundamental equations of the quaternion calculus in the case where the vectors of reference i, j, k have the positions given (Fig. 16) as it is always considered in mechanics.

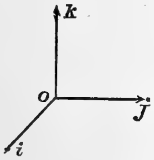

Fig. 16.

Dealing with coplanar quaternions, we find de Moivre's formula

$$[a(\cos \alpha + A \sin \alpha)]^n = a^n (\text{ces}\, n\alpha + A \sin n\alpha)$$

Now let us consider a series of vectors $v_1\ v_2 \ldots\ldots v_n \ldots\ldots$

$$\Omega = v_1 + v_2 + \ldots\ldots + v_n + \ldots\ldots$$

where $v = ai + bj + ck$

that series is said to be convergent when the sum of its n first terms has a limit for n infinitely great, that is to say when the series

$$A = a_1 + a_2 + \ldots + a_n + \ldots$$
$$B = b_1 + b_2 + \ldots + b_n + \ldots$$
$$C = c_1 + c_2 + \ldots + c_n + \ldots$$

are separately convergent.

There is a very important case when that condition of convergence is fulfilled; it is when the series of tensors

$$T = \sqrt{a_1^2+b_1^2+c_1^2} + \sqrt{a_2^2+b_2^2+c_2^2} + \sqrt{a_n^2+b_n^2+c_n^2} + \ldots$$

is converging; for, in that case, the terms of A, B and C are separately smaller than those of the converging series T.

Then the series Ω is said to be *absolutely convergent.**

If now we consider a series ordered with regard to increasing powers of a variable vector v

$$\Omega = a_0 + a_1 v + a_2 v^2 + \ldots + a_n v^n + \ldots$$

$a_0, a_1, a_2 \ldots a_n$ being constant scalar quantities, then t being the tensor of v

$$v = t (\cos \alpha + A \sin \alpha)$$

the series of tensors

$$a_0 + a_1 t + a_2 t^2 + \ldots + a_n t^n + \ldots$$

is converging when

$$t < \lim \frac{a_n}{a_{n+1}} \text{ for } n = \infty$$

Let $\lim \frac{a_n}{a_{n+1}} = R$, then the condition of convergence is

$$t < R$$

or in geometrical language, the point determined by the vector (variable) v drawn from an origin o must be interior to a sphere of radius R which we may call *sphere of convergence of the series.*

As an example let us consider the series

$$1 + \frac{v}{1} + \frac{v^2}{2!} + \ldots + \frac{v^n}{n!} + \ldots$$

which by natural extension of algebraic notation we will represent by e^v; in that case

$$\frac{a_n}{a_{n+1}} = n+1 \text{ so that } \lim_{n=\infty} \frac{a_n}{a_{n+1}} = \infty$$

therefore $R = \infty$ that is to say the series e^v is absolutely convergent for the whole space.

Now consider the series $e^{\alpha A}$

where α is a scalar and A a unit vector we have

* Of course a series of vectors may be convergent but not absolutely convergent.

$$e^{a\text{A}} = 1 + \frac{a\text{A}}{1} + \frac{a^2\text{A}^2}{2!} + \frac{a^3\text{A}^3}{3!} + \frac{a^4\text{A}^4}{4!} + \frac{a^5\text{A}^5}{5!} + \dots$$

$$= 1 - \frac{a^2}{2!} + \frac{a^4}{4!} + \dots$$

$$+ \text{A}\left(\frac{a}{1} - \frac{a3}{3!} + \frac{a^5}{5!} + \dots\right)$$

$$= \cos a + \text{A} \sin a$$

so that any quaternion with tensor a

$$a\,(\cos \alpha + \text{A} \sin \alpha)$$

can be put under the form $ae^{\text{A}\alpha}$

comparable to form $ae^{i\alpha}$ of plane complex quantities. But owing to non-commutativity of multiplication of quaternions, we cannot write

$$e^{\text{A}\alpha} \times e^{\text{B}\beta} = e^{\text{A}\alpha + \text{B}\beta}$$

as Newton's binomial formula is no more true.

Division.—It is the inverse operation of multiplication, but owing to the non-commutativity of the latter operation two definitions could be given :

Being given two quaternions A and B, find a quaternion Q such that

$$\text{A} = \text{Q} \,.\, \text{B}$$

or such that

$$\text{A} = \text{B} \,.\, \text{Q}$$

The first definition has been chosen.

The geometrical interpretation is obvious from the definition of multiplication of quaternions, and it is easy to see from it that a quaternion $\overline{\text{AOB}}$ is equal to the quotient of the two vectors which form it.

$$\overline{\text{AOB}} = \frac{\overline{\text{OB}}}{\overline{\text{OA}}}$$

Conclusion.—We now come to the conclusion I have given at the beginning of this paper, that is to say that the quaternion calculus constitute a natural extension of algebra.

I hope also that I have established a fact which would be an advantage to have better known, to wit that *Algebra is not scalar but vectorial.*

The spreading of that truth would help singularly to the spreading of quaternions. But independently of that fact, the historical order for the introduction of the different kinds of algebraic quantities is certainly not the logical one, and it is therefore fully time that the teaching of such an important branch of mathematics as algebra should be improved.

BOLEITE, NANTOKITE, KERARGYRITE, AND CUPRITE FROM BROKEN HILL, N. S. WALES.

By A. Liversidge, M.A., F.R.S.,
Professor of Chemistry in the University of Sydney.

[With Plate II.]

[Read before the Royal Society of N. S. Wales, June 6, 1894.]

The first of these minerals was sent to me by Mr. J. R. McKay, manager of the Broken Hill South Mine, on February 28th last, for identification with a request to make a confirmatory analysis. Accompanying the letter was an analysis of the mineral by Messrs. A. D. Carmichael and J. O. Armstrong; the composition, as found by them, agrees so closely with that of boléite (a variety of percylite) that I thought it would be a pity to use any more of the small specimen for the purpose of a second analysis. It was however necessary to determine the amount of water, the specific gravity etc.

Analysis of Mineral by Messrs. Carmichael and Armstrong.		Boléite by MM. Mallard and Cumenge.		
		Cubic crystals. 1	2	Octahedral crystals. 3
Silver	8·25 °/o	8·85	8·70	9·4
Lead	47·20	48·45	49·75	50·7
Copper	19·20	13·95	14·50	15·0
Chlorine	13·50	19·98	19·00	19·7
Oxygen (calculated) ...	[6·10]	[4·00]	[4·05]	undetermined
Water (calculated) ...	[5·44]	4·77	4·00	undetermined
	99·69 °/o	100·00	100·00	
or				
Copper oxychloride ...	33·67			
Lead oxychloride ...	55·02			
Silver chloride	10·95			

I have since determined the amount of water and found it to be 6·39 per cent.

The combined water was determined on ·3253 gram. of the mineral, this being the largest amount at my disposal. It was dried at 100° C., at which temperature it did not change in weight, then mixed with sodium carbonate, previously dried at a red heat, and fused in a hard glass tube through which a current of dry air was drawn; the water was arrested and weighed in a tube of pumice stone moistened with pure sulphuric acid.

The amount of water is rather higher than the percentage calculated by Messrs. Armstrong and Carmichael, this may be due to the sodium carbonate not having arrested all the chlorine and a little of the oxide of lead may have been carried forward, although the process was conducted as slowly and carefully as possible. I had, unfortunately, so little of the mineral that I was unable to perform any check experiments.

Mr. McKay states that the specimen was thought, by the finder, to be azurite, and that he (Mr. McKay), did not receive it for some days, when there was no possible chance of getting further specimens. This is much to be regretted since the mineral is a very rare one, and hitherto has only been found at the copper mines of Boleo, near Santa Rosalia, Lower California.

The specimen from Broken Hill is of an indigo blue colour, crystallised in cubes with the angles replaced by planes of the octahedron and the edges by those of the rhombic dodecahedron. (See *Plate* 2.) The crystals vary from four to seven millimetres along the edge, there are also embedded fragments of larger ones. The cubes interpenetrate, similar to fluor spar. The matrix is brown hæmatite and quartz, some of the crystals are seated on the hæmatite and others embedded in it. The hardness = 3·5; brittle. Sp. Gr. = 5·02 at 15° C. The specific gravity was determined by weighing fragments of the mineral in a very light stirrup pan in distilled water on an Oertling's best chemical balance. The lustre is strongly vitreous.

Cleavage is nearly perfect parallel to the cube, and apparently there is an imperfect octahedral cleavage as well. The fracture is minutely conchoidal. Under the microscope it is seen to have a striated structure in places. Heated quickly in a glass tube it decrepitates, then fuses and spreads much, gives off a little water and yields a slight sublimate. On charcoal before the blow pipe, it fuses, yields white fumes and incrustation, a bright green flame and globules composed of copper and lead. Soluble in nitric acid.

MM. Mallard and Cumenge (C.R. 113, 519, Oct. 26, 1891) found both cubic and octahedral crystals, the former sometimes 2 cm. in diameter or nearly three times the size of the Broken Hill crystals. They regard the octahedral crystals as tetragonal, so that if this be confirmed, the mineral is dimorphous.

Nantokite.

Some specimens of this rare mineral were forwarded to me for identification, on December 22nd, 1893, by Mr. J. R. McKay, manager of the Broken Hill South Silver Mining Company, N. S. Wales. To save time, as this Society did not then meet for the reading of papers for nearly six months, I sent an account of the nantokite to the Mineralogical Society of Great Britain and Ireland which was read at their meeting in April last. Mr. McKay also sent me a report upon the mineral by Mr. J. O. Armstrong of the above mine, and Mr. A. D. Carmichael of the Broken Hill Proprietary Block 10 Mine, as follows :—

"Mineral found at the Broken Hill South Mine, at the three hundred feet level in the carbonate of lead stopes, below original water level. It was found in one boulder about $\frac{2}{3}$ foot diameter; the boulder consists principally of carbonate of lead, native and oxide of copper, with films of oxychloride of copper. The crystals on examination, were found to consist wholly of copper and chlorine, a quantitative analysis showing :—

Copper	64·28
Chlorine ...	35·92
	100·20

This corresponds extremely closely to the calculated percentage composition of cuprous chloride, Cu_2Cl_2 which is—

Copper	64·18	(with at. wt. of 63·17)
Chlorine... ...	35·82	(with at. wt. of 35·37)
	100·00	

At the time of making this examination only small portions of the mineral was available. S. G. (approx.) 4·3. Insoluble in water, soluble in ammonia, hydrochloric acid and solution of common salt; on heating with water in presence of air, it is decomposed; lemon yellow coloured hydrated sub-oxide of copper being precipitated, which on further heating is changed into red anhydrous sub-oxide, part of the copper going into solution as cupric chloride."

The properties of the specimens forwarded to me correspond with those given by Messrs. Armstrong and Carmichael, hence any additional analysis seems unnecessary.

The specimens received consisted of the mineral in its matrix of cuprite, associated with native copper, cerussite, and a little quartz; the nantokite was of a pale pea green tint with a slightly effloresced surface; there were also some selected pieces separated from the matrix, from $\frac{1}{4}$ to $\frac{1}{3}$ inch through; at first these possessed but a very pale shade of green, from superficial change, but they gradually became of a darker green and in two or three days the surface effloresced and became opaque and powdery; when freshly fractured the mineral is practically colourless and transparent and has a highly vitreous or even adamantine lustre. The fracture is small conchoidal, and an occasional obscure cleavage plane is presented. Before the blowpipe it fuses and colours the flame a vivid blue, and on charcoal leaves a globule of copper. I found the specific gravity of these pure fragments to be 4·7 at 27° C., and the hardness 2·5.

Although the fragments look like portions of crystals, I could not identify any faces.

The mineral corresponds in all respects to the description given by Dana (System of Mineralogy, 1892, p. 154) of the original specimens found at Nantoko, Chile.

Kerargyrite.

The specimen figured on *Plate* 2 is a particularly fine group of crystals of silver chloride from the Proprietary Mine, Broken Hill, made up of cubes and octahedra without any matrix or extraneous matter whatever. Collected by Mr. J. O. Armstrong.

Cuprite.

The cuprite crystals figured on the same plate are of unusually large size, the principal cube being 12 m.m. across and of a splendid transparent ruby-red colour with high lustre; the principal crystal is a cube with its edges replaced by the rhombic dedecahedron and its angles by the octahedron. It was found in the same boulder as the nantokite at the Broken Hill South Silver Mine.

ABORIGINAL BORA HELD AT GUNDABLOUI IN 1894.

By R. H. Mathews, Licensed Surveyor.

[With Plates III. and IV.]

[*Read before the Royal Society of N. S. Wales, July 4, 1894.*]

For some years past this Society has taken a great interest in the manners and customs of the Australian aborigines, with a view of collecting and preserving authentic records of a race who are now rapidly passing away. It seems therefore, that no circumstances could be more appropriate, no time more suitable, no opportunity more fitting than the present to bring before our members an account of the Bora which has recently been held by the aborigines near the town of Gundabloui, in the parish of the same name, in the County of Finch, in this Colony. Gundabloui is on the Moonie River, about ten miles below where it is crossed by the Queensland boundary.

The Bora is a great educational institution for the admission of the youths of the tribes to the privileges, duties and obligations of manhood, and is the most important ceremony practised by the aborigines. The youths who are initiated, are carefully instructed by the old men in their traditions—their moral and religious codes—and the laws of consanguinity and intermarriage. The ceremonies are intended to strengthen the authority of the older men over the younger, and to impress in an indelible manner those rules of conduct which form the moral law of the tribe. This national rite partakes partly of a civil, and partly of a religious character, and is the great educational system by which the exact observance of the laws is inculcated. The games and dances of their forefathers are also taught by the old men who conduct the ceremonies. Meetings for the Bora are summoned at irregular periods as emergencies arise; they are generally held in the summer on account of the greater chance of having fine weather; but they may be held at any time of the year. The Bora mentioned by Mr. Glass, which will be referred to presently, was held during May, June, and July, which are winter months. The Bora which was held at the Mole, near Quambone, last year took place in April, May and June. The Kunopia Bora, referred to in this paper, was held in October, November and December, 1891. The time of full moon is generally selected for the commencement of the ceremonies, so as to have light at night, but this also depends upon circumstances. The ceremonial of the Bora is much the same in all parts of the colony; there are a few variations in the mode of assembling the tribes, in the form of the Bora grounds, and in the actual initiation, but so far as I have been able to learn, there is no very essential difference. It cannot be doubted, however, that the aborigines have left off some of their native customs, in consequence of their contact with Europeans, and it is every year becoming more difficult to obtain reliable information about the Bora.

I will now digress for a few minutes for the purpose of briefly drawing attention to descriptions of Boras by other writers many years ago. I do this because the books containing the narratives to which I will refer are now out of print, and can be found only in few libraries. I have introduced them here for the purpose of reference and comparison, and to give them publicity in our Journal for the benefit of all who may wish to study the subject.

The earliest description of the Bora with which I am acquainted is that given by Lieut.-Col. Collins, in his *Account of the English Colony of N. S. Wales*, published in 1804, pp. 365 – 374.—This Bora, at which fifteen youths were initiated, was held at the head of Farm Cove, Sydney, in February 1795, nearly one hundred years ago. The Bora-ground was oval in form, and measured twenty-seven feet in length by eighteen feet in width, and was cleared of grass and timber. In the evening the novices were placed sitting down, with their legs crossed under them, at one end of this ground, in which position they were to remain all night. Two *coradgies** then threw themselves prostrate on the ground, and rolled about in apparent agony. After a time each of them pretended to bring up a bone out of his mouth. It being by this time quite dark, Mr. Collins left the place for the night. On his return the following morning, the boys were placed at the head of the circle, while the operators, some twenty in number, paraded round it on their hands and feet, imitating dogs. Then two men appeared, one carrying on his shoulders a kangaroo, the other carrying a load of brush wood. After this, the boys were left sitting in their place in the circle for about an hour, during which time the actors went into a valley near the place, and fitted themselves with long tails made of grass, which they fastened to the hinder part of their girdles, and came jumping back to the Bora ground imitating a mob of kangaroos. They then threw off their grass tails, and each of them caught up one of the boys, and carried him on his shoulders to the last scene of this extraordinary exhibition, which was a short distance off. Here the boys were let down from the shoulders of the men, and after some further very secret preliminaries, the boys were led over the prostrate

* The native name for wizard.

bodies of a number of blackfellows lying flat on their faces on the ground. Following this there was a spectacular display of native weapons, after which the ceremony of knocking out the front tooth commenced. The first boy to be operated upon was seated on the shoulders of one of the men, who sat on the grass. The boy's gum was lanced with one of the bones produced by the *coradgies.* A wooden peg was then placed against the tooth and hit by a stone, which forced out the tooth. After this a girdle was tied round his waist, in which was stuck a wooden sword; a ligature was put round his head, in which was placed slips of grass tree, which being white, had a curious and pleasing affect. The same operation was performed on each of the boys, after which the assemblage dispersed.

The next authentic account of the Bora is that contained in Mr. J. Henderson's work, *Observations on the Colonies of New South Wales and Van Diemen's Land,* published in 1832, pp. 145 – 148. This Bora was held near Wellington in this Colony, sixty or seventy years ago, and I will give the account of it in Mr. Henderson's own words :—" The portion of the valley selected for performing this sacred rite was beautifully situated in a secluded part of the forest, near the banks of the river Macquarie. A long straight avenue of trees extended for about a mile, and these were carved on each side with various devices, most of which were intended to represent serpents in all their different attitudes. On the upper extremity of this, the earth had been heaped up so as to resemble the gigantic figure of a human being extended on his breast, while through the whole length of this sylvan temple, a variety of other characters were observed rudely imprinted on the turf. The devices represented snakes, opossums, emus, kangaroos, the cockchafer, &c. The evil spirit seemed to be described under the form of an eagle; an imitation of his eyrie formed a conspicuous object at the upper end of the grove. At the lower extremity of the avenue, a narrow pathway turned off to the left, and soon terminated in a circle, which was enclosed by a wall composed merely of loose earth.

"The candidate was first taken to the upper end of the avenue, and was there instructed by the old men in their mythology; and while conducting him down the long line of trees the meaning of all the various symbols was particularly detailed. At the same time certain dramatic representations were performed, the principal one being the destruction of the eagle-hawk by Baiamai. The youth was then brought into the circular enclosure, where he had one of his upper front teeth knocked out with a stone, after which he was sent into the bush for a time. On his return to the tribe he was permitted to wear a slight girdle, composed of narrow stripes of opossum skin, and to carry the spear and other war arms like men."

Mr. Henderson gives a plan of this Bora-ground which is highly interesting and valuable, because it is the only plan given by early writers on this subject. This plan shows the position of the circle, the narrow pathway, and the avenue; also, the position of the trees along this avenue, and some of the devices which were carved upon them. I have thought Mr. Henderson's plan of sufficient importance to reproduce that part of it which shows the Bora-ground, omitting the carvings on the trees. (*Plate* 4, fig. 2.)

An account of a Bora held between the Lower Castlereagh and Barwon Rivers in 1862, more than thirty years ago is given by Rev. W. Ridley in his work, *Kamilaroi and Other Australian Languages*, pp. 154, 155. A place was cleared and surrounded with bushes laid as a fence, like a sheep-yard, but the dimensions of the enclosure are not given. Within this bush fence were three old men. After describing some preliminary ceremonies, Mr. Ridley says, "the old men called in the youths one by one, and as each came in, by leaping over the fence, one of the old men flogged him as hard as he could with a strip of bark two feet long and six or eight inches wide. Then, with two stones, one used as a peg the other as a hammer, they broke off, and knocked out one of his front teeth, leaving the root of the tooth in his jaw. During the next four days they were allowed to walk about within a short distance, and at the end of that time they were again brought one by one into the enclosure, and compelled to eat the excrement of old women, mixed with *tao*, the root of a plant called pigweed. After this the young men were allowed to go away. White men have stated that this custom was observed in several parts, but it is only fair to state that some of the aborigines have strenuously denied the truth of it. From all I have heard, I conclude that it is actually observed by some tribes, but not by all." See also, *Anthr. Jour.* VII., p. 252.

With the view of testing the correctness of Mr. Ridley's conclusions, I have made enquiries of squatters and station managers who have lived in the back country and had opportunities of observing the customs of the blacks for many years. Mr. Jackson, now manager of Dulwich Estate, near Singleton, informs me that a Bora was held on the Namoi River near Wee Waa, about 1860 or 1861. He was at that time managing Mr. Quinn's station, on which a large number of blacks were employed, and was well acquainted with "Bunna Bunna Jack," the head-man at the Bora, who at Mr. Jackson's request, permitted him to be present at the ceremonies. There were about six or seven young blacks to be initiated, averaging about fourteen years of age. Some human excrement was collected on a sheet of bark, and each of the novices had to eat a small portion of it. This took place in Mr. Jackson's presence, so that he was an eye witness of what he relates.

Mr. James A. Glass, of Long Point, near Singleton, states that in 1862 a Bora was held on Eurie Eurie run, on the Barwon River, which at that time belonged to his father. A black boy named "Jacky," and a half-caste called "Billy Clark," who were both in Mr. Glass' father's service on the station named, attended this Bora for the purpose of being initiated; and on their return my informant states that "Jacky" had a tooth out of the front of his mouth, whilst the half-caste did not exhibit this mutilation. On being asked the reason of this, they stated that at the Bora they had been allowed the option of having a front tooth knocked out, or eating the excrement of an old gin; "Jacky" preferred the former, and "Billy Clark" the latter alternative.

Mr. George Gibson, owner of the Wullamgambone run, on the Mole, informs me that he has resided in that part of the country for more than forty-five years, and is well acquainted with the blacks and their customs, and can speak their language fluently. He states that the natives of the Bogan and Macquarie Rivers have admitted to him, in answer to his enquiries, that the custom of eating human ordure at the ceremony of the Bora was practised among them, and that their mode of eating it was to mix it with wild honey. He says he got this information from about half a dozen different blackfellows, at various times, and is quite satisfied of the truth of it. The Bora was called *bŭrbŭng* by these blacks.

Mr. A. Brown, the owner of a station on the Castlereagh River, informed me that the blacks had told him that the reason for eating human ordure at the Bora ceremonies was to impress upon the novices that if they did not strictly carry out the rites and ceremonies which they were commanded by Baiamai to perform, they would have to eat excrement "in the land of the hereafter."

From the enquiries I have made I am forced to the same conclusion as that arrived at by Mr. Ridley, that there can be no doubt the practice referred to was observed by some tribes, but was not general.

Mr. Ridley describes another Bora-ground near the junction of the Page and Isis Rivers. It was circular in form, about a hundred and fifty yards in circumference, and was bounded by a raised earthen path. In the centre of this circle was a large fire. There was the horizontal figure of a man, roughly modelled by laying down sticks and covering them with earth, so as to raise it from four to seven inches above the ground. This figure was twenty-two feet long, twelve feet wide from hand to hand, the width of the body being four feet. Around this spot were one hundred or one hundred and twenty trees marked with a tomahawk in various patterns. While the young men were awaiting the ceremony of initiation they were made to lie flat on the ground, just in the posture of the figure above described. The candidates were made to pass through an ordeal of pain, but there was no knocking out of a tooth, nor was the revolting custom above mentioned practised by the blacks of that locality.—*Anthr. Jour.*, VII., p. 255. *Kamilaroi and Other Australian Languages*, p. 156.

I will now state how I obtained the information respecting the Bora which forms the subject of this paper. Early in the present year I heard that the blacks were mustering at Gundabloui near Mogil Mogil, for the purpose of holding a Bora, and as I was very busy at home, and could not possibly get away to visit the place myself, I wrote to Mr. J. T. Crawley, the Police Officer stationed at Mogil Mogil, fifteen miles from Gundabloui, who is well acquainted with the blacks of that district, and in whom I knew I could place entire confidence, and asked him to collect the fullest details he could. I told him all the points on which I wanted information, and gave him an outline of the procedure at Boras generally. I also gave him exhaustive directions how to proceeed in collecting the details.

This gentleman set about the duty in an enthusiastic manner, and wrote to me from time to time, communicating the results of his observations and enquiries; and in my replies I drew his attention to any points requiring further investigation. In one of his letters he says:—"Although the blacks were very reluctant and reticent at first, they soon put faith in me, and made me promise that any information they gave me would not be divulged to local people or be published in local papers. One would be reticent if another were present, so I had to question them separately and unknown to each other, and in this way I found that one corroborated the other, which gave me full confidence in the truth of their statements." In another letter he says: "they would not permit me to be present during their ceremonies at the sacred circle, for it was guarded day and night in turns, but as soon as the ground was abandoned, I visited it, and took full descriptions and made sketches of everything on it." A large quantity of correspondence passed between myself and Mr. Crawley, who displayed great zeal and industry in collecting details relating to the numerous difficult points submitted to him. From the information thus obtained I have been able to prepare a full account of this Bora from its commencement to its close.

Mustering the Tribes.—About two years ago a Bora was held at Kunopia on the Boomi River, and after its conclusion two of the head-men of the aboriginal tribes of that part of the country who are known amongst the Europeans as "Billy Whiteman" and "Moogan Billy" arranged with the head-man of the tribes about Gundabloui, who is known as "Jack Bagot," that a Bora should be held in the last named district, for the purpose of initiating a number of young men who could not attend the Kunopia Bora, and also to finally admit some of those who had been there initiated. The Kunopia head-men gave Jack Bagot three boomerangs,* according to custom, as tokens of their concurrence, and in due course he visited all the neighbouring tribes for the purpose of consulting the several head-men about making the necessary arrangements in regard to the best time and place for holding the Bora. These preliminary duties occupied him for a considerable time, and on his return to Gundabloui a few months before last Christmas, he despatched messengers† to all the places he had recently visited, to inform the blacks that a Bora would be held at Gundabloui, and requiring them to assemble there at a certain time. Some of the messengers were men who had been initiated, and who went on their mission alone; but two of the messengers were half-castes who had never been at a Bora, and in their case each was accompanied by an old man until the first camp was reached, when the old man returned to the camp he had left. From there the messenger was similarly escorted by an old man to the next camp, when he also returned to his own tribe. In this manner these half-castes were conducted from camp to camp

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* *Anthr. Journ.*, VII., p. 252.

† I endeavoured to ascertain whether these messengers were of the same *totem* as Jack Bagot, the principal head-man who summoned the Bora, and also if the head-men of the tribes to whom they were sent were likewise of the same *totem*, but was unable to obtain satisfactory particulars.

until their respective destinations were reached. The initiated messengers, as before stated, went from camp to camp without any convoy.

The messengers went away separately, each having his own route, and before being despatched they were each provided with a piece of wallaby skin,* as an emblem of their mission, which they had to keep hung in front of them by means of a string tied round the waist; and they were instructed to wear this badge all the time they were engaged in this duty. On the first evening of the arrival of one of these messengers at a camp, he would strip quite naked, paint himself with raddle, and appear with the piece of wallaby skin hanging in front as a covering. He then went through a ceremonial dance before the tribe, after which he delivered his message to the head-men. The same procedure was gone through at every camp visited by him until he reached his final destination. It may be mentioned that the messengers sent out to muster the tribes were considered persons of some importance by the blacks whom they visited. When a messenger at length arrived at the last of the camps he had been directed to summon, he remained with the blacks there until they were ready to accompany him, when the return journey to the Bora-ground was commenced, the assemblage being increased by a fresh contingent of natives at each of the places visited by the messenger on his way out. During the journey to the Bora ground, when the contingents camped at night, they sometimes had dances and songs at the camp fire. When this concourse neared the Bora camp, one of the chief-men went a-head and informed those already assembled, of the near approach of the visitors. All the men in that camp were then mustered with their weapons of war in their hands, and on the new comers approaching they were welcomed with volleys of joyous shouting, which they returned. Then the messenger who had escorted them thither, having now finished the task assigned

* Ridley says, "The herald who summons the tribes to the Bora bears in his hand a boomerang, and a spear with a padamelon skin hanging upon it."—*Kamilaroi and Other Australian Languages,* p. 153.

him, was released from further duty. The same course was followed on the arrival of each messenger with his contingent at the main camp. These arrivals generally took place about nightfall, and appeared to have been so arranged. When all the contingents had arrived, the head-men fixed the day on which the great ceremony should commence.

The Camp.—The general encampment consisted of three sections; the blacks who had come from Mogil Mogil, Collarendabri and Walgett occupied one section; those from Kunopia, Mungindi and Welltown another; those from the Moonie and St. George forming a third section. The blacks who thus went into sections by themselves all belonged to the same tribe, therefore the whole concourse assembled in this camp represented three distinct tribes all belonging to the same community; and each tribe occupied that side of the main camp which faced the direction of their own *tauri*, or country.* The blacks from Welltown and St. George had the farthest to travel to reach the Bora-ground—the distance being over one hundred miles. The Narran and Namoi tribes had been invited, but did not attend. The aborigines from the Moonie, St. George and Welltown belonged to Queensland. The blacks of all ages assembled to witness this Bora numbered about two hundred and three persons, comprising ninety-six men, fifty-eight women, and forty-nine children. This includes half-castes—the same privileges being accorded to them as to natives of full blood. The Aborigines Protection Board, on being informed that the Bora was to be held, authorised the issue of rations to the aged blacks and children; and on one occasion a special issue of a hundred half-rations was made to the able bodied natives.

The Bora Ground.—While the messengers were away mustering the tribes who had been invited to participate in the ceremonies, some of the head-men, assisted by young fellows who had been to at least one Bora, were employed preparing the ground, which was about half-a-mile westerly from the general encampment, and

* *Jour. Roy. Soc., N.S.W.*, XXIII., p. 37.

was situated in a dense scrub of sandalwood and coolabah. The main camp was about half a-mile westerly from the town of Gundabloui, the latter being on both sides of the Moonie River, from whence water was obtained by the blacks for camp use. It is the custom for that section of the community which called the tribes together, to prepare the ground, and get everything ready for the arrival of the various contingents. The locality is situated in the country of the head-man who calls the assembly.—*Anthr. Jour.*, XIII., p. 440.

Two circles had been formed on the ground, very much resembling the rings seen at a circus (*Plate* 4, fig. 1). These circles were cleared of all timber and grass, and carefully swept; and the surface of the ground within them levelled, and slightly hollowed so as to obtain sufficient loose earth to form the outer walls, which were about a foot high. The largest of the circles was about seventy feet in diameter, most regular in shape, and in the centre stood a pole about ten feet high, with a bunch of emu feathers tied on top; in the western wall of this enclosure an opening about five feet in extent was left as an entrance. Around this circle on all sides except the opening mentioned, was a bush fence composed of a number of forks set in the ground, with rails from one to the other, and against these rails bushes were laid. From the opening referred to, an ordinary uncleared bush track ran about S. 60° W. for about twenty-three chains, connecting with another and smaller circle about fifteen yards in diameter. This ring was not so perfect in shape as the other, and the walls were roughly made; there was, moreover, no opening left for the purpose of ingress or egress, as in the other circle, but any one wishing to enter it had to step over the wall. Near the centre of this circle were two saplings which had been taken out of the ground by the roots; the branches were then cut level across, after which they were fixed in the ground with their roots upward. Although the surrounding country is level, the dense scrub prevented one circle being seen from the other.

On leaving the larger circle, and proceeding along the pathway, nothing was noticeable for about one hundred and forty yards, then for a distance of about three hundred and twenty yards numerous devices and figures were carved in the turf, extending about twenty feet back from the track on either side. In order to obtain a clean even space on which to work, the loose surface soil had been removed and piled into little heaps like ant hills, and the earth cut out in carving the outlines of the figures was disposed of in the same manner; every heap having a small stick stuck upright in the top of it, which had rather a pleasing effect.

The most interesting of these carvings in the soil was a group of twelve persons, life size, with their heads in the direction of the smaller circle, and were on the south side of the pathway. (*Plate* 3, fig. 1.) All the figures were joined together—the hands and feet of one joining the hands and feet of others. These figures were formed by cutting a nick or groove in the ground along the outline of each. They represented young men who were with Baiamai at his first camp.

A large number of devices, somewhat similar in character to those seen on trees about Bora grounds were outlined by a groove cut in the soil, about two inches deep, and from two to three inches wide, cut out with tomahawks and sharpened sticks. Three of the most representative of these are reproduced on *Plate* 3, figs. 5, 6, 7. There were about forty of these designs cut in the ground in various places and at irregular intervals throughout the space of three hundred and twenty yards before mentioned. Each one had a separate pattern, and some were on one side of the path, and some on the other; they are remarkable for their great number and variety. Some of the largest of these designs were from ten to fifteen feet square, but others were much smaller.

On the northern side of the path was a representation of a horse and parts of a vehicle, outlined by carving in the soil like the preceding; and near a stump which was naturally in that place, was the effigy of a blackfellow composed of sticks and old clothes, like a scare-crow, having round his neck a string from which was suspended a crescent shaped piece of tin resembling the brass plate sometimes given by Europeans to aboriginal kings. The native artist who did this group said it was purely imaginary, and was meant as a humorous representation of an old king going to the Bora, and having a break-down on the road.

The foregoing comprise all the carvings cut in the soil, which I have distinguished from raised earthen figures formed on the surface of the ground, which I will next describe.

About two hundred and thirty yards from the smaller circle, and about six feet from the southern side of the path, and at right angles to it, was the horizontal figure of a man about fifteen feet in length and otherwise built in proportion, composed of logs covered with earth, the height of the chest being two and a-half feet from the ground, and the feet pointing towards the track; this the blacks said represented Baiamai, who presides over the ceremonies of the Bora. On the opposite side of the path, with the feet towards it, was a life-sized figure which represented Baiamai's female consort, whom the blacks call Gunnanbeely. (*Plate* 3, figs. 3 and 4.) They say that Baiamai gave them the country and all that is in it for their use, after which he and Gunnanbeely went away. A short distance from these, on the north side of the track, the figure of a man and woman were formed on the ground in the same manner; they were lying together behind a tree, and were partly hidden. The blacks said these represented the original parents of that tribe, whom they call *Boobardy* and *Numbardy*—meaning father and mother respectively.

On the northern side of the pathway was the life-sized figure of an emu formed with raised earth, with its head towards the smaller circle and a spear stuck in its body, the other end of the spear resting against a tree. (*Plate* 3, fig. 13.)*

The figures of two snakes,† each about fifteen feet long, were formed of raised earth; they were lying beside each other, parallel

* The figure of the emu on Bora grounds has been noticed by different writers. See *Anthr. Journ.* VII., p. 255, *Ib.* XIII., p. 452, and Henderson's *Obs. Cols. N. S. Wales and V. D. L.*, pp. 145 – 148.

† Henderson says that snakes were delineated on the turf at the Bora he visited near Wellington in 1832.

to the track, and on the south side of it, with their heads in contrary directions. (*Plate* 3, fig. 2.) These represent a large snake called by the natives "mungan," and its flesh is preferred to that of other snakes.

The body of a bullock was formed by logs covered with earth, on one end of which was laid a dry skeleton of a bullock's head, with the horns on it, and a stick stuck in the other end of it for a tail.

There was a mound of earth, four feet long, representing a grave, on the north side of the pathway. On opening this it contained some old clothes placed in a sheet of bark, which was doubled round them and fastened by a cord to keep it from opening, showing the way natives are buried.

On the south side of the track was a life-size male figure cut out of bark, and placed on top of some raised earth about nine inches high, so as to resemble a man lying on the ground. On the other side of the path, opposite to this, was the figure of a female formed in the same way. These represented the men and women of the tribes.

Not far from the track were three small gunyahs made of bark, indicating the dwellings of the natives. Two of these were on the southern, and one on the northern side of the path.

At intervals along the track, some being on one side and some on the other, were sixteen bushes naturally growing there, containing representations of birds' nests, in which were placed stones and prickly pears for eggs. Dispersed along the track in the same manner were half a dozen imitations of caterpillars' nests, made of about a quart of sand tied up in cloths like puddings, and hung on trees; the caterpillars* were represented by small leaves of the prickly pear threaded on a string by means of a hole through one end of them, and the string tied round the tree. These nests, the natives say, represent the gifts of Baiamai to them.

* Representations of the cockchafer were shown on the Bora ground described by Mr. Henderson.

A short distance from the image of Baiamai was the imitation of an eagle-hawk's nest* in a tree, twenty feet from the ground. The blacks said there was an eagle-hawk's nest near Baiamai's first home, and that he chased the eagle-hawk away.

Not more than a dozen trees were carved, none being marked higher than a man could reach from the ground. Five of the most representative of these are delineated in *Plate* 3, figs. 8 to 12. I may add that suitable trees for carving were scarce, the timber consisting chiefly of small scrub trees.

On the northern side of the track, near the effigy of the old king, was the figure of an iguana about three feet long, cut out of bark and fastened to a tree.

A figure of the sun two feet in diameter, and one of the moon eighteen inches, were cut out of bark, and hung on trees; the sun being at the eastern and the moon at the western extremity of the symbolical representations I have been describing—perhaps to indicate the sources of illumination by day and night. (*Plate* 3, figs. 14 and 15.)

Not far from the image of the sun were two male figures cut out of bark, and fixed up against trees, one on each side of the pathway. One of these had his head ornamented with emu's feathers, and the other held in his hand a *hielaman*, or native shield. These figures gave a visitor the impression that they were warriors who had been placed there to guard the entrance to the mystic silvan temple beyond. The natives said these figures represented the two sons of Baiamai—Cobbarailbah and Byallaburra.

On the track, about forty yards from the figure of Baiamai, in the direction of the larger circle, was a big fire which was kept burning day and night, called "Baiamai's fire."

From the time the Bora was commenced until the ground was abandoned, two of the old men kept guard over it day and

* See Henderson's remarks at p. 101 of this paper, in reference to an eagle's eyrie observed on the Bora ground described by him in 1832.

night; they camped at Baiamai's fire, and had dogs to give the alarm if any stranger approached. All the men of the tribes took their turn in watching the ground, and there were always two of them on this duty at the same time.

One of the natives told my informant that the Bora ground represents Baiamai's first camp,* the people who were with him while there, and the gifts he presented them with; the figures on the ground and the marked trees are emblematical of the surroundings of such camp. They also state that Baiamai intended the larger circle for the recreation of the women and children—this is why it is greater in extent than the other, which is only intended to accommodate a few.

The Bora ground was ready for more than a month before all the mobs of blacks had mustered, and during this interval the head-men would go and sit around Baiamai's fire, and arrange matters of tribal concern, and discuss subjects in connection with the ceremonies which were shortly to take place. Sometimes these discussions would lead to warmth and unpleasantness, but would always terminate amicably. While the blacks already assembled at the main camp were waiting for the arrival of other contingents, the young men would go out hunting or fishing during the day. The women and children would find employment for themselves about the camp or in assisting the men. During this period there were songs and dances at the camp fire nearly every night. Mr. J. L. Gwydir, manager of Mr. J. Tyson's Gundabloui Station, close by, gave the blacks an allowance of beef free of charge, in addition to the Government rations before referred to.

The Ceremonies.—When at length the last mob of natives had arrived, the ceremonies of the Bora commenced. Every forenoon the initiated blacks went to the Bora ground, and walked about looking at the carvings and other imagery there displayed, spending some of their time talking about these things near Baiamai's

* Ridley says, "the ground on which the Bora is celebrated is Baiamai's ground."—*Anthr. Journ.*, VII., p. 243.

fire, the gins and novices remaining at the main camp. In the afternoon, the mothers of the novices or their nearest female relatives* who had them in charge, painted them with red ochre and grease, after which they decorated their necks with beads, and their hair with feathers. When the novices were thus ornamented, they marched in single file from the main camp to the larger circle, keeping their eyes fixed on the ground. The women who had charge of them, accompanied by the rest of the women in the camp, as well as the children, walked with the novices, watching that they did not raise their eyes from the ground. The mothers, or relatives who had charge of the boys, were naked to the waist, and were painted with raddle and pipeclay. On arrival at the large circle, the boys entered it through the opening previously described, and sat down on the raised border of the circle, their feet being within it. The Mogil Mogil, Collarendabri and Walgett boys sat on the southern side of the entrance of the circle; the Mungindi, Kunopia and Welltown boys sat in a similar manner on the opposite side of the entrance; and on the left of the last named, the boys of the Moonie and St. George tribes took up their position in the same way;—the boys of the three tribes thus sitting in that part of the circle which faced their respective districts. As soon as the boys had sat down, the women and children also entered the circle, and commenced to dance, sing, and play. During all this time the boys were required to keep their eyes cast down. About sun-set, the men, who had been at the Bora ground, as before stated, since the forenoon, joined the assemblage at the larger circle, and took part in a short dance. After this, all hands, with the exception of the two men left to guard the ground, before referred to, went back to the main camp, the boys being escorted on the return march in the same manner as on their way out. This concluded the ceremonies for the day, and nothing more was done on the Bora ground till the following morning.

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* When the mother of the novice is dead, or is unable to be present, it is usual for one of her sisters, *own* or *tribal*, who would therefore be the boy's "tribal" mother, to attend, and discharge the mother's duty.

At the main camp during the early part of nearly every night, one of the masters of the ceremonies would go alone into the bush a short distance from the camp, and for about two hours would sound a wooden instrument which these blacks call *murrawan*, which is supposed to represent the voice of Durramoolan,* their native name for the evil spirit, who rules in the night.

During the time the instrument referred to was being sounded in the adjacent forest, the men of the tribes would dance, yell, and make hideous noises, and all the gins would sing in a monotonous chant, and beat time; those of each tribe singing their own peculiar song. The gins sat down in a line on one side of the camp fire, having on their laps a piece of thin dry bark with a cloth thrown over it, on which they beat time with both hands. Such of the old men who were too infirm to dance, also beat time with two boomerangs or time sticks, one in each hand. The dancers were on the other side of the fire, retiring into the darkness, or advancing to the light as the sentiment seemed to require. The various contingents danced alternately, being in turn performers and audience. The uninitiated youths did not take part in these dances, but will be allowed to dance with the men at the next Bora they go to. These performances were gone through for the instruction as well as the amusement of the novices.

The ceremonies I have been describing were gone through from day to day with slight variations, for upwards of three weeks. At

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* Howitt says:—"Daramulun was not everywhere thought to be a malevolent spirit, but he was dreaded as one who could severely punish the trespasses committed against their tribal ordinances. He, it is said, instituted the ceremonies of the initiation of youths; he made the original *mudji*, (bull-roarer) and the noise made by it is the voice of Daramulun." —*Anthr. Journ.* XIII., p. 192 and 446.

Wyndham states, that among the blacks of the western parts of New England, "the principal man who presided over the Bora personated the Devil, and he made a most terrific noise with a bull-roarer."—*Jour. Roy. Soc., N.S.W.*, XXIII., p. 38.

Greenway says:—"Among the Kamilaroi tribes about Bundarra, Turramulan is represented at the Bora by an old man learned in all the laws and traditions, rites and ceremonies, and assumes to be endowed with supernatural powers."—*Anthr. Jour.*, VII., p. 243.

the end of this time, one morning about sunrise, all the blacks, men, women and children, assembled adjacent to the larger circle. All the males, including the novices, then stripped naked, and painted their bodies with red ochre and grease. The men then formed into a group and danced in front of the women and children. The mothers of those to be initiated, or their female relatives discharging the parental duty, stood in the front row of the women during this dance, and at its conclusion they commanded the novices to enter the circle, thus relinquishing their authority over them. Up to this time the women retained possession of the youths, but now surrendered them to the headmen of the tribes. The youths then walked into the circle through the opening before described, the members of the three tribes keeping by themselves, thus forming three distinct sections within the ring.

Each novice had a guardian or sponsor assigned him by the headmen, or masters of the ceremonies, this guardian being selected from among the initiated men of the class and totem with which he was, by the tribal laws, entitled to intermarry.*

As soon as all the novices were inside the circle, the women and children were made to lie face downwards on the ground on the outside of the ring, on that side of it farthest from the pathway, and their heads were closely covered up with rugs and blankets to prevent them from seeing what was to take place. Some of the old men were deputed to see that this formality was strictly carried out. When the gins and children were securely covered up, the guardians or sponsors entered the circle, and each caught his novice by the hand and led him to a convenient place within it, and painted him with pipeclay, those of each tribe using a distinguishing pattern. The guardians also adorned each of the

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* Howitt says:—"The novice is taken from among the assembled women by the initiated men of that part of the community to which belong the women, as regards whom he has inherited potential marital rights. The men who especially instruct him, and watch over him during the ceremonies, are the brothers—own or tribal—of those women."—*Trans Aus. Assoc. Adv. Sci.*, III., p. 345.

youths with a kilt of wallaby skin suspended in front by means of a girdle tied round the waist; these badges must be kept by the recruits till they have passed through another Bora.* Such of the adult males as were not engaged in the ceremonies also entered the ring if they chose, and stood with the people of their respective tribes.

As soon as the novices, who are called *wommarois*, were thus ornamented, their guardians took them by the arm above the elbow, and led them towards the smaller circle, with their eyes fixed on the ground, care being taken that they did not look at any of the figures as they passed along the track. Each guardian and his novice walked abreast—one pair following the other—thus forming a file of two and two. Each guardian gave his boy instructions as to his duty while on the Bora ground. When the procession of novices started the men who were present as spectators raised a shout. This shouting is kept up to cover the noise made by the departing guardians and their novices; the women not being supposed to know what has become of them.†

When the men and novices got out of sight of the larger circle, the women and children were permitted to rise from the prostrate position in which they had been placed, and were escorted back to the main camp by the old men left in charge of them. This was the last appearance of the women on the Bora ground.

On reaching the smaller circle, the *wommarois* were made to lie face downwards on the ground with their heads resting on the raised earth forming the boundary, and their feet from it. They were allowed to vary this posture by resting on their knees and elbows, with their heads bent to the ground—when they got tired of one position they could adopt the other—and during all this time they were forbidden to look up.

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* These kilts and girdles were similar in every respect to those worn by the messengers when summoning the tribes, as stated in an earlier part of this paper. Sometimes these kilts are made of kangaroo-rat skin. —*Anthr. Journ.*, XVIII., p. 321.

† *Anthr. Jour.* XIII., p. 442, note 3.

There were amongst the assemblage a number of young men who had been to one Bora before, and attended this one for further instruction; these are called *tuggabillas*, and had no guardians, but walked unrestrained with the old men all over the Bora ground, and everything on it was fully explained to them, so that when they become old men they may be able to produce similar figures and explain their meaning to the young men of the tribe, so that their customs and traditions, rites and ceremonies, may be handed down from one generation to another.

After the *wommarois* had been lying down as before stated, for about two hours, the *tuggabillas* were brought and placed standing round the outside of the ring. Two old men* then entered it, and showed them Bora dances, after which the old men each ascended one of the saplings before referred to, and sitting on the roots sang traditional Bora songs in a low monotonous chant. These performances continued for about an hour, when the old men retired, and two of the most accomplished of the *tuggabillas* took their places within the circle. The *wommarois* were now allowed to rise, and were placed in a standing position around the outside of the ring, while receiving from the two *tuggabillas* similar instruction to that imparted by the old men. When this was concluded the *wommarois* resumed their former prone position around the circle. The *tuggabillas* then withdrew, and went over the Bora ground again with the old men.

About one o'clock in the afternoon, the head-men and guardians called the novitiates out of the circle, and took them away about six miles to a place called Mungaroo. This was the last scene enacted at the Bora ground, which was now finally abandoned. The journey to Mungaroo from the Bora ground was performed at a leisurely walk, during which the catechumens were not allowed to gaze about them, nor to show any levity of manner. As they walked along their guardians were explaining to them the signifi-

* These old men have sometimes been described as "wizards," and their performances have been called "magical dances."

cance of what they had gone through at the smaller circle. On their arrival at Mungaroo, the old men formed a camp on the edge of a scrub near water; and about one hundred and fifty yards from it in the scrub a separate camp was made for the boys. The latter consisted of a partial enclosure in the shape of a horse-shoe, the open end being that farthest from the men's camp. The width across the open end was about thirty feet, and the depth from there to the back wall about twenty feet,—the walls being about four feet high, and were formed of boughs. Across the open end small fires were kept burning, and when in this yard, the youths were never without a few of their guardians, who furnished them with food, and attended to their wants. Whilst in the yard they were not allowed to look up, but when out hunting or playing with the men they were allowed greater liberty. On leaving this yard in the morning or returning to it in the evening, the novitiates had to keep their eyes on the ground while the camp was within sight. Women were not permitted to approach either of these camps.

Many of the men unconnected with the ceremonies accompanied the men and catechumens to Mungaroo, but the women and children, and any of the men who were infirm or did not care to go, remained at the general camp. Mungaroo, which is on a warrambool of the same name, is a great place for marsupials and native game of all sorts. During the daytime the men and youths would strip and paint themselves with raddle and grease, and ornament themselves with kilts made of wallaby skin suspended in front by girdles round the waist, when they would all go into the bush and hunt. The old men taught the novitiates how to play the native games, to sing the songs of the tribe, and to dance certain corroborees which neither the gins nor the uninitiated are permitted to learn. They were also instructed in the sacred traditions and lore of the tribe; to show respect to the old men; and not to interfere with unprotected women.

On some of the days spent at this camp the men and boys cut grass and reeds, and tied them up so as to resemble kangaroo's tails*—these they stuck in their girdles and danced a corroboree, imitating kangaroos.†

At night the courage of the novices was tested by making them lie on the ground in the yard in charge of some of the men, who were instructed to observe them, while the old men would each take a youth who had been to at least one Bora before, and would thus go in pairs in different directions some distance into the adjacent scrub, where they would make hideous noises, and raise a terrific din, sounding the wooden instrument called *murrawan*, previously referred to, and during this time the youths were not allowed to exhibit any alarm. During the daytime these instruments were hidden away in great secrecy by the old men. This was carried on every night for about a week, at the end of which the secret wooden instruments were shown to the novices, and their mysterious significance was fully explained, after which they were placed on the camp fire and burnt.‡

On some days the novitiates would be ranged in a line in the bough yard before described in front of the old men, and those who had lately been admitted as men of the tribe, all of whom would go through many obscene gestures for the purpose of shocking the young fellows; and if the latter had shown the least sign of mirth or frivolity, they would have been hit over the head with a nullah nullah by an old man appointed to watch them. This pantomimic representation was enacted for the purpose of teaching them to abstain from masturbation, and from those offences which

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* The blacks told my informant the following legend about Baiamai and his two sons in regard to these tails.—They were out huuting one day and caught two kangaroos, and cut their tails off. The next Bora they went to Baiamai's sons danced with these tails tied behind them like kangaroos, and this custom has been followed by the tribes at all Boras ever since.

† At the Bora described by Collins, referred to at p. 100 of this paper, he mentions a similar dance.

‡ E. Palmer says, that "in the Bellinger River tribe, the humming instrument (bull-roarer) is called *yeemboomul*, and when the ceremony of the Bora is over, they burn it."—*Anthr. Journ.*, XIII., p. 296.

have been called "the abominations of the Cities of the Plain."* During these performances, which took place in the day time, the men and novices would be naked and painted, and one or two of the men would act as guards to see that no one came upon them unawares.

The extraction of a front tooth was not practised by any section of the tribes assembled at this Bora, but while at the Mungaroo Camp the novices had their hair cut short, and a few of them who had beards had them cut off. The guardians and other men who accompanied them also had their hair and beards cut short in a similar manner. The cutting off of the hair was probably intended to take the place of knocking out a tooth, or the eating of human ordure, practised by some tribes as stated in previous pages of this paper.

The ceremonies at the camp at Mungaroo occupied between a week and ten days, at the conclusion of which they washed the red paint off their bodies and painted themselves white, and then started back to the camp at Gundabloui.

During the absence of the men and catechumens at Mungaroo, the women and children, assisted by such of the men who remained with them, had shifted the main camp about half a mile southerly from its former position.† About two hundred yards westerly from this new camp, a bough yard was erected, similar in size and shape to the one used by the novitiates during their stay in the

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* *Anthr. Journ.*, XIII., p. 450.

† A long and heated discussion took place with regard to the locality where the new camp should be erected. The Mungindi, Kunopia, and Welltown tribe wished to have it erected at Collybidgelah, seventeen miles from Gundabloui in the direction of Kunopia, and therefore seventeen miles nearer their respective districts. To have put the camp there would have caused great inconvenience to the other two tribes after the ceremonies were finished, their *tauri* being in the contrary direction. Eventually the arguments of the two latter tribes prevailed, and the new camp was formed in the place above stated.

It is customary at these ceremonies to remove the camp during the time the men and boys are away.—*Anthr. Jour.*, XIII., p. 454.

bush. The entrance to this yard was on the side farthest from the camp, and faced the direction of Mungaroo. When the men and boys started to return to the main camp one of the men went ahead, and announced that they would shortly arrive. All the children, and all the gins—with the exception of those next mentioned—lay down outside of the convex end of the yard, and were covered with bushes by the old men who had remained at the main camp. The mothers, or female guardians, then entered the enclosure, and formed into three groups according to their tribes, each group having a flag* of their own, and taking up their position on that side of the enclosure nearest their own district. As soon as they were settled in their places, they were blindfolded by tying handkerchiefs over their eyes and round their heads. When all was ready, the messenger above referred to, went back and met the men and boys coming from Mungaroo, and they all came on and marched into the bough yard. Each guardian led his catechumen to his mother, or female relative discharging the parental duty, who felt the boy's hands and face till she was satisfied that he was the same person who was handed over to the men at the larger circle on the Bora ground. During this manipulation neither the women nor the boys were allowed to speak. The mothers then had their eyes uncovered, and the boys went through a short dance before them. During this dance the guardians withdrew, and a great smoke† was made by burning green bushes at the entrance to the yard. At the conclusion of the dance the catechumens plunged through the dense smoke, and proceeded with their guardians to a separate camp which had been provided for them in a sandalwood scrub about one hundred and fifty yards southerly from the new camp. They were not allowed to look back at the enclosure which they had just left; and as soon as they were out of sight, the women and children who had been lying down were allowed to rise and join the other women, after which they all returned to the main camp from which they had

* The use of a flag is probably copied from the whitefellows.

† *Anthr. Jour.*, VII., p. 252; *Ib.*, XIII., p. 455.

come. The neophytes and their guardians remained in their own quarters until the tribes finally dispersed, and during this time the former were not allowed to speak to the women or children. This seclusion was enforced lest the young men, while the excitement of the Bora was fresh upon them, might divulge any of the mysteries in which they had been instructed.

This concluded the whole of the rites in connection with this Bora, and the tribes shortly afterwards dispersed and returned to their own districts. According to what could be gathered from the blacks, these novices will be under the surveillance of their guardians for about a couple of months longer before they will be allowed to associate with the women of the tribe.

The rites conducted on the Bora ground itself commenced about the 12th of February and continued till about the 10th of March. But from the time of the arrival of the first mob of blacks at the general encampment till the commencement of the ceremonies upwards of two months elapsed, owing to the non-arrival of some of the tribes who had long distances to travel.

The number of youths who had never been to a Bora before and attended this one for the purpose of initiation, was about twenty, three of whom were half-castes. They were not permitted to see any of the symbolical figures described in previous pages, or to have their significance explained to them. In order to obtain this knowledge they must attend another Bora, when they will be shown all that may be on or around the Bora ground where they may assemble. Until then, also, they are forbidden to eat certain of the choicest kinds of food; amongst the animals which they are forbidden to eat may be enumerated the cod fish, the porcupine, the yellow iguana, the black iguana, &c.* The ages of these twenty recruits ran from about twelve to twenty years, but three or four of them, whom circumstances had prevented from attending previous Boras, were between twenty-five and thirty years of age. Besides these, there were about twenty-three young men who had

* These animals are probably *totems.*

been at one Bora previously, and attended this one to be further instructed or admitted as full men of the tribe. As stated before, these young men were allowed to see everything upon the Bora ground, and had all the devices explained to them. Five or six of these were half-castes. It will therefore be seen that in all about forty-three young men attended the Bora I have been describing.

Many of the blacks who attended this Bora could speak fairly good English, and were able to understand the purport of questions and give suitable replies. Some of them were very intelligent men who could give a clear and progressive account of all that took place. This was a very great advantage to me in collecting my information, because most previous writers have either found that they could not fully understand the blacks, or that the latter could not properly understand them. Henderson, in his able work before quoted, complains of this disadvantage.

Other Bora Grounds.—In conclusion I wish to refer to the form and position of Bora grounds generally, and the direction of one circle from another, because this part of the subject has received little or no attention from previous writers, and what little has been said is of a misleading character, owing to conclusions having been formed without sufficient investigation.

In the Boras described by Collins and Ridley respectively, referred to in this paper, they mention only one circle, and their descriptions of the grounds are likewise too meagre and indefinite to be of much value in that respect.

In the plan given by Henderson (*Plate* 4, fig. 2) which I have accurately copied from his work previously quoted in this paper, he does not state the direction of the pathway, but he shows that it was not straight. His plan does not appear to be drawn to scale, but it gives a good general representation of the Bora ground described by him.

Dr. Fraser, in a pamphlet published by him in 1892, gives a plan of a Bora ground showing a straight pathway running east from the first circle to the sacred one, the latter being represented as the larger of the two; although at p. 16 he speaks of the "smaller or sacred circle,"—this being the description which his plan, facing that page, is supposed to illustrate.

Last Christmas time I visited a Bora ground near Wilpinjong Creek, in the Parish of Wilpinjong, County of Phillip, and took accurate measurements and bearings. In that instance the direction from the larger circle to the small one on some rising ground is S. 35° W., and the distance between them is seventeen chains. The track is not straight, and winds about as shown on *Plate* 4, fig. 4, following along the top of a spur which runs in the direction mentioned. The larger circle which was on sandy soil was almost obliterated, but I gathered that its diameter was about fifty feet. The small circle which is on a gravelly, well wooded ridge, is fairly well preserved. What appears to have been intended for the representation of a human figure on a very large scale is formed on the ground by means of raised earth, and is in the attitude assumed by blackfellows when dancing the corroboree.* The body is fifteen feet long, ten feet wide, and two feet six inches high now, but was probably higher at the time it was used by the blacks. The arms are about twenty-four feet long; and the legs which would be twenty-six feet long if straight, are bent in such a manner as to enclose an oval space twenty-six feet by twenty-two feet, the heels approaching to within about four feet of each other. The space thus enclosed by the legs was used as the smaller or sacred circle of the Bora ground, and the track leading to the large circle emerged from between the heels. There are a few marked trees still standing around this figure and along the track, and the devices upon them are of the ordinary kind appearing at these places. Mr. Wm. Carr, who was with me, and who has resided

* As stated at p. 101 of this paper, Henderson mentions a "gigantic human figure" as being moulded in the soil at one end of the Bora ground visited by him, which was perhaps such a figure as I am now describing. On one of the Bora grounds described by Ridley, quoted by me at p. 104, there was a rude figure of a man, twenty-two feet long, formed of sticks covered with earth.—*Anthr. Journ.*, VII., p. 255.

in the district since he was a boy, told me there were formerly numerous trees marked, but most of them have been burnt down by bush fires. He says he has known this Bora ground for more than thirty years, and that several Boras have been held there.

Mr. J. A. Glass told me that after the Bora which was held on the Eurie Eurie run, referred to at p. 103 of this paper, he frequently saw the Bora ground and took a good deal of notice of it. In answer to my enquiries he told me there were two circles cleared of timber, and enclosed by a narrow wall of loose earth about nine inches or a foot high. The larger circle was situated in some moderately open country about half a mile from the Barwon River; and in a belar scrub about a quarter of a mile south-westerly from this was a smaller circle, where the secret ceremonies were performed, with a track connecting them. This track was not straight, but was bent something in the way shown in *Plate* 4, fig. 3, following some high ground between the river and a watercourse. About half-way along this track, on each side of it there were delineated on the ground a few figures of men, iguanas, dogs, &c., and also some markings on trees. About three hundred yards southerly from the small circle, there was a gigantic figure of an iguana, about twenty feet long, composed of pieces of bark covered with earth, its head pointing towards the smaller circle.

I would also like to draw attention to the statements of some writers, which would lead us to suppose that Bora grounds were always formed on the tops of hills or mountains, Sadleir, at p. 12 of his *Australian Aborigines*, speaks of having seen such places on the "tops of hills"; and Dr. Fraser in his pamphlet before quoted speaks of having seen one on a "mountain spur"; and he says, "*as usual* the path from the lower to the sacred circle leads up hill."

The Bora referred to by Collins took place where the Botanical Gardens are now situated. Henderson says, the Bora ground he visited was in "a valley," and the sacred circle in which the tooth was knocked out, was at the lower end of it. Ridley describes a Bora ground which was situated in a "pleasant glen."

The one I have described in the parish of Wilpinjong, was on undulating country, surrounded by high hills, within less than a mile distant, which could have been selected if the natives had had any particular fancy for such a site. The Bora ground described by Glass was on level country, and the track from the larger to the sacred circle led about a quarter of a mile *down the creek.*

From the facts stated in the last few paragraphs it appears to me that the direction of one circle from the other is entirely dependent on the conformation of the country within which the ceremony is being held, and its fitness as regards a well-timbered and isolated spot for the location of the sacred circle with reference to the position of the main encampment. If the district is everywhere hilly, the Bora ground must be selected somewhere within it, but if the country consists partly of hills and partly of level country, the natives select a site easy of access and fit for camping purposes. It would seem that it is immaterial which circle is the higher of the two ; and the track connecting them is likewise subject to the suitableness of the ground ; if the space between the two circles is all of the same character, the track runs straight, but if a better path can be obtained by going along some high ground, or for any other reason, the track is flexuous accordingly.

The circle at which the initiatory ceremonies commence, and at which the women and children are permitted to be present, is the larger of the two in all Bora grounds which have been brought under my notice, and has throughout my descriptions been taken as the starting point from which the direction of the other circle is given. But in order to prevent any possible ambiguity, it would perhaps be desirable to call the ring at which the women are allowed to appear, the "First," or "Public" circle, and the other one the "Second," or "Sacred" circle.

Earth is generally used in forming the boundaries of the circles, but one of those described by Mr. Ridley was bounded by "bushes laid as a fence," and I have heard of circles which were defined by logs and bushes, and others by logs and earth. Wyndham mentions circles marked by stones, and others by sheaves of grass, &c., laid around.* If the ground were easily worked, using the earth scraped from the surface in levelling it would be the best way of forming a boundary; but if the ground were hard and compact, as it generally is in dry seasons, enclosing the circle by boughs or small logs would be the easiest way of doing it. If stones were plentiful, laying them round the margin of the ring would be a convenient way of defining it. In any of these cases an enclosure is made, which is all that is required.

There must be a number of gentlemen living in the interior of the country where the natives are still numerous, who could furnish us with valuable information in regard to Bora ceremonies. If any of these gentlemen would take the trouble to collect all the information within their reach on this subject, and send it to me, their efforts will be suitably acknowledged.

OBSERVATIONS AND ORBIT-ELEMENTS OF COMET GALE, 1894.

By JOHN TEBBUTT, F.R.A.S.

[*Read before the Royal Society of N. S. Wales, July 4, 1894.*]

THE object of this paper is to furnish the Society with a statement of the Windsor observations of the comet recently visible here, and of the orbit-elements derived from them. Seeing that the comet itself was discovered in New South Wales and by a member of our Society, I thought it would be well that a record concerning it should appear in our Proceedings. On the evening of April the 1st, Mr. Walter F. Gale of Paddington, F.R.A.S., while scanning the heavens about the constellation *Horologium*, picked

* ***Journ. Roy. Soc., N.S. Wales,*** **XXIII., p. 38.**

up a nebulous object which he could not identify with any in the catalogues. In the forenoon of April 3rd, civil time, Mr. Gale communicated his discovery to me by telegraph, and in the evening of the same day I succeeded in finding the object, but not without having to wait for upwards of an hour for a large bank of cloud to disappear from the south-west horizon. As some alterations were at the time in progress for enlarging the room which accommodates the eight inch equatorial, I had recourse to the four and a-half inch instrument.

Seven measures with a square bar-micrometer showed that the object was moving due east, and must therefore be a comet. As soon as the comparisons were reduced on the following day, I dispatched a telegram to the Melbourne Observatory. The following is an exact copy of it from the impression in my Observatory letter-book :—" Comet discovered by Gale of Sydney on first instant. Three days eight hours forty-three minutes Windsor M.T. R.A. two hours thirty minutes forty-eight seconds. Declination south fifty-five degrees thirty-five minutes. Motion easterly. Round with bright condensation." At Melbourne the Windsor mean time was reduced to Greenwich mean time, and the telegram was then converted into cypher and cabled to Kiel, but unfortunately the date of discovery was omitted. For some weeks therefore there was a misapprehension in Europe as to this date. It was commonly assumed that Mr. Gale had discovered the comet on April 3rd, and it was not till about May 16th that my report by mail reached Kiel, and the misapprehension was removed.

On the evening of April 4th measures of the comet were repeated by me with the four and a-half inch equatorial, but after that date all my observations were made with the same micrometer on the eight-inch instrument. On the whole the weather was remarkably favourable for observation, and I succeeded in securing positions on twenty-seven evenings. These comprise two hundred and ninety-nine comparisons and forty-eight comparison stars. Observations were discontinued after May 11th, as the comet could then be easily observed on the meridian in the northern hemisphere, and is doubtless still under observation there. The first published elements of the comet's orbit are by Mr. R. T. A. Innes of Sydney, F.R.A.S. They are based on the Windsor positions for April 4th, 8th, and 12th. Although the position for the 8th rested on a single comparison, and I could not therefore recommend its adoption as a fundamental one, Mr. Innes' elements were a good approximation. Elements were subsequently computed by Mr. P. Baracchi of the Melbourne Observatory from the Windsor position for April 3rd and Melbourne positions for April 7th and 11th, and by the Rev. Dr. Roseby of Marrickville, from the Windsor places for April 3rd, 6th, and 12th.

Considering the short heliocentric arc over which these data extend, the three sets of elements agree remarkably well. Lastly a set of elements, uncorrected for aberration or parallax, was computed by me from the Windsor observations of April 3rd, 12th and 21st, the heliocentric arc in this case being twenty-five degrees or about twice as long as that embraced by the other determinations. As it will be interesting to compare the four sets of elements, I reproduce them in the following table :

Computer.	Innes.	Baracchi	Roseby.	Tebbutt.
Greenwich M. T. of perihelion passage 1894, April ...	d. 13·42	d. 13·7489	d. 13·757	d. 13·53267
Distance of perihelion from ascending node	° ′ 324 14·5	° ′ ″ 324 19 15	° ′ ″ 324 18 7·8	° ′ ″ 324 16 19
Longitude of ascending node from M. Equinox 1894·0...	206 22·9	206 14 59	206 14 23·8	206 19 24
Inclination of orbit	87 0·7	87 15 13	87 16 15·3	87 6 36
Perihelion distance	0·98308	0·98492	0·98512	0·98362
Heliocentric motion	Direct	Direct	Direct	Direct

As soon as I could spare the time from the ordinary reductions of the observations I proceeded to a second approximation founded on my extreme observations for April 3rd and May 11th and the early position for the evening of April 22nd. The selected apparent places with the parallax corrections derived from my first approximate orbit are as follow :

Windsor mean time.				α				δ			
d.	h.	m.	s.	h.	m.	s.	s.	°	′	″	″
April 3	8	43	3	2	30	46·11	+0·97	—55	34	52·1	—5·0
„ 22	7	2	25	5	39	6·82	+1·28	—45	50	5·5	—0·2
May 11	6	48	25	9	26	2·33	+0·19	+16	59	21·5	—15·1

Reducing the times to the meridian of Greenwich, correcting them for aberration and adopting the ecliptic as the fundamental plane, these places referred to the mean equinox of 1894·0 are

Greenwich mean time.	λ			β		
d.	°	′	″	°	′	″
April 2·93926	358	33	0·1	—63	25	27·3
„ 21·87188	79	45	59·6	—69	6	18·7
May 10·86205	138	29	41·3	+1	46	48·5

In the determination of my first approximate orbit I adopted the ratio of the time intervals between the first and second and the second and third observations in obtaining the ratio M of the curtate distances for the first and third observations, and since these two intervals were nearly equal the resulting value of M proved to be very satisfactory. In computing my second orbit, however, I employed the complete expression (33) given by Professor Watson in his *Theoretical Astronomy*, Ed. 1869, p. 178, the radii vectores and anomalies of the comet for the three fundamental positions being derived from the first approximate orbit. The value of M came out as 1·15808 and this with the curtate distance 0·386468 for April 2 was found to satisfy Euler and Lambert's well known equation, and gave the following system of parabolic elements :—

Perihelion passage, 1894, April 13·51310 d., Greenwich mean time.

	°	′	″
Distance of perihelion from ascending node	324	17	8·6
Longitude of ascending node from M. Equinox 1894·0	206	20	56·5
Inclination of orbit	87	4	6·2
Perihelion distance	0·983392		
Heliocentric motion	Direct		

It will be seen from a comparison of these elements with my first determination from an arc only half as long that the latter was a pretty good one. The three fundamental places are thus represented in the sense of *observation minus calculation* :—

Date.	$\Delta\lambda \cos\beta$	$\Delta\beta$
	$''$	$''$
April 2	+0·2	—0·5
„ 21	+13·2	—16·1
May 10	—0·4	—0·1

By redetermining the values of the comet's radii vectores and anomalies from these elements and substituting them in Watson's expression for M before referred to, this value becomes 1·15804 instead of 1·15808 as previously obtained. The improvement by this substitution is really so small that it becomes hardly necessary to redetermine the elements ; the residuals for the middle place would not, I think, be materially reduced. It is quite possible that the magnitude of these residuals is due partly to errors of observation and partly to a small departure of the real orbit from the assumed parabolic form. It will be vain to attempt the determination of elliptic elements till the northern observations are completed and published. In order further to test the elements thus derived, I have compared the theoretical places for April 12th and May 2nd W.M.T. with the observed places for those dates duly corrected for aberration and parallax with the following as he residuals in the same sense as before :

Date.	$\Delta\lambda \cos\beta$	$\Delta\beta$
	$''$	$''$
April 12	+9·8	—19·8
May 2	+21·6	—9·3

I believe Messrs. Innes and Merfield and the Rev. Dr. Roseby are at present engaged in a redetermination of the orbit from the Windsor positions for April 3rd and 21st and the Melbourne meridian observation on May 17th. The method adopted is that known as the varying of the geocentric distance, and I hardly need say I shall await the result with interest. I shall also look out with equal interest for the determinations we shall receive from Europe in the course of two or three weeks.

It will now be interesting to note a few particulars based on the orbit which I have computed. Previous to June 1st, 1891, Sydney time, the comet was approaching the plane of the terrestrial orbit from the northern region of space. On that date it crossed the plane at a distance of 966 millions of miles from the sun, and thereafter its course lay south of the ecliptic. On April 1st last, the comet was detected by Mr. Gale just before it attained its extreme limit of south declination. On the evening of April 3rd when my first observations were made, the earth and comet were almost exactly equidistant from the sun, namely 92,400,000 miles. The comet's distance from the earth, however, was eighty millions. It will be seen by a glance at the table of observed places appended to this paper that the comet reached its greatest south declination on April 5th and thereafter proceeded northward with daily increasing rapidity. It arrived in perihelion at twenty-two minutes past ten o'clock a.m., Sydney mean time, on April 14th, at a distance of ninety-one millions of miles from the sun. It then receded slowly from the sun, but at the same time rapidly approached the earth, arriving at its closest approximation to our planet, about thirty-one millions of miles, in the beginning of May. On May 11th at forty-two minutes past three o'clock a.m., the comet, in accordance with prediction, again crossed the plane of the earth's orbit, but this time northward and at a point only seven and a-half millions of miles outside of the earth's path. The earth, however, had passed the place of near approach of the two orbits on April 16th, so that at the time of the comet's nodal passage, the earth was really twenty-four days in advance in her annual path, and consequently about forty millions of miles distant from the comet. If the comet had arrived in perihelion about March 21st instead of April 14th, it would have been close to the earth and thus have presented a more imposing appearance. At the time of my last observation, May 11th, the comet had attained to a distance of one hundred and one millions of miles from the sun and forty-one millions from the earth, and at the present time while I am reading this paper these distances have increased to one hundred and fifty-four and one hundred and sixty-three millions respectively. Its light has diminished in apparent intensity to one-tenth of that for April 3rd last, and a telescope of considerable power is therefore now required to observe it.

Appended to this paper will be found the complete results of my observations. The reductions have been troublesome in consequence of the rapid motion of the comet, both in right ascension and in declination. Having no means for observing with a fila. micrometer in a dark field I was obliged to employ a square bar-micrometer. I do not, however, complain of the additional reductions for proper motion seeing that the work done with the same micrometer has turned out remarkably well in various European investigations of cometary orbits. The arrangement of the table will not require any explanation beyond the circumstance that I have substituted the logarithmic parallax factors $\frac{p}{P}$, $\frac{q}{P}$ for the usual parallax logarithms $p\ \Delta$, for the reduction of the observed positions to the earth's centre. As the calculation of the factors referred to does not involve any assumed parallax of the sun, the computer can choose any value he pleases for this element. P represents the equatorial horizontal parallax of the comet in seconds of arc, and p and q the reductions in seconds of time and arc respectively. In those cases where the comparison stars are found in Stone's Cape Catalogue and the Glasgow Catalogues the precessions and secular variations of those catalogues have been employed in the reduction of the mean places to 1894·0. In all other cases the precessions for the middle epoch between the year of the catalogue and the current year have been calculated from Peters' elements. The first comparison star is a wide double whose components are both to be found in the Cordoba Zones and Stone's Cape Catalogue, but in the latter authority the north polar distances are transposed.

OBSERVATIONS OF COMET GALE 1894.

Date.	Windsor Mean Time.	Comet—Star. Δα	Comet—Star. Δδ	Comparisons.	Comet's Apparent. α	Comet's Apparent. δ	Parallax Factors. Log. $\frac{p}{P}$	Parallax Factors. Log. $\frac{q}{P}$	Star Reductions. α	Star Reductions. δ	Comp. Star.
1894.	h. m. s.	m. s.	′ ″		h. m. s.	° ′ ″	+	—	s.	″	
April 3	8 43 3	—4 52·09	—17 14·0	7	2 30 46·11	—55 34 52·1	8·9780	9·6876	—0·96	—1·9	1
„ 4	7 11 18	+0 29·93	—18 26·1	10	2 36 8·12	—55 36 3·9	8·9880	9·3204	—0·97	—1·6	1
„ 5	7 36 29	—4 28·58	—1 59·5	7	2 42 17·32	—55 36 20·0	8·9924	9·4434	—1·00	—1·8	2
„ 5	7 36 29	—5 55·86	—5 38·4	7	2 42 17·06	—55 36 20·5	8·9924	9·4434	—0·99	—1·8	3
„ 6	7 27 32	+1 53·93	—1 0·6	10	2 48 39·82	—55 35 20·8	8·9906	9·3868	—1·01	—1·5	2
„ 6	7 27 32	+0 26·61	—4 39·3	10	2 48 39·51	—55 35 21·1	8·9906	9·3868	—1·01	—1·5	3
„ 8	7 7 50	+8 3·64	—2 28·9	1	3 2 34·80	—55 28 51·5	8·9819	9·2261	—1·04	—1·2	4
„ 12	7 41 36	+4 34·81	—6 12·3	7	3 36 29·35	—54 46 49·7	8·9796	9·3446	—1·07	—1·8	5
„ 12	7 41 36	—5 21·26	—10 19·6	7	3 36 29·36	—54 46 51·0	8·9796	9·3446	—1·06	—2·3	6
„ 12	7 45 48	—3 50·91	+1 40·6	6	...	...	8·9806	9·3680	—1·07	—2·2	7
„ 14	7 12 15	—3 8·87	—9 10·3	10	...	...	8·9532	9·0356	—1·05	—2·6	8
„ 16	7 10 39	+3 11·64	+11 42·3	10	4 18 48·94	—52 58 2·3	8·9306	8·8869	—1·05	—2·9	9
„ 16	7 10 39	+2 47·21	+9 6·2	10	4 18 49·12	—52 58 3·2	8·9306	8·8869	—1·04	—2·9	10
„ 16	8 3 16	+3 12·97	+10 41·4	10	4 19 14·88	—52 56 28·0	8·9588	9·3476	—1·04	—2·9	10
„ 17	7 37 26	+8 26·11	—2 23·5	9	4 31 9·68	—52 12 58·7	8·9360	9·1268	—1·02	—3·0	11
„ 20	7 37 55	+4 25·60	+6 26·9	5	5 10 50·42	—49 0 23·0	8·8861	8·9877	—0·88	—4·6	12
„ 20	7 37 55	+1 33·95	+10 55·3	5	5 10 50·57	—49 0 21·8	8·8861	8·9877	—0·88	—4·8	13
„ 20	8 27 56	+4 53·78	+9 23·2	10	5 11 18·60	—48 57 26·7	8·9174	9·3563	—0·88	—4·6	12
„ 21	7 37 54	—4 28·47	+1 50·5	8	5 24 59·00	—47 31 20·5	8·8640	8·9504	—0·79	—5·6	14
„ 21	7 37 54	—8 10·11	—8 31·0	8	5 24 59·20	—47 31 19·5	8·8640	8·9504	—0·77	—5·7	15
„ 22	7 2 25	—1 33·04	+2 57·4	8	5 39 6·89	—45 50 4·7	8·7938	8·0401	—0·72	—5·8	16
„ 22	7 2 25	—4 48·60	—8 38·6	8	5 39 6·75	—45 50 6·3	8·7938	8·0401	—0·70	—6·0	17
„ 22	7 50 54	—1 3·45	+6 41·1	10	5 39 36·48	—45 46 21·0	8·8522	9·0600	—0·72	—5·8	16
„ 23	7 31 19	—3 46·65	+7 5·0	10	5 54 8·51	—43 47 20·2	8·8034	8·8596	—0·62	—6·4	18
„ 24	7 13 1	+4 47·45	+2 3·5	7	6 8 49·79	—41 31 7·9	8·7446	8·6729	—0·56	—6·3	19
„ 24	7 13 1	—2 2·05	+6 44·2	7	6 8 49·74	—41 31 9·9	8·7446	8·6729	—0·54	—6·7	20
„ 24	7 54 51	—1 36·63	+11 2·9	5	6 9 15·16	—41 26 51·2	8·8023	9·1039	—0·54	—6·7	20
„ 24	8 32 3	+5 35·77	+10 14·7	5	6 9 38·11	—41 22 56·7	8·8370	9·3159	—0·56	—6·3	19
„ 25	7 25 30	+1 32·60	—0 35·8	9	...	...	8·7301	8·9188	—0·44	—6·8	21
„ 26	7 33 6	+6 32·49	+3 27·3	7	6 38 42·93	—35 56 33·0	8·7075	9·0696	—0·36	—6·7	22
„ 26	7 33 6	+4 36·43	+4 45·0	7	...	...	8·7075	9 0696	—0·35	—6·8	23
„ 27	7 42 41	+2 38·84	—1 23·6	8	...	...	8·6887	9·2057	—0·23	—6·9	24
„ 27	7 42 41	—1 38·18	—6 8·8	8	6 53 24·33	—32 40 52·7	8 6887	9·2057	—0·21	—7·1	25
„ 27	8 26 19	—1 12·06	+0 5·5	10	6 53 50·45	—32 34 38·4	8·7501	9·3606	—0·21	—7·1	25
May 1	6 49 9	+0 2·32	+2 30·8	6	7 47 27·82	—17 28 10·6	8·3862	9·4740	+0·22	—5·7	26
„ 2	7 39 39	—0 19·68	+5 21·4	10	8 0 15·82	—13 10 55·7	8·5165	9·5803	+0·33	—5·0	27
„ 2	8 4 39	—0 7·14	+9 22·7	3	8 0 28·36	—13 6 54·4	8·5764	9·5956	+0·33	—5·0	27
„ 2	8 4 39	—2 36·78	+5 11·8	3	8 0 28·58	—13 6 52·6	8·5764	9·5956	+0·34	—5·1	28
„ 2	8 31 35	—2 23·55	+10 4·0	4	8 0 41·81	—13 2 0·4	8·6277	9·6132	+0·34	—5·1	28
„ 3	8 50 21	+1 0·29	—8 29·5	7	8 12 37·33	—8 52 11·7	8·6391	9·6651	+0·43	—4·0	29
„ 3	8 50 21	+0 18·98	—5 50·7	7	8 12 36·79	—8 52 9·0	8·6391	9·6651	+0·43	—4·1	30
„ 3	9 20 15	+1 9·25	—5 46.1	8	8 12 50·28	—8 46 59·8	8·6794	9·6783	+0·43	—4·0	31
„ 3	9 20 15	+0 32·44	—0 46·7	8	8 12 50·25	—8 47 5·0	8·6794	9·6783	+0·43	—4·1	30
„ 4	6 58 25	+3 58·38	+10 9·1	5	...	...	8·3030	9·6796	+0·49	—3·2	32
„ 4	6 58 25	+2 33·98	—1 48·9	5	...	...	8·3030	9·6796	+0·50	—3·2	33
„ 4	8 12 40	+1 8·44	—10 0·6	4	...	...	8·5508	9·6927	+0·52	—3·2	34
„ 4	8 12 40	—4 25·82	—6 10·9	4	8 23 29·74	—4 57 53·0	8·5508	9·6927	+0·55	—3·4	35
„ 4	8 12 40	—4 32·69	+0 7·7	4	8 23 28·70	—4 57 49·3	8·5508	9·6927	+0·55	—3·5	36
„ 5	7 53 38	+5 15·31	+2 19·6	10	8 33 57·12	—1 9 50·2	8·4832	9·7292	+0·58	—2·2	37
„ 5	7 53 38	+1 31·93	+4 10·3	10	8 33 57·01	—1 9 49·2	8·4832	9·7292	+0·60	—2·4	38
„ 6	6 58 52	—4 28·08	+2 12·0	5	8 43 37·34	+2 21 5·9	8·2356	9·7653	+0·72	—1·8	39
„ 6	6 58 52	—4 45·83	+7 26·4	5	8 43 37·36	+2 21 3·0	8·2356	9·7653	+0·72	—1·9	40
„ 6	7 43 24	—4 10·22	+8 47·0	9	8 43 55·20	+2 27 40·9	8·4322	9·7643	+0·72	—1·8	39
„ 7	6 53 24	+6 16 03	+1 32·2	5	8 53 5·22	+5 45 49·9	8·1676	9·7983	+0·74	—0·5	41
„ 7	6 53 24	+4 9·26	—6 8·2	5	8 53 5·06	+5 45 52·6	8·1676	9·7983	+0·75	—0·6	42
„ 7	7 36 59	+4 25·97	—0 12·5	7	8 53 21·77	+5 51 48·3	8·3908	9·7953	+0·75	—0·6	42
„ 7	7 36 59	+3 30·96	—6 26·7	7	8 53 21·80	+5 51 44·7	8·3908	9·7953	+0·76	—0·6	43
„ 9	8 40 51	—0 59·69	+7 56·0	9	9 11 7.66	+12 4 39·2	8·5597	9·8278	+0·94	+0·6	44
„ 10	7 42 46	—0 46·98	—0 33·0	10	...	...	8·3714	9·8602	+1·00	+1·3	45
„ 10	7 42 46	—2 21·93	—7 30·3	10	9 18 47·20	+14 38 18·3	8·3714	9·8602	+1·02	+1·3	46
„ 11	6 48 25	—2 52·24	+4 13·5	8	9 26 2·35	+16 59 22·5	7·9916	9·8845	+1·08	+1·7	47
„ 11	6 48 25	—5 10·56	+4 33·1	8	9 26 2·31	+16 59 20·6	7·9916	9·8845	+1·09	+1·6	48

MEAN PLACES OF THE COMPARISON STARS FOR 1894·0.

Star.	α	δ	Authorities.
	h. m. s.	° ′ ″	
1	2 35 39·16	−55 17 36·2	Cordoba Zone 128, 13; Stone 1079.
2	2 46 46·90	−55 34 18·7	Cordoba Zone 128, 27; Stone 1169.
3	2 48 13·91	−55 30 40·3	Cordoba Zone 128, 29; Stone 1177.
4	2 54 32·20	−55 26 21·4	Cordoba Zone 128, 36; Stone 1234.
5	2 31 55·61	−54 40 35·6	Stone 1494.
6	3 41 51·68	−54 36 29·1	Cape Cat. 1850, 564; Stone 1586.
7	3 40 23	−54 48	Equatorial, Star =8¼ mag.
8	3 59 33	−53 54	Equatorial, Star =8½ mag.
9	4 15 38·35	−53 9 41·7	Stone 1836.
10	4 16 2·95	−53 7 6·5	Cape Cat. 1850, 640; Stone 1842.
11	4 22 44·59	−52 10 32·2	Stone 1896.
12	5 6 25·70	−49 6 45·3	Stone 2266.
13	5 9 17·50	−49 11 12·3	Stone 2294.
14	5 29 28·26	−47 33 5·4	Stone 2482.
15	5 33 10·08	−47 22 42·8	Cape Cat. 1850, 859; Stone 2518.
16	5 40 40·65	−45 52 56·3	Cape Cat. 1850, 878; Stone 2587.
17	5 43 56·05	−45 41 21·7	Stone 2617.
18	5 57 55·78	−43 54 18·8	Stone 2753.
19	6 4 2·90	−41 33 5·1	Cordoba Zone 100, 49; Stone 2816.
20	6 10 52·33	−41 37 47·4	Stone 2875.
21	6 22 18	−38 52	Equatorial, Star =7½ mag.
22	6 32 10·80	−35 59 53·6	Stone 3098.
23	6 34 7	−36 1	Equatorial, Star =8½ mag.
24	6 50 46	−32 39	Equatorial, Star =8 mag.
25	6 55 2·72	−32 34 36·8	Stone 3338.
26	7 47 25 28	−17 30 35·7	Lalande 15391-2.
27	8 0 35·17	−13 16 12·1	Lalande 15855-6.
28	8 3 5·02	−13 11 59·3	Stone 4126.
29	8 11 36·61	−8 43 38·2	Lalande 16228.
30	8 12 17·38	−8 46 14·2	Lalande 16260.
31	8 11 40·60	−8 41 9·7	Lalande 16234.
32	8 18 59	−5 20	Equatorial, Star =8 mag.
33	8 20 23	−5 8	Equatorial, Star =9 mag.
34	8 22 21	−4 48	Equatorial, Star =7½ mag.
35	8 27 55·01	−4 51 38·7	Lalande 16816.
36	8 28 0·84	−4 57 53·5	Lalande 16820.
37	8 28 41·23	−1 12 7·6	Lamont 2002; Glasgow₁ 2174.
38	8 32 24·48	−1 13 57·1	Lamont 2041; Göttingen 2229.
39	8 48 4·70	+2 18 55·7	Lalande 17543.
40	8 48 22·47	+2 13 38·5	Lalande 17560; Göttingen 2341; Glasgow₁ 2278.
41	8 46 48·45	+5 44 18·2	Quetelet 3750; Glasgow₁ 2273; Armagh₂ 1036.
42	8 48 55·05	+5 52 1·4	Lalande 17572; Göttingen 2346; Armagh₂ 1040. Armagh (α) rejected.
43	8 49 50·08	+5 58 12·0	Lalande 17601; Glasgow₁ 2286.
44	9 12 6·41	+11 56 42·6	Lalande 18319; Quetelet 3920; Glasgow₂ 797.
45	9 19 33	+14 39	Equatorial, Star =9 mag.
46	9 21 8·11	+14 45 47·3	Lalande 18584; Glasgow₁ 2441; Glasgow₂ 806. Lalande (δ) rejected.
47	9 28 53·51	+16 55 7·3	Lalande 18815.
48	9 31 11·78	+16 54 45·9	Lalande 18877; Glasgow₁ 2492; Greenwich Cat. 1872, 923; Greenwich Cat. 1880, 1583.

AN ESSAY ON SOUTHERLY BURSTERS.

By Henry A. Hunt.

Second Meteorological Assistant, Sydney Observatory.

[With Plates V.–VIII. and Five Diagrams.]

Awarded the Prize of £25 offered by the Hon. Ralph Abercromby, for the best Essay on Southerly Bursters, 2 May, 1894.

ORIGIN OF THE PRIZE.

In December 1892, the Honorable Ralph Abercromby gave to the Royal Society a sum of £100 to promote the study of Australasian Meteorology by offering prizes for essays upon particular phases of weather, and in rewards for special investigations, suggesting that the subject of the first essay should be "The Southerly Burster." The foundation of this Prize Fund was announced at the general meeting of the Royal Society at the December 1892 meeting. Subsequently the Council appointed a Committee consisting of the Hon. R. Abercromby, Professor Liversidge (Chemistry), Professor David (Geology and Physical Geography), and H. C. Russell, Government Astronomer.

The Committee met to determine the conditions for the competition and advertised these freely in Melbourne and Sydney, and by correspondence with various kindred Societies in Europe and America, and a note appeared in *Nature* about it; one of the conditions was that the competition was open to all. It was advertised in March 1893, and the last day for receiving essays was 31st March, 1894.

The contents of this essay may be briefly summarized as follows: It begins with a short note on bursters past and present, and weather indicating their approach. Deals with the burster in other colonies, shows that it is intensified in New South Wales by geographical features. Is sometimes caused by monsoonal depressions. Traces the changes in isobars with various kinds of bursters. Shows that duration and strength of bursters have wide ranges. Gives a sketch of the Pampero. Traces different kinds of bursters, their rate of progress along the sea coast and relation to general weather conditions. Gives detailed description of two bursters with diagrams of weather before and after, and photographs of clouds, also full notes of cloud changes. Gives diagram and short note about the most violent burster ever known on the coast. Gives tabular particulars of all the bursters that have taken place between September 1863 and March 1894. Showing the number in each hour of the day in each month and in each year, and the total number nine hundred and ninety-one which have been recorded, the prevalence in each month in each year with the greatest velocities of wind and the mean velocities, etc., also a diagram showing the relation of the number of bursters in each hour of the day to the temperature curve.

THE PRIZE ESSAY.

In the early days of Australian settlement, when the shores of Port Jackson were occupied by a sparse population and the region beyond was unknown wilderness and desolation, a great part of the Haymarket was occupied by the brickfields from which Brickfield Hill takes its name.

A BRICKFIELDER.

When a "Southerly Burster" struck the infant city its approach was always heralded by a cloud of reddish dust from this locality, and in consequence the phenomenon gained the local name of "brickfielder." The brickfields have long since vanished and with them the name to which they gave rise, but the wind continues to raise clouds of dust as of old under its modern name of "Southerly Burster." A consideration of the earliest reliable records, and a comparison of them with these of later times, appears to prove that the phenomenon itself, as well as its surroundings, has changed.

SIXTY MILES PER HOUR.

Even up to within ten or fifteen years ago the velocity of wind was frequently as high as sixty miles per hour, and occasionally attained the tremendous force of eighty miles—on one memorable occasion it went far beyond this and registered the unprecedented velocity of one hundred and fifty-three miles in the hour in a gust.

ONLY FORTY MILES PER HOUR.

Now the southerly burster seldom exceeds fifty miles, and generally ranges between twenty and forty miles per hour. Whether this result arises from the fact that civilisation has raised much brick and mortar to obstruct the atmospheric disturbance, or whether it is that the absorption or radiation of heat is less from the cultivated soil than from the hard, unbroken surface of the pre-cultivation days, is a matter of conjecture only.

BURSTER ANTECEDENTS.

The climatic conditions preceding a southerly burster are, first, a period of high temperature varying from three hours to three or more days, accompanied in the early part of the summer, or towards its close, by wind from the west or north-west, and in the midsummer months, generally from the north-east. In the early morning on the day of a "burst" the sky is white and hazy of aspect. As the hour of the outbreak approaches there begin to accumulate in the south, ball-shaped cirro-cumulus or pilot clouds, and frequently, if electric disturbances are to accompany the squalls, heavy cumuli thunder-clouds rise gradually in the south-west.

THE CLOUD ROLL.

An hour or so before the squall, a heavy cumulus roll appears low down on the southern horizon—the interval between this apparition and the beginning of the gusts depends entirely on the velocity of the wind. Afar off this cloud roll appears most frequently due south, but sometimes south-south-west, or even south-west; it is sharply defined, dark on the edges with lighter shades towards the centre. The roll is from thirty to sixty miles in length. Sometimes it appears singly; on other occasions there are a multitude of these formations heaped one above the other, with light cirrus below. Generally, if the burst is of the first order, it is followed by an overcast sky composed of nimbus from which patchy rain descends. (See *Plate* 8.)

As the cloud roll approaches it gradually loses its symmetrical aspect, and careful observation reveals a light cirrus fringe rising from underneath it in front, falling over the top, and trailing behind the advancing cloud. Up to this time the wind has been blowing with steadily increasing force from a northerly direction,

INTERVAL OF CALM

but at this stage it drops suddenly and a profound calm prevails, broken only at intervals by a few fitful puffs. This state of things lasts for a varying space ; if the southerly arrives during the heat of the day, it endures but a very short time ; if at night the calm is of longer duration.

THE BURST.

Meantime the cloud roll is seen rapidly approaching, clouds of dust rise in the southern part of the city four miles away, and gather volume as they come, until they almost hide the city as viewed from Observatory Hill, while from immediately under the roll light clouds rush forward with great velocity only to be thrown back over the top of it as they reach the front, the wind vane on the Time Ball tower flies to the south and the wind reaches us on the ground a moment latter, and in a few moments is blowing with the force of a gale.

VERY LITTLE DEW.

It is noteworthy that the night preceding a burster, however clear it may appear, seldom precipitates any measurable quantity of dew. This affect is, no doubt, owing to the excessive dryness of the northerly current which absorbs any moisture obtainable by radiation from the earth, or by condensation from the upper strata.

A BURSTER FOLLOWS A FOGGY MORNING.

But it is a curious circumstance that during a period of hot weather, should a fog exist at daybreak a southerly change is almost certain to follow within twenty-four hours. Such a condition is of rare occurrence and is always preceded by high pressures without energy or grade, and consequently at a time when land and sea breezes prevail.

THUNDER AND RAIN.

A burster rarely brings immediate rain, except when it is accompanied by a thunderstorm. In the event of a three days blow the downpour, if any, seldom takes place until the second day and even then—as is the case with all coastal rains—is heaviest on the promontories, but little falls over the eastern slopes of the mountains and it seldom reaches the highlands. In nearly all cases the coastal region benefits by rain from the southerly half of the following anti-cyclone.

CONDUCIVE TO DRYNESS.

As noted above, the burster is itself conducive to dryness rather than rain, it being caused, apparently, by the hot, dry conditions prevailing on the plains. The rain by which it is accompanied is caused entirely by electrical disturbances.

A GRADUAL VEERING OF WIND TO SOUTH WITHOUT A BURSTER.

This fact may be demonstrated by studying the progress of a southerly change when it is not accompanied by the "burst." As the advance isobars of the approaching anti-cyclone reach Central Australia, the northern part remains stationary while the southern expands eastward with rapidity. The barometers rise rapidly in Tasmania and the region of high pressure, then extends itself northwards east of this coast, and thus in part surrounds a pocket of low pressure. This low pressure area is then forced northwards or towards the equator, but not to the eastward, and this temporary stoppage of the usual easterly motion is the precursor of gales, not only in the burster season but at all times in the year. In the course of the further development of this system the low pressure is ultimately forced to north-east off the coast of New South Wales, and the isobars trend from north-west to south-east about the thirty-second or thirty-third parallels of latitude.

STRAIGHTENING OF ISOBARS AND RAIN.

At the same time the rear isobars of this retreating high pressure are becoming flatter or straighter, and causing a divergence of the south-east trades—which prevail almost constantly north of New South Wales—into a north-east wind. The result of this movement is an inflow of humid air which penetrates into the southern part of the continent as far as the South Australian border, and sometimes still further west.

SOUTHERLY WIND THE PRECIPITATING AGENT.

As the following high pressure approaches, the southerly or surface precipitating current in front of it travels eastward, and meeting this humid atmosphere rain *invariably* falls inland, the most copious downpour being along the western slopes of the mountains. Ultimately this approaching anti-cyclone reaches the eastern sea-board, thereby forcing the low pressure off and up the coast, and by this time the wind which was southerly inland has a tendency to veer to east following the isobars, and developes one of our ordinary forms of easterly weather, which although sometimes dangerous to mariners by reason of its high winds and stormy seas, is by no means so hazardous as the burster. The wind rises gradually, and thus several hours warning is given before the disturbance assumes a serious aspect.

A change of this character rarely makes itself felt beyond the Queensland border. While the fury of the storm is spending itself, the high pressure continues its forward motion south of the storm, the low pressure fills up, and the storm is over.

The weather during the forty-eight hours preceding this change may be, and generally is, locally hot and fine, but the developments in the twenty-four hours immediately antecedent to the outbreak are exceedingly rapid. On the day of such a change the weather reports, even from the inland districts, may tell of fine weather, but by the evening the disturbance is felt in the far west, travelling with great speed towards the highlands, and during the night, or by daybreak, it reaches the coast lands.

LOCAL CONDITIONS.

The weather prevailing locally presents exactly the same features as that which heralds the southerly burster, and unless the observer is furnished with complete data, both from South Australia and Queensland, it is practically impossible to differentiate the conditions.

DIFFICULTY IN FORECASTING.

Given these data however, it is possible to foretell accurately a disturbance of the kind above described. So far back as the date of the very first of the series of daily weather charts upon which this essay is mainly founded, the conditions which I have endeavoured to describe have produced the same results without exception. I have thus traced the changes by which the conditions promising a "burster"—*i.e.* an approaching anti-cyclone with its low pressure ⋀—are modified locally so that we have no southerly burster but in its place a south-east gale. There are other, though less important factors, tending to rob the southerly wind of its velocity.

RAINFALL IN THE WESTERN COLONIES.

The first and most important of these is rainfall, only in this instance the precipitation takes place further to the westward. The anti-cyclone appears on the coast of West Australia accompanied by severe gales and rain, which have, in a great measure, wasted themselves before the disturbance reaches Bass Straits, and on the coast of New South Wales only the last dying breath of the atmospheric upheaval is felt. The barometric evolutions may be related as follows :—In the first place the high pressures both to east and west of the ⋀ depression, are in unseasonable latitudes, the summer tracks lying between 36° and 37° south, and never travelling much below that. At first the adjacent isobars of both high pressures are very full and round ; the col between is narrow, subsequently the conditions become intensified, the isobars straighten, and the ⋀ becomes acute.

EFFECT OF COASTAL FORMATION.

As they advance, the anti-cyclones gradually become separated by a wider space and isobars of the depression open out and become round instead of pointed, grow more obtuse in fact, and were it not for the mountains of the east coast intensifying these conditions the wind should reach us as westerly instead of southerly.

BURSTERS IN SOUTHERN COLONIES.

While the barometric conditions just referred to are travelling over West and South Australia they produce weather somewhat similar to that experienced here under similar conditions, and hence it is said that the burster is felt in South Australia and Victoria as well as on the eastern coast, but although this is true in a sense, the local conditions on the east coast intensify the characteristics of the "burster" to such a degree that it is very unlike the burster of the southern Colonies, and is in fact quite different.

GEOGRAPHICAL CONDITIONS IN SOUTHERN COLONIES.

In South and Western Australia particularly, the atmospheric waves pass over comparatively level country, and the fact that two high pressures are sometimes so close together may be ascribed to accident. But in New South Wales the geographical aspect is widely different. This province is traversed along the east coast by a mountain range, whose pinnacles have a mean altitude of from three to four thousand feet, and this checks the forward motion of the anti-cyclone until the moment of the mass of high pressure carries it over, but while the power to do this is accumulating there is formed in the hollow or vast basin, west of the

BURSTERS INTENSIFIED ON THE PLAINS.

highlands, what may be termed a local depression, the sun heating the plains and causing an up draught from the soil, which makes the Λ assume an intensified character. And it is retained in this situation until the high pressure at its back gathers sufficient force to send it also over the mountains, which it ultimately does suddenly, and the southerly wind relieved of the surface friction of the land comes up over the coastal water with a violent rush or "burst."

DIVERTING THE ANTI-CYCLONES TO SOUTH EAST.

Under the influence of this accumulated motive power which has placed the burster on the coast, the anti-cyclone is occasionally diverted from its easterly course to a south-east direction, and instances are recorded where, so far as it is possible to trace its movements it has disappeared travelling almost due south.

ANOTHER CONDITION MODIFYING BURSTERS.

There is yet another condition, or set of conditions, which not only modifies the southerly burster but retards it to a considerable extent. As a general rule when there is a Λ depression lying with its centre approximately south of Wentworth, it may be confidently anticipated that the southerly will reach the sea-board after a period varying from twelve to eighteen hours.

EFFECT OF ELECTRICAL CONDITIONS.

But should the front of the Λ develope more than the normal electrical activity, it will inevitably be delayed for another day, and in the meantime the barometric conditions advance but slightly. A southerly of this type is almost invariably only one of a series. The local weather features which herald its advent are the same as those which foretell the coming of the ordinary burster, except that the temperature on the day of thunderstorm is higher than that of the day on which the burster reaches us. The isobaric curves accompanying this particular form of disturbance are notably disorganised and irregular to the east of the Λ, while on the high pressure to the west they remain smooth and even.

TYPES OF LOW PRESSURE.

Southerlies have been observed to result from three distinct types of low pressure. The first of these is the familiar Λ depression, resulting in the true southerly burster. This is the one most commonly experienced, and as a rule, the sharper the Λ the more sudden is the change.

THE MONSOONAL DEPRESSION.

The second variety is the tropical depression or tongue which may be looked upon as an inverted Λ, which only occurs during the monsoonal season, and even then only on rare occasions; in fact the tongue has never been observed to exist east of the mountains, though west of the range it has been known to reach to the Victorian border. This peculiar type of disturbance is accompanied by an overcast tropical sky, which almost invariably is found preceding the southerly current.

BURSTERS WITH HIGH TEMPERATURE.

The temperature is very high; thunderstorms are prevalent; and the southerly itself is not, generally speaking, very strong. Still it is, perhaps, more beneficial than the first description of southerly, as it is attended by rain in the northern parts of Australia, and west of the highlands in the northern parts of New South Wales.

TROPICAL DEPRESSIONS.

Should the tropical tongue, when it retreats towards the equator travel east, as occasionally happens, the lower part seems to become detached and forms an active rain cyclone on the south-east coast of Queensland. The floods which took place in that locality early in 1892, as well as those on the northern coast of New South Wales, may be ascribed in part to this cause. This opinion, however, it is necessary to mention, rests upon few data and must be taken subject to correction.

The apparent parting of the tropical tongue to which I have alluded is by no means the invariable, or even the most common form of development. The low pressure always exists in a fluctuating state, north of this continent, the isobars sagging down between the high pressures as they pass along, and drawing up again as the high pressures pass under them. In this way they act upon the low pressure to much the same effect as a succession of ocean waves might do, while passing under a long, pliable, floating body set at right angles to them.

BURSTERS FROM SECONDARIES.

The third and last modification results from a secondary. Of this particular variety very few have been recorded on the weather charts. They develop so suddenly that unless they are actually in a state of evolution at the hour when observations are taken (9 a.m.), the meteorologist has no indication of their proximity. They develop on the south coast of New South Wales through the formation of a "kink" in the outlying isobars of the retreating high pressure. Prior to such a development the barometric conditions are neutral or dormant—in other words, the existing high and low pressures have little grade, and are only relatively high and low. Southerlies caused in this way partake of the well known characteristics of secondaries, wherever they may occur—that is, violent and of small compass, most severe in the extreme south east, and seldom affecting the coastal districts north of Cape St. George. The depression which follows the retreating high pressure brings on the following day, a southerly of the ordinary character, the strength of which is regulated according to the intensification or otherwise which has taken place during the interval in the adjacent high and low pressures.

BURSTERS NOT CONDUCIVE TO RAIN.

The next point to be considered is the relation of bursters to rainfall. The burster, on the whole, must be regarded as unfavourable to rain, for though its advent may benefit the coastal areas to the extent of a few showers it serves as an indication that the country west of the ranges is at least in a temporarily dry condition. A succession of bursters especially denotes a want of rain in the interior. As a proof of this, and also as an evidence of the comparative powerlessness of merely local weather conditions to directly cause, or even to intensify, the burster, it is only necessary to point out its frequent occurrence under circumstances apparently most unfavourable for its development.

ARRIVES WHEN TEMPERATURES ARE LOW.

It often arrives during a period of low temperature at Sydney, and also when rain has actually been falling—on some occasions when it has been falling heavily. This statement is, of course, not intended to imply that the southerly may not be modified by the existence of such conditions upon the immediate scene of its action. Still, despite any modification which may take place, the wind attains a by no means inconsiderable velocity, some storms recording as high a rate as forty miles per hour. Moreover the rain generally ceases and a period of fine weather follows, proving

RAINFALL FROM NORTHERLY WIND

conclusively that, in these particular instances, at all events, the rainfall which takes place on the arrival of the burster is the precipitation from the moist northerly current, and not from the southerly one. Bursters have also been recorded when the local maximum thermometer has registered little over 74° in a midsummer month, and effecting a diurnal range of only four degrees. At such times the temperatures in the interior are always high, especially to the north-west of New South Wales and in south-west Queensland.

BURSTERS DESIRABLE.

Though the individuality of the burster is, in itself, opposed to rainfall, yet the frequent recurrence of this phenomenon is a thing to be desired. Its infrequency denotes a failure of activity in the seasonal cyclonic and anti-cyclonic systems, and also in the cyclones which come from the eastward on to the northern coast; also in the early part of the year it denotes the failure of the monsoonal rains.

DROUGHT COINCIDENT WITH THEIR ABSENCE.

Instances of drought from such causes were especially marked in the summer of 1875-76. In seasons when southerlies are rare the loss of the interval of cool weather adds to the severity of the summer.

MONOTONOUS WEATHER.

During such droughty periods as that just referred to, the barometrical changes over the whole of Australia are very slight. The temperatures, however, are not excessively high, at all events on the coast, neither are the diurnal ranges great. Even locally, and during the mid-summer months, the maximum shade temperature has been known to range only between 80° and 86° for twelve consecutive days, with persistent north-east winds. Experiences of this nature are monotonous for the pastoralist and agriculturalist, and equally so for the meteorologist, presenting as they do, no interesting features for observation, and no change of moment, either in weather or temperature can be anticipated until the barometer shows renewed activity.

CHANGES OF TEMPERATURE.

Generally the greatest diurnal range of the temperature resulting from bursters occurs in October. The mean minimum temperature for this month is 55·1° so that when the maximum reaches from 85° to 90° and a southerly takes place, the temperature in some cases drops as much as 30° to 35° This range is seldom reached in the hotter months, in fact it is only attained when a maximum of about 100° is recorded—an event of very rare occurrence.

A BURSTER OF THE POPULAR TYPE.

An anti-cyclone of good energy, and one from which a popular type of southerly burster lasting three days results, has a latitudinal axis of approximately two thousand four hundred miles and as it travels at the rate of four hundred miles per diem,* it follows that, if a vertical line is drawn in front of it, an observer stationed in this line will record three days of southerly weather in the front half of it and three days of northerly winds in the rear, due to the normal circulation about an anti-cyclone. This is the actual experience: provided no meteorological agencies affect or modify its symmetrically oval form during its passage over the Australian continent, steady breezes throughout its circulating areas are the rule during the six days it occupies in passing over the comparatively low lands of Australia, as it travels from west to east.

ISOBARS FLATTENED BY MOUNTAINS.

But when the anti-cyclone reaches the mountains of New South Wales, the symmetry is disturbed by a flattening of the front isobars against the mountains, which concurrently show a tendency to spread northwards, aided probably, by the inclination of the mountain chain towards the north east.

INTENSIFICATION OF THE LOW PRESSURE BY MOUNTAINS.

While this change is taking place in the high pressure, the isobars of the Λ depression in front of it are undergoing a similar

* "Moving Anticyclones," in Journ. Meteorol. Society, 1892.

process. But as this depression is a much smaller system, the front isobars are being squeezed against the highlands, while those at the rear are also being compressed by the advancing high pressure. The result is an acceleration of force in the northerly and southerly winds which enclose the ∧ depression. When the squeezing process has amassed sufficient energy to overcome the obstruction, the gradients of the high pressure, in their efforts to regain their normal condition, expand with great rapidity on the eastern slopes and send the ∧ depression at a great rate to the south-east. (See page 162.)

For the previous twenty-four hours the northerly currents have been maintained by the ∧ depression, but when once the mountains are passed the anti-cyclone takes up the running of the southerly one. As a proof of this—speaking particularly of the central and northern parts of the coast—the southerlies have nearly always been found to circulate along the line of the seaboard in the anti-cyclonic isobars. After an anti-cyclone of this character has entered by a three days march into Australia, it is very rarely indeed that its progress is checked; but occasionally, as the ∧ depression still travels on, it seems to drag the heel of of the high pressure after it. At the same time, while the body of the high pressure remains over Australia, the one preceding continues on its way towards New Zealand. This results in an attenuated state of atmosphere on the northern coast of New South Wales and on the shores of Southern Queensland.

TROPICAL CYCLONES.

If it so happens that one of the north-east cyclones is on a visit to this region at the same time it is diverted from its customary course—the track of these storms being generally to the eastward of our coast—and avails itself of this partial void. Its irruption, acting with the already existing ∧ depression, seems to result in that peculiar class of storm, of which the Dandenong gale is a notable example.

Considering the intensity of this particular storm a few facts concerning another of a similar character may not be considered out of place. A study of its leading characteristics may, in some future time, assist the meteorologist in recognising the early signs and portents of another such calamity.

A RECENT GALE OF THE DANDENONG TYPE.

The second gale referred to occurred on the 23rd of September, 1892—sixteen years after the famous "Dandenong" storm. On this occasion the wind attained a velocity of one hundred and twenty miles an hour. The series of anti-cyclones in August and those in the early days of September were of considerable energy, and in each case the high pressure to the west, which, from its unusually energetic state, doubtless aggravated the violence of the storm, had completely disappeared on the following days. All that remained were horizontal isobars of a relatively low pressure in the southern ocean. Particulars of the "Dandenong" gale may be found in Mr. Russell's paper on "Storms on the New South Wales Coast," read before the Royal Society of New South Wales on 7th August, 1878. (See following diagram, also page 175.)

BAROMETERS FALL AFTER WIND VEERS TO SOUTH.

These are two noteworthy instances in which the barometers, after a southerly, have been observed to fall instead of rise, with active high pressure in the rear at the commencement of the blow. The gale of 1892 was not a burster, but a gradual change to south which took place some thirty hours previously. In this instance the Λ depression, which seemed to act in concert with the tropical cyclone, appears to have backed from a situation midway between Australia and New Zealand.

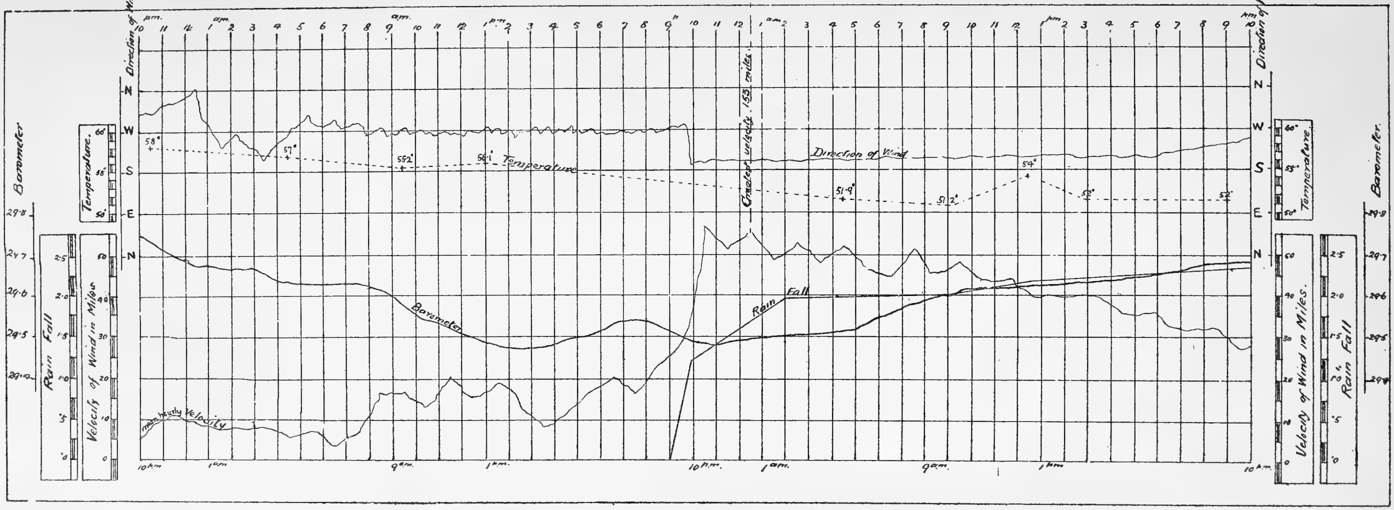
CONDITIONS WHICH REGULATE THE NUMBER OF BURSTERS.

Before proceeding further, it may be advisable to offer a suggestion as to the causes which seem to the writer to justify the two apparently anamalous statements made in an earlier part of this essay; (1) that bursters are less frequent and also less violent than usual, during those seasons when the interior of the country is suffering from drought; and (2) that they are also less frequent

Meteorological Diagram.

from 10 pm on the 9th to 10 pm. on the 11th of September 1876.

During Dandenong Gale.



and of less than their ordinary violence, when the same region is visited by persistent rains with overcast skies. In other words, seasons of drought and desolation and seasons of deluge are both inimical to the existence of bursters.

The following theory is tentatively submitted, to account for the greater prevalence of bursters during what may be called a moderately dry season. This term is used here to indicate, not so much a season in which the rainfall does not exceed the average, as one in which the number of rainy days is a shade below the average. It will be remembered that strong southerlies have been said to result from energetic anti-cyclones; also that energetic anti-cyclones bring with them possibilities of great extremes in our summer temperatures. But since in summer their sphere of action is in high latitudes the weather of the northern parts of Australia is controlled chiefly by tropical depressions, and consequently great heat prevails there as a rule. Now if, after a period of hot weather, rain were suddenly precipitated on this northern area, the consequence would be a great uprush of air with the vapour produced by the rain falling on heated ground, and a consequent inrush of air from southern areas.

RECURRENCE AND DURATION OF BURSTERS.

Bursters are not only uncertain in their duration, but the periods of their recurrence are extremely erratic. Two have been frequently known to take place within twenty-four hours; between two others, an interval of a month has been known to elapse. The shortest one recorded extended over a period of three hours; the longest covered the space of ten days. These figures of course, embrace all the variations of the wind during the continuance of the storm.

SHORT-LIVED BURSTERS.

The short-lived bursters are generally experienced during a seasonal prevalence of north-east winds; those of longer duration are usually met with during a southerly prevalence.

PARTIAL TO COAST OF NEW SOUTH WALES.

Not only during the summer, but in all seasons of the year, the southerly has a remarkable partiality for the sea-board of New South Wales.

OVER-STEP ISOBARS.

So much is this the case in the hot months that the approaching currents from the south have been observed on the coast when the isobars indicated northerly winds.

BLOW CONTRARY TO ISOBARS.

Sometimes, too, for several consecutive days, the wind has blown with appreciable velocity from this quarter when the isobaric lines—from their relation to the centre of the anti-cyclone—should be producing northerly winds. This latter peculiarity is most noticeable in winter months and with necessarily small gradients.

THE AREA OVER WHICH THE BURSTER EXTENDS.

The land area over which the burster exercises its influence may be generally described as including all the country east of the mountains in New South Wales, from the extreme south-east point of the colony to a little above Port Macquarie on the north coast. It occasionally oversteps this northern limit, but when it does so it is usually the result of a cyclonic disturbance on the north coast, such as existed, for example, in the "Dandenong" burster, the effects of which were felt considerably north of Brisbane. The northern boundary of the burster may be defined, as limited by the south-east trade winds, which blow almost incessantly north from about 30° S. latitude. Other areas of actual experiences are given on page 145.

CHANGE OF TEMPERATURE.

Bursters always result in a diurnal drop in temperature, the said drop ranging between 37·5° and 4·2° with an average fall of 18·1°. The greatest diminution of temperature takes place during the first hour, and the fall is most sudden when the burst comes at midday. The steepest drop on record was that registered at 1·50 p.m. on the 30th December, 1891. The maximum then read 97·5°; five minutes after the change to south it read 80·3°, being a difference of 17·2°; two minutes later there was a fall to 79·7° or a further difference of 0·6°. The thermometer remained at this reading until after two o'clock, but at 2·15 it descended to 75°, being a drop of 4·7° more and a total drop of 22·5° in twenty-five minutes. The diurnal range in this instance was 23·8°.

VELOCITY OF WIND IN THE BURSTER.

It occasionally, though rarely, happens that the greatest velocity of a burster is reached at the change or during the first hour thereafter. In most cases, however, the maximum force is attained about twelve hours afterwards. As the majority of bursters occur between the hours of seven and twelve p.m. (see Table I.), it therefore follows that the wind is usually strongest between seven and twelve a.m. on the following day.

UNSEASONABLE WINDS.

In those instances where the greatest velocity was reached immediately on the arrival of the burster, the winds preceding were generally of an unseasonable character—that is to say north-westerly in the summer and north-easterly in the spring and autumn months. Under these circumstances the burster, though strong, was generally of brief duration.

THE PAMPERO.

The opinion has long been held that there is a close analogy between the sutherly burster of Australia and the pampero of South America. The writer therefore sent a detailed description of the burster to a friend formerly resident in Brazil, and requested him to note the points of similarity between it and the pampero. The following is a copy of his reply which is based, as will be seen, partly on personal observation and partly on information gathered by him from sources on which he places reliance:—

"In answer to your letter of 14th of April, I am afraid I can afford you very little information on the subject of the South American pamperos from personal observation. They never reached, on the coast, as far north as Rio de Janeiro which was my usual place of residence, but I twice experienced their violence when on my exploring expedition across Brazil in 1872-3. The first time was in September, 1872, when we were camped on the banks of the Paraguay River as far north as 20° south. On that particular occasion we were awakened in the night by a roaring sound which rapidly drew nearer and burst upon us, overturning tents and everything else that offered much resistance without being stable. My hammock was slung to a branch of a big tree, which was torn off, but did me no damage as I had turned out to save the tents. It had all blown over by the morning. On the second occasion, in October, 1873, I was surveying the Alto Parana River, about 21° south, when my Indians noticed the clouds gathering in south, and made at once for the lee of the islands in their canoes. The river at this part is due north and south for many miles, and from one to four miles wide, and as the wind came from due south it beat up a great sea, the waves being quite three feet from crest to bottom. I sailed up before it, and was able to go up rapids that, on ordinary occasions. could only be negotiated by poling and ropes. It did not last long, and on both these occasions was, I imagine, a more violent effort than usual of a pampero which found its way so far north owing to the immense width and openness of the river Plate Valley, of which river both the Paraguay and Parana are confluents. The pamperos are mostly felt at the mouth of the River Plate, where by their violence they often cause considerable damage to shipping. If they are not recorded further south, it is because there are no ports on the east coast nor inhabitants or towns where their recurrence could be noted.

"In the southern States of Brazil, they are frequently felt, and a friend of mine who has just arrived from Rio Grande du Sul, the most southerly state of Brazil, tells me they occur mostly in the winter months (my friend was asked to verify this statement and his reply will be found further on.—H.A.H.), from April to November. He says they are preceded always by three days rain, which, when over, is immediately followed by the pampero, coming from what he called the south-south-west or nearly due south. They last then for nearly three days and blow with great violence and low temperature. My informant goes on to say, from his own experience, that the pampero does not get so far north on the coast, although, as I have told you, in the interior it does seem to penetrate. There are high ranges of mountains south of Rio de Janeiro which would, I have no doubt, have the effect of breaking up and deflecting any part of the pampero which might get there."

The friend's account is as follows :—" Pamperos proper occur in the winter, say from the end of May till October, and generally last three days. Occasionally in the summer time we have, in Rio Grande, smart breezes from the south-west after rain, but they do not last long, and although they come from the same quarter and cool the atmosphere wonderfully, are not called pamperos. While the pampero is blowing the sky is beautifully clear and cloudless. Occasionally in the summer in Rio Grande when the weather is very sultry, it breaks by a squall suddenly setting up from the west by south-west, and though the sky was clear ten minutes before, you can see the cloud roll forming in the west as the cool breeze advances, and down the rain comes in torrents, and in a few hours all, wind and rain, is over. Thunder may or may not accompany the rain, which almost always precedes (at least in Rio Grande) pamperos. I have seen pamperos as strong after rain, when there was no thunder accompanying, as when there was. Our thunder, too, is generally, in the summer and rarely in winter. I must add that Rio Grande being further north than the Plate, we do not get the pamperos with the full force experienced in the Plate region. With us they are a steady continuous blow for three days, varying little in force till the third day, when they are felt to be gradually declining. They always blow from the same quarter, the south-west, and are cold and dry."

The most interesting fact evidenced in this description of the pampero is that it always follows rain. This would seem to imply that the evaporation arising from the plains is one of the immediate causes of its existence. If this is the case it lends support to the theory, hereinbefore submitted, that the vapour arising after rain from the vast heated areas of the Australian interior is at least one of the agencies from which the burster has its origin. The difference between the two sets of circumstances is that, in South America, the cause and effect act on the same region, and therefore one follows the other with no appreciable interval, while in Australia the seat of the effect is removed by something like one thousand miles from that of the cause, and consequently the connection is more difficult to trace.

Winter northers of Texas are a somewhat similar experience. The following is a short extract :—"The northers prevail from November to March, and commence with thermometer at 80° or 85°. A calm ensues on the coast; black clouds roll up from the north; the wind is heard several minutes before it is felt; the thermometers begin to fall; the cold northers burst upon the people bringing the thermometers down to 28° and sometimes even to 25°, men and cattle being killed from the severe cold. This is the only description I have come across of similar changes in the northern hemisphere.*

SIMILARITY OF WEATHER ON EAST AUSTRALIA AND SOUTH AMERICA.

Before finally leaving the subject of the pampero, I may mention that many old sailing ship captains recognise numerous points of similarity between the southerly bursts upon the east coast of South America and those upon the east coast of Australia, and make the same preparations to meet either case.

ADMIRAL FITZROY AND OTHERS ON THE PAMPERO AND BRICKFIELDER.

Perhaps the earliest reference to the pampero appears in the "Weather Book" of Admiral Fitzroy, pp. 150 and 151. In chapter xxl., he gives thrilling accounts of two occasions when his vessel was struck by it and nearly foundered. The same author, in the same book, speaks of the brickfielder (southerly burster) of New South Wales, page 263. A more exhaustive account of the pampero in its strictly scientific aspect, appears in "Weather," by the Hon. Ralph Abercromby, page 263, and a

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* Physical Geography of the Sea by Maury, pp. 93-94.

description will be found in the Scottish Meteorological Journal, Vol. v., No. lx., p 335.

A DESCRIPTION OF A BURSTER WRITTEN EIGHTEEN YEARS SINCE.

The following description of the southerly burster is taken from "The Climate of New South Wales," by Mr. H. C. Russell, B.A., The passage in question contains the best description of it that I have met with, and it is the more interesting as being one of the first accounts published by any scientific observer of this interesting phenomenon. It is as follows:—"If in fine north-east hot weather the barometer falls fast in the forenoon, a southerly wind (burster) may be expected before night; if the day is very hot the change will come sooner; and if the barometer is falling very fast and clouds be seen in the west, a thunderstorm may be expected in the afternoon. Sometimes the thunderstorm bursts first, and the wind sets in from south afterwards; if only the storm comes it will probably be hot again next day.

"Southerly bursters are generally to be expected from November to the end of February; they are always attended with strong electrical excitement, a stream of sparks being sometimes produced for an hour at the electrometer at the ends of the exploring wire. The approach of the true burster is indicated by a peculiar roll of clouds, which when once seen cannot be mistaken; it is just above the south horizon, and extends on either side of it 15° or 20°, and looks as if a thin sheet of cloud were being rolled up like a scroll by the advancing wind.

Clouds of dust, which penetrate everwhere, announce the arrival of the wind, scud flies by overhead with great rapidity, being sometimes less than two thousand feet high; rain may follow, but if so, thunder and lighting come first. The velocity of wind is, in most cases, greatest within the first two hours, and varies from thirty to seventy miles per hour, but is usually from fifty to sixty and the rate of progress along the coast about forty miles per hour. The change of wind is sometimes very sudden; it may be fresh north-east, and in ten minutes a gale from south, hence vessels not on the lookout are sometimes caught unprepared, and suffer accordingly. When the wind is light these storms are often carried to sea by the general easterly motion of the atmosphere, and may be seen passing by, the peculiar clouds indicating unmistakably their position."

APPARENT DOUBLE BURSTERS.

The following is a detailed account of a double burster, or of two distinct simultaneous bursts on different parts of the coast. It will be convenient to commence with a table, showing the hours at which the burst reached various points on the coast-line, with relative rates of travel from place to place :—

10th October, 1893.

Stations.	Distances.	Hour.	Rate of Travel. Interval. h. m.	Miles.
Eden	—	2 a.m.	—	—
Moruya	79	8·30	6 30	12·2
Jervis Bay... ...	47	10·36	2 6	22·4
Wollongong ...	41	11·45	1 9	32·8
Sydney	41	1 p.m.	1 15	32·8
Newcastle	62	3·40	2 40	23·3
		Mean rate of travel		25·3
Port Macquarie ...	110	2 p.m.	—	—
Clarence	122	5·30	3 30	34·9

Wind velocity at Sydney 35 miles per hour.

From this table it will be seen that the wind changed to south at Eden, the southern point of the coast at 2 a.m., and made its way gradually up the coast, reaching Sydney at 1 p.m. and Newcastle at 3·40 p.m. in the mean time that is at 2 p.m. Port Macquarie, one hundred and ten miles north of Newcastle, reports the change at 2 p.m., or one hour and forty minutes before it got to Newcastle, or to put it another way, when one burster reached a point on the coast twenty miles north of Sydney, another made itself felt at Port Macquarie, one hundred and ten miles farther north, it appears then that there were two bursters separated by one hundred and ninety miles and simultaneously making their way along the coast. It is probable, however, that the southerly burster is a *line storm*, and that the change of wind occurs along a certain isobar, and if this be the true explanation it is entirely in accordance with what has already (page 151) been shown as to the trend of the isobars in certain cases. When the approaching anti-cyclone flattens its isobars against our dividing range, and then taking advantage of the easier western slope in the northern districts, and the lower altitude of the mountains generally, to the west of Port Macquarie, protrudes some of the isobars over the mountains, so that they come to the eastward at that point like a nose or easterly extension of the isobars, while the southern half of the anti-cyclone is retarded. This feature was noticeable upon the occasion in question, and, as is invariably the case under such circumstances, thunderstorms were prevalent. These, I think, may be safely accepted as the causes which gave rise to the phenomenon of two simultaneous, yet entirely independent, bursters.

In speaking of the areas over which the burster exercises its coastal influence, mention has been made of the fact that it is rarely met with north of Port Macquarie. The present case was not, in reality, any exception to the general rule; the burster did not reach Clarence Heads as such, and the change there was simply a veering of the wind from north-east through west to south-east, accompanied by a thunderstorm and hail. The downfall of hail was heavy and some of the stones were very large. This storm lasted on the north coast until 7 p.m., and was also very severe in the northern highlands. It was accompanied by a rainfall of from one to three inches.

DESCRIPTION OF THE DOUBLE BURSTER.

The notes taken of this burster—the second of the season—are as follows:—During the 7th, 8th and 9th October the barometers all over the continent showed little or no grade. The centres of the high pressures were situated, one over the Tasman Sea, and the other off the west coast of West Australia, with a shallow trough of low pressure between. On the 10th the western high pressure had intensified and had made much progress, compressing the low pressure into a sharp Λ, with its axis lying in a north-west and south-east direction, or from Bourke to a little east of Gabo. Strong north to north-west winds were experienced on the western borders of Queensland and in New South Wales north-east, while exceptionally hot weather was reported from the

Queensland inland stations, In Sydney, for three days previous to the arrival of the burster, the sky was hazy and almost tropical in its aspect. The barometer at Sydney fell three-tenths during the twenty-four hours immediately preceding the burst, and rose rather sharply after it had passed, the lowest point making half-an-inch in twenty-four hours. The temperature was moderate immediately before the change, the thermometer stood at 75°, and at 2 p.m., rather less than one hour after, it had fallen to 65°. A roll of cumulus cloud of a rather undefined character was first seen at 12·30 p.m., with a line of ragged cirrus beneath. The latter, as the storm advanced, rose in front of and obscured the cumulus. Five minutes later, cirrus were moving horizontally, vertically, and in every other direction from a point in the cloud lying due south. The change of wind at Sydney came at 1 p.m., and was attended by much dust, and some rain which was entirely owing to electrical influences, it was generally light from the western slopes to the coast.

Passing from this record of the double burster, it is now necessary to consider various facts relating to the time taken by bursters in travelling along the coast.

RATE OF TRANSLATION OF BURSTERS.

From the preceding remarks and the figures quoted in the table page 161, as well as other figures appended to page 164, it will appear that no definite relation can be traced between the rate of translation and velocity of the wind in bursters. As already demonstrated, it is quite possible for two bursts to occur on different parts of the coast at the same time, and it is also possible for a

BURST SIMULTANEOUS OVER A WIDE AREA.

burst to be felt at the same moment over an extensive area. (See table 28th November, page 165. Since there is no visible connection between the velocity of the wind and the ratio of translation of the burst itself, it may throw light on the matter if we look for some explanation of the fact that the southerly change is generally first experienced on the south coast of the Colony.

BURSTERS FELT FIRST SOUTH OF SYDNEY.

The most probable explanation is as follows :—The high pressure following the Λ depression in many cases moves faster over Victoria than it does over this Colony, and thus forces the lower part of the Λ to the east making the axis of it more or less towards south-east and north-west. Were it not for this swinging of the Λ depression, the wind, from its natural inclination to the centre of a low pressure, would be south-west instead of due south.

CONDITIONS GOVERNING THE RATE OF TRANSLATION.

The southerly isobars of the Λ depression usually reach the south coast first, hence it follows that the burster touches the coastal stations in rotation, beginning at the south. The rate at which it travels in its northerly course is decided, first by the inclination of the axis of the Λ to the trend of the coast, and secondly, by the then prevailing rate of the general atmospheric motion to the eastward.

DIFFICULTY IN FORECASTING TIME OF BURSTER'S ARRIVAL.

These few remarks will show how many and how serious are the difficulties to be contended with in predicting the moment at which a burst will arrive at any given point, for up to the present moment it has been found impossible to decide how far the axis of the Λ may deviate from its vertical position before reaching the coast, or whether the rate of atmospheric motion may diminish, maintain or increase.

TABULAR STATEMENT OF THE PROGRESS OF SOUTHERLY BURSTERS UP THE COAST.

13th November, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ⅌ hr. Miles.	
Moruya	4·45 p.m.				Velocity of
Jervis Bay	5·30 p.m.	47	0 45	62·7	wind at Syd-
Wollongong					ney 36 m. in
Sydney	7 p.m.	88	1 30	58·7	short gusts,
Newcastle	11 a.m.	62			42 miles.

16th October, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ⅌ hr. Miles.	
Jervis Bay	2·30 p.m.				Velocity of
Sydney	9·50 p.m.	88	7 20	12	wind at Syd-
Pt. Macquarie (Oct. 17)	8·30 a.m.	172	19 20	9	ney 20 miles.

28th November, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ꝑ hr. Miles.	
Moruya	8·10 a.m.			,,	Velocity of wind at Sydney 48 miles.
Jervis Bay	7·30 p.m.	47		,,	
Wollongong	7 p.m.	41		,,	
Sydney	7 p.m.	41		,,	
Newcastle	10 p.m.	62	3 0	20·7	
Port Macquarie	2 a.m.	110	4 0	23·3	

30th November, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ꝑ hr. Miles.	
Moruya	2·40 p.m.				
Jervis Bay	4·15 p.m.	47	1 35	29·7	Velocity of wind at Sydney 26 miles.
Wollongong	6·15 p.m.	41	2 0	20·5	
Sydney	7·15 p.m.	41	1 0	41·0	
Newcastle	9·30 a.m.	62	2 15	27·5	

6th December, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ꝑ hr. Miles.	
Moruya	1 p.m.				
Jervis Bay	3·30 p.m.	79	2 30	31·6	Velocity of wind at Sydney 40 miles.
Sydney	6 p.m.	82	2 30	32·9	
Newcastle	10 p.m.	62	4 0	15·5	
Port Macquarie	2·30 a.m.	110	4 30	24·4	

12th December, 1893.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ꝑ hr. Miles.	
Jervis Bay	11 p.m.				Velocity of wind at Sydney 25 miles.
Sydney	4·30 a.m.	82	5 30	15	

15th February, 1894.

Stations.	Time.	Distances. Miles.	Interval. h. m.	Translatn. Rate ꝑ hr. Miles.	
Moruya	9 a.m.				Velocity of wind at Sydney 21 miles.
Cape George...	1 p.m.	79	4 0	19·8	
Sydney	5·55 p.m.	82	4 55	16·7	

CHARACTER OF WINDS PRECEDING A BURSTER.

When the wind preceding a burster blows from some point between north-west and west, it is always drier and hotter than when it proceeds from between north-east and east. The latter, however, produces peculiarly uncomfortable and relaxing effects, such as might be experienced by one who went into a steam-bath. The north-westerly wind on the other hand is of a dry and parching character, but apart from its occasionally irritating effect upon the nostrils, and the stinging sensation which it sometimes causes in the eyes, it is endurable, and is enjoyed by many persons and much preferable to the sweltering north-easter.

As would naturally be imagined, when the northerly wind is strong the southerly by which it is succeeded is strong likewise, being effects arising from the same cause. This intimate relation between the force of the two currents is especially noticeable should the burst occur while the northerly wind is in full force—in other words, should it occur in the daytime, for northerly winds, and particularly those from the north-east, moderate considerably by sunset.

RELATION OF VELOCITY OF NORTH AND SOUTH WINDS.

But while it may be said that, as an almost invariable rule, strong southerlies follow strong northerlies, the mean velocity of the former is generally less than that of the latter, by about ten per cent.

WITH STRONG WINDS THE BAROMETER RISES SLOWLY.

And it may be noted, as a peculiar circumstance in a gale with such antecedents, that the barometer rises very slightly after the first short and rapid rise, the accumulation of pressure in the west, no matter how steep the gradient is, seems to be used up in maintaining the gale on the coast, and along the coast the barometers rise little or nothing. There are remarkable records of cases in which steady high barometric readings have been the precursors of prolonged southerly gales upon the coast, even the diurnal fluctuations being totally ignored.

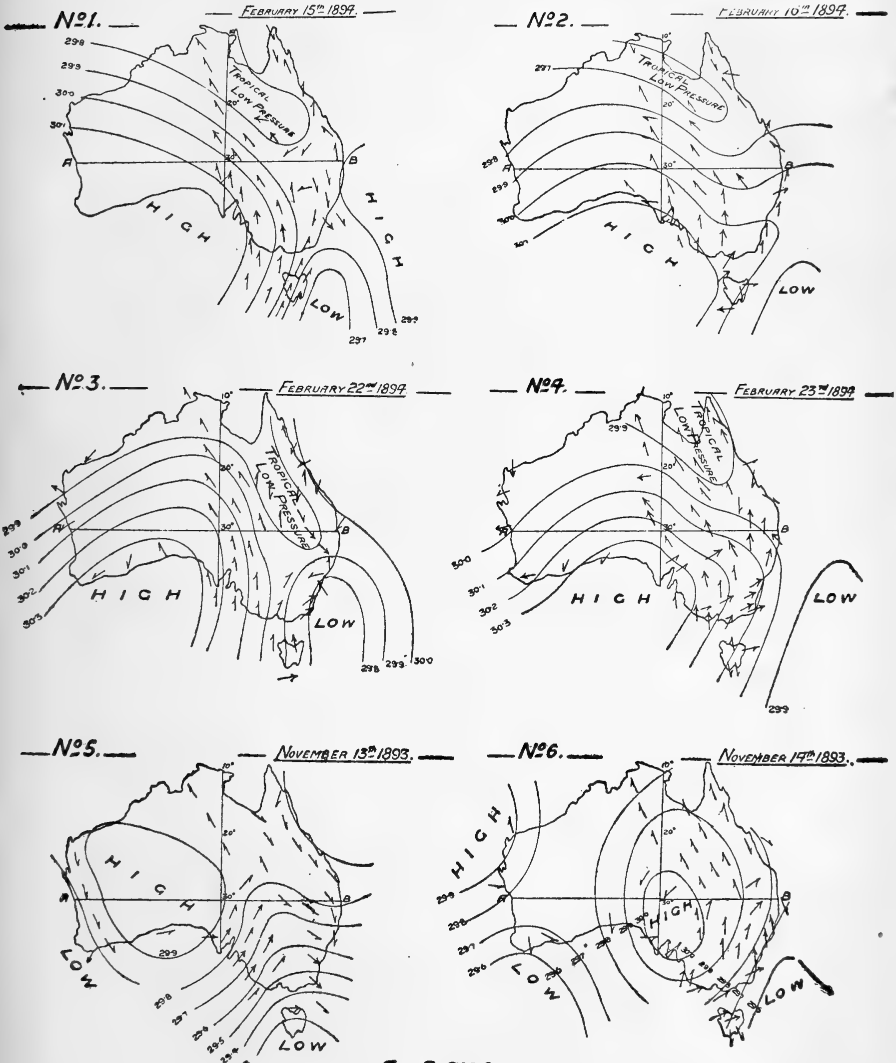
GRADIENTS.

The subject of gradients is a difficult one to touch upon, because our range of latitude is so great, and local geographical features modify it so much, but as a general rule a change of pressure of ·4 on the central coast districts of New South Wales may be considered as denoting a steep gradient, while in Tasmania double this range, or ·8 would not indicate any more serious change.

DESCRIPTIONS OF PARTICULAR BURSTERS.

The past twelve months have, unfortunately, been a most unsuitable season for the study of the subject with which this essay is concerned, and it has been especially unsuitable for the observation of cloud movements. The bursters during the past year have not only been few in number, forty per cent. below the average, but also unusually mild in character, and hence it has been impossible to find a burster of strongly marked character for study, of the comparatively small number however, the best have been chosen.

The first of these occurred on February 15, 1894, it has been selected mainly because the clouds admitted of better notes than



A to B 2100 miles

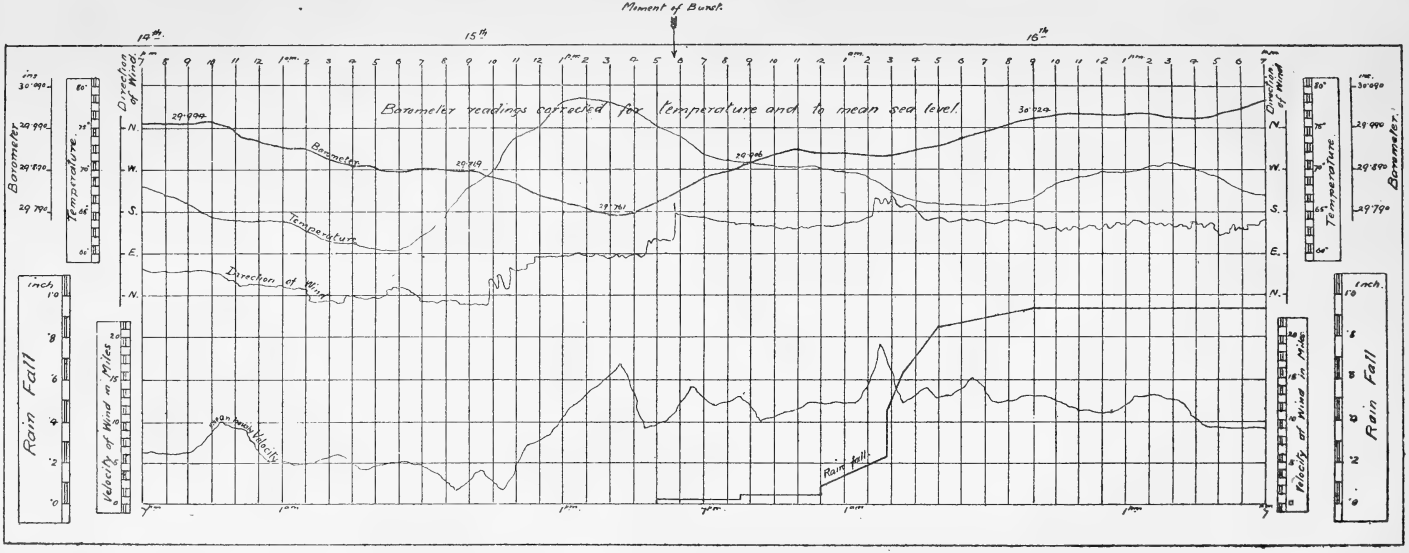
others, and because I am able, through the courtesy of Mr. Russsell to submit photographs of it from the Observatory records. At 9 a.m. of the 14th an anti-cyclone was over Perth in West Australia, another of rather more decided character was over the Tasman Sea, and between these there was a low pressure wanting in intensity; winds were light and without character, and the weather generally hot and unpleasant, but fine, except some passing showers on the coast of New South Wales. Fresh northerly winds were blowing in Bass's Straits. Diagram No. 1 shows the instrumental conditions of this change from 7 p.m. of the 14th to 7 p.m. of the 16th. It will be observed that the barometer began to fall steadily at 10 p.m. of the 14th, and reached the lowest point at 3 p.m. of the 15th, two and a-half hours before the burster arrived, at the time of lowest barometer the wind was from east, and attained its greatest velocity for the day, seventeen miles per hour, at 3·30 p.m. Temperature was highest 78·8°, between 1 and 2 p.m. of the 15th, and the coming of the southerly at a quarter to six p.m. made but little difference; light rain began to fall two hours after minimum temperature was reached, and became gradually heavier from between 2 and 3 p.m. of the 16th, at which time the wind veered a little to west of south with a considerable increase of velocity.

On the morning of the 15th February weather chart No. 1 gives the barometric conditions over Australia and New Zealand, conditions which had materially hardened since the 14th, winds generally were fresher and conforming to the isobars, and weather fine and warm in the eastern colonies. Up to noon there were light cirro-cumulus clouds in the south-west, at 1 p.m. they had become much more dense and somewhat thundery looking, and seemed to be working round the horizon to the north, with one remarkable mass of cumulus. The following diagram of this date shows the instrumental changes during this southerly.

At 2 p.m. south-west clouds slightly advanced, at the same time those low down obscured by haze or dust: up to 2 p.m. north-east, east, and south-east horizons beautifully clear. 2·40 p.m., clouds

Meteorological Diagram.

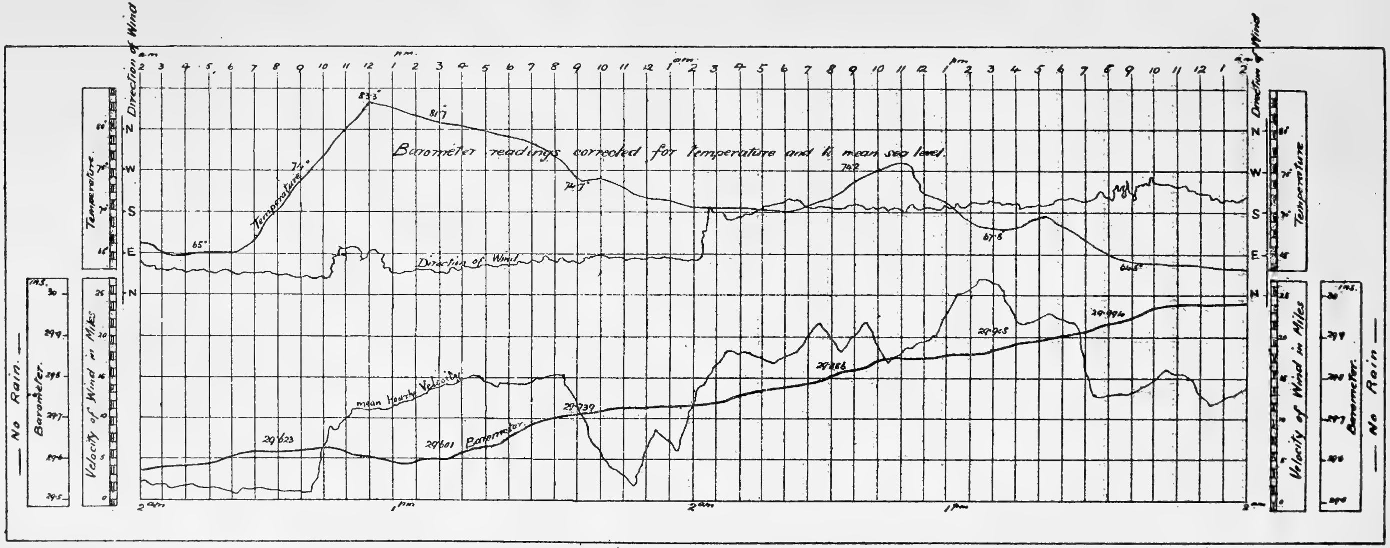
from 7 p.m. on the 14th to 7 p.m. on the 16th of February 1894.



still working further round to due north, with a few light cirrus forming and evaporating east of this point, and a general drift to the east, then thunder cumulus worked up from south-west very slowly, the advanced cirrus reaching Sydney at 3·30 p.m.; no trace of cloud observable with surface wind up to this time; a roll of cloud appeared at 3·15 p.m. above south horizon (See *Plate* 5, taken at 3·43 p.m.), which seemed to be made up of a band of stratus surmounted by cumulus 30° in length; at 4 p.m. the roll merged into the general clouds, which were then fringed overhead and stratified on the southern boundary, beyond which the sky was clear for a space of about 10°, at the same moment an uneven roll of heavy cumulus began to rise above the horizon; as it lifted, the sky still further beyond was clear. Up to this hour, 4 p.m., only one strata of cloud visible, and that moving from south-west; a very dense and extensive cloud of smoke to south-west, which worked backwards and forwards between north-west and south-east on the horizon. At 4·20 p.m. the eastern point of the roll was immediately over Botany Bay, the western limit extending indefinitely to the west. (See the details in *Plate* 6, taken at this time.) Small shower at 5·15 p.m. The cloud roll then seemed to melt away like the earlier one, and the upper clouds still moving from south-west became very wild looking, and *Plate* 7 was taken at 5·50 p.m., showing only a trace of the cloud roll and the disturbed looking upper clouds. Southerly burster arrived at 5·55 p.m., but depth of the current very shallow, for the clouds were still maintaining their course from the south-west. The cumulus observed earlier in the evening, at 6 p.m. remained stationary until 7·30 p.m., with general outline unchanged, but with variations in facial aspects meanwhile rising to higher altitudes. At 7·15 p.m. a fine cluster of festoon clouds developed on a prominent outstanding cloud to the west. As the evening became cooler a few light cirro-cumulus clouds came up from the south at 7·35 p.m., the cumulus of the upper strata first dissolved into cirrus when the influence of the southerly reached them, and then quickly dispersed before the wind; lightning visible occasionally to the north until 8·30 p.m. 9 p.m., cirro-cumulus

Meteorological Diagram

from 2 a.m. on the 21st to 2 a.m. on the 23rd of February 1897.



and cumulus extent 4; 10 p.m., overcast nimbus, raining lightly and intermittently until 3 a.m. on 16th, when it came down heavily in Sydney; to south of city it started to rain heavily three quarters of an hour before, and at 2·45 a.m. a heavy clap of thunder was heard with continued rumblings. The rain continued heavy for another hour, when it tailed off.

February 16th—A heavy shower at 9 a.m., light showers during rest of day.

The weather chart of the morning of the 16th February shews that in the previous twenty-four hours the whole storm system had moved about five hundred miles to the east (see weather chart No. 2), the front isobars of the anti-cyclone overlapping the coast line and the low pressure between Tasmania and the Bluff. The isobars are numerically of the same value as on the 15th, but they have spread out and lost energy, weather generally cooler, with rain in Victoria and on western slopes of the main range in New South Wales.

The second burster to which I shall refer, reached Sydney at 2·15 a.m., February 22nd, 1894, weather chart No. 3 and the accompanying diagram of this period show a great deal more energy in weather conditions generally than there was on February 15th. The isobars enclosing the approaching anti-cyclone are more numerous and of higher value. The wind circulation is more regular and moderate to fresh in force generally. The tropical low pressure is also a defined and active feature. The Λ depression it will be observed on the 22nd was ill-formed, and hence notwithstanding the anti-cyclonic feature favouring a good blow, this burster was little better than that of the 15th February.

The weather antecedent to this southerly was comparatively speaking cooler in central parts of Australia than on the coast, there was also much thunder cloud, and scattered showers fell in south-west Queensland and northern parts of South Australia on the 21st, these points may in part account for the want of force in this burster. The preceding north-east wind blew for the greater part of three days with a force varying between five and fifteen miles per hour, and at 1 a.m. on the 22nd immediately before the burster it was practically calm. This burster began with a velocity of seventeen miles per hour; between 4 and 11 a.m. the hourly force pulsated between eleven and fifteen miles, it then again rose and twenty-seven miles per hour was reached at 3 a.m., and at 3·15 a.m. thirty-eight miles the greatest velocity; it then gradually fell away and veered through east to north early on the 26th. This may be taken as a modified type of the popular burster. (See page 150).

Cloud notes on burster of 22nd February, 1894—Warm sweltering day on 21st, excepting a small patch of cumulus visible at 3 p.m., not a cloud was seen up to midday 22nd. At daylight on the 23rd cirro-cumulus to extent of ·3 moving from the south, upper strata very light mackerel with just a perceptible motion from west-north-west; clouds gradually extending up to 11 a.m., when it became completely overcast and a light misty rain began to fall at 11·40 a.m. Thunder at 12·50 p.m.; thunderstorm between 1 and 2 p.m., clouds breaking at 3 p.m. to south. An upper strata of cirrus visible to the south-west, but too distant to note motion; cleared by evening.

On November 13, 1893, came a burster of little intensity or interest save for the very remarkable cloud roll, the finest that has been seen in Sydney for some years, The weather conditions at 9 a.m. of November 13 are well shown in weather chart No. 5. An anti-cyclone rested over Western Australia, with its centre about latitude 30° south, and longitude about seven hundred miles west of Adelaide, while in front of it is a well marked Λ depression, with its axis north-north-west and south-south-east, and lying centrally over Victoria and the western districts of New South Wales, about three hundred miles west of Sydney. The whole system was moving very rapidly, and from the position of the centre of the high pressure at 9 a.m. of 14th (weather chart No. 6) the forward motion in twenty-four hours is seen to be fully eight hundred miles. About the Λ there was a well defined circulation of fresh winds, north-west and south-west, rain had fallen in the northern districts of South Australia and Queensland, and during the forenoon of 13th there were passing thunder squalls and half formed festoon clouds, which were in rapid motion and had a mild disturbed appearance. All day the upper strata of cloud was coming from north-west to west, during the forenoon temperature in the shade rose to 81·8°. At 3 p.m. seven-tenths of the sky was obscured by cumulus, cirro-cumulus, cirrus, and stratus. At 4 p.m. they were much the same, except that in the north the cumulus clouds were bolder and looked like a wall of rocks, snow-white in colour, with horizontal seams or joints. At 5 p.m. thunder clouds seemed to be in all directions. At 6 p.m. a southerly roll could be seen low down in south-west, with much lightning playing about over it in the cumulo-stratus and cumulus.

As the burster came on, the stratus on the horizon rose gradually up and revealed its true character, at 6·25 p.m. the roll was about 4° in diameter, and had a lower fringe like a very narrow roll of cumulus, above this a dark black roll of stratus surmounted by a feathery fringe, turning up and trending to south, while under the great roll at its northern end, could be seen a well defined shower with rain drifting to north at an angle of 45°. (See *Plate* 8 taken at 7 p.m.) Above this well defined roll cloud another fainter and less defined one is clearly but faintly shown in the negative. The whole storm could be seen to great advantage from the Observatory, and the roll came along getting more and more defined, showing all the features just described from 6·25 to 7 p.m., including the shower and the duplicate roll above. At 7 p.m. it looked very close to us, and could not have been more than three or four miles away, for five minutes later the squall with a velocity of forty-two miles per hour and the rain were upon us. On the photograph taken at 7 p.m., (reproduced as *Plate* 8) the altitude of the lower edge measures 5°, and taking the distance to be four miles, the actual height above the ground comes out one thousand eight hundred and thirty feet, and it spread over at least 100° of the horizon, seventy of which the photograph includes. The sun had set at 6·38 p.m., and night was closing in fast, hastened by the dark masses of cloud which almost covered the sky.

At 6·45 p.m., a long way off and due south, a thunder squall was seen and no doubt marked the arrival of the burster there, showing that the axis of the Λ was still inclined to south-south-east as it was in the morning. The rate of motion of the axis of the Λ eastward to Sydney from its barometrically defined position at 9 a.m., three hundred miles west of Sydney, to the Observatory by 7 p.m. *i.e.*, in ten hours, is seven hundred and twenty miles per day, and agrees fairly well with the rate of the whole system from map 5 to map 6, that is eight hundred miles in the twenty-four hours, or thirty-three miles per hour.

In the original photograph delicate shading shows the rounded cloud perfectly, with another delicate roll above it, but much of the fine detail is lost in the reproduction.

DANDENONG GALE.

I have also added a diagram, (page 153) giving barometer and anemometer conditions at Sydney during the famous Dandenong gale, for comparison, the extensive and disastrous possibilities which a burster may develop made this desirable. During this gale the wind attained, locally, to the abnormal velocity of one hundred and fifty-three miles per hour in a gust, the rate of one hundred and twelve miles for ten minutes, and fifty-seven miles per hour for nine hours, while its influence was severely felt for hundreds of miles in every direction. The most remarkable points in this diagram are, first the comparatively steady barometer curve ; and second, the pulsatory action of the wind velocity shown by the mean hourly number of miles registered during the heaviest part of the gale.

UNFAVOURABLE SEASONS FOR CLOUD OBSERVATIONS.

The opportunities for making cloud observations this summer have been eminently unfavourable, but I have made the best use of such chances as presented themselves, showing the conditions which prevailed for several hours, both before and after the burst. During the present season they have been preceded by clear skies and by overcast skies, and by cirrus and stratus and cumulus, separately and in combination, and to varying extents.

The skies obtaining with the north-westers were more often than not, hazy or overcast, almost tropical of aspect, with hazy stratus and occasional heavy thunder cumulus on the several horizons, but with a special partiality to the south-west.

With the north-easters the skies have been clearer and the smoke-cloud arising from the metropolis, which is seldom noticeable during a north-wester owing to the thick condition of the atmosphere, has generally been perceptible round the horizon in stratified form. The background, or upper strata, when seen, has been composed of fine cirrus, the surface wind occasionally bringing in detached cumulus travelling very low. At times also, as with the north-westers, detached cumulus have been visible to the south-west. The lower strata always moved with the wind, while the upper moved from the west, with an occasional tendency to west-north-west or west-south-west, but this motion could only be discerned in a few instances. In the majority of cases no movement could be detected. Whether the easterly motion is a current or merely the general drift of the atmosphere cannot be decided but as it was noticeable at night I should incline towards the latter hypothesis. No atmospheric current, apart from these two, was observed at any time, except when an agitation was remotely visible overhead between the two, due to vertical uprising or lowering of either one or the other. In these rare instances the clouds moved in all directions.

There were fewer opportunities for observing the upper strata after the burst than while the northerly winds prevailed, but when the conditions permitted observation the cloud movements generally tended from due west. I do not, however, feel inclined to commit myself more definitely on the subject of cloud aspects since the observations from which these statements are deduced are for one season only, and that season an eminently unfavourable one for the collection of useful data.

The question whether bursters arrive here by preference at any particular hour, and whether such hour varies from year to year, as well as the average number for each hour, the percentage of the whole that came at each hour seem to me best answered by a diagram and

TABLE I.

In Table No. 1, all the bursters that have been recorded at Sydney from September 30, 1863 to March 31, 1894, are grouped together so that they can be seen at a glance, all the bursters that

NUMBER IN EACH HOUR AND YEAR.*

are on record for each year, and for each hour of the day, also the total number at each hour for the whole period, and the percentage of bursters that have taken place at each hour in figures and in diagram. Each stroke in the table represents a burster, where several bursters have occurred at the same hour there is a group of strokes, and the eye catches at once those hours in each year in which bursters have been most frequent, the greatest number for any hour in any year was between 9 and 10 p.m., 1891, where ten were recorded.

VARY FROM YEAR TO YEAR.

The number for each year varies considerably, the greatest being fifty-six in 1869; the least, sixteen, in 1890. Since 1888 there has been a gradual falling off in the number, and this is coincident with abundance of rain each year.

PREFERENCE FOR A PARTICULAR HOUR.

The Table No. 1 shows that from 11 a.m. to 1 p.m. bursters are fewest, while they are most frequent from 6 p.m. to midnight, the chances being slightly in favour of 7 to 8 p.m.

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* See also at foot of Diagram III., page 179.

It also appears that the hour of maximum varies from year to year, in 1891 it was from 9 to 10 ; 1888, 11 p.m. to midnight ; 1875, 1 to 2 p.m. and so on.

The questions as to the number and strength of bursters in the several seasons and months of the year I have treated in the same manner.

TABLE II.

In Table No. 2, all the bursters on record have been grouped in another way, which brings into evidence other characteristics. The table has the years on the sides and months across the top, and the information given under each month and for each year is the maximum velocity of the wind, and if there are several bursters in the month the average of their greatest velocities ; at the right hand side the average of the greatest velocities for the year, and the greatest velocity attained at any time during the year. It is also shown that the average number in each year is thirty-two, the greatest in any year fifty-six, and the least sixteen. The average of all the greatest velocities is 42·7 miles per hour, the greatest one hundred and fifty-three miles per hour. (It must be borne in mind that all the anemometer results at Sydney are recorded on the assumption that the velocity of the wind is three times that of the centres of the cup, this has been the practice since 1862, and it is deemed better not to alter it until the exact ratio has been decided and generally accepted.)

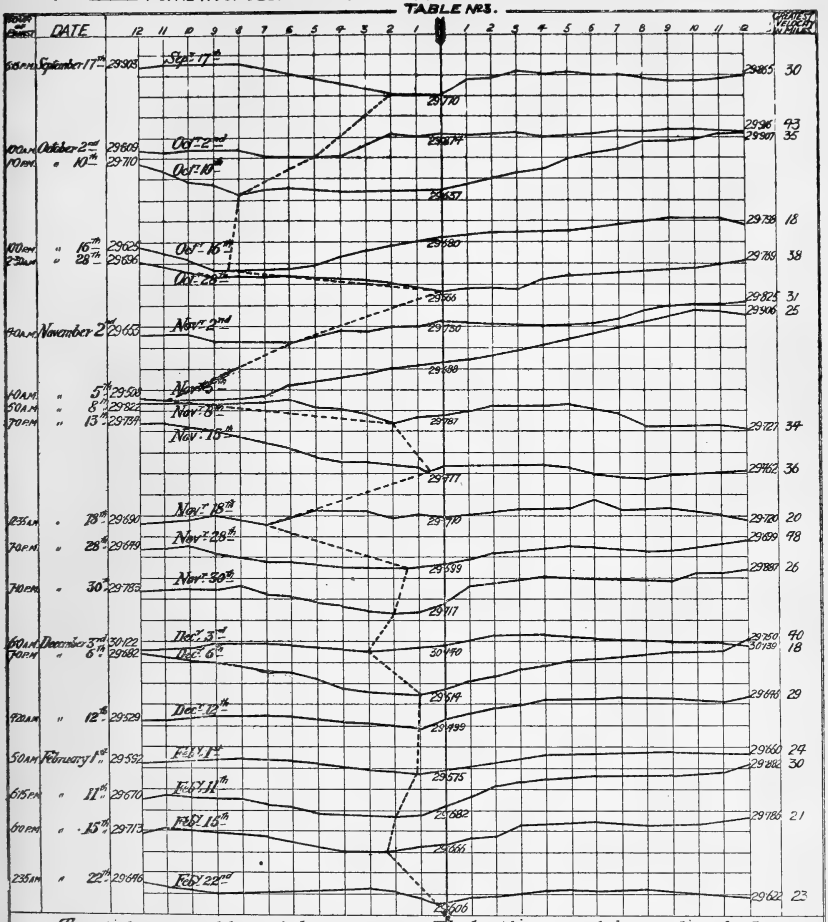
It is necessary to state here that in the conditions under which this prize essay was written, there is no express definition of the minimum velocity of wind which shall constitute a burster, I have therefore taken as such every sudden shift of wind to south or south-west, from any point between west and north on the one side and east and north on the other side, irrespective of the velocity of the wind ; always provided however, that the velocity was maintained subsequently for some hours with force.

It will be observed that the table brings to light the fact, that the mean velocity of the wind is greater in spring than in autumn,

DIAGRAM SHOWING FLUCTUATIONS OF BAROMETER

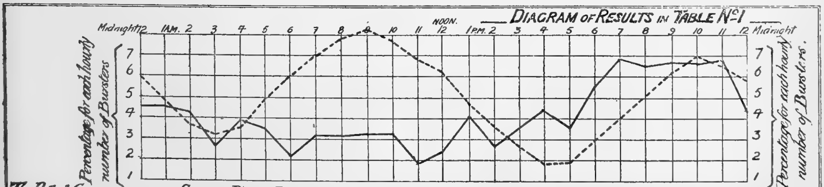
FOR 12 HOURS BEFORE AND AFTER BURSTERS OF THE SUMMER 1893 TO 1894.

TABLE No. 3.



The vertical spaces equal ·1 of an inch. The dotted line connects the lowest readings of each curve.
The curves are uncorrected both for temperature and altitude. The several barometer readings are corrected for temp— only.

DIAGRAM OF RESULTS IN TABLE No. 1



The Dotted Curve represents a Summer Diurnal Range of Barometers at SYDNEY from a mean of 5 years and drawn to a scale of 0·01 of an inch equal to one space. The Continuous Curve shews for each hour, the Percentage of total No. Southerlies recorded.

which may be accounted for by the fact that our September equinox is windy and the March one wet. The discrepancy between the seasonal total in the tables is accounted for by the fact that the anemometer on a few occasions failed to record the hours of arrival, in these cases the burster is omitted from Table 1.

One other point seems important in respect to the arrival of bursters, and that is the time between the lowest barometer and the arrival of the burst.

DIAGRAM III.

Gives the fluctuations of the self recording barograph for twelve hours before and after nineteen bursters of the summer 1893 to 1894. The curves have been drawn with their lowest points in a vertical line, and the times at which the burst commenced on each curve have been connected by lines, thus showing the relation between the barometric minimum and the time that the burst of wind reached Sydney. It will at once be seen that the bursters occur some hours after the barometers have commenced to rise, and if this set of curves be accepted as the general rule, the diagram shows that in any season the lowest readings take place more remotely from the change of wind, early in the summer. It is also patent that no particular height of barometer is peculiar to the burster. A sudden rise does not indicate that the blow will be a hard one, see the sharpest that of 17th September and of 30th November, while the velocity of forty-eight miles per hour, the heaviest of the season, resulted from a very gradual rise and with a range of only ·1 in the whole twenty-four hours. The curves at the foot of diagram 3 relate to one feature of Table I.

HOT SOUTHERLY WINDS.

Instances have been recorded of hot southerly winds which lasted for some hours. These are no doubt, the winds blowing on the western aspect of the tropical depression. The following is an account of a hot southerly wind copied from notes made by Mr. Russell, and kindly placed at my disposal :—

"December 12th, 1883.—Yesterday was hot, to-day hotter still, and by 9 a.m. the temperature had risen to 82·6, wind from north and hot. At noon the humidity fell to twenty-nine, and the temperature had risen to 99·6. At 3 p.m. the dry bulb stood at 95·6 and the wet at 71·1; from 9 a.m. to 6·30 p.m. the barometer fell 0·350 and then began to rise rapidly, and by 8 p.m. had risen 0·215. At 6·30 p.m. as the barometer began to rise the wind changed suddenly to south, and it felt more like a furnace blast than a southerly burster. The wind continued as a hot wind for more than an hour, but not strongly after the first violent gusts were over; by 9 p.m. a light warm air from south-west had set in but the temperature was still 86·6. I do not remember a hot southerly like this before. On the morning following we had a cool wind from north-west."

In conclusion, it is needless to state that this investigation has involved much labour and a vast amount of patient research, and though I will be gratified if my efforts should in some degree, however small, contribute to a better knowledge of this phenomenon and in any case, I will consider myself rewarded for the labour I have given to it by the knowledge I have acquired while gathering materials for this essay. I am largely indebted to Mr. H. C. Russell, who has kindly given me access to all the valuable records of the Sydney Observatory, and furnished me with copies of weather maps, photographs, etc., for which my warmest thanks are hereby expressed.

TABLE II.—TABLE SHOWING NUMBER OF BURSTERS IN EACH

YEAR.	AUGUST.			SEPTEMBER.			OCTOBER.			NOVEMBER.			DECEMBER.		
	Number	Velocity. Mean	Velocity. Extreme	Number.	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme
Summer.				Rate in Miles per hour			Rate in Miles per hour			Rate in Miles per hour			Rate in Miles per hour		
1863 – 64	...	...	...	2	58·0	70	6	54·8	108	7	29·4	41	3	32·3	49
1865	...	...	...	2	11·0	12	3	32·3	49	5	25·6	50	4	24·3	36
1866	...	...	...	2	26·5	32	5	43·8	64	10	38·9	74	7	28·3	48
1867	1	20·0	20	6	25·7	40	...	...	...	6	28·7	42	4	38·0	56
1868	...	...	...	3	30·0	47	3	23·3	29	10	29·4	43	4	36·3	69
1869	...	...	...	5	17·4	27	7	43·0	60	11	37·0	72	8	37·8	73
1870	1	18·0	18	2	29·0	36	4	32·5	47	4	44·3	70	8	30·5	53
1871	...	...	...	1	39·0	39	7	33·8	52	6	40·0	69	6	45·0	63
1872	...	...	...	1	37·0	37	5	35·6	54	5	30·2	40	6	42·5	64
1873	...	...	...	2	40·0	42	2	40·0	44	1	47·0	47	4	29·3	45
1874	...	...	...	...	...	...	5	36·8	54	4	34·7	44	6	37·3	61
1875	...	...	...	1	20·0	20	6	40·8	54	5	29·4	41	8	32·9	54
1876	2	33·5	37	3	24·3	30	6	28·3	34	6	26·7	37	4	31·0	50
1877	...	...	...	6	47·2	153	5	34·8	43	6	30·8	55	7	32·9	54
1878	...	...	...	2	29·0	32	3	46·3	59	8	40·0	53	9	40·1	64
1879	...	...	...	4	29·3	42	7	45·9	72	9	30·5	45	9	31·0	52
1880	...	...	...	...	...	...	4	39·2	76	5	35·4	63	8	37·8	61
1881	...	...	...	2	28·5	33	7	38·3	59	6	40·0	68	8	61·1	82
1882	...	...	...	2	36·5	41	3	47·0	63	5	42·0	54	5	29·6	48
1883	1	16·0	16	4	43·8	68	5	34·2	59	4	34·3	53	7	32·1	43
1884	...	...	...	1	32·0	32	5	34·4	45	4	22·5	27	7	30·6	54
1885	...	...	...	5	28·8	48	7	35·4	41	5	34·0	48	5	38·2	50
1886	...	...	...	1	30·0	30	8	26·9	36	7	33·0	47	4	38·0	41
1887	...	...	...	...	...	...	4	32·5	63	3	24·3	29	4	30·3	37
1888	...	...	...	1	43·0	43	3	35·3	37	4	34·5	48	5	28·0	50
1889	...	...	...	1	18·0	18	4	34·0	43	3	35·0	46	6	29·0	43
1890	...	...	...	1	21·0	21	1	26·0	26	3	19·7	24	8	29·1	42
1891	...	...	...	1	21·0	21	2	27·0	35	2	31·0	48	4	22·5	30
1892	...	...	...	...	...	...	2	21·0	21	3	35·7	41	5	28·8	35
1893	...	...	...	...	...	...	6	29·7	48	2	33·0	42	6	32·3	58
1894	...	...	...	1	30·0	30	4	33·5	43	7	31·4	48	3	29·0	40
Total	5	...	...	62	...	...	139	...	...	166	...	...	182	...	...
Percent.	·5	...	...	6·3	..	...	14·0	...	...	16·8	...	...	18·3	...	...
Mean	·2	21·4	...	2·0	30·3	...	4·5	35·5	...	5·4	33·5	...	5·9	33·7	...
Extreme	2	33·5	37	6	58·0	153	8	54·8	108	11	47·0	74	9	45·0	73
Year	...	1876	1876	...	1864	1876	...	1864	1864	...	1873	1866	...	1871	1869

NOTE.—In making out this Table the greatest velocity of each southerly has if there are several bursters in the month, the average of their greatest veloci-

MONTH WITH MEANS AND EXTREMES OF GREATEST VELOCITIES.

January.			February.			March.			April.			May.			Total Number.	Velocity.		Year.
Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme	Number	Velocity. Mean	Velocity. Extreme		Mean	Extreme	
Ra Mile	te in s per	hour	Ra Mile	te in s per	hour	Ra Mile	te in s per	hour	Ra Mile	te in s per	hour	Ra Mile	te in s per	hour	Ra Mile	te in s per	hour	
7	22·0	48	4	30·5	31	2	34·0	34	...	...	...	...	...	...	31	37·3	108	1864
8	29·5	45	7	22·4	36	4	24·5	38	3	27·3	40	...	...	...	36	24·6	50	1865
6	29·8	46	3	40·5	46	2	50·0	54	2	22·5	23	...	...	...	37	35·0	74	1866
5	48·4	69	6	26·7	44	4	16·0	18	5	26·0	26	...	...	...	37	25·3	69	1867
8	35·4	54	3	51·0	77	4	33 3	63	3	14·7	16	...	...	...	38	31·7	77	1868
7	34·4	63	5	24·0	33	8	34·3	61	2	24·0	36	3	14·5	15	56	29 6	73	1869
5	39·8	49	5	41·6	55	...	...	...	...	...	...	...	...	...	29	33·6	70	1870
3	35·3	52	4	38·8	51	3	19·0	25	3	40·0	56	1	43·0	43	34	37·1	69	1871
6	34·0	50	7	33·4	40	1	40·0	40	3	19·3	24	...	...	...	34	34·0	64	1872
6	35·7	45	2	29·5	34	5	20·4	27	...	...	...	...	...	...	22	34·4	47	1873
6	34·3	47	5	28·8	44	1	35·0	35	3	20·0	29	...	...	...	30	32·4	61	1874
9	38·1	52	3	38·0	64	5	29·0	36	1	23·0	23	...	...	...	38	31·4	64	1875
4	32·3	44	5	32·4	39	3	35·0	43	2	29·0	35	...	...	...	35	30·3	50	1876
7	26·0	38	4	26·0	34	1	39·0	39	1	44·0	44	...	...	...	37	35·1	153	1877
4	35·3	44	2	39·0	41	4	19·7	24	...	...	...	...	...	...	32	35·6	64	1878
7	39·0	52	4	31·3	36	3	34·7	47	4	27·5	46	...	...	...	47	33·7	72	1879
7	29·0	36	1	36·0	36	3	30·0	32	...	...	...	...	...	...	28	34·6	76	1880
5	48·0	71	5	34·6	54	3	27·3	30	1	64·0	64	...	...	...	37	42·7	82	1881
8	37·6	67	5	30·8	66	4	34·7	45	2	20·0	20	...	...	...	34	34·8	67	1882
5	34·0	50	3	28·7	37	1	28·0	28	...	...	...	...	...	...	30	31·4	68	1883
8	39·3	54	7	29·9	46	3	33·7	43	...	...	...	...	...	...	35	31·9	54	1884
6	29·3	40	7	30·1	50	7	28·7	41	1	20·0	20	...	...	...	43	28·5	50	1885
4	25·5	30	5	35·8	46	3	39·0	47	...	...	...	...	...	...	32	32·6	47	1886
2	30·5	32	1	41·0	41	4	27·8	34	2	34·0	42	...	...	...	20	31·5	63	1887
8	29·8	46	5	31·6	45	4	27·0	30	2	23·5	31	...	...	...	32	31·6	50	1888
5	27·8	35	5	31·0	34	3	24·0	33	...	...	...	...	...	...	27	28·4	46	1889
3	37·3	40	...	...	...	...	...	...	...	...	...	...	...	...	16	26·6	42	1890
6	26·3	40	7	24·1	42	1	27·0	27	...	...	...	...	...	...	23	25·6	48	1891
2	40·5	46	5	22·0	26	3	25·7	27	1	21·0	21	...	...	...	21	27·8	46	1892
3	33·0	57	3	24 0	35	1	30·0	30	...	...	...	...	...	...	21	30·3	58	1893
...	...	...	4	27·0	30	...	...	...	...	...	...	...	...	...	19	30·2	48	1894
170	...	...	132	...	...	90	...	...	41	...	...	4	...	...	991	...	...	...
17·3	...	...	13·2	...	...	9·1	...	...	4·1	...	...	·4	...	...	100	...	...	...
5·5	33·9	...	4·3	31·7	...	3·2	30·2	...	1·3	27·7	...	0·1	28·8	...	32	31·9	...	...
9	48·4	71	7	51·0	77	8	50·0	63	5	64·0	56	3	43	43	56	42·7	153	...
...	1867	1881	...	1868	1868	...	1866	1868	...	1882	1871	...	1871	1871	1869	1881	1876	...

been found by ascertaining the shortest time in which four miles of wind was recorded; ties is shown under the head "Mean."

TABLE I.—TABLE SHOWING NUMBER OF BURSTERS IN EACH HOUR FROM SEPTEMBER 1863 TO MARCH 1894.

Years	A.M. 0—1	1—2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—11	11—12	P.M. 12—1	1—2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—11	11—12	Total	Year.
1863–64	...	////	//	/	...	...	/	///	...	...	...	/	/	...	///	...	...	/	///	//	///	//	//	//	31	1864
1865	...	/	///	...	...	/////	//	//	//	/	..	...	...	/	...	//	//	...	///	//	////	//	///	/	36	1865
1866	//	//	/	/	...	/	...	///	...	...	/	...	//	//	...	///	//	...	/	///	///	/////	///	//	37	1866
1867	...	///	/	...	//	/	/	////	////	...	/	/	...	/	/	///	...	/	//	/	/	/	/	//	32	1867
1868	///	///	///	...	/	...	...	/	/	//	...	/	...	//	/	/	//	...	//	////	////	//	/	////	38	1868
1869	////	/	///	/	...	//	/	//	//	///	/	/	///	////	//	//	//	/	///	//////	///	/	//	//////	56	1869
1870	/	/	/	...	/	...	...	...	...	...	/	/	...	//	...	...	///	//	//	////	...	///	//////	/	29	1870
1871	/	...	...	//	/	//	...	...	/	/	////	...	/	///	///	/	//	...	///	//	///	/	/	//	34	1871
1872	///	...	/	//	/	/	//	...	...	/	//	/	...	/	...	//	...	/	//	//	///	//	///	///	33	1872
1873	/	...	//	///	//	...	/	...	//	...	/	...	...	/	/	...	...	/	...	...	//	/	/	///	22	1873
1874	/	/	//	///	//	...	/	...	//	/	...	...	/	/	...	...	//	///	/	...	//	//	//	///	30	1874
1875	/	/	//	...	//	...	...	//	/	/	////	...	...	/////	///	////	//	...	////	//	//	/	/	...	38	1875
1876	/	/	//	...	...	...	/	...	//	//	///	/	//	...	...	/	/	...	/////	/	////	////	...	////	35	1876
1877	///	/	...	...	...	/	...	//	//	//	///	...	/	////	/	/	///	/	///	//	/	////	//	/	37	1877
1878	//	/	//	...	//	//	...	...	...	////	/	/	...	...	...	//	///	//	//	//	...	/	////	/	32	1878
1879	////	////	...	//	///	//	...	...	...	///	/	...	...	//	///	//	...	/	/	///	/////	//	//	///////	47	1879
1880	...	//	//	...	///	...	///	////	...	...	...	...	/	...	...	/	//	/	/	///	///	...	/	/	28	1880
1881	//	/////	/	/	...	...	...	...	...	/	...	//	//	/	...	/	//	////	/	//	//	///	////	///	37	1881
1882	/	///	/	...	...	//	/	//	...	/	/	/	/	///	/	/	...	//	/	//	/	//	////	//	33	1882
1883	...	...	///	///	///	/	...	...	/	/	/	...	...	...	...	...	...	/	/	/	////	///	//	///	28	1883
1884	////	...	//	/	/	...	/	//	...	/	...	/	...	/	/	/	/////	//	//	/////	...	...	//	///	35	1884
1885	/	//	/	/	///	////	///	...	///	//	/	...	/	//	//	/	///	/	/	///	/////	/	/	...	42	1885
1886	...	//	/	...	...	///	...	/	///	//	...	///	//	/	...	/	///	...	...	///	///	...	////	...	32	1886
1887	...	/	/	...	/////	...	/	...	...	...	//	...	...	...	/	...	/	...	//	////	...	//	...	...	20	1887
1888	/	/	...	...	//	/	/	/	//	/	/	...	/	...	//	...	...	/	/	//	///	//	////	/////	32	1888
1889	//	//	...	/	/	/	...	...	...	...	...	...	/	/	...	///	...	////	/	//	...	////	/	///	27	1889
1890	/	//	...	//	/	...	...	...	/	...	/	...	/	/	...	...	...	/	...	/	/	/	/	/	16	1890
1891	/	...	...	...	...	/	...	/	...	//	...	...	...	...	...	/	...	/	/	...	...	/	//////////	/	///	23	1891
1892	/	...	//	//	/	/	...	...	...	...	...	//	...	//	/	...	...	/	//	...	/	//	///	...	21	1892
1893	//	...	...	//	...	/	...	...	/	...	/	...	...	...	...	/	/	/	/	/	/	//	////	//	21	1893
1894	/	/	//	...	//	//	/	...	...	...	/	...	...	/	...	...	...	/	//	////	...	/	...	...	19	1894
Total	44	45	41	28	39	34	21	30	30	32	31	17	21	41	27	34	43	34	54	69	65	67	66	68	981	31
Percentage.	4·5	4·6	4·2	2·8	4·0	3·5	2·1	3·1	3·1	3·3	3·2	1·7	2·1	4·2	2·7	3·5	4·4	3·5	5·5	7·0	6·6	6·8	6·7	6·9	Mean 31·6	Yrs.

Preliminary Note on the OCCURRENCE of GOLD in the HAWKESBURY ROCKS about SYDNEY.

By A. Liversidge, M.A., F.R.S.,

Professor of Chemistry in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, October 3, 1894.*]

I have long wished to make a systematic examination of the New South Wales sedimentary rocks for the occurrence of gold in them, but it was not until 1892 that I was able to commence the work upon the sandstone and shale about Sydney. My experiments are by no means complete, and I am only induced to bring forward this preliminary note because there is rather a dearth of papers for this evening's meeting.

The Hawkesbury sandstone and Waianamatta shale are, of course, derived from older, (and in all probability gold bearing) rocks, hence it is not unreasonable to expect to find gold in them, especially when we bear in mind that gold has been detected in the carboniferous limestone and other rocks in England, (See Minerals of N.S.W. 1888, p. 24); the limestone is also likely to contain less gold than a sandstone.

Gold is found in the coal measure conglomerate of New South Wales, but the presence of gold in this is very natural, the conglomerate is simply an old gravel and is analogous to later "cements" and similar gold bearing deposits; the Hawkesbury sandstone is in turn analogous to a gold bearing sea beach.

The late Revd. W. B. Clarke states in his "Southern Gold Fields," Sydney, 1860, pp. 44 and 244, that he had seen minute specks of gold in the quartz pebbles of the sandstone on the North Shore and at Govett's Leap, but no assays are quoted, and he remarks in italics that he considers these have *no commercial value.*

Some of the sandstones examined were being used at the University for building purposes, in other cases the stone was obtained expressly from the Pyrmont quarries.

The amounts of gold present were determined by the ordinary process of assaying 1,000 grains of the rock with red lead and cupelling and correcting for the gold in the red lead. The amount of silver present was neglected, it being unessential to the present inquiry. The dry assay was supplemented, in some cases, by extraction with potassium cyanide solution, and also by means of chlorine, but the latter is not very satisfactory for small proportions of gold as shown by the following experiment.

Five pounds weight of sandstone, No. 10 in the following table, was treated with chlorine water, but yielded only 1·17 grains of gold per ton, although this sandstone had yielded 2·24 grains of gold per ton to the potassium cyanide solution; therefore, to test the chlorine process, five fluid ounces of photographers' gold solution, containing roughly two and a half grains of metallic gold was added to the exhausted sandstone and left for twenty-four hours, it was then extracted with fresh chlorine water and leached until free from chlorine, the solution was evaporated to dryness, scorified and cupelled, but only ·054 grain of gold was obtained. Then, since the chlorine did not remove the gold, the sandstone was extracted with 1,600 c.c. of a ·025% potassium cyanide solution, when 1·510 grains of gold were obtained; as the amount of gold was still short, it was again extracted with 1·5 litres of ·5% potassium cyanide solution, when an additional ·075 grain of gold was obtained or,

(1)	By chlorine	·054	grain of gold.
(2)	By potassium cyanide	1·510	„
(3)	„ „	·075	„
		1·639	

leaving nearly a grain of the added gold to be accounted for, as well as 1·07 grains of the 2·24 grains originally present in the sandstone.

The above is a solitary experiment and much importance cannot be attached to it—for if over two grains of gold were always retained by every five pounds of sandstone or its equivalent of mineral matter, the chlorine process would be useless.

	By Fusion.	By KCN Solution.
No. 1 Building Stone... ...	none	not treated.
No. 2 ,, ,, ...	none	not treated.
No. 3 ,, ,, ...	not assayed ...	35·84 grains per ton.
No. 4 ,, ,, ...	trace	8·96 ,, ,,
No. 5 Pyrmont Stone... ...	14 grains per ton	12·32 ,, ,,
No. 6 ,, ,, ...	none	2·24 ,, ,,
No. 7 ,, ,, reddish	none	not treated.
No. 8 ,, ,, ...	7 grains per ton ...	not treated.
No. 9 ,, ,, ...	18 ,, ,, ...	not treated.
No. 10 ,, soft and micaceous	none	2·24 grains per ton.

The fusion assays of Nos. 5, 6, 8 and 9 were made for me by Mr. Nardin, B.E., a student in the Mining School of the University.

Nos. 1 to 4 were ordinary sandstones, suitable for rough work; Nos. 5, 6, 8, and 9 were of a better quality and more compact; No. 7 was a soft red friable stone of little value for building; No. 10 was of poor quality, soft, friable and micaceous with a good deal of kaolin.

None of the above contain sufficient gold to pay for extraction but the two following are much richer; the first was a very ferruginous red sandstone expressly selected because it might prove to be richer, and this was found to be the case, for two closely agreeing assays yielded 9 dwts. 19 grains of gold per ton, it would therefore be worth about £2 per ton. The second specimen, a pebbly sandstone, gave 3 dwts. 6 grains per ton, and this would be worth about thirteen and nine pence a ton.

Waianamatta Shale from the University grounds. So as to be quite certain that the material had not come in contact with photographic or other refuse likely to contain gold, this was taken at a depth of two feet from the trenches as they were being put down for the foundation of the Engineering Laboratory buildings.

The light coloured shale examined, did not yield any gold; but the deep red shale yielded 2 dwts. 23·8 grains to the ton, worth about twelve and sixpence a ton. A nodule of hard ferruginous shale, practically hæmatite, was somewhat richer and yielded 3 dwts. 13 grains (worth about fifteen shillings) per ton. This nodule was probably derived from a mass of iron pyrites, and does not, of course, represent the bulk of the shale.

Now that the cyanide process has been so much cheapened (by Siemens and Halske's modification it is said that the cost of treatment of tailings is reduced to three shillings a ton, and it is expected that this may be reduced to two shillings and sixpence a ton) large quantities of tailings and other gold bearing material that are now useless will become of value, and it may be, that some of the richer sandstone and shale may be found to pay for extraction; if these latter should do so, the result will be much more satisfactory than a rich patchy reef, for, although the profit per ton might be only a few shillings, the immense quantity available would compensate for the low returns.

The quartzite, (a metamorphosed sandstone) occurring at Goulburn was also examined and found to contain a trace of gold.

I wish it to be clearly understood that my experiments, as far as they go, do not show that it will pay to work the sandstone and shale about Sydney for gold; but that with the newer and cheaper cyanide process, certain selected portions, if obtainable in sufficient quantity, probably would do so. The cost of working the sandstone or shale would necessarily be much greater than for treating tailings, as the stone would have to be quarried, crushed and otherwise handled prior to extraction, whereas the tailings are ready for treatment with the cyanide.

THE TIMBERS OF NEW SOUTH WALES.

By J. V. De Coque.

[*Read before the Royal Society of N. S. Wales, August 1, 1894.*]

I NEED hardly state that the study of the timbers of this Colony opens up to the student a wide field for investigation. It will be found after reading this paper, that I have given prominence to the several species of Eucalyptus, first because they are in universal use throughout the country and therefore of general interest, and secondly, notwithstanding all that has been written regarding their relative merits, our knowledge is yet far from perfect in regard to them. I take it that any information contained within these pages (the result of many years of practical experience), which may tend, in some small degree, to throw further light on the habits and peculiarities of this magnificent genus is of the greatest importance. No one possessing any knowledge of the timbers of this colony can afford to be dogmatic. I should like it to be understood however, that before committing my opinions and statements to paper, I have in each instance satisfied myself as to their accuracy as far as it was possible to do so.

I should have preferred to have put botanical names entirely to one side and adhered to vernacular ones alone, but in many instances I found it impossible to do so. In several districts the same variety of timber frequently goes under different names, and very often the same name is applied to different timbers.

Hence to be accurate in dealing with the eucalypts I have referred to the species by their botanical as well as the names they are commonly known by. I am fully alive to the great importance of Professor Warren's work on the relative strength of our hardwoods, and although I make no reference to the value of each species in this particular direction, the results of his tests, which I have carefully studied, have not been overlooked by me.

In dealing with the fancy or figured timbers in which I include the brush varieties, I have as far as possible adhered to vernacular names only, as notwithstanding their number, many of them are quite distinct enough in grain and general appearance for easy identification.

The Study of Hardwoods.

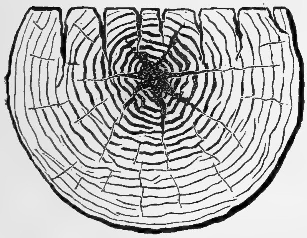
I have frequently been asked by architects and others for some suggestions whereby they may be able to distinguish one hardwood from another. It is an utter impossibility to set forth any fixed rule which would act as an effectual guide. The pale hardwoods are equally as conflicting to the inexperienced eye as the dark and red varieties, yet to the expert there are no two species but differ in some respect or other.

Another and even greater difficulty presents itself in the fact of the same species of timber differing, often to a considerable extent, in appearance in various localities where it grows. No one need attempt to undertake this interesting study with any prospect of success in a half-hearted manner. He must in the first place be enthusiastic, beginning with one timber at a time, studying it carefully until the eye gets accustomed to its peculiarities; he must not be discouraged at finding from time to time his pet ideas and conclusions upset when comparing two or more timbers of one species. The essential point is getting the eye accustomed to the timber, which can only be achieved by continual application and close study. Above all things the student must remember, in his search for information, that in ninety nine cases out of a hundred his informant has a personal motive in recommending a particular timber to his favourable consideration; before believing anything he is told, he should first satisfy himself that the statements are correct. Every saw-miller and timber getter will positively assure you that the particular varieties growing close to his mill or axe are superior to all others.

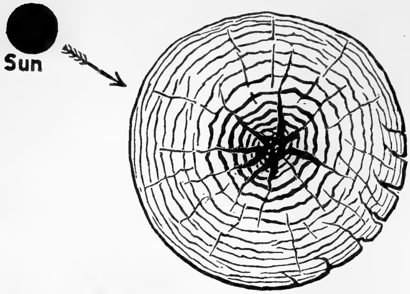
In the various Government Departments of this Colony experts are appointed whose duty it is to see that only approved timber is used in the construction of public works, but with architects the case is different, and they are repeatedly imposed upon by unprincipled suppliers, who, actuated by personal motives, tender inferior timbers for those specified. To this body of gentlemen I would suggest the advisability of appointing a reliable man with a practical knowledge of hardwoods to inspect all timber for their works before it is used. An arrangement such as this would be a trifling expense among so many, and would be highly satisfactory to both architect and client.

Hardwoods—Effect of Natural Drying or Seasoning.

It is useless for me to suggest the necessity of only falling and utilizing our timbers in certain seasons of the year when the sap has descended. The call for timber all the year round, and the unquestionable fact that it deteriorates when exposed after being cut makes it essential that freshly cut timber should be always available irrespective of sap. Take in the first instance, what is termed a half-round girder, that is a round log adzed level along its face on one side, a class of girder much in use in the construction of road bridges where the length of span does not exceed thirty-five feet; this half-round log during the process of drying in a bridge will split in a similar manner to the sketch. The best of our timbers, such as iron-bark or tallow wood split to a lesser degree, but such species as spotted gum, blackbutt, blue gum, and others of our second-class hard-woods will open in this way, that is, they will split first along the adzed surface, being the weakest and most exposed to damp, through the deck which covers it, and afterwards to a lesser degree along any portion of the surface where defects exist, particularly where gum veins appear.

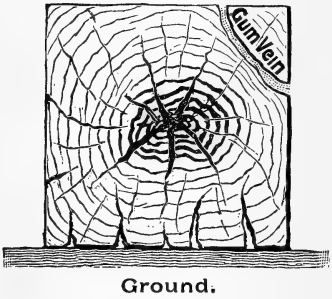


Take a round log stripped of its bark, and expose it to the rays of the sun thus: It will be found that it will always crack and

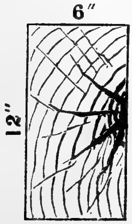


open on the side least exposed to the sun's rays. I attribute this to the fact that the dryer or more seasoned the wood is, the stronger it is across the grain, consequently the least exposed side being greenest does the greatest proportion of splitting during the seasoning process.

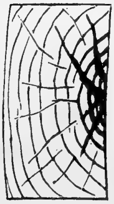
Take a squared girder and place it on the ground; it will open on the side that is in contact with the ground, for the same reason, namely, that it is the greenest, also that it is exposed to moisture to a more or less degree. If the timber is subject to gum veins, the piece, as shown in sketch, will shell off after the vein of gum dries, a bad fault in all our hardwoods subject to gum veins.



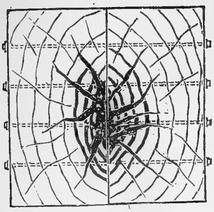
All sawn hardwood timbers will invariably, to a more or less degree, according to class, during the process of drying shrink from the side nearest the heart, as the following sketches demonstrate:



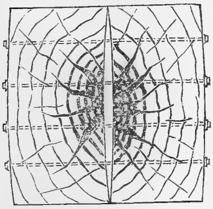
Sawn piece unseasoned, planed and worked square.



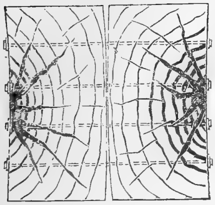
Sawn piece seasoned but originally worked square, showing shrinkage from heart.



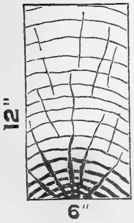
Two pieces of timber unseasoned, planed and worked square, also bolted together, heart side to heart side.



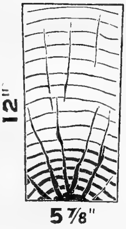
Effect of drying or seasoning on these pieces; "open at the heart $\frac{1}{4}$ inch."



Effect of drying or seasoning on these pieces if heart side is reversed thus; "open top and bottom $\frac{1}{4}$ inch."



Piece of timber cut on the quarter.



Will always shrink when drying in this manner.

These dimensions apply to ironbark; other hardwoods shrink in a similar manner, but to a greater extent.

These sketches point conclusively to the fact that no matter how accurate the fit in the first instance may be, or how strongly the timber may be bolted together, no unseasoned two or more pieces will maintain a perfectly close joint.

In using hardwoods, the heart side of each piece should always be turned down or inside, as the case may be, because as I have already shown, the shrinkage is from the heart, also because our timbers split from the heart side only.

For all classes of work and in all sizes, except square with heart in centre, hardwoods should be cut off the back, thus  and not on the quarter thus 
A fact which architects would act wisely in making a note of.

It is always advisable when possible to avoid using hardwoods of any description with heart in. The heart is invariably the weakest portion of the tree, and defects such as rot will always start first in the heart and extend afterwards throughout the whole piece.

Artificial Seasoning of Timbers.

Many intelligent men, fully alive to the importance of devising some method whereby the timbers of these colonies may be artificially seasoned, have spent time and money in various schemes, but so far without accomplishing any practical result. It must however be remembered that before success is assured, special difficulties will have to be overcome. The timbers of this Colony may be divided into three classes: First, the hardwoods such as ironbark, blackbutt, mahogany, etc. Secondly, the fancy or figured, including the brush varieties. Thirdly, our softwoods such as cedar, beech, pine, etc.

In the effectual seasoning of the hardwoods and semi-hardwoods a great difficulty presents itself, for could we but offer to the world the magnificent genus Eucalyptus in a thoroughly seasoned state, we should not only be able to absorb a great quantity for our local wants, but our export trade with the markets of the world would be enormous, and when we come to consider that our rosewoods, beans, oaks, etc., are second to none in beauty of grain or colour and in durability, it seems to me to be nothing short of a national calamity that any difficulty should stand in the way of developing this great industry.

It is unfortunately an undisputed fact that none of our timbers season to perfect satisfaction from natural causes only. In our hardwoods the elements of shrinking, warping, cracking, and the gradual shedding of their natural juices, render them to a great extent unfit for cabinet work or similar purposes; it is therefore essential that some mode of treatment will have to be devised to master these defects. All our hardwoods are charged more or less, according to class, with these natural juices, necessary to the life of the tree when growing, but which must be removed before the sawn or hewn timber can be said to be effectually seasoned. It is in the shedding of these juices that our timbers split and crack. Unfortunately the grain of our hardwoods is not continuous; were this otherwise, under favourable circumstances, there would be a possibility of devising some plan whereby the juices might be forced out of the ends of each piece, the cavities made to be replaced at the same time with some composition which would have the effect of preserving the timber.

Among the many methods tried, the process of first steaming and afterwards drying by injecting hot air into chambers specially designed seems to me to be the most likely to have the desired effect. A process similar to this is now in use in the different colonies, but its absolute success has yet to be demonstrated. A few figures showing the effect of this process on timber in its green state cannot fail to be interesting, more particularly as regards weight and size.

	GREEN.		SEASONED.	
	Weight.	Size.	Weight.	Size.
Blackwood	110 lbs.	$12\frac{1}{6} \times 2''$	52 lbs.	$11\frac{1}{2} \times 1\frac{15}{16}$
Blue Gum (*E. globulus*)	113 lbs.	$10\frac{1}{4} \times 2\frac{1}{8}''$	84 lbs.	$9\frac{7}{8} \times 1\frac{7}{8}$
Stringybark	$108\frac{1}{4}$ lbs.	$10\frac{1}{4} \times 2\frac{1}{8}''$	82 lbs.	$9\frac{7}{8} \times 1\frac{7}{8}$

These figures speak for themselves, and go to prove conclusively that providing no serious injury is done to the timbers by this process, the difficulty of excessive weight, which up to the present has stood in the way of their use for cabinet and other purposes, can to a considerable degree be overcome. I am well aware that some gentlemen, thoroughly competent to judge, contend that the process of steaming and hot air drying to a more or less degree lessens the strength of the timber, but presuming such to be the case, can we not with perfect safety sacrifice a little of this strength when such satisfactory results may otherwise be obtained? This process has not yet got beyond the extent of treating flitches no larger than say 6″ to 8″ inches thick. A chamber specially fitted up for the purpose is filled with flitches and scantling of all sizes; each piece is stacked so as to allow space between. The chamber is then charged with steam for a certain time. The effect of this is to as it were to open the pores of the skin of the timber, and the juices commence to shed rapidly, mixing with the condensed steam producing by contact with the iron-work of the chamber, a black liquid of the consistency of writing ink. When these juices cease to flow the steam is shut off. The whole of the timber in the chamber is now charged with condensed steam, which of course must be removed, and it is at this point the great difficulty presents itself. The use of the thermometer in regulating the exact degree of heat or hot air, so that the process of slowly extracting the moisture may go on day by day requires infinite care and great experience, for it should be remembered that the steaming process has already reduced the timber to a highly sensitive condition with its cells open ready to discharge. Should these cells be closed quickly by too much heat before they become thoroughly empty, the result is of course failure.

We have such a variety of different timbers, hardly any two of which require the same treatment, yet it appears to me that as soon as the question of the actual degree of heat required for each species is regulated, we may look forward to the solution of this important question, which I have reason to know is at the present time engaging the attention of one who is thoroughly in earnest in his experiments and sanguine of success. I have been shown some hardwoods treated by this process, and they leave nothing to be desired.

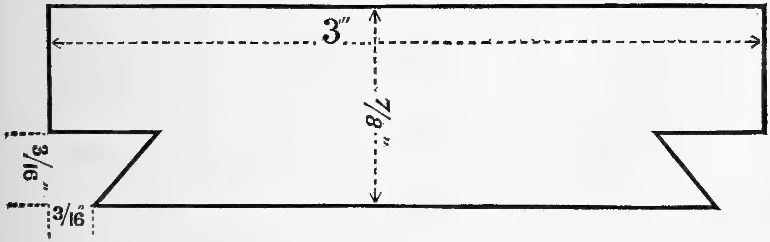
Hardwood in Parquet Flooring.

It speaks well for the enterprise of Mr. Raht, the architect for the Equitable Life Assurance Society's building now in course of erection in George Street, that he has decided to lay the parquet flooring of hardwood in lieu of imported timber. This kind of flooring, although new to the Colonies, is much in use in America.

The timber used in this instance is tallow wood, supplied by the Federal Timber Company from their Northern Mills, the quantity required being 40,000 superficial feet, and it is seasoned by the steam and hot air drying process in Victoria. We have actually to send our timbers to another colony to get them seasoned !

The tallow wood is cut into lengths not exceeding two feet and laid in squares, each piece being grooved and dressed as shown in sketch—

SECTION OF EACH PIECE.



The timber is laid on a concrete floor on heated bitumen $\frac{1}{8}$" thick. When each two pieces come together the V joint forms a dovetail which enables the bitumen to curl up and secure them together firmly. This system dispenses with the ordinary plan of nailing each board, and produces a perfect floor.

It requires ten pounds of bitumen for each square yard of flooring. The cost of bitumen in this Colony is £20 (twenty pounds) per ton. This class of flooring when complete, costs irrespective of concrete, about 12/- (twelve shillings) per square yard, but no doubt when the principle is better known and the seasoning of the timber can be satisfactorily carried out in this

Colony, the cost will be considerably reduced. There is a wide scope for many beautiful designs of inlaying different timbers, which only requires time and energy to develop.

Hardwood Timbers for use in Shipbuilding.

Ironbark.—For keels, keelsons, bilge strokes, and stringers, there is no timber to approach this. It is a remarkable fact that notwithstanding its density and hardness it can be bent into any reasonable shape when properly steamed, yet it quickly dries in its bent position retaining its valuable properties uninjured.

Blue Gum (E. saligna)—For planking of ships' bottoms etc., this timber is the most suitable.

Spotted Gum ranks next in order of merit.

Blackbutt—though sometimes used, is only a third-rate timber for this purpose, owing to its liability to split (when bent) along the gum veins.

Tea Tree is the most suitable timber for ships' timbers (knees, &c.)

Swamp Mahogany is also an excellent timber for this work; both these timbers are wonderfully durable, resisting damp, and are generally to be found perfectly sound to the last.

Swamp Oak.—The *heart* of this timber is admirably suited for ships' caulking mallets and lasts for years.

Colonial Beech is the best timber growing in the Colony for ships' decks, and is much in use.

Hewn *v.* Sawn Hardwoods.

It is a general rule for engineers and architects requiring girders with the intention of using them in what is termed fine work, that is planing and painting them before fitting them, to order sawn timber, on the ground of economy to save dressing them square to receive the plane. As a matter of fact a hewn piece of timber shews very much less disposition to crack or shell than a sawn one, and this I attribute to the closing or condensing of the outer grain, owing to the continued jarring caused by the adze or axe in the timber squarer's hands in dressing the piece to the required size. I experimented to satisfy myself on this point recently, with the result as follows: Two pieces of ironbark, twenty feet long, fourteen by ten inches, sawn, and to my knowledge from the same tree, were submitted to me; both these pieces started to shell and crack. One piece I used in the work, the other I had adzed-dressed down to size of fourteen by seven inches and then planed. The smaller piece although three inches nearer the heart remained free from blemish, while the larger piece continued to split and crack for some time afterwards. I look upon this point as one of importance, hence my referring to it.

Hardwoods Painted or Tarred.

Our timbers contain natural juices to a more or less degree (no matter what season of the year the trees are fallen), which gradually exudes from each piece along its face and at the ends while drying. It is a common practice among architects and engineers in the erection of buildings and public works to have the unseasoned timber painted or tarred, as the case may be, as quickly as possible, to prevent splitting and cracking, a process which not only serves to check the natural process of drying, but worse still, sets up an element of decay inasmuch as the juices are prevented from flowing and are transformed from a natural element into an injurious one. No green or unseasoned timber should be tarred until it becomes to some degree dry, while in planed work a coating of oil in lieu of paint will stop the splitting or cracking equally as well, and does not check the flow of the sap.

How often we see in bridges months after erection the painted members sap-stained through the weak painted places along the face, presenting an unsightly appearance.

When iron bolts are used, they should always be oiled throughout their length, otherwise the sap when it reaches the iron, produces an iron stain which eventually flows through the bolt hole, and can only be removed by scraping.

The Export of Timbers.

This is a question of great importance to the Colony, inasmuch as there is beyond any doubt a wide field in Europe and America for the introduction of our timbers. Up to the present time shipments of hardwood to Europe have resulted in financial loss. The cause of this is easily accounted for; the outside world is ignorant of their value, and people are chary of using anything they have no knowledge of.

In my opinion before any success can be achieved, it will be necessary for the Government to first publish the relative value of our different timbers, their suitability for certain works, their probable cost etc., together with all information and data available. It is well known that neither Europe, America, or Canada, have any timbers to approach ours for street blocking; also that their native woods have but a short life in public works in comparison to ours. When a market is secured it will be necessary for the State to see that only the specified timbers leave our shores, otherwise inferior varieties will be shipped and failure will unquestionably follow. This to my mind is the greatest element of danger to the future of our timber industry, which properly controlled and judicially advertised, should as far as an export trade is concerned, prove a valuable source of revenue to our Colony. The colony of New Zealand having few suitable hardwoods of their own, annually purchase large quantities of ironbark from us. I fear however, that notwithstanding the care they exercise in having each shipment inspected, they are sometimes imposed upon with inferior varieties.

Ironbarks.

Red Ironbark—(Eucalyptus sideroxylon).
White Ironbark—(E. paniculata).
Broad Leaved Ironbark—(E. siderophloia).
Narrow Leaved Ironbark—(E. crebra).

I do not purpose dealing to any great extent with the merits of these grand species of Eucalyptus. The strength, durability and general excellence of ironbarks are universally known and appreciated. Among builders, architects, and the trade generally, ironbark is commonly divided into three classes—the white, grey, and red.

White Ironbark is so called owing to its pale colour when green; it however darkens during the process of drying. In comparison with the grey and red varieties it is closer in grain and much more difficult to work.

Grey Ironbark comes to us in considerable quantities from the northern rivers, and is best known in connection with public works, particularly in the construction of large bridges. The magnificent piles, girders, etc., in lengths up to sixty and seventy feet, are mostly produced from this timber, which is more plentiful and grows to greater proportions than the other two varieties. The true white ironbark with its beautiful wavy appearance is comparatively a rare timber in the open market, but I look upon it as the most valuable of all.

Red Ironbark is likewise in great demand, but most in general building purposes. The ironbarks from the Richmond and Clarence River districts are unfortunately very free in the grain and subject to shelling in concentric rings; they are therefore not accepted to anything like the same extent as similar varieties grown elsewhere. The timber grows to large dimensions, but the ring shakes which seem peculiar to these two districts are a serious fault, and timber in both large and small sizes showing them at the ends should be avoided.

I could were it necessary, produce abundant proof of the wonderful strength and durability of this great timber, rightly called the "King of Hardwoods," but so much has already been written on the subject that further testimony is needless. I should however, like to point out one or two defects unfortunately only too common in all our ironbarks.

First the large round holes made by the larva of the wood-moth called I believe "*Eudoxyla.*" The erratic movements of this grub makes it often difficult to discover the extent of the injury to the log. It will sometimes enter a tree from the outside and not finding the timber exactly to its taste will probably bore its way for a few inches and come out again, more often, however, it bores across the grain until it reaches the heart, which it carefully avoids, and continues its course parallel for several feet when it either dies or comes out again.

The actual hole made is but little injury to the girder, the real danger lies in its touching the heart, exposing it to moisture, which begins at once to cause decay, and rot, which rapidly increases. An experienced hand can detect the rot inside a girder by the sound made with the blow of a hammer, but in ordinary cases when grub holes are to be seen, it is well to bore an auger hole through the heart close to the entrance and along the line. If no rot appears you can rely on the soundness of the piece. I have frequently seen logs quite rotten inside for several feet in length, yet no outward warning except a grub hole.

Dry limb knobs should always be carefully examined in girders containing heart; providing no rot shows in or around the knob in the generality of cases the log or piece is sound, but some unprincipled timber getters are experts at plugging what may be a very faulty stick; a blow with a hammer on the knot will quickly expose plugging, as it will move under the blow. The heart of the ironbark tree is always first to decay. It is better therefore to avoid using heart pieces when possible.

Grey Gum—*Eucalyptus saligna*, var.

This timber must not be confounded with the Blue Gum—*E. saligna.* It is a remarkably close grained, durable timber, and except as regards strength, (to which it is inferior to ironbark), it makes an admirable substitute, particularly in the erection of large beam bridges. It is very like red ironbark in general appearance, and is often substituted for it. An experienced man can however detect the difference owing to the shortness of grain. A chip of grey gum bent between the fingers will snap instantly.

The quality of this timber varies considerably like most hardwoods in different districts. I found that the best variety is found in the Hawkesbury district, particularly around Wyong and Cooranbong. Grey gum from these places have a record of thirty years in bridge members. For general building work it is hardly so suitable as some of the pale hardwoods; it is hard to plane, and and in scantling sizes subject to crack and open. As piles or girders I consider it next to ironbark and one of the best of our timbers.

TALLOW WOOD—(*Eucalyptus microcorys*).

This truly valuable timber grows to perfection along the northern rivers of this Colony, and for many descriptions of work ranks superior to ironbark. It shrinks less in drying than any other hardwood; it is very dense and close in the grain. Architects do not value this timber to the degree it merits, and this is mainly due to the fact that sawmillers are in the habit of substituting inferior timbers such as spotted gum, white stringy bark, white mahogany, and others, which to the inexperienced eye resemble the tallow wood in colour. I have frequently seen shipments of timber in Sydney ordered as tallow wood, and not containing a piece of that timber.

Tallow wood in colour ranges from a milky-white shade to a dark yellow, hence the opening to dishonest timber suppliers to subtitute other varieties of hardwoods similar to it in appearance.

In some districts such as Camden Haven and Port Macquarie, I found it almost white in colour, in fully matured trees. After the tree reaches maturity the timber commences to darken in colour, but I do not look on this fact as any detriment, except so far as the tensile strength is concerned. I am of opinion that a light coloured matured piece of tallow wood will be found to stand a greater breaking strain than a dark yellow piece of the same dimensions. The darker the timber is in colour the greater the amount of greasy substance or gum it contains. A piece burst open with an axe will disclose under the microscope numbers of minute round crystals similar in colour to the timber. After the tree reaches maturity rot invariably sets in beginning at the heart it gradually widens in a circle round it. This rot is damp, spongy to the touch, and a reddish-brown colour, where any defects exist in the tree communicating with the heart, the rot attacks them and rapidly fills the cavities.

It is unfortunately in most districts attacked more or less by a small insect or borer. The holes made by this pest are very small and round, some of them being no larger than a pin's point, hence the name "pinholes," by which they are known. To a casual observer these pinholes seem to have no injurious effect, but as a matter of fact the damage done is often very great. It is a peculiar fact and worthy of note that these borers enter and eat their way through the timber across the grain and generally at right angles, all other hardwood borers follow the grain of the timber as far as my knowledge extends. This timber is unsuitable for ship's planking and decking, even presuming it to be free of pinholes, owing to the fact that it will not hold oakum in consequence of its greasy nature.

To the architect it should possesss special attractions. It is easily worked, gives a beautiful face under the plane, does not warp or crack, and takes nails and screws readily. For flooring it stands before all other hardwoods For ballroom floors it is extensively used, generally cut not larger than four inches by one and a half inches, but it should not be laid as a floor unseasoned.

A peculiar property of this timber is that the friction of the feet in dancing causes the greasy substance to rise to the surface producing a perfect natural ballroom floor, yet in the course of a few days, if unused it returns to its natural condition.

For turned and carved work such as verandah posts, staircase handrailing, etc., it will be found superior to all other hardwoods. In the erection of road bridges it ranks next to ironbark, and has been known to stand well as girders and piles without injury for twenty years. For bridge decking it stands first; it wears well, and shrinks but little.

An enormous quantity of this timber is cut and used annually, particularly by the Public Works Department, for bridge decking, and unless the State takes some measures to protect it, before many years this magnificent species of Eucalyptus will be a thing of the past so far as this Colony is concerned. It might be advisable to warn the cabinet maker that in its unseasoned condition this timber will not take glue, in fact when quite dry it is very difficult to make a glue joint to one's perfect satisfaction.

RED MAHOGANY—(*Eucalyptus resinifera*, Sm.)

This beautiful timber is not appreciated to anything like the extent it deserves. For general building work except in beams, it should rank first in comparison with other hardwoods. It is deep red in colour, close in grain, and works readily. It rarely splits or cracks if cut from matured trees. It might be used to advantage in ornamental work, and for carved pillars and other similar works will be found to give satisfaction. It shrinks to some extent in its green state, but the shrinking is evenly distributed. It seasons quickly in sawn sizes, a commendable quality and of much importance to the builder.

It is found at its best on the northern rivers, where for house-building it is universally used. When seasoned white ants do not attack it if any other timber is within reach. I have been informed that white ants will not touch it except when green, but I have yet to see any hardwood these pests will pass by if they are pushed for sustenance except perhaps true turpentine. I saw a culvert on the northern rivers composed of blackbutt and red mahogany; the ants were plentiful in the former, and I watched them pass over the mahogany planks to the blackbutt ones, but I have little doubt however that in time when the blackbutt is destroyed they will develop a liking for the mahogany.

WHITE MAHOGANY—(*Eucalyptus triantha*, Link.)
(Syn. *E. acmenoides*, Schau.)

This timber bears no resemblance in colour to the red mahogany but is remarkably like the light coloured tallow wood; in fact it takes an experienced eye to detect any difference in the two timbers. It is often substituted for tallow wood, and unfortunately is not equal to it in durability or value. Unlike tallow wood it shrinks a good deal in seasoning, and is much more open in grain. For general purposes it should only rank as a third-class hardwood and when called upon to stand exposure should be avoided.

Swamp Mahogany—(*Eucalyptus robusta*, Sm.)

Dark red in colour, very like the red mahogany in general appearance, this timber may be classed as inferior for general building purposes and public works. In the ground and used in ship's framing it is very durable and much appreciated. Architects would however do well to avoid it.

White and Grey Box—(*Eucalyptus hemiphloia*, F.v.M.).

The study of this species of Eucalyptus is confusing, owing to the number of so called varieties met with in so many districts, all more or less inferior to the true box.

Its use is of more importance to the engineer than the architect inasmuch as it is a hard interlocked timber non-fissile in nature, and of great durability when exposed to the weather.

In Victoria a light grey coloured variety is much valued for railway sleepers and public works, bearing an excellent record for durability and tensile strength. The white box of this Colony is extremely tough and interlocked and suitable for piles, girders, etc. On the southern coast we have a pink or light red coloured timber of the same species as the white box above (*E. hemiphloia*). It is commonly called "red box," and it should take a prominent place of merit for sleepers, also railway and road bridges as soon as our ironbarks become less plentiful.

Red Box or Bastard Box—(*Tristania conferta*, R. Br.)

The darker coloured box from the northern rivers is much in use in Sydney for building purposes, being free in grain and more easily worked.

We have also a brush box coming to us from the vicinity of Cape Hawke and along the northern rivers; an inferior timber, the use of which should be avoided; it is easily recognised by its dull almost white colour when dry. In comparison with other box timbers it is very free in grain and soft.

TRUE RED BOX—(*Eucalyptus polyanthema*, Schau.)

This timber must not be confused with the pink timber of the south, known by the same vernacular name. It is found at its best in the Mudgee district, and is dark red in colour, resembling the red gum (*E. tereticornis*) somewhat in appearance when dry; very tough and interlocked it stands well in the ground, but is too hard for general building purposes. It is very durable and shrinks but little.

YELLOW BOX—(*Eucalyptus melliodora*, A. Cunn.)

Also dense and interlocked. Stands well in the ground, also when exposed to running water in culverts, etc. It is in most districts subject to concentric gum rings, making it unsuitable for piles or girders. It does not grow to any size in this Colony.

BLUE GUM AND FLOODED GUM—(*Eucalyptus saligna*, Sm.)

It will be seen that I have given this species of Eucalyptus two vernacular names. I find this necessary owing to the fact of the former being a superior timber to the latter, and in the building trade they are known as two distinct timbers, the blue gum being accepted where the flooded gum is rejected.

Blue gum is a close grained valuable timber for general house building, and is much in favour among architects. It takes the plane readily and presents a beautiful face when worked, resembling the red mahogany in appearance. It also rarely shows any disposition to split or warp after drying. The flooded gum on the other hand is short in grain, very brittle and decays quickly. The name blue gum is most unsuitable; we have two other blue gums in the colony *E. globulus* and *E. Maideni*, to neither of which it presents the slightest resemblance.

The blue gum is found throughout the northern and southern rivers as well as inland for miles, while the flooded gum seems to flourish best on the northern rivers only, particularly in the vicinity of Cape Hawke.

The flooded gum is much lighter in weight than the blue gum and floats in water in small sizes just beneath the surface, hence the name floating gum, which is sometimes given to it. I am of opinion that in furniture making, flooded gum will be found an excellent substitute for red cedar, particularly for verandah posts, table legs and similar work. I look upon it as a matter of great importance to the architect that he should guard against using flooded gum in general building work, particularly in positions where it is called upon to take any strain whatever.

SPOTTED GUM—(*Eucalyptus maculata*, Hook. f.)

Derives its vernacular name owing to the spotted appearance of its bark and is of all our hardwoods the most common in use for general building purposes; for elasticity it is almost unequalled, and is largely used on that account for spokes and shafts for vehicles. This timber has a pretty wavy appearance in grain, and is generally known by this peculiarity, but at least two varieties of our white gums possess the same wavy appearance in the grain. It is fairly free, though not entirely, from gum veins.

A very wide difference of opinion exists regarding the value of this timber for use in public works and general building purposes. By some it is contended that it decays rapidly, and is referred to as quite an inferior timber, on the other hand many people assert that it is a good timber, and I have been shown specimens which I was assured had lasted for twenty years in a house as posts. I am very diffident about making any positive statements regarding its merits, as large interests are involved in the spotted gum industry in New South Wales, and the information I have gathered is so conflicting that it is but just to all concerned that I should write reservedly.

The spotted gum of the southern rivers is much superior to that growing elsewhere throughout the Colony. I shall content myself by stating that I deem it advisable to suggest not to utilize the spotted gum of New South Wales, particularly for exporting, until definite information regarding its durability is made available.

BLACKBUTT—(*Eucalyptus pilularis*, Sm.)

This timber is best known of all our hardwoods in the Sydney market, and is generally distinguished by its gum veins which show in the log in concentric rings. It cannot however be recognized by this feature alone, as many other timbers carry gum veins, and in the Camden Haven and Port Macquarie districts it grows to maturity absolutely free of gum in many instances, and is supplied as tallow wood, which it closely resembles in colour. It is without doubt a first-class timber and deserves its popularity among architects for general building purposes. Except in decking it is rarely used in the erection of bridges owing to its disposition to crack and open, particularly in square girders. It is subject to pinholes, particularly in the fully matured timber. I have referred to the ravages of this insect in the notes on tallow wood. The northern blackbutt is much superior to the southern timber, it being cleaner and closer in grain, less gummy and more durable.

TURPENTINE—(*Syncarpia laurifolia*, Ten.)

Regarding the merits of this timber there is a wide difference of opinion. It is extensively used for piles, particularly in rivers and harbours infested with cobra. I have heard most conflicting statements as to its durability as well as its resistance to the pest. I have been shown piles years in the water untouched and uninjured, but I have also seen them in the same structure riddled. Some authorities persist in their contention that cobra will never attack true turpentine, and when confronted with a cobra-eaten piece, assert that the timber is a bastard variety. I have taken no little trouble to find out the true merits of this timber, and my enquiries and tests lead me to the following conclusions :—It is not the bark of the timber that is cobra resisting. It is a thin vein of resin between bark and sapwood ; if you remove the bark the resin is also removed, as it adheres to the latter. When bark and resin are removed cobra will attack the wood if pressed for sustenance, but only in extreme cases as the timber to a small degree is charged with resin, and is therefore objectionable to them. There are in reality two classes of turpentine : the trees growing on stony ridges and on the sides of the mountains are vastly superior in every respect to the timber found on the flats and low-lying ground. The turpentine from the northern rivers is largely composed of the inferior class and warps and twists sadly, particularly from unmatured trees.

This timber which grows in abundance between Gosford and Teralba, bears a splendid record for durability, and does not warp or twist. To architects I would strongly recommend this timber, particularly from the district mentioned above. It should never be used in sawn sizes unless cut from fully grown trees. It is easily worked, but is extremely short in grain, consequently it will not bear much breaking strain, but in all other parts of a building I can speak of it in terms of praise. Another redeeming feature of turpentine is that white ants rarely or ever touch it, green or dry. Another strong recommendation is that it will not burn, it chars but it will not ignite. If you put a turpentine log on a fire the chances are that it will go out.

River Murray Red Gum—(*Eucalyptus rostrata*, Schl.)

This timber tree grows in large quantities and to a considerable size on the banks of the Murray River; it also extends inland for some distance on the flats. It is generally to be found growing at its best on the river banks and skirting the lagoons and water courses. The late Director General of Forests took considerable interest in this timber, I cannot help thinking however, that he confounded it in quality and durability with the red gum of the adjacent colonies.

I have taken some trouble to ascertain the true value of the Murray River variety, and have no hesitation in pronouncing it a most inferior timber for use in public works as well as for general building. Comparing it only with the red gum timber of Victoria and South Australia, I attribute its inferiority to two causes: First, but only to a small degree, to climatic influence. Secondly, to its rapid growth, owing to the fact that the localities it inhabits causes it to be subject to excessive moisture, the roots and often the trunk of the tree being under water in the rainy season for two and three months at a time.

When squared it will shrink while drying one inch to the foot across the grain. The heart is to some extent actually separated from the outer wood by rings or gum veins, and in a tree of any size is more or less dead and often dozy, the result of this defect being that the heart of the tree forms a comparatively unshrinking core, and the outer wood in drying is put into a state of tension, and therefore splits along the weakest lines. The red gum of the sister colonies has a remarkable record for durability in public works, particularly in longitudinal beams in railway bridges and as sleepers, and when sawn in sizes not smaller than say ten inches by six inches, will dry or season evenly. The Murray River variety unfortunately shells badly and shrinks unevenly.

In using the timber it should never be sawn or hewn square, first because when you remove the sap-wood it is certain to split and open, and in the second place in squaring you remove the best of the timber, the heart being always weak and brittle. Sawing it into large sizes free of heart has a similar injurious effect, while in scantling sizes it not only cracks and shells, but it also warps and twists badly.

It is sometimes used in the districts adjacent to where it grows for bridge decking, but the result has been far from satisfactory. The only use I would recommend it being put to would be for round piles, and where possible, driven with the bark on to admit of the sap-wood seasoning slowly, and then only in small bridges.

RED GUM—*(E. tereticornis,* Sm.)

To be found at its best along the south coast. It is closely allied to *E. rostrata*, which it resembles. It is unfortunately soft in the heart and decays quickly. Free of heart it is a fairly good timber, but except for wheelwright's work it is not suitable for general purposes. This timber must not be confounded with the many varieties, all more or less inferior, and many useless. The architect in particular would do well to avoid all red gums for building purposes.

APPLE TREE GUM—*(Eucalyptus stuartiana,* F.v.M.)

A vicious useless timber except for rough posts, sometimes substituted for box timber, which it unfortunately resembles somewhat in its green state.

WOOLLYBUTT—*(Eucalyptus longifolia,* Link et Otto.)

A fairly useful building timber, by no means remarkable for durability, which can with safety be called a third-class hardwood.

EURABBIE OR BLUE GUM—*(Eucalyptus globulus,* Labill.)

This timber is the true *E. globulus* of Victoria and Tasmania, and is only found, so far as my knowledge extends, in the Tumberumba district of New South Wales, and is only to be seen growing at a certain altitude, viz., 2,500 to 3,000 feet above sea level. In the Tumberumba district it is valued highly and largely used in tailraces for mining purposes, also for bridge decking and girders. It is not quite so free in the grain as the Victorian variety, which opens up from the heart in a surprising manner. I have seen a round log in the Otway Forest, Victoria, twenty feet long and three feet through, split open from end to end after the first three feet of it had been entered with a circular saw.

Except in the district where it grows it is but little known in the Colony, and quite recently it fell into disrepute owing to its being mistaken for the local messmate *(E. amygdalina)*, a timber lacking strength and durability, but resembling it in colour. The name Eurabbie is purely local. I found that it does not attain anything like the size or height it is to be found in the two colonies referred to.

Blue Gum—(*Eucalyptus Maideni*, F.v.M.)

Up to a quite recent date this timber was supposed to be the true *globulus*, and received the name given to it by Baron von Mueller, owing to the Curator of our Technological Museum having discovered that although in outward appearance it closely esembled the true blue gum, yet botanically it differed.

It grows in limited patches along the southern ranges, on the ridges and sides of mountains, and is often difficult of access. Its timber is quite distinct from the *E. globulus* in colour and texture, and is mostly to be found full of gum veins, and shells sadly in small sizes. It is dark yellow in colour, remarkably tough and interlocked, and very durable. In large sizes such as squared piles and girders it bears an excellent record, particularly in the Braidwood district. For building purposes it is only suitable in large sizes, such as beams, etc.; in scantling sizes it warps and opens. When green it is easily worked but when seasoned it is almost of the consistency of bone and stands exposure well. In round piles there are few timbers to equal it in durability.

Bloodwood—(*Eucalyptus corymbosa*, Sm.)

This timber can be dismissed in a few words. In colour it ranges from a dirty white to yellow, is full of gum-pits, splits and opens badly, also shells. When green it is soft and spongy, but dries hard. Is only suitable for fencing posts, in the ground it resists white ants to a great extent, but for general purposes it is a worthless timber.

Swamp Gum Tree—(*Eucalyptus Gunnii*, Hook.)

Another worthless timber, soft and spongy, open in grain and retains moisture. I have seen it in bridge decking decay after two years. It is totally unfit for any work whatever, and should never be used under any circumstances.

Stringy Bark, Messmate, Peppermint.

I hasten to dismiss these timbers in a few words. Considering the number of valuable species at our command, these inferior eucalypts may safely stand aside except for rough work, such as palings, rails, etc., for which they are extensively used.

Mountain Ash—(*Eucalyptus Sieberiana*, F.v.M.)

This timber is best known to the wheelwright and coachbuilder, and I fail to see why it should not entirely take the place of American ash for work of this nature. It is more durable and quite equal to it in every other respect.

White Ash—(*Eucalyptus stricta*, Sieb.)

But little known in the Sydney market except for high-class furniture work. It is an expensive timber to procure owing to the fact that it is only procurable close to the Victorian border.

Mountain Gum—(*Eucalyptus goniocalyx*, F.v.M.)

This is a remarkably durable clean grained useful timber. In the Braidwood district it is very highly esteemed, and I find a record of nineteen years in bridges, perfectly sound. It also stands well in water and damp places. For general building purposes I would recommend it highly. It is, for a hardwood, easily worked, and gives a clean face to the plane. It shrinks evenly and does not split to any great extent during seasoning.

White Gums—(*Eucalyptus haemastoma*, Sm., *E. pauciflora*, Sieb. and others.)

Are to be ranked as inferior timbers and are seldom used, except in the districts where they grow, and then only for rough fencing purposes; they are of no interest to the architect, and should be religiously avoided for use in works of any description.

Ribbony Gum—(*Eucalyptus viminalis*, Labill.)

An inferior timber possessing no durability, and of no interest to architects, except to be avoided. It is sometimes called Manna

Gum. It is used extensively throughout the Colony where it grows for cheap rough fencing.

Softwoods.

I take this class of timber under one heading, as unfortunately their varieties are few in number. It is hardly a matter for surprise that all men who trade directly or indirectly in the softwoods of this Colony, should have protectionist principles. The Sydney market is flooded with imported timbers, such as pine—Oregon, Baltic, etc.—and yet our pines, beeches, etc. are in almost every way equal to the imported article. Unfortunately we cannot produce our own softwoods at as cheap a rate as we can import, and as long as such a state of things is in existence, we must be content to see our timbers take a second place and limit their uses to the districts in which they are found.

Our red cedar is so well known that it is needless to comment on its beauty and value in cabinet work. Unfortunately it is disappearing from our forests, and before many years matured trees will be a thing of the past.

Fancy, Figured and Brush Timbers.

I should very much like to devote a few pages of this paper to a detailed description of the above timbers, but at the present time all I might say regarding their merits would go for nothing, as the time is not yet ripe for their general use in cabinet or furniture work. A visit to the Technological Museum will give some idea of what this country possesses in the way of beautiful grained timbers of various colours, but so far as their practical use is concerned we are again face to face with the question of due seasoning, as in their natural state they more or less crack and warp. Our beans, rosewood, yellow-woods, sycamore, tulipwood, sassafras, and a variety of other species need but to be seen to be admired. Yet we can do but little with them until we find the way to lessen their natural weight and season them. True, there are in use a few of the open grained varieties, but only to a very small extent. Our pencil cedar, myall, rosewood, silky oak, and perhaps one or two others, are converted into furniture in Sydney, but only in very limited quantities and at a heavy cost.

As regards the brush timbers of which so little is known, I submit some specimens to give some idea of the possibility of utilizing them for cabinet work. They do not grow to large sizes in trees, but are plentiful in the Hawkesbury and northern districts, and are cheap to procure.

I conclude with an account of Cypress Pine. For many years this timber had the reputation of being ant proof, but recently this theory has been upset as several instances are known of white ants destroying it.

I find from enquiries that white ants attack this timber either growing or when fallen so far as the sap-wood and bark are concerned. They will also attack the fresh cut timber before the sap dries. There are four varieties recognised in the western district.

The black pine is a decidedly inferior timber, spongy and of no durability. The timber is dark, also the branchlets and fruit-pods, which are quite black. It decays in the ground in two years.

The white, red, and yellow varieties, as far as I can gather are of one species, the branchlets are light in colour of bark, also the fruit cones as compared with the black pine. These three distinctions are made owing to the respective colours of the lines running through the timber, but no difference exists as to their durability in works.

The black pine can be distinguished from the other varieties for weeks after it is cut, as it glistens along the face of the timber like thousands of minute diamonds. The knots of the black pine are not so large, but are much more plentiful throughout the tree; again the black pine invariably grows on the southern and western slopes of the mountains. It is also much more highly scented than the other pines when being cut.

The white, red, and yellow varieties are in great demand throughout the western district for house building. They seem to dry quickly, and have some wonderful records for durability; for example, I have a reliable record of a white pine post, twenty inches in diameter, put into the ground near Wellington, the soil infested with white ants. It was removed after thirty years and was quite sound, except sap-wood, and of the consistency and colour of iron. It is a capital timber for house building purposes, but is rarely used in Sydney, owing to the expense of bringing it so far by rail.

I failed to find a single instance recorded in the western districts where white ants attacked the timber after it was dry, and the majority of the houses etc., round the towns of Dubbo and Wellington are built of this timber. It is also forwarded for upwards of a hundred miles by rail for building purposes, and invariably gives satisfactory results as long as the black variety is not used.

ON THE STRUCTURE AND COMPOSITION OF A BASALT FROM BONDI, NEW SOUTH WALES.

By Rev. J. MILNE CURRAN, F.G.S.

[With Plates IX. - XII.]

[*Read before the Royal Society of N. S. Wales, July 4, 1894.*]

CONTENTS.

INTRODUCTION.

There is at the present time very little information available as to the microscopic structure and the chemical composition of our tertiary basalts. A glance at the geological map of New

South Wales will show what an enormous extent of country is overlain by the vast sheets of lava we term basalt, and my own observations go to show that these rocks are even more extensively developed than the latest maps indicate. We have a considerable varietv too, both in the structure and the composition of these lavas, ranging from the more basic basalts to the acidic trachytes. The physical aspect of much of the Colony is due to the distribution of basalt, and quite recently I have noted that this rock is the matrix of the sapphire found so widely over the New England tablelands. Having made some notes on our basalts during the past few years I venture to place before the Royal Society some of the results obtained.

In this first paper I propose to deal with a basalt from Bondi, near Sydney, intrusive in the Hawkesbury Sandstone. There is very little of the undecomposed rock visible, but the physical effects of its intrusion and its proximity to Sydney are matters of interest.

Previous Observers.

The first reference I find to a basalt near Sydney, is contained in a paper by the late Rev. W. B. Clarke, on the "Transmutation of rocks in Australasia," read to the Philosophical Society of New South Wales, on the 10th of May, 1865.* Mr. Clarke refers to the basalt as part of a dyke which he traced "from the mouth of Lane Cove, through the Greenwich isthmus, on the other side, and so into a dyke of similar character at Point Piper, and into the sea, very near to the occurrence of the Meriveri columnar sandstone and dyke of basalt a distance of six geographical miles."†

There can be no question as to the identity of Meriveri with the locality I refer to, that is the country around the north shore of Bondi Bay. The name Meriveri has dropped out of usage, and I will refer to the same rocks and place as Bondi sandstone and basalt. Mr. Clarke deals with the basalt merely as the agent

* Transactions of the Philosophical Society of New South Wales, 1862 – 1865, page 294.

† *Loc. cit.*, page 298.

"transmuting" the sandstones, and so giving rise to the very remarkable columnar sandstone seen hereabouts. (*Plate* 9, fig. 2.)

I can find only one other reference to the rock I am dealing with. Professor David writes, that "The basalt here forms an irregular mass surrounded and intermixed with shattered fragments of Hawkesbury Sandstone, and of an intercalated bed of carbonaceous shale. The mass is in places about a chain wide and several chains in length, and sends off horizontal sheets and vertical dykes into the surrounding sandstone." There is a drawing illustrating the intrusive nature of the basalt with Professor David's paper.*

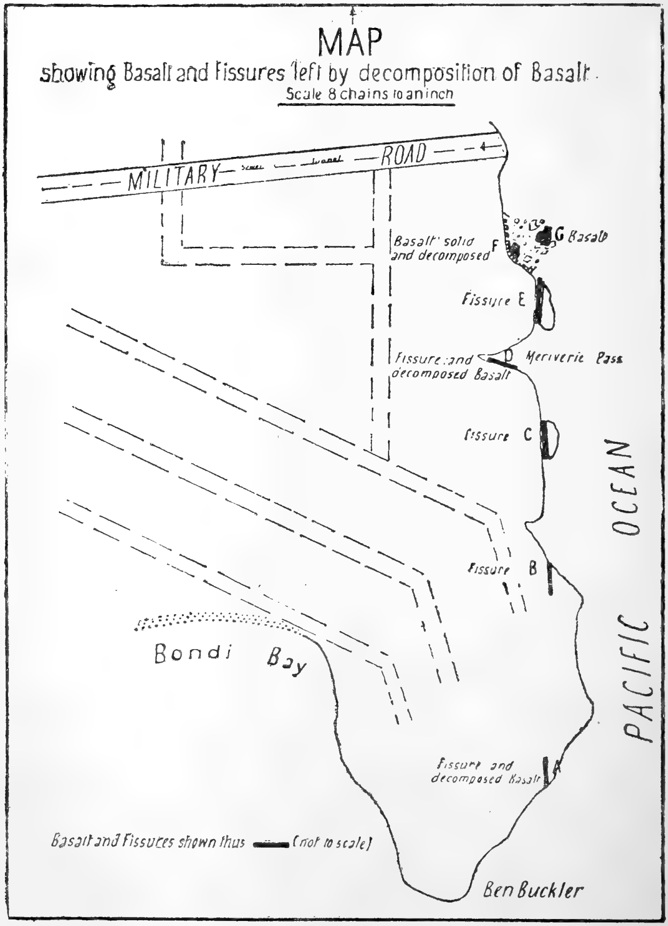
Locality and Occurrence.

The Bondi basalt occurs as part of a dyke intrusive in the Hawkesbury Sandstone on the coast to the east of the city of Sydney. As a land mark the ventilating shaft of the Bondi main sewer is easily found. Close by is a quarry of columnar sandstone. From the floor of this quarry a winding path leads down to the base of the cliffs and to sea level. To the right of this path, some fifty feet from the top, undecomposed basalt may be found. Part of the path is cut through the same basalt, decomposed and altered to a grey, soft, and when wet, pasty rock. A few chains south, a deep and narrow fissure can be seen cutting a mass of sandstone away from the mainland. There is no doubt but this and similar fissures here about are left as the walls of previously existing dykes of basalt.

A second fissure is noted (marked D. on map), running in a north-westerly direction, and still retaining some decomposed basalt in situ. Further south is a third fissure, (C. on the map attached). *Plate* 9, fig. 1, is a photograph of this fissure, taken from a point at sea level, which may be reached through the Meriveri Pass. The photograph shows basalt filling the lower part of the fissure, but now soft and decomposed. Still further

* "Notes on some Points of Basalt Eruption in New South Wales," by T. W. Edgeworth David, B.A., F.G.S.—Geological Society of Australasia Vol. I., part i., page 25, Melbourne 1886.

south there are two other fissures—five in all—that unmistakably show they were once filled with basalt. These are shown as **A.** and B. on the sketch map. The former retains portions of the decomposed basalt as an unctuous or soapy-grey and yellowish mass, with amygdules of decomposition products. At this point some very bright green colours seen in the decomposed rock were proved to be due to traces of chromium, which chemical analysis show the rock contains.



At the date of writing, undecomposed basalt could be found in two places only, in the vicinity of these dykes and fissures—the projecting knob of basalt already referred to, on the path down the cliff, and on a point of rock standing above the sea in calm weather, a few chains from the mainland, and marked G. on the sketch map. The small amount of undecomposed basalt remaining is noteworthy, as continued operations at the quarry may hide the little that there is completely from view. But even should the last traces of the basalt proper be lost, the fissures, the decomposed rock filling them in part, and the prismatic sandstone will point unmistakably to the proximity of masses of basalt.

The Bondi basalt dykes have, it is evident, been one of the factors in the shaping of the present coast line. In my opinion there are two separate intrusions, but not necessarily of different ages. The fissures at A. B. C. and E. (see sketch map) are all belonging to a dyke which cut through the sandstones in a north and southerly direction. Besides the dyke running north and south there exists a dyke as described above by the Rev. W. B. Clarke, coming from the direction of Greenwich, and of which the basalts at D. and G. are branches.

The most notable feature of the locality is the columnar sandstone as shown in *Plate* 9, fig. 2. This structure was no doubt induced by the proximity of the igneous rock. Some of the sandstones, that were in contact with the molten basalt, show very little trace of metamorphism, while in other parts the same sandstones are rendered quartzose in texture and prismatic in structure. No very clear relation can now be made out between the more extreme examples of metamorphism and any special massing of the igneous rock. But denudation has so affected the locality that, at this date it is practically impossible to say whether the basalt may not have almost surrounded the masses that show the columnar structure so perfectly.

Macroscopic Examination.

In hand specimens, the Bondi rock is a blue-black dense rock, that rings under the hammer. The texture is compact, and to the unaided eye, a fine glistening structure is the only indication of its varied constituents. A hand-lens will show an occasional porphyritic mineral not more than half a millimetre long. On slicing the rock these prove to be olivines or augites. It decomposes to a light grey crust as seen in the specimens exhibited. This by the further removal of its more soluble constituents becomes the soapy stiff rock in appearance, not unlike fuller's earth, that fills the fissures already referred to. The light grey colour of the decomposed crust is somewhat remarkable, as the rock contains 13% of ferrous and ferric oxide—quite as high a percentage as many basalts have that weather to a bright red clay. A polished slab of the rock is etched with more than ordinary rapidly by hydrochloric acid. The polished slab is almost black. When acted on by the acid it shows a light grey ground with the unattacked minerals standing out as black granules. Its specific gravity is 2·94, a density somewhat above typical basalt.

Magnetic Properties.

The appearance of the etched surface suggested trying the effect of a magnet on the rock. A thin bar of the basalt, five millimetres long was cut, and I found that a magnet lifted the bar readily. A second bar was cut and mounted as a magnetic needle. Permanent polarity was induced in this by placing it between the poles of an electro-magnet, with the result that the needle of rock became sensitive to opposite poles of a magnet. It is too heavy to respond to the directive influence of the earth's magnetism, but on subjecting the whole apparatus to a gentle vibratory motion the bar will set north and south.

Chemical Composition.

The peculiar colour of the weathered basalt that was immediately around the fresh rock, suggested the determination of its solubility in acids; ·5 gram of finely powdered basalt was digested in dilute hydrochloric acid for two and a-half hours, then it was heated with strong acid for one and a-half hours, with the result that ·218 gram remained insoluble. This gives 56·4 per cent. of the rock as soluble in hydrochloric acid.

A fresh portion of the powder was ground to the finest possible condition, in an agate mortar, moistened with water and just covered with strong hydrochloric acid in a small watch glass. In six hours the whole mass had gelatinised rigidly at the ordinary temperature of the laboratory 65 – 70 F. The mass was just covered with water and let stand for forty-eight hours. The edges of the gelatinised silica then showed under the microscope, numbers of cubes of sodium chloride—far in excess of what one should expect, even if all the felspars were completely decomposed by the acid. A drop of strong hydrochloric acid was placed on a polished slab of the basalt. In two hours the acid had become rigid and gelatinous and showed cubes of sodium chloride under the microscope. A portion of the finely powdered rock was digested for half an hour with acetic acid, hydrochloric acid added to the filtered solution, and on evaporating on a glass slide cubes of sodium chloride were formed in abundance.

In order to guard against the possibility of the sodium chloride being contained in the rock as an impurity, derived from its proximity to the sea I determined the presence of chlorine in four separate samples of the basalt, in the manner recommended by Messrs. Fouqué and Lévy.* A gram of the basalt was powdered and ground in an agate mortar, washed well on a filter with boiling water, and then acted on by nitric acid. The acid was evaporated to dryness to render the silica insoluble, and taken up with water, on the addition of silver nitrate a precipitate of chloride of silver forms immediately.

There can be no question then as to the presence of chlorine and some easily soluble soda bearing mineral in the Bondi basalt.

The soda minerals found in basalt are—soda felspars, nepheline, hauyne and nosean, and analcime as a secondary product.

The soda felspars do not gelatinise with acids, and certainly are not rapidly soluble in weak hydrochloric acid or acetic acid. So

* Minéralogie Micrographique, p. 449.

we cannot consider the felspars the source of the soda that crystallises as sodium chloride.

Nepheline if present would certainly answer to the tests just stated, but a microscopic examination of the rock shows that the mineral so readily soluble is isotropic. Certain minute clear six-sided forms can be found under high powers in every slide, but this mineral too is isotropic, and so far as I could observe no trace of the uniaxial figure that nepheline would show, can be seen.

Hauyne is excluded, as barium chloride gives no reaction in a hydrochloric acid solution of the soluble portion of the rock.

We have then an isotropic, and an easily soluble soda-bearing mineral in a rock that gives a reaction for chlorine and contains no sulphuric acid, evidence that points to the presence of sodalite in this rock.

Some of the powdered basalt was gently warmed in weak hydrochloric acid (one part of acid to ten of water) for two hours. The solution was then evaporated to dryness, and repeatedly moistened and almost dried alternately for two days. Well formed crystals of sodium chloride were then visible. The whole was transferred to a glass slide, the surplus acid removed by introducing the edge of a filter-paper. The crystals were then dried on the slide moistened with turpentine and mounted in balsam. *Plate* II, fig. 1, is a micro-photograph of the slide. Fig. 2 shows cubes of Na Cl obtained by etching a square inch of surface of polished basalt. The face of the slab was just covered with a few drops of strong hydrochloric acid. This was moistened again with acid as it had gelatinised in three hours. The whole was transferred to a glass slide, and after standing two days was photographed. The figure shows the Na Cl cubes just as they appeared in the strong acid, × 30 diameters.

A complete analysis of the basalt was next made in duplicate, and three separate determinations of the soda were made, all giving practically the same result.

Analysis of Bondi Basalt.

	Fresh undecomposed Basalt.	Decomposed Basalt filling fissures.
Silica	43·5	... 42·0
Alumina	14·60	... 40·2
Ferric oxide	5·40	... trace
Ferrous oxide	8·28	
Lime	8·70	... nil
Magnesia	6·16	... nil
Soda	7·34	... 4·4
Potash	2·95	... 1·6
Titanic oxide	·10	
Phosphoric oxide	trace	
Chromic oxide	trace	... trace
Chlorine	·37	
Water	2·50	... 12·00
	99·90	100·2

Specific gravity 2·94.

As one would have expected from the preliminary examination of the rock, the notable feature of the analysis is the large per centage of soda. I have already stated my reasons for believing the rock contains sodalite. An analysis of the decomposed basalt is also given, where it will be noted that iron, lime and magnesia have been extracted completely by natural weathering.

If we assume that the soda and chlorine found are present as sodalite, we may calculate the soda required for sodalite based on the amount of chlorine present. The mineral sodalite requires from 4·6% of chlorine (minimum) to 7·3% chlorine (maximum). Chlorine found in basalt = ·37%. ·37% of chlorine represents a maximum of 8% of sodalite in the Bondi rock.

The total soda combined with silica and chlorine, as sodalite is 29·9%,* from this we can calculate that the total soda in the soda-

* Haughton and Hull—Report on the Chemical, Mineralogical, and Microscopic Characters of the Lavas of Vesuvius—Trans. Roy. Ir. Acad., Vol. xxvi., page 51.

lite of our basalt, = 1·92 per cent. The total soda as shown by the analysis, equals 7·34%, so that there is still 5·42 per cent. of soda to be allotted to other minerals in the rock. Even if the felspars are soda-lime plagioclase, they cannot use up 5·42 per cent. of soda, for the microscope shows that these felspars are not particularly plentiful in the rock; on the contrary, the use of a quartz plate shows a considerable amount of glassy base. It is not unreasonable to suppose that some soda unaccounted for may exist as a constituent of the residual glassy base. I may add that there is nothing in the appearance of the augites to connect them with the soda-pyroxenes. It only remains to decide whether the soda may not be due to analcime, a soda-bearing mineral common in basalts. After a persistent search I failed to find analcime in any of the slices or portions of the rock selected for analysis. The slides all show a well preserved rock with the olivines fresh but broken and cracked, and only the smaller crystals are altered to serpentine. Analcime may be present in more decomposed portions of the mass; my samples were taken from very fresh looking rock, showing in thin slices nothing that can be identified as a zeolite. Besides, the presence of chlorine supports the view I have already taken.

Microscopic Structure.

The general structure of the rock under the microscope may be described as micro-porphyritic, with practically no traces of flow in the disposition of the felspars. The amount of base present is somewhat in excess. Much of the latter is isotropic, or so feebly double refracting as to be undeterminable. The minerals which occur micro-porphyritically in the base are, olivine, augite, plagioclase, aggregates of magnetite and sodalite. The olivine crystals are abundant on every slide, and only occasionally showing alteration into serpentine. The large individuals are idiomorphic, but rarely perfect; they are for the most part broken and the parts separated. Cubes of magnetite are common as inclusions. The peculiar way wedge-shaped masses penetrate the olivine crystals is really characteristic of all the slices made.

On *Plate* 10, fig. 2, a large olivine is seen penetrated in this way. The larger olivines show a disposition to develop in lath-shaped forms rather than in forms familiar in basalts. Some of the crystals will occasionally measure one-twelfth of an inch.

The augite in the slides is abundant and characteristic. Idiomorphic crystals can be seen, measuring from the one-twenty-fifth to the one-twelfth of an inch. They show a warm brown border which fades towards the centre of the crystals. A faint pleochroism is noticeable, but not in every augite on a slide. *Plate* 10, fig. 1 shows an augite in the centre of the field.

Plagioclase is not so well defined and distinct as in ordinary types of our tertiary basalts, neither is it so abundant. Perfect lath-shaped crystals are not common. There is no difficulty however in identifying them, as they are the first to catch the eye and give character to the rock in thin slices.

The magnetite can be seen on every slide. It is a common inclusion in the olivine and augite, and may be seen forming a fringe or line around the faces of these minerals. A reddish colouration is sometimes seen in the neighbourhood of the magnetite, evidently due to an incipient alteration of the magnetite. As a rule magnetite is seen in crystals, but also forms irregularly shaped patches. It was one of the first minerals crystallized out of the magma.

Besides occurring in porphyritic forms the minerals named are also found as granules imbedded in the base. Microliths of apatite can also be found in most of the slices as an inclusion in other minerals.

There is another mineral not determined in this basalt. It is seen in minute six-sided forms measuring not more than the one seven hundredth to the one thousandth of an inch in diameter. The mineral is clear and colourless. It may be a hexagonal or a cubical mineral. It is absolutely isotropic, showing no light between crossed nicols. If a hexagonal mineral it should show an axial figure in convergent polarized light, but unfortunately no apparatus at my command will show interference figures in so small a crystal. Mr. Smeeth suggests that it may be microsomite.

Mica can also be recognised in the ground mass of most slices. It occurs in small blades and irregular plates. The blades are strongly dichroic. They can be detected by rapidly rotating the lower nicol of the microscope.

Scattered through the micro-crystalline base perfectly clear and isotropic patches are noted. These are absolutely isotropic. Fine needle-like bodies shoot through this clear mass, but without affecting its isotropic character. This is a soda bearing, and is most probably sodalite. It might be described as a glass and a portion of the base, but on a careful examination it will be seen as a mineral clearly separate from the base, and in no instance merging into it. It is soluble in cold hydrochloric acid. The acid acts on it without effervescence. If a portion of a cover glass is removed and a second cover glass arranged so as to form a cell that may be filled with acid, the action can be noted under the microscope. A few bubbles of gas are given off from parts of the slide but not from the soda mineral. This latter disappears gradually, sometimes canals are developed as it goes into solution but giving no clue to any crystalline structure. After treatment with acid the whole surface has a muddy and dull appearance; even in polished slabs this action of cold hydrochloric acid is remarkable. The acid always shows cubes of sodium chloride on evaporating to a syrupy consistency. The easiest method of viewing the abundance of sodium chloride crystals formed by acting on this rock with hydrochloric acid is as follows: Grind one gram of the basalt in an agate mortar, just moisten with water and then cover with strong hydrochloric acid; after standing overnight (without warming) the acid will have gelatinized; add some weak acid, filter and evaporate to the volume of say two or three drachms; then further evaporate on a watch glass, at lowest temperature practicable, when the cubical crystals will appear, and if the evaporation is conducted slowly enough, of a size visible without a lens. (See *Plate* 11.)

The rapidly gelatinising character of the rock may also be seen by reducing a gram to fine powder, and covering it with about twice its own volume of hydrochloric acid in a test tube. The mass will set solid in the test tube.

A polished slab of the basalt shows the effect of hydrochloric acid rapidly, the black of the polished surface altering to a light grey uniformly. If it was a zeolitic product, such as analcime, in the slab that yielded so readily to the acid, the grey and affected portion would most likely show in patches, whereas we find the whole surface attacked around the porphyritic and insoluble constituents. The mineral so affected is not a zeolitic product, but rather a constituent very evenly distributed through the rock.

I have cut thirty thin slices of the basalt. Under the microscope they vary very little in structure. A description of two slides will be fairly descriptive of the microscopic structure of the whole.

Slide No. 206.—Micro-porphyritic structure, pronounced olivine forms the largest individuals, measuring up to the one-fiftieth of an inch. They are for the most part only portions of larger crystals; some show a few idiomorphic faces, the others being lost by corrosion of the liquid magma. The fractured and broken condition of the larger olivines is due to mechanical causes that acted while the rock was yet plastic. They contain inclusions of the ground mass, and in two instances are broken in parts, and wedge-shaped masses of the base penetrate the crystals to their centres. Blades of brown mica occur interstitially. The augites show a few good examples of zoned structure, and lines of secondary growth, which latter are marked by lines of magnetite crystals along the former faces. There is a remarkable mosaic aggregate of augite microlites, the whole surrounded by a line of magnetite grains. The triclinic felspar laths are seen lying along the faces of micro-porphyritic ingredients in a rudely parallel fashion. This does not amount in character to a decided "flow" structure. The feldspar laths measure on an average the one-hundredth of an inch in length. The undetermined six-sided mineral already referred to, is plentiful, a section being visible on every field of the slide. It is seen in the ground mass, and in one instance as an inclusion in an augite crystal. Magnetite is abundant, evenly distributed over the slide, and showing a disposition to group itself around the augites and olivines. The clear soda mineral is seen as a primary constituent, in many cases felspar laths penetrating it. It alters to a cloudy grey sub-granular substance, but not in the least resembling the devitrification of a glassy base.

Slide No. 209.—The augites here attract attention by their reddish-brown tint, which increases in depth towards the faces of the crystals. The more strongly coloured augites are somewhat dichroic. Both augites and olivines are well preserved and fresh looking. Just along the cracks of the latter a light green serpentinous product may be noted, but only in one instance is a small olivine altered into serpentine. The larger olivines are shattered and bent, while very many of the smaller crystals are idiomorphic. Magnetite is more plentiful in this slide.

As to the age of this basalt there are no data to go on to form an opinion. It is of course newer than the Hawkesbury Sandstone, into which it is intruded. It may be as old as the newer Mesozoic rocks, or as recent as the Eocene basalts of the Colony, and was probably *in situ* before the shaping of the present coast-line.

Conclusion.

The basalt occurring as a dyke at Bondi contains a high percentage of soda. The soda bearing mineral of the basalt is isotropic and gelatinizes with cold hydrochloric acid. As there is chlorine in the rock and no sulphuric acid, the mineral is most probably sodalite. The hydrochloric acid solution of the rock gives abundant cubes of sodium chloride on slowly evaporating. Based on the chlorine present, it is found that there is a surplus of soda, after allowing for sodalite and soda felspars. It is probable that some soda exists as a constituent of the residual basis.

There are two igneous dykes at Bondi, one including the fissures running north and south, a second along a line coming seawards from the direction of Greenwich. The basalt contains traces of chromium.

A needle of the basalt is susceptible of permanent magnetism, and when swung freely will act as a magnetic needle.

Explanation of Plates.

Plate IX.

Fig. 1.—View of a fissure left by the decomposition of a previously existing dyke, Bondi. The lower portion of the fissure is filled with decomposed basalt. The figure shows characteristic weathering of the Hawkesbury Sandstone. From a photograph by the author.

Fig. 2.—Prismatic or columnar sandstone, Bondi. The columnar structure was induced by the intrusion of the heated igneous dyke. The columns are about one foot in diameter. From a photograph by author.

Plate X.

Fig. 1.—Microscopic structure of Bondi basalt. The porphyritic figure in the centre of the field is an augite.

Fig. 2.—Microscopic structure of Bondi basalt. The centre of the field shows an olivine crystal, penetrated by a bent wedge-shaped intrusion of the ground mass. From micro-photographs by the author; both figures magnified 30 diameters.

Plate XI.

Fig. 1.—Crystals of sodium chloride formed in a weak hydrochloric solution of soluble portion of Bondi basalt. Magnified 35 diameters.

Fig. 2.—Sodium chloride crystals, magnified 35 diameters, formed by etching one square inch of Bondi basalt with strong hydrochloric acid. Figures from micro-photographs by the author.

Plate XII.

Fig. 1.—Twin of olivine, magnified 30 diameters.

Fig. 2.—Corroded olivine, some of the faces are idiomorphic. The other faces have been attacked by the molten magma, magnified 30 diameters.

Fig. 3.—Olivine with glassy inclusions.

Fig. 4.—Six sided mineral not identified. Probably microsomite, magnified 500 diameters.

Fig. 5.—Corroded augite, magnified 30 diameters.

Fig. 6.—Characteristic olivine, magnified 30 diameters.

Fig. 7.—Augite showing a secondary growth, in which is embraced a lath of felspar, magnified 40 diameters.

Fig. 8.—Zoned augite, magnified 35 diameters.

Fig. 9.—Broken crystals of olivine, magnified 40 diameters.

Fig. 10.—Secondary growth in an augite crystal, magnified 40 diameters

Fig. 11.—Streaming of felspars around olivine, magnified 45 diameters.

NOTES ON SOME AUSTRALASIAN AND OTHER STONE IMPLEMENTS.

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[With Plates XIII. - XXXVI.]

[*Read before the Royal Society of N. S. Wales, December 5, 1892.*]

THE implements, referred to in the following notes, form a comparative series from the Australasian Colonies, with the exception of South and Western Australia.

All the specimens, with but one exception have been obtained directly from the natives themselves, or from the localities formerly occupied by them, many of them have been personally and expressly procured for me by friends, to whom I have much pleasure in tendering my thanks for their kind assistance. The exception referred to is that from Niagara bought from a dealer at the Falls, but I have no reason to doubt its authenticity.

Some of the specimens described are not figured, as they do not differ sufficiently from others from the same locality, to warrant the cost of extra plates. All of the figures are somewhat reduced in size, and some of them considerably, the true dimensions however are given in the text.

For comparison, representative forms from New Britain, New Guinea and other Oceanic localities are added; there is also one from Java, which is of the New Zealand type, *i.e.*, with a chisel edge or bevelled on one side only, and one from Niagara Falls District, America, obtained by me there in 1887, which is included because it bears a remarkable resemblance to some of the New South Wales specimens, especially to No. 2 from Botany, New South Wales.

I do not consider it necessary to describe the specimens minutely, as I trust that the figures will give sufficiently correct idea of their shapes and sizes.

Professor David kindly assisted me in identifying the rocks of which they are composed, and I am particularly indebted to him for his assistance in the case of Nos. 9, 10, 11, 12, and 13, from Bondi, *i.e.*, those composed of a spotted altered claystone, which he recognised as being the same material as that of some implements from Vegetable Creek, described by him in the Journal of the Linnean Society of N. S. Wales.

Wherever necessary, chips were taken from the implements and converted into slides and examined under the microscope.

The pebbles of spotted altered claystone, from which many of the weapons have been made, were probably brought from the old river bed cut through by the road and railway at Lapstone Hill, Emu Plains; the source of this rock is not known.

The minute pits in the surfaces of the older implements made of the spotted altered claystone, are evidently caused by the removal of the "spots" by weathering. The weathering and pitting on some of the weapons indicate considerable antiquity, and especially where such weathering exists on the cutting edge. The effects of wear are quite different, and they cannot be mistaken for those of weathering.

In some cases the implements, *e.g.*, No. 8, (*Plate* 13.) have evidently been etched or corroded by wind borne sand.

Nos. 24 and 25 (*Plate* 33.) serve to show the method of mounting the weapons in vines, which is much the same as that used by blacksmiths at the present day for mounting or holding chisels and punches.

I do not give references to the literature of the subject, as the recent publications by Mr. R. Etheridge, Jun., in the Memoirs of the Geological Survey of New South Wales, the Linnean Society of New South Wales, and elsewhere, render it unnecessary for me to do so here.

Most of the implements from Sans Souci and Bondi were obtained by me from the few blacks who, some twenty years ago, used to camp at these places.

Native Implements.

1.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

Of dolerite; the cutting edge is fairly well ground, but the haft or upper part is merely roughly chipped into shape. Weight 1lb. $12\frac{1}{4}$ ozs. Dimensions $5\frac{1}{4}'' \times 3\frac{3}{16}'' \times 1\frac{7}{8}''$. (*Plate* 13.)

2.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

Of diorite; the whole of this has been worked into shape, except the top end; in general make and appearance it is very like No. 68, from Niagara, America. Weight 1lb. $1\frac{1}{4}$ oz. Dimensions $4\frac{3}{8}'' \times 2\frac{3}{8}'' \times 1\frac{5}{8}''$. (*Plate* 14.)

3.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

A flat pebble of spotted altered claystone, with ground edge. Weight $12\frac{1}{4}$ ozs. Dimensions $4\frac{9}{16}'' \times 2\frac{5}{8}'' \times 1\frac{1}{8}''$. (*Plate* 14.)

4.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

Of spotted altered claystone; much worn. The cutting edge of this is so blunted as to be practically non-existent. Dimensions $4\frac{1}{16}'' \times 3\frac{3}{8}'' \times 1''$.

5.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

Of spotted altered claystone; an attempt has been made to form thumb and finger pits. One side has been flattened, as if it had been rubbed down on a rock or used as a rubber or grinder; from the appearance of the ground surface this seems to be of much more recent origin than the implement itself; probably it was used as a grinder after it had become useless as a tomahawk. This is not well shown in the plate. Weight $13\frac{1}{4}$ ozs. Dimensions $4\frac{11}{16}'' \times 3\frac{3}{8}'' \times 1\frac{1}{8}''$. (*Plate* 15.)

6.—Tomahawk. The Blacks' Camp, Sans Souci, Botany, N.S.W.

Of spotted altered claystone; the shape is unusual, it is apparently merely a flat pebble with a ground cutting edge at one end. Weight 12 ozs. Dimensions $4'' \times 2\frac{3}{4}'' \times 1\frac{1}{4}''$. (*Plate* 16.)

7.—TOMAHAWK. The Blacks' Camp, Sans Souci, Botany, N.S.W. Of spotted altered claystone; edge much worn and blunted, roughly formed finger pit on one side; evidently old and weathered. Weight 13 ozs. Dimensions $4\frac{3}{16}'' \times 2\frac{1}{8}'' \times 1\frac{5}{16}''$.

8.—TOMAHAWK. The Blacks' Camp, Sans Souci, Botany, N.S.W. Of spotted altered claystone; much pitted, of smaller size and thinner than usual; the cutting edge is in fairly good order, but, like the rest of the implement, is much pitted from the action of wind blown sand or weathering. Weight $4\frac{3}{4}$ ozs. Dimensions $3\frac{9}{16}'' \times 2\frac{1}{8}'' \times \frac{5}{8}''$. (*Plate* 13.)

9.—TOMAHAWK. From the Sandhills, Bondi, near Sydney, N.S.W. Of dark quartzite. The cutting edge is in fairly good order; there is a finger pit on one side, this pit is just above the figure 9 on the implement, but it does not show well in the plate, and is apparently of comparatively recent date. Weight $10\frac{1}{2}$ ozs. Dimensions $3\frac{3}{4} \times 2\frac{7}{8}'' \times 1\frac{1}{16}''$. (*Plate* 17.)

10.—TOMAHAWK. From the Sandhills, Bondi, near Sydney, N.S.W. Of spotted altered claystone. Evidently a flat pebble ground to a cutting edge at one end. Weight 1lb. $5\frac{1}{2}$ ozs. Dimensions $4\frac{1}{2}'' \times 3\frac{9}{16}'' \times 1\frac{7}{16}''$. (*Plate* 18.)

11.—TOMAHAWK. From the Sandhills, Bondi, near Sydney, N.S.W. Of spotted altered claystone; old and much weathered or corroded by wind borne sand, even on the cutting edge; with thumb and finger pits on both sides. Weight $7\frac{3}{4}$ ozs. Dimensions $3\frac{3}{16}'' \times 2\frac{15}{16}'' \times 1\frac{1}{16}''$. (*Plate* 16.)

12.—TOMAHAWK. From the Sandhills, Bondi, near Sydney, N.S.W. Of spotted altered claystone, which is rather more schistose than some of the preceding. Old and weathered or corroded by wind borne sand. Outline of implement more rectangular than usual, cutting edge in fairly good order but much pitted from weathering. Weight $7\frac{1}{2}$ ozs. Dimensions $3\frac{1}{2}'' \times 2\frac{11}{16}'' \times \frac{3}{4}''$. (*Plate* 19.)

13.—CIRCULAR STONE IMPLEMENT. Bondi, near Sydney, N.S.W.

Of quartzite; with deep thumb pit on one side and shallow one on the other; this was originally a tomahawk which has evidently been used as a hand hammer (*i.e.*, without a handle) until the original cutting edge has been entirely worn away. Weight $7\frac{3}{4}$ ozs. Dimensions $2\frac{13}{16}'' \times 2\frac{1}{2}'' \times \frac{15}{16}$ to $1\frac{3}{8}''$. (*Plate* 19.)

14.—TOMAHAWK. Uralla, New England District, N. S. Wales.

Indurated black claystone. Cutting edge in fairly good order; the upper part is merely roughly chipped into shape. Weight 12 ozs. Dimensions $4\frac{7}{16}'' \times 2\frac{3}{16} \times 1\frac{1}{2}''$. (*Plate* 18.)

15.—TOMAHAWK. Uralla, New England District, N.S.W.

Basalt; weathered to a brown colour, even on cutting edge, hence the implement is doubtless of considerable age. The original dark colour of the basalt is shown by the freshly fractured surfaces. This, together with the other Uralla specimens, was obtained by Mr. Cleghorne, J.P., of Uralla, and presented to me by him. Weight $8\frac{1}{4}$ ozs. Dimensions $3\frac{5}{8}'' \times 2\frac{11}{16}'' \times 1''$. (*Plate* 19.)

16.—TOMAHAWK. Victoria Park, near the University, Sydney, N. S. Wales.

An elongated pebble of the spotted altered claystone; worn and blunted at both ends; it is very much heavier and larger than usual; it was turned up in trenching the ground of Victoria Park, near the University, the soil of which is derived from a patch of the Waianamatta shale. Weight 4 lbs. 7 ozs. Dimensions $9\frac{1}{8}'' \times 2\frac{15}{16}'' \times 2\frac{1}{4}''$.

17.—TOMAHAWK. Fairfield, Southern Railway Line, eighteen miles from Sydney, N. S. Wales.

A large flattened pebble of spotted altered claystone; of unusual size and weight; the cutting edge in very good order; this in common with Nos. 16, 18, 19, and 20, was dug up from a clay soil, free from stones or pebbles, derived from the Waianamatta Shale. Weight 4 lbs. 9 ozs. Dimensions $9\frac{11}{16}'' \times 4\frac{1}{16}'' \times 1\frac{1}{8}''$ to $1\frac{7}{16}''$ (*Plate* 20.)

18.—TOMAHAWK. Fairfield, as above.

Of spotted altered claystone; this is a pebble ground down at one end; the cutting edge is almost obliterated. Weight 1 lb. 7 ozs. Dimensions $4\frac{7}{16}'' \times 3\frac{1}{2}'' \times 1\frac{3}{4}''$.

19.—TOMAHAWK. Fairfield, as above.

Of spotted altered claystone. A flat pebble ground to an edge, much weathered; the weathered skin is about $\frac{1}{8}''$ deep. Weight 1 lb. $4\frac{1}{2}$ ozs. Dimensions $5'' \times 3\frac{1}{4}'' \times 1\frac{1}{4}''$. (*Plate* 17.)

20.—TOMAHAWK. Fairfield, as above.

Of spotted altered claystone. This was evidently a rounded pebble which has been split in half longitudinally. Much weathered, the original structure of the rock is shown by the chip from the upper left hand corner. Weight 11 ozs. Dimensions $4\frac{1}{4}'' \times 3\frac{7}{16}'' \times \frac{7}{8}''$.

21.—TOMAHAWK. Long Bay, near Sydney, N. S. Wales.

Of weathered spotted altered claystone; with finger and thumb pits; the cutting edge in fairly good order but pitted from weathering. Weight $14\frac{3}{4}$ ozs. Dimensions $4\frac{5}{16}'' \times 3\frac{1}{16}'' \times 1''$.

22.—TOMAHAWK. Uralla, New England District, N. S. Wales.

Of black indurated claystone. An unusual form, being elliptical in section and much more symmetrical and highly finished than is usual with the New South Wales aboriginal implements. Weight 1 lb. $8\frac{3}{4}$ ozs. Dimensions $5\frac{3}{8}'' \times 2\frac{5}{8}'' \times 2\frac{1}{8}''$. (*Plate* 15.)

23.—TOMAHAWK. Metung, Gippsland Lakes, Victoria.

Of mica schist; cutting edge much blunted and weathered. Weight 1 lb. $1\frac{1}{2}$ ozs. Dimensions $6\frac{3}{16}'' \times 2\frac{1}{2}'' \times 1\frac{7}{16}''$. (*Plate* 21.)

24.—MOUNTED TOMAHAWK. From Queensland near the borders of N. S. Wales.

Of diorite; this is mounted in the original vine handle but without gum or resin, the vine is cut away as usual, to a flat surface inside, *i.e.*, next to the stone head. This example is very much like a modern steel tomahawk in form; the groove for the vine handle, which passes completely round it, is unusual. The vine handle is nearly new, but the tomahawk itself is an old one. Weight 1 lb. $4\frac{1}{2}$ ozs. Dimensions $5\frac{1}{8}'' \times 3\frac{11}{16}'' \times 1\frac{1}{16}''$. (*Plate* 22.)

25.—TOMAHAWK. Tarampa, Queensland.

Basalt; mounted in vine handle with cement made of native bee's wax. This implement was actually in use amongst the few remaining members of the Tarampa tribe at the time of my visit in December, 1872; and was obtained personally from the head-man or so called "King." Weight 15 ozs. Dimensions $4\frac{3}{4}'' \times 3'' \times 1\frac{5}{16}''$. Handle about fourteen inches long, also thinned flat inside where it comes in contact with the stone head. (*Plate* 33.)

26.—CHISEL. Mount Bulloo, Queensland. (Mount Bulloo is situated about 28° S. latitude and 143° E. longitude.)

The cutting edge consists of a chipped piece of flint or chert mounted in a handle seventeen inches long, with what appears to be a mixture of native bee's wax and grass-tree gum (*Xanthorrhea*). This chisel was in use by the blacks in 1874, and was obtained for me by Mr. Vincent Dowling; I had been informed that flint and chert were never used by the Australian aborigines, but as I had seen flint or chert gravels in Queensland, I felt sure that it must be used by them, so at my request Mr. Dowling kindly made search amongst the blacks in his district and was successful in obtaining this interesting flint chisel. Diameter of stick $1\frac{1}{16}''$ to $1\frac{3}{16}''$, total length $17\frac{5}{8}''$. (*Plates* 22 and 23.)

27.—TOMAHAWK. Mount Bulloo, Queensland.

Of green jasper; polished, well formed. Obtained by Mr. J. de V. Lamb from the Mount Bulloo blacks about 1870. Weight $6\frac{3}{4}$ ozs. Dimensions $2\frac{7}{8}'' \times 2\frac{13}{16}'' \times 1\frac{1}{4}''$ (*Plate* 21.)

28.—TOMAHAWK. Mount Bulloo, Queensland.

Of diorite: small but well formed. Obtained about the same date. Weight $3\frac{3}{4}$ ozs. Dimensions $2\frac{3}{16}'' \times 2'' \times 1''$. (*Plate* 22.)

29.—"BORA STONE." Cape River Diggings, Oxley Creek Queensland.

Of quartzite. Said to be used for knocking out the front teeth at the "Bora" ceremony, This is an egg-shaped pebble and probably selected by the blacks on account of its remarkably symmetrical form. Weight $4\frac{1}{2}$ ozs. Dimensions $2\frac{3}{16}''$ $\times 1\frac{11}{16}'' \times 1\frac{1}{2}''$. (*Plate* 23.)

30.—ADZE. New Zealand.

Of diorite; this has a distinct haft or handle worked out of the solid stone, it is symmetrical in form and highly finished. Weight 2 ℔s. $13\frac{1}{2}$ ozs. Dimensions $9\frac{5}{8}'' \times 2\frac{1}{2}'' \times 2\frac{3}{16}''$. (*Plate* 24.)

31.—ADZE. Otepepo, Hokianga River, New Zealand.

Of chloritic felstone. Polished; the upper part is curved out so as to form a handle; well formed and smooth with a dull polished surface. Weight 2 ℔s. 5 ozs. Dimensions $7\frac{11}{16}'' \times 2\frac{7}{16}'' \times 1\frac{13}{16}''$. (*Plate* 25.)

32.—PATU. New Zealand.

Of schistose rock. A Moriori war-implement; much worn and weathered. The Morioris were the original inhabitants of New Zealand, who preceded the Maoris. Weight 1 ℔. $11\frac{3}{4}$ ozs. Dimensions $8\frac{9}{16}'' \times 5\frac{15}{16}'' \times 1\frac{1}{4}''$.

33.—TOMAHAWK. Ploughed up on Mr. J. Webster's property at Tammatawiwi, Hokianga River, New Zealand.

Of trachyte; cutting edge somewhat blunted. This, although very ancient, has the narrow sides at right angles to the faces or broad sides, a characteristic of the modern New Zealand adzes. Weight 1 ℔. $6\frac{3}{4}$ ozs. Dimensions $5\frac{3}{8}''$ $\times 3\frac{1}{8}'' \times 1\frac{3}{16}''$.

34.—TOMAHAWK. Ploughed up on Mr. John Webster's property as above, at Tammatawiwi, together with Nos. 38, 39, 42, and 44.

Of diorite; old and much weathered. To ascertain the depth of the weathering, I broke this implement across, and found that the decomposition had penetrated almost to the centre, as is shown by the lines of differently coloured material; hence the implement is probably very old and may date back to the Moriori times. The weathering contour lines (internal) follow the outer external form, (See *Plate* 25, but very imperfectly shown in the plate), which is artificial, *i.e.*, the implement is not a pebble which has had an edge put to it as in some of the New South Wales specimens, in which case the internal weathering might not indicate so much, an old weathered pebble would hardly however be selected to grind into a tomahawk. Weight 1 lb. $2\frac{1}{2}$ ozs. Dimensions $5\frac{5}{16}''$ $\times 2\frac{11}{16}'' \times 1\frac{3}{8}''$. (*Plates* 25 and 26.)

35.—TOMAHAWK. Ploughed up at Tammatawiwi, as above.

Of basalt; weathered to a grey colour; the cutting edge is in very good order considering the weathering which the weapon has undergone. Weight 1lb. $2\frac{3}{4}$ ozs. Dimensions $4\frac{1}{2}'' \times 2\frac{1}{4}'' \times 2\frac{1}{4}''$. (*Plate* 27.)

36.—TOMAHAWK. New Zealand.

Made of "greenstone," jade or pounamu, well finished and polished. Both faces about equally bevelled at the cutting edge. Weight 13 ozs. Dimensions $5\frac{5}{8}'' \times 2\frac{1}{2}'' \times \frac{13}{16}''$. (*Plate* 27.)

37.—TOMAHAWK. Kaiapoi, Gnahati Pa, New Zealand.

Made of jade or nephrite, polished; only one side is bevelled off to form the cutting edge, which, therefore, resembles an ordinary chisel for wood working. Weight $8\frac{3}{4}$ ozs. Dimensions $4\frac{15}{16}'' \times 2\frac{3}{8}'' \times \frac{13}{16}''$.

38.—TOMAHAWK. Tammatawiwi, New Zealand.

Hornblende-granite. Well finished, and with good cutting edge made with one bevel, like the edge of a wood chisel. Weight $11\frac{1}{4}$ ozs. Dimensions $4\frac{1}{2}'' \times 2\frac{5}{8}'' \times \frac{3}{4}''$. (*Plate* 28.)

39.—TOMAHAWK. Ploughed up at Tammatawiwi, New Zealand.

Of fine grained andesite. Rather roughly formed; edge with a single chisel-bevel. A piece has been broken out on one side. Weight 10 ozs. Dimensions $4\frac{7}{8}'' \times 2\frac{1}{4}'' \times 1''$.

40.—TOMAHAWK. Wairoa, North Island, New Zealand.

Of gritty argillyte, with chisel edge. Dimensions $3\frac{3}{4}'' \times 1\frac{11}{16}'' \times \frac{13}{16}''$. (*Plate* 28.)

41.—TOMAHAWK. Chatham Island, New Zealand.

Of andesite; with chisel edge, of Moriori make. Dimensions $3\frac{7}{8}'' \times 1\frac{11}{16}'' \times \frac{9}{16}''$. (*Plate* 26.)

42.—TOMAHAWK. Tammatawiwi, New Zealand.

Of gritty argillyte. Of smaller size than usual, with sharp chisel edge. Weight $2\frac{1}{2}$ ozs. Dimensions $3\frac{3}{8}''$ x $1\frac{1}{8}''$ x $\frac{5}{8}''$. (*Plate* 28.)

43.—FRAGMENT OF TOMAHAWK. Moa Hunter's Camp, South Rakaia, New Zealand.

Andesite. Weight 13 ozs. Dimensions $4\frac{1}{16}''$ x $2\frac{1}{4}''$ x $\frac{5}{8}''$.

44.—CHISEL FOR CARVING. Hokianga, New Zealand.

Of jade, "Greenstone" or pounamu. (*Plate* 25.)

44A.—SPLIT PEBBLE SCRAPER. Moa Hunter's Camp, South Rakaia, New Zealand.

Dimensions $3\frac{13}{16}''$ x $3\frac{1}{16}''$ x $\frac{9}{16}''$.

44B.—OBSIDIAN OR TUHUA. Found by Mr. J. Webster on the Sandhills opposite Tammatawiwi, Hokianga, New Zealand. Brought from the south part of the Northern Island for making knives.

44C.—OBSIDIAN CHIPS (6). Moa Hunter's Camp, South Rakaia, New Zealand.

45.—TOMAHAWK. Louisade Islands, New Guinea.

Of diorite; well formed, originally this was apparently smooth or polished from end to end. It is weathered and pitted by the removal of felspar crystals, and is therefore of some antiquity. Weight 1 lb. $13\frac{1}{2}$ ozs. Dimensions $7''$ x $2\frac{5}{8}''$ x $1\frac{3}{4}''$. (*Plate* 29.)

46.—TOMAHAWK. Louisade Islands, New Guinea.

Nos. 46 to 50 are apparently composed of an indurated diabase tuff, and were, together with Nos. 45, 52, and 53, collected by Dr. McKinlay of H.M.S. "Swinger," in 1885 and presented to me by him. The upper part has not been worked smooth but only chipped into shape. Weight 1 ℔. $4\frac{3}{4}$ ozs. Dimensions $7\frac{1}{8}''$ x $3\frac{7}{16}''$ x $1\frac{1}{4}''$. (*Plate* 30.)

The New Guinea and New Britain adzes have the sides sloped or rounded off, and not squared off at right angles to the faces like those from New Zealand.

47.—TOMAHAWK. Louisade Islands, New Guinea.

This has been shaped and smoothed from end to end, and is a handsome well formed weapon, although the plate does not convey that impression. Weight 1 ℔. $0\frac{3}{4}$ ozs. Dimensions $6\frac{3}{4}''$ x $3\frac{11}{16}''$ x $1\frac{5}{16}''$. (*Plate* 31.)

48.—TOMAHAWK. Louisade Islands, New Guinea.

The larger chip-pits have not been removed by grinding, which has been done in the case of some of the others. Weight 1 ℔. 12 ozs. Dimensions $6\frac{3}{4}''$ x $3\frac{5}{16}''$ x $1\frac{1}{2}''$.

49.—TOMAHAWK. Louisade Islands, New Guinea.

This has been worked more or less smooth from end to end. The same applies to Nos. 50 and 51. Weight 1 ℔. 6 ozs. Dimensions $6\frac{7}{8}''$ x $3\frac{5}{16}''$ x $1\frac{1}{4}''$.

50.—TOMAHAWK. Louisade Islands, New Guinea.

Weight 1 ℔. $0\frac{3}{4}$ oz. Dimensions $5\frac{5}{8}''$ x $3\frac{1}{8}''$ x $1\frac{3}{16}''$.

51.—TOMAHAWK. Louisade Islands, New Guinea.

Probably an indurated pyritous trachyte tuff. Weight $15\frac{1}{2}$ ozs. Dimensions $5\frac{3}{8}''$ x $3\frac{9}{16}''$ x 1″.

52.—TOMAHAWK. Louisade Islands, New Guinea.

Of diorite. This is somewhat weathered or sand worn. Weight $3\frac{3}{4}$ ozs. Dimensions $3\frac{1}{8}''$ x $2\frac{1}{16}''$ x $\frac{9}{16}''$. (*Plate* 29.)

53.—TOMAHAWK. Louisade Islands, New Guinea.

Probably an indurated diabase tuff. The edge of this is very keen. Weight $1\frac{1}{2}$ ozs. Dimensions $2\frac{5}{16}''$ x $1\frac{13}{16}''$ x $\frac{7}{16}''$. (*Plate* 30.)

54.—Omitted.

All of the following from New Britain were collected by and presented to me by the Rev. G. Brown.

55.—Tomahawk. New Britain.

An indurated volcanic ash. The cutting edge is broken or chipped. Weight 10 ozs. Dimensions $4\frac{3}{4}''$ x $2\frac{7}{16}''$ x $1''$. The form of the New Britain adze is very similar to those from New Zealand.

56.—Tomahawk. New Britain.

Of lava. Weight 5 ozs. Dimensions $3\frac{7}{8}''$ x $2\frac{3}{16}''$ x $\frac{13}{16}''$.

57.—Tomahawk. New Britain.

Of indurated ash; apparently sand worn. Weight $5\frac{1}{2}$ ozs. Dimensions $3\frac{7}{8}''$ x $2''$ x $\frac{3}{4}''$. (*Plate* 32.)

58.—Tomahawk. New Britain.

Weight $4\frac{3}{4}$ ozs. Dimensions $3\frac{5}{8}''$ x $2\frac{1}{16}''$ x $\frac{13}{16}''$.

59.—Tomahawk. New Britain.

Weight 3 ozs. Dimensions $3\frac{3}{16}''$ x $1\frac{9}{16}$ x $\frac{3}{4}''$. (*Plate* 32.)

60.—Tomahawk. New Britain.

Of lava. Weight $1\frac{1}{2}$ oz. Dimensions $2\frac{3}{4}''$ x $1\frac{5}{8}''$ x $\frac{7}{16}''$.

61.—Tomahawk (unmounted). Fiji Islands.

Of andesite. Nos. 62, 63, and 64 are probably composed of the same rock. The shaft or body of this adze (and Nos. 62, 63, 64) is almost cylindrical, with an elliptical section near the cutting edge. Weight 1 ℔. $4\frac{1}{2}$ ozs. Dimensions $8\frac{3}{4}''$ x $1\frac{5}{8}''$ x $1\frac{1}{2}''$. (*Plate* 34.)

62.—Tomahawk. Fiji Islands.

Mounted in a crook handle and secured by cocoa nut fibre sinnett. Weight 1 ℔. $4\frac{1}{4}$ ozs. Wooden handle 17″ long, 1 to 2″ diameter. (*Plate* 33.)

63.—Tomahawk. Fiji Islands.

Mounted in handle. Weight 1 ℔. $14\frac{3}{4}$ ozs. The wooden handle is $13\frac{1}{2}''$ long, 1 to $1\frac{5}{8}''$ diameter, and is free from any crook, the stone head meets the end of the handle and the two are firmly bound in position by the sinnett, this mode of mounting is far inferior to that of No. 62 on the same plate. (*Plate* 33.)

64.—TOMAHAWK. Fiji Islands.

Mounted in handle. Weight 1 lb. $7\frac{1}{2}$ ozs. Wooden handle $14\frac{5}{8}''$ long, 1 to $1\frac{1}{2}''$ diameter.

65.—TOMAHAWK. New Britain.

Made of shell. Weight $12\frac{3}{4}$ ozs. Dimensions $5\frac{3}{8}''$ x $2\frac{11}{16}''$ x $\frac{1}{4}$ to $\frac{3}{4}''$. (*Plate* 36.)

66.—CHISEL. Probably mounted and used as a chisel or gouge. Guadalcanar Island, Eastern Solomons.

Worked smooth from end to end and tapered, the cutting edge is a single bevel, sharp and extremely well formed. Weight $10\frac{3}{4}$ ozs. Dimensions $7\frac{3}{8}''$ x $2\frac{13}{16}''$ x $\frac{7}{8}''$. (*Plate* 32.)

67.—TOMAHAWK. South Seas.

Jade; of a roughly triangular outline, one edge, probably the working one, is sharper than the others. Weight $6\frac{3}{4}$ ozs. Dimensions $3\frac{9}{16}''$ x $3\frac{1}{4}''$ x $\frac{3}{4}''$. (*Plate* 31.)

68.—TOMAHAWK. Niagara Falls District, U.S.A.

Of garnet schist. This, together with No. 69 from Java, is placed with this collection for comparison; the American one does not differ very materially in form from some of the Australian adzes, and the Javanese one is closely alled to the New Zealand forms. Weight $7\frac{1}{2}$ ozs. Dimensions $3''$ x $2\frac{3}{16}''$ x $1\frac{1}{8}''$.

69.—TOMAHAWK. Java.

Of spotted flesh coloured jasper. The cutting edge is chisel like but with two steps to the bevel—not shown in the plate—and somewhat similar to that of the New Zealand adzes. The sides are also finished off at approximately right angle to the body, this is another characteristic of the New Zealand adzes, both Maori and Moriori. Dimensions $3\frac{1}{16}''$ x $1\frac{7}{16}''$ x $\frac{7}{16}''$. (*Plate* 30.)

70.—Hammer or Old Worn-Out Adze. Coalbaggie Creek, New South Wales.

71.—Chipped Flint or Chert. Tasmania.

The Tasmanian examples are merely roughly chipped to cutting edges and show no traces of grinding or smoothing.

72.—Chipped Implement resembling a spear head. Tasmania. Chert. (*Plate* 35.)

73.—Chipped Implement. Tasmania. Chert. (*Plate* 35.)

74.—Chipped Implement. Tasmania.

Nos. 70 to 75 were collected in 1892 by Mr. Alexander Morton, F.L.S., Curator of the Tasmanian Museum.

CURRENT PAPERS.

By H. C. Russell, B.A., C.M.G., F.R.S.

[With Plate XXXVII.]

[*Read before the Royal Society of N. S. Wales, October 3, 1894.*]

I hope the members will understand that I do not claim, that the collection of current papers is new or original; it has been a common practice for fifty years, and an occasional one for some centuries; but in those very early days it was resorted to more for the purpose of sending a last dying message to friends than for the purpose of seeing which way the currents set, which has been the main purpose for the last fifty years.

Some twelve years ago, I began to collect these papers, and later, in 1888, I determined to get some printed and distributed with the view of encouraging the use of them, and if possible throwing some light upon our coastal currents. Some of those who have been kind enough to assist by setting these papers afloat, have been in the habit of doing it regularly between Sydney and

London, and as a consequence papers have come back to me from Burmah, Ceylon, Maldive Islands, from near Perim, from the north coast of Africa at Tunis, and from the south coast of England; but I wish to night to confine our attention to those nearer home. The total number of papers I have collected is forty-three, of these seventeen were found on the south coast of Australia, Tasmania, and New Zealand, and eighteen on the east coast.

A tabular statement showing the particulars of all these is appended, and also a chart showing the localities where the more interesting ones were put into the water and where they were found. The great majority of those which have been put into the water near the coast have gone ashore close to where they were cast adrift. These have been omitted from the chart because they tend to make less distinct the positions of some of the more important ones, the majority of these are on the central parts of the east coast; and in passing it may be mentioned that the chart shows simply the start and the finish in each case, and these points are connected by the shortest possible lines. It is not intended to convey the idea that the actual tracks are known, but simply that the shortest routes indicate the general direction in which the current paper travelled. No significance is to be attached to the very different routes shown for Nos. 1 and 27, except that they are the shortest, both pass the southern coast of Tasmania. No. 1 lands at Wangarie, and No. 27 at Canterbury; but No. 1 may have gone round the south of New Zealand and made its way along the east coast, indeed that is not improbable, for during a a strong westerly gale in 1890 an iron buoy broke adrift from the east coast of Foveaux Straits, and after three years and four months it was found in Poverty Bay, having thus made its way along the whole length of the middle island and nearly all the eastern coast of the north island. The paper then which was found at Wangarie may have gone that way, although it is much longer, but the shorter route was taken in accordance with the rule laid down.

The longest route made by any of the papers was that of No. 3 which starting from a point north of Kerguelen found its way on to the west coast of New Zealand near Wellington, and the next one in length of journey, No. 37, was put into the sea in about the same latitude as No. 3, but instead of finding its way to New Zealand, it went ashore near Cape Northumberland on the coast of Victoria; obviously something, probably persistent southerly winds made it trend farther north than No. 3. No. 30 is interesting as having been picked up in mid-ocean, and instructive in that it was on the point of sinking when it was picked up; it was then so hampered by the growth of shells, weeds, etc., on the elaborate wooden cradle which had been built round the bottle, that it never could have reached the land.

South Coast.

Taking these long journey south coast current papers, it is interesting to compare their daily rates of progress:—(See *Plate* 37.)

No. 2	travelled	4·0	miles per day
„ 3	„	12·0	„
„ 27	„	9·5	„
„ 30	„	6·3	„
„ 31	„	7·0	„
„ 37	„	7·0	„
Average rate		7·6	„

As these have made their journeys at all seasons and in different years, the average rate probably has a real significance, but it is noteworthy that the two farthest south, Nos. 3 and 27 show the greatest daily progress, and it may be observed that No. 30 which had simply an ocean track, and therefore no time lost resting on a beach, before it was found, shows a smaller velocity than any of the others except No. 2; No. 40 with only a short route made but 0·5 miles per day, and No. 29 in the same region made five miles per day.

The East Coast.

On the east coast the routes are all much shorter, and as already noted there are a larger number of very short routes not put on the chart for want of space, of the twelve plotted, it is remarkable that only two travelled to the south, while seven travelled to the north, and three to the west :—

No. 4,	direction	west,	4	miles per day.
„ 5,	„	south,	11	„
„ 6,	„	north,	1	„
„ 8,	„	west,	16	„
„ 16,	„	north,	0·8	„
„ 17,	„	north,	0·7	„
„ 23,	„	north,	3·6	„
„ 24,	„	south,	6·0	„
„ 36,	„	west,	1·0	„
„ 38,	„	north,	4	„
„ 39,	„	north,	0·4	„
„ 41,	„	north,	12	„
		Average rate	5·0	„

The mean rate from the twelve is five miles a day, but the individual rates differ so widely that no great value can be attached to the mean. Separating them we find the average rate of those moving to north 3·2 miles per day; those moving to south, *i.e.*, with the prevailing current 8·5 miles per day; and for those moving west on to the coast 7 miles per day; and this is what we should expect, viz. that those moving against the prevailing current get along very slowly, while those going south made 8·5 miles per day; but the question naturally arises how do they make their way north against the prevailing southerly set at all? and especially over such long distances as some of them have travelled. It has already been stated that in connecting the starting and finishing points of these current papers by the shortest line, it is by no means intended to convey the idea that they travelled the shortest route, and from what is known of the currents on the east coast it is quite possible, nay probable, that they reached their resting place by a much longer course than that I have indicated on the chart. Take for instance, No. 23, this was thrown over in the fairway of the current setting eastward from the mainland towards New Zealand, and it may have been carried with that current and then made its way northwards until it got into the great equatorial current setting westward past New Caledonia on to the Australian coast, about Brisbane and the Tweed River district, where the paper was found. Such a journey would measure considerably over 2,000 miles and represent a daily progress of about seven miles, or the paper may have made its way northwards in the northerly current, which Lieut. C. Jeffreys observed (Sailing Directions, Vol. II., p. 204) and which runs outside the southerly current, until it reached the westerly current just referred to, and with it travelled on to the coast.

I am not prepared upon the few data to hand to say which is the more probable course. There is however another feature which has been observed by many, and was studied by Lieut. C. Jeffreys, who came to the conclusion that the coast current had a southerly set in summer only, and a northerly set in winter. Certain it is, that in all the notices of the set of the current which I have been able to collect, the strong current is found in summer only, and with one or two exceptions, setting south. No. 39 was put into the water on 15th July, 1893, just outside Sydney Heads, and in March 1894 it was found near Port Stephens, having travelled one hundred and eight miles northward along the coast. No. 41 was put into the water on July 26th, 1894, and sixteen days after was found on the coast at Little Coogee Bay, one hundred and eighty-eight miles north of the starting point. No. 16 was put into the water on April 24th 1890 just off Newcastle, and on May 5, 1891, it was found at Byron Bay, two hundred and ninety miles north of the starting point. It thus appears that all these began their passages in winter, and the one that made the most rapid rate northwards performed its journey wholly in winter. On the other hand No. 5 which travelled south-west at the rate of eleven miles per day, made its passage in March and first five days of April; and No. 24, which made six miles a day south, started on May 16th and finished on June 11th. So that it would appear that a current paper may go north or south in winter for reasons which are so far not apparent.

It is however a remarkable fact that of the twelve papers which came on shore on the east coast seven made northing decidedly; three made westing, and only two decidedly southing. I do not propose to draw conclusions from such a small number of records, they are interesting and instructive so far as they go, and will I hope, induce masters of ships trading to Australia to help in the distribution of current papers, which will without doubt throw much light upon the question of currents on our coasts.

If instead of forty-three papers we had four hundred and thirty, a number we may readily get, if all those most interested—the masters of ships trading to Australia—would take the matter up and distribute current papers regularly, we should then have something to base conclusions upon that would be valuable.

In the following tabular statement particulars of current papers will be found in a condensed form. It will be observed that nine or twenty-one per cent. were put into the sea near the land and made their way to the shore in a few days,—these have not been plotted on the chart; fourteen on the south coast have been plotted, and twelve on the east coast, and eight others were found in places out side the chart, making a total of forty-three. The majority of these current papers have been found in good order after their voyages, and there is but little of special interest to record.

No. 1 was six years and seven months on its journey, and then only travelled eighteen hundred and eighty miles, while No. 3 covered five thousand one hundred miles in less than one-fifth of the time. When found the bottle was incrusted with barnacles but otherwise in sound condition, although the paper within it had in part decayed.

No. 30 is the only one picked up at sea. It was one of a series that Captain Orr of the s.s. *Port Caroline* put over at 1000 miles intervals between the Cape of Good Hope and Australia. The bottles were carefully fitted into specially prepared wooden floats, so that the bottles would be protected on a rocky coast. When crossing the Australian Bight it was found by Captain Blackmore of the *Scottish Dales*, who noticed that the float was held together by copper bands, and he was thereby induced to lower a boat and pick it up. Barnacles were growing over the float, and a lead weight underneath was covered with large shells; it was Captain Blackmore's opinion that in another month it must have sunk owing to the weight of the things growing on it.

It will be useful to give here some reports of the rate and direction of the currents on our coast made by ships coming into Sydney harbour:—

Extract of log of the barque *John Knox*, from Lyttleton to Sydney, 1873:—"Feb. 26, arrived off Sydney Heads in the evening in thick rainy weather. Rain ceased 11 p.m., wind veered to west very light, at midnight got a glimpse of Sydney light bearing S.W. five miles. Feb. 27, still very thick, ship heading N.W., and going about one and a half knots all night; daylight calm with thick fog, 7 a.m. fog cleared, and found the ship off Botany, fourteen and a half miles south of Sydney Heads, we are drifting to south at the rate of about four miles an hour; 10 a.m. a fresh breeze from N., stood off until 4 p.m. then tacked towards the land; made the land at 10 p.m. off Wollongong forty miles south of Sydney, again tacked to eastward, became calm at midnight, Feb. 28, 4 a.m. light northerly wind, ship heading E.N.E. and going about six knots, tacked ship occasionally throughout the day; at 6 p.m. saw Point Perpendicular bearing west twenty-five miles, eighty-four miles south of Sydney. March 1st, 10 a.m. a fresh southerly wind sprung up and ship got into Sydney Heads 7 a.m. March 2nd."

Decr. 31, 1888.—During the past three or four weeks every ship boarded by the *Herald's* shipping reporter mentioned a very strong southerly current off the coast. One fine iron ship from Melbourne to Sydney was abreast of the heads on Dec. 30, and on January 1st, found herself twenty miles south of the heads, although tacking with a N.E. wind all the time, the wind being strong during the day.

On 26th January, 1889, the chief mate of the *Rodondo* said the current is now runing three or four knots to south, and that he always found it strongest in January and February.

March 2, 1889, *Herald* reports that the ship *Patriarch* on her voyage for several successive days sailed three hundred to three hundred and forty-eight miles, but when she got on the coast of New South Wales passed the Jervis Bay light-house three times, having been driven back twice by a current running to south at the rate of three knots per hour.

Dec. 31, 1889, *Herald* reports *Jean Pierre* a well known trader between Adelaide and Newcastle, left Adelaide Dec. 17th, on the 25th; when off Wollongong a strong current met her running at the rate of three knots per hour, and carried the vessel back sixty miles in twenty-four hours.

Ulrica, Feb. 18 and 19, 1890, found a current setting to south at rate of two and a half miles per hour, and this was confirmed by other ships.

Feb. 20, 1892, Captain Creer of the Pilot schooner at Sydney Heads says the current is setting to the south at fully three knots per hour.

Oceana, passing Jervis Bay 7 a.m. Feb. 21, 1892, reported unusually strong current setting to south; no particulars given.

January 20, 1894, the *Hilda*, a large schooner carrying timber on the coast, reports that on her voyage from Bellinger River to Sydney January 3 to 19, met with strong southerly gales, three times made Seal Rocks and was twice beaten back by gales, and "an unusually strong *northerly* current helped to retard her progress."

Herald, March 26 and 27, 1894, reports estimate the current at two and a half to four knots per hour to south, a schooner was seen in the offing from South Head Signal Station on Friday morning, and with a light head wind went steadily and quickly down the coast with the current, so quickly, that by Sunday afternoon nothing could be seen of her from the lookout station. On 26th a large tree two miles off the heads was seen drifting by at a speed that looked like four knots. Light winds were blowing and all the small craft that left the heads went rapidly to south.

S.S. *Port Pirie*, reports that on the 26th March, 1891, in from 134° to about 140° east longitude and 45° S. he met with the current setting to the westward instead of the opposite direction, and what was even more remarkable was the high temperature of the sea (quite smooth at the time), the thermometer recording a temperature of 60° to 65°. Coming round the coast towards Sydney the *Port Pirie* met with a current setting to the southward like a sluice. Captain Dulling states that in order to save the daylight for arriving he pushed the ship hard. The speed by the engines showed eleven to twelve knots, but the observations proved that all she was doing was from seven and a half to eight knots. Captain Dulling has a theory that the extraordinary temperature just mentioned to the westward of Tasmania, is probably due to this remarkably strong stream of warm water running to the southward and being carried to the westward round the south coast of Tasmania. Southerly set on east coast by log and observation of three and a half to four knots.

A correspondent in the *Herald* of March 29th, 1894, writes:—"It may not be uninteresting and prossibly useful in shipping circles to mention that my boat was moored east from Miss Jenkins's house, Long Reef, one mile off, in seven fathoms, and while watching two yachts passing east of us, the second yacht came west very suddenly, about 2 p.m., and very shortly after this a body of discoloured water was noticed approaching at a great pace. On this water reaching the boat she bobbed about like a cork in the surf, and it was not long before she was off right in shore, for half a mile, when the kellick fortunately caught and gave the occupants time to think what was to be done to prevent going on to the reef running north from the shore end of Long Reef. Efforts were made to pull up the kellick, and after this sculling as well, to assist in lifting the anchor, but without gaining an inch. Finally, after an hour's holding on, the kellick was slipped, and sculling north as quickly as possible the reef was cleared. The current from east to west, dead inshore for one mile or so, lasted to within fifty yards of the sandy beach. The facts mentioned prove an inshore current on the north side of Long Reef at times. It would be well to rember this when coupled with the wrecking of the steamer *Collaroy*, and later on the *Duckenfield* at about the same spot."

On October 10, 1894, *The Gleaner* schooner, from New Zealand arrived in sight of the Heads at 5 a.m. She was then about fifteen miles to the east. Had the light breeze that brought her in sight of the heads held for a couple of hours longer she would have concluded the voyage, but it fell light, and the strongly southerly set of the current carried her helplessly to leeward down the coast. At dark she was eighteen miles south of Sydney Heads, the wind then fresh from the N.E. Another instance cropped up off Newcastle. On March 23rd, a three-masted schooner, evidently beating to the northward, was off Nobbys. She was well handled, making every inch to windward possible, but, with a current variously reckoned at from two to three knots against her, was badly handicapped. Standing off shore at dusk nothing was seen of her until next morning at 9 o'clock, when the signalman at Newcastle caught sight of her, twelve miles south of the port.

I cannot let this opportunity pass without expressing very warmly my thanks to all who hve taken part in this work and distributed the current papers, what they have done as shown by this record is a very valuable beginning, small though it is. My part in the matter has been a very small one, simply putting the facts together as they come to me as the result of the labour of others; but I must claim a great interest in the work and a confidence that by continuing the distribution of current papers we shall learn a great deal more about important ocean currents than we know now, and find it most useful. I hope therefore that all the ocean going vessels trading between here and other parts of the world will take the matter up systematically and we shall soon see a considerable accession to our knowledge of ocean currents on the coast of Australia and in neighbouring seas.

OCEAN CURRENTS.

Ref. No.	Date when put into the sea.	Name of Ship.	Name.	Thrown over. Lat. ° ′	Thrown over. Long. ° ′	Where Found. Lat. ° ′	Where Found. Long. ° ′	Date when found.	Locality.	Inter-val. Days.	Shortest dist. btw. points in miles.	Rate per day, miles.	Ref. No.
1	July 19-83	Ship "Deveron"	Master...	43 30 S.	147 13 E.	35 55 S.	174 30 E.	Feb. 11-90	South Coast.	2,397	1,880	0·8	1
2	Feb. 15-86	Ship "Bismarck"	— Ascher, Master	41 17 S.	111 57 E.	34 36 S.	172 48 E.	May 4-88	,,	808	3,300	4	2
3	Novr. 3-87	Barque "Luna"	Master...	45 5 S.	71 10 E.	40 26 S.	175 14 E.	Decr. 26-88	,,	418	5,100	12	3
4	Novr. 8-87	Ketch "Index"	W. E. Langley, owner ...	33 20 S.	152 55 E.	32 49 S.	152 9 E.	Nov. 26-87	East Coast.	18	70	4	4
5	March 9-88	Ketch "Index"	W. E. Langley, owner ...	32 44 S.	154 22 E.	35 39 S.	150 12 E.	April 5-88	,,	29	313	11	5
6	May 28-89	H.I.G.M.S. "Sophie" ...	Lieut. Z. V. Bachen ...	35 53 S.	163 40 E.	28 40 S.	153 30 E.	Feb. 11-91	,,	623	700	1	6
7	Octr. 9-89	H.M.S. "Calliope" ...	A. C. Evans, Chaplain ...	26 35 S.	153 23 E.	26 24 S.	154 0 E.	Novr. 6-89	,,	28	...	...	7
8	Novr. 9-89	Schooner "Mary Ogilvie"	Wm. Powell, Master ...	33 31 S.	153 40 E.	33 55 S.	151 13 E.	Novr. 17-89	,,	9	142	16	8
9	Novr. 12-89	R.M.S. "Orizaba"	G. N. Conlan, Commander	7 38 N.	76 6 E.	6 43 N.	73 6 E.	Jany. 12-90	India	61	206	3·5	9
10	Novr. 17-89	Steamship "Namoi" ...	W. H. Knowles, Master ...	33 0 S.	151 44 E.	33 0 S.	151 40 E.	Decr. 17-89	East Coast	30	...	...	10
11	Novr. 29-89	Ship "George Thompson"	J. Barneson, Master ...	32 48 S.	152 23 E.	33 38 S.	151 14 E.	Decr. 17-89	,,	19	90	5	11
12	Decr. 11-89	Steamship "Lubra" ...	R. E. Mannigel, Master ...	33 0 S.	151 43 E.	33 0 S.	151 40 E.	Decr. 14-89	,,	2	...	...	12
13	Decr. 25-89	Steamship "Menmuir" ...	S. G. Green, Master ...	38 31 S.	141 45 E.	38 22 S.	142 12 E.	Decr. 29-89	South Coast	4	30	8	13
14	Decr. 27-89	Steamship "Menmuir" ...	S. G. Green, Master ...	36 0 S.	150 20 E.	35 45 S.	150 12 E.	Decr. 29-89	East Coast	2	20	10	14
15	Jan. 30-90	Steamship "Australasian"	Alex. Simpson, Master ...	34 52 S.	151 1 E.	34 19 S.	150 58 E.	Feb. 26-90	,,	27	33	1·2	15
16	April 24-90	Brig "Peerless"	W. H. Heays, Master ...	33 10 S.	152 0 E.	28 34 S.	153 34 E.	May 5-91	,,	375	290	0·8	16
17	Octr. 19-90	Steamship "Australasian"	Alex. Simpson, Master ...	37 39 S.	156 0 E.	31 40 S.	159 0 E.	Aug. 12-92	,,	662	440	0·7	17
18	Decr. 14-90	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	38 27 S.	141 12 E.	37 54 S.	140 23 E.	Decr. 25-90	South Coast	11	90	8	18
19	Decr. 21-90	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	35 20 S.	117 34 E.	34 30 S.	119 15 E.	Decr. 23-91	,,	367	112	0·3	19
20	Jany. 2-91	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	8 36 N.	71 14 E.	21 0 N.	92 30 E.	May 20-92	Burmah	503	1,800	3·5	20
21	Jany. 7-91	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	12 36 N.	45 47 E.	12 43 N.	43 27 E.	Jany. 17-91	Arabia	10	310	31	21
22	Jany. 22-91	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	49 20 N.	5 20 W.	50 34 N.	2 25 W.	Feb. 8-91	Eng. Channel	17	...	...	22
23	Mar. 11-91	H.I.M.S. "Saida"	Lieut. Florios	40 18 S.	157 39 E.	28 0 S.	153 20 E.	Feb. 10-92	East Coast	336	1,200	3·6	23
24	May 16-91	Ship "George Thompson"	A. G. Ransom, Master ...	32 13 S.	153 23 E.	33 44 S.	151 16 E.	June 11-91	,,	26	156	6	24
25	June 8-91	Ship "George Thompson"	A. G. Ransom, Master ...	4 34 N.	160 54 E.	5 0 N.	168 40 E.	July 23-91	North Pacific	45	506	11·2	25
26	June 21-91	Steamship "Arcadia" ...	J. M. Purves, Esq.... ...	39 0 S.	142 33 E.	41 35 S.	144 55 E.	Sept. 20-91	South Coast	87	170	2	26
27	Jany. 31-92	S.S. "Port Adelaide" ...	D. E. Jamieson, Master ...	46 4 S.	103 14 E.	44 0 S.	172 30 E.	March 3-93	,,	396	3,600	9·5	27
28	Febr. 9-92	Ship "Sophocles"... ...	A. Smith, Master	42 40 S.	162 20 E.	41 0 S.	175 0 E.	Decr. 25-92	,,	319	960	3	28
29	May 4-92	S.S. "Gulf of Bothnia" ...	T. E. McLigertwood, Mast.	38 15 S.	130 15 E.	38 35 S.	143 50 E.	Octr. 2-92	,,	151	760	5	29
30	Aug. 14-92	S.S. "Port Caroline" ...	S. M. Orr, Master	44 6 S.	105 46 E.	41 31 S.	130 32 E.	March 2-93	,,	200	1,260	6·3	30
31	Octr. 11-92	S.S. "Gulf of Bothnia" ...	T. E. McLigertwood, Mast.	43 15 S.	72 0 E.	35 0 S.	116 30 E.	Octr. 3-93	,,	357	2,450	7	31
32	Octr. 28-92	Ship "Melanope"	R. W. Neville, Master ...	1 38 N.	176 54 E.	1 50 N.	173 0 E.	Nov. 15-92	North Pacific	19	70	4	32
33	Novr. 9-92	S.S. "Port Denison" ...	C. Hepworth, Master ...	37 14 N.	10 26 E.	37 21 N.	9 43 E.	Nov. 14-92	Mediterranean	5	40	8	33
34	Decr. 5-92	Schooner "Orbost" ...	F. Limschon, Master ...	38 23 S.	144 40 E.	38 21 S.	144 50 E.	Decr. 8-92	South Coast	3	12	4	34
35	Decr. 13-92	S.S. "Gulf of Bothnia" ...	T. E. McLigertwood, Mast.	34 16 S.	113 30 E.	34 20 S.	115 23 E.	April 23-93	,,	131	115	0·9	35
36	Jany. 22-93	Steamship "Lubeck" ...	Master...	27 58 S.	170 47 E.	31 12 S.	152 50 E.	June 20-94	East Coast	515	500	1	36
37	March 4-93	S.S. "Port Hunter" ...	S. M. Orr, Master	45 52 S.	62 22 E.	38 4 S.	140 41 E.	Sept. 15-94	South Coast	560	4,100	7	37
38	July 12-93	Schooner "Orbost" ...	F. Limschon, Master ...	37 46 S.	149 26 E.	36 49 S.	149 56 E.	July 31-93	East Coast	18	74	4	38
39	July 15-93	H.I.M.S. "Saida"	Lieut. Noppes	33 48 S.	151 38 E.	32 40 S.	152 12 E.	Mar. 19-94	,,	247	108	0·4	39
40	May 7-94	S.S. "Gulf of Bothnia" ...	T. E. McLigertwood, Mast.	38 13 S.	130 7 E.	37 30 S.	140 0 E.	July 19-94	South Coast	73	47	0·5	40
41	July 26-94	Barque "Southern Belle"	Jno. Olerson, Master ...	35 48 S.	152 10 E.	33 53 S.	151 13 E.	Aug. 11-94	East Coast	16	188	12	41
42	Decr. 21-90	R.M.S. "Orotava"... ...	G. N. Conlon, Commander	34 53 S.	115 42 E.	34 27 S.	115 46 E.	Sept. 12-94	South Coast	1,361	25	...	42
43	June 14-94	R.M.S. "Orotava"... ...	R. L. Routh, Commander	7 15 N.	77 48 E.	Ceylon	S. Coast	July 2-94	Ceylon	18	150	8	43

THE METEOR OF JUNE 27TH, 1894.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[*Read before the Royal Society of N. S. Wales, September 5, 1894.*]

ON June 27th, 1894, at 5·30 p.m. a magnificent meteor was seen to travel from west to east and then burst into a thousand shining fragments to the south of Sydney. I did not see it, but attention was called to it by Miss Warren Jenkins, and a letter I put in the daily papers called forth a response of descriptive letters in reference to the meteor, and involved me in much correspondence, out of which came certain facts which I think should be placed on record. I should say here that the bearings &c., given were all quite independent, and considering the difficulties in the way of getting correct bearings, they are in remarkable accord as to the locality where the meteor burst.

First from the eastern side of Rose Bay, Miss Warren Jenkins gave me a bearing which cuts Botany Bay near the tramway terminus. Rev. E. Hargrave of Castle Hill gave me the direction and subsequently measured the azimuth of it with a good compass; —a house and other local features noted at the moment made it possible to go back and do this—this line also cuts the north side of Botany Bay near the tramway terminus. Mr. Reid observing from the North Ferry-boat gives a direction which cuts the bay a quarter of a mile west of the others. Mr. Bucknell, walking down George Street, saw it over Hordern's buildings in a line which projected cuts the north side of Botany Bay very near Mr. Hargrave's line. Mr. Hooker walking to the south at the north end of Wynyard Square, saw it over buildings at the south end of the square, a line which cuts the tramway terminus at Botany Bay. Mr. Pemberton, driving on the Randwick road near the toll-bar, gives a line which cuts the jetty near the Botany tram terminus; these six observations agree in placing the point of explosion near the Botany Bay tram terminus, agreeing much more satisfactorily than is usual in such cases.

But in addition to seeing it Mr. Pemberton distinctly heard a loud explosion, which he describes as like a quarry blast at a distance of two or three hundred yards, and being a contractor, he is perfectly familiar with blasting sounds, and therefore not likely to make a mistake except in the distance, and the explosion may have been more violent than he thought, and therefore been further away than he imagined. His estimate of the time between seeing the explosion and hearing the sound was three seconds, but such an estimate is difficult for anyone to make. Asked how far the trap travelled in the interval, he said, about fifty feet, this at the pace he was travelling would take six seconds, *i.e.*, a mile and a quarter from where he was to where the explosion took place, and he was four and a half miles from the north side of Botany Bay.

A carter passing the old toll-bar heard the explosion at the time named, and was startled by it, but could give no other particulars.

The evidence here collected is not proof, but it amounts to very strong presumptive evidence that the meteor exploded somewhere between the old toll-bar on the Randwick road and Botany tram terminus, a distance of four miles. If the Rev. E. Hargrave made an error of only five degrees too much to south, then his line would cut the others one and a half miles north of the tram terminus, where all the other bearings are closer together and within about a mile of the point indicated by Mr. Pemberton's estimate of the distance of the explosion from him.

It will thus be seen that the observations agree in placing the point of explosion within a narrow line, that is, one mile in width and extending north and south from three to four miles, remembering the difficulties in the way of accuracy in such observations, I think the agreement here is very remarkable, and I hope to hear that some of the fragments have been found. Many persons saw and reported the meteor without giving the details as to direction, altitude, and time, and in regard to the appearance there is a still more remarkable agreement of observers, making it appear that the meteor came from the west and travelled towards some point between east and south-east, that just before explosion it seemed to become momentarily dim as if it went behind a cloud, coming out brightly and then exploding into thousands of falling stars.

Mr. Pemberton as a contractor and builder is very familiar with blasting, and is therefore able to give a valuable opinion as to the distance and direction of the explosion; subject of course, to the fact it may have been a much louder explosion than he took it to be, and therefore further off. I met Mr. Pemberton by appointment on the ground, got his exact position on the road and a land mark six hundred feet away and thus got a bearing by azimuth compass, also, I saw Mr. Bucknell and Mr. Hooker, and by means of a chart of the city verified the directions given by them. The direction given by the Rev. Mr. Hargrave, eighteen miles away, cuts the other bearings at angles of from 40° to 70°, it was fortunately fixed by local objects, and subsequently verified by azimuth compass; so that the evidence is very strong that the meteor fell within the area already defined.

RECENT RESEARCHES IN THE TESTING OF CEMENT.

By W. S. DE LISLE ROBERTS.

[With Plate XXXVIII.]

[*Read before the Royal Society of N. S. Wales, September 5, 1894.*]

THE composition of Portland cement being of such a complex nature, the present crude method of burning the material is liable to vary its character considerably, unless great care is taken to maintain the temperature necessary for the formation of the proper compounds of silica, alumina, and lime.

Chemical analysis may show the several constituents to be in the proper proportion, but nevertheless not properly combined to form a true Portland cement; and the accidents which have occurred through the failure of concrete, especially in sea water, have generally been traced, not to an improper choice of material, but either to over, or under burning. It is therefore of the greatest importance in large engineering works, where cement concrete occupies such a prominent position, to ascertain before hand, whether the cement is sufficiently reliable to withstand the strain it is calculated for, and that a reasonable time will not change its nature to such a degree as to render it dangerous.

The usual methods of testing cement are well known, but there are a few points concerning the behaviour of cement while under test, which are important to users of cement. In order always to obtain a uniform crushing and tensile strain, entirely independent of the operator, there are two points necessary, first the percentage of water used for making the cement briquettes should in every case be exactly the same for the same class of cement, and secondly, the pressure exerted in filling the moulds should be the same in every case. The practice of guessing the quantity of water, which varies for each quality of cement, has been universally practised, and consequently the operator could, according to his own ideas, or inclination, vary the results of the crushing and tensile strength very considerably, and in so doing, good cement might be condemned, and inferior cement could be made to stand the required tests of strength. The pressure exerted in filling the moulds, as well as the percentage of water, has also generally been left to the operator to decide, and it affects the strength no less than the percentage of water used.

The amount of pressure exerted may be regulated approximately by having the moulds kept together with springs, which open out with too great a pressure, and if the percentage of water used is correct, the greatest pressure the springs will stand without opening out, must be exerted before the water will come to the surface; therefore the only difficulty to overcome was to discover definitely independent of the operator, how much water should be used for the kind of cement under test.

This point was open to so much criticism, that it became absolutely necessary to devise some means of overcoming the difficulty. After various experiments, an apparatus was decided upon, based on the principle that under a given pressure, a given quantity of cement of one quality, will always absorb the same percentage of water.

The method of operating is as follows :—A weighed quantity of cement is placed in a mould, into which a piston fits, pressure is then applied to the top of the piston by means of a screw, and a spring underneath the mould is depressed to a certain point; water is then poured in around the mould, then the water is first drawn , and afterwards the pressure is released, the cement is then taken out and weighed again, and the difference in weight will give the percentage of water absorbed, which is the percentage that must be used in making the briquettes. By varying the pressure, the amount of water absorbed is as follows for one kind of cement :— (See diagram No. 1.)

From this it will be understood how great an influence the pressure and percentage of water has over the strength of cement.

The manner in which cement briquettes are kept until tested, will sometimes vary the strength very much. The usual rule is to keep them in air in a damp place for the first twenty-four hours and the rest of the time in water; but if allowed to become in the least dry during the first day, the strength is afterwards affected; the same thing happens if the briquettes are taken out of the water any time during the process of hardening, and put back again.

Diagram 2 shows the the progressive increase in strength of neat cement, from one to three days, under different treatments. No. 1 represents the increase in strength of briquettes placed in water immediately after being made; No. 2 the same cement kept out of water for twenty-four hours, and the rest of the time in water; No. 3 the first two days in air and the third day in water.

This effect varies greatly according to the time of setting and temperature of the air, and in some instances may show a greater strength after three days than after seven days.

When neat cement is dried there is in nearly every case a strain exerted due to an internal expansion, with cement mortar in the proportion of three to one, the reverse happens; the voids between the grains of sand being filled with the expansible matters, the mass becomes more solid, and the strength is increased. Taking an average of many good samples of cement, and by taking the briquettes out of water for twenty-four hours, and drying them thoroughly before breaking on the twenty-eight day, the neat cement has about two-thirds the strength, and the mortar three to one, about one-third more strength than if kept continuously under water.

Another important point in the testing of cement is the quality of sand used. The greatest care is necessary to maintain a uniform standard from year to year. The strength of cement when mixed with sand is affected greatly by the size and shape of the grains; the dosage, or amount of cement required to fill in between the grains, and also (in some instances where the sand used is not pure quartz) by the strength of the sand itself. The usual method of preparing standard sand is to sift it through a sieve of four hundred meshes to the square inch, and then through one of nine hundred meshes, retaining that left on the nine hundred sieve as standard, but even then the strength obtained will vary according to the quality of the sand, even when taken from the same quarry. Diagram 3 represents the variations which occur; No. 1 is the coefficient of strength of standard sand obtained from a Pyrmont quarry; No. 2 from Arncliffe; No. 3 from the same quarry at Pyrmont, but of a softer quality. No. 1 is 15% over and No. 3 10% under the proper standard.

The variation in strength obtained by using different kinds of sand, in concrete work, is necessarily very much greater; in Diagram 3 is represented the coefficient of strength of various qualities of sand obtained about Sydney, as compared with the standard. In ordinary concrete work therefore the calculations for computing the strength necessary to stand a given load, these points should always be taken into consideration.

For instance, eight blocks of cement mortar 4″ diameter (made with 15% of water, or about the proportion of water usually used for concrete work when three of sand to one of cement is used), gave after seven days an average crushing strain of 361lbs. per square inch, using standard sand; by substituting an average good sand for standard sand the average strength was reduced to 233lbs. sand coefficient of 73·5, the average crushing strain of the same cement, using standard sand with 9·7% of water; was 1042lbs. per square inch, so that by using an ordinary good sand, the actual coefficient of strength of cement when mixed with 15% of water would only be 25·5, or about a quarter of the strength the cement was shown to have when tested. This would naturally upset all calculations when computing the size necessary to withstand a given load, based on the strength of cement as tested in the ordinary way.

For such work as the Monier system, where cement mortar is used without stone, great compression is much easier than with concrete, and a much smaller percentage of water can be used.

As the most common defect in cement is too large a proportion of free or uncombined lime, the greatest attention should be given to its detection especially as the strength of cement with an overdose of free lime for the first month or so, is greater than a normal cement. The free lime may either be in a state of hydrate, or it may be unslaked, if unslaked the first effect will be an increase in bulk due to slaking with overburnt cement, or with a silicate of lime, this process of slaking may not be completed for several months; after slaking the formation of carbonate of lime commences, this means another increase in bulk, which continues more or less, according to the situation, and the facilities afforded it to take up CO_2 from the atmosphere.

The first effect due to the slow hydration of unslaked lime may be facilitated by hot water, which rapidly disintegrates any cement containing unslaked lime, either free or combined with silica. The percentage of unslaked lime required to injure neat cement is very small.

In diagram 4, is represented the tensile strength obtained after seven days in hot water at 180° Fahr. with various percentages of slow slaking lime added. A represents the strength after twenty-eight days in cold water which should with a normal cement be equal to seven days in hot water. This diagram must not be taken as showing absolutely correctly the proportionate strength due to the addition of certain percentages of free lime, because a certain proportion of silica, not ascertained, was combined with the lime, and the samples of cement used were not absolutely free from unslaked lime—it is therefore only approximate.

When test briquettes are made in the usual proportion of three of sand to one of cement, a small percentage of free lime has a certain space between the grains of sand not filled with cement, into which it can expand—with a richer proportion of cement this is not so. Diagram 5 represents the progressive increase in strength of briquettes made in the proportion of three to one and two to one—containing each a small amount of free lime—with a proportion of three to one the strength, when kept in cold water, increases steadily up to twelve months, but with the proportion of two to one, kept under the same conditions, there is an internal strain exerted, in this instance between six and twelve months, which reduces the strength so much that the proportion of three to one becomes almost as strong as two to one, after twelve months in water.

When a larger proportion of free lime is present, mortar briquettes made in the usual way three to one are often effected in cold water. Diagrams 6 and 7 represent samples which each show a partial break-down at different periods—this breaking down appears to be independent of the hardening effect which continues in every case at the same ratio as the average increase for that class of cement minus the strength lost by the breakdown.

The partial break-down which becomes more serious, the richer the cement, has a great effect upon the cement facing of buildings —the facing is generally finished with a coating in the proportion of two to one or even one to one; and there is very little if any cement manufactured which could remain so constant in volume, when exposed to the weather as not to show cracks after a few months near the surface.

Now if the present practice were reversed, viz., the richer rendering put on first, and a finishing coat of three or even four to one—or better still a proportion of three or four to one all through—there would be sufficient voids to allow of any expansion, and the formation of carbonate of lime would by gradually filling up the voids, add so greatly to the strength, that it would be in some cases as strong or stronger than the neat cement after a few months, and remain perfectly free from cracks.

As no cement is ever made chemically perfect, there is always a certain amount of free lime, or feebly combined lime, which generally makes itself apparent when the cement is so rich that there are no voids left.

Now it might be urged that no cement should be used with over a certain proportion of free lime; that is very true, but there is a certain amount of decomposition of the more feeble compounds with lime, especially when exposed to the sun and rain, thus setting more lime free which then becomes (by contact with CO_2 in moist air,) carbonate of lime. In diagram No. 8, is shown the percentage increase of carbonate of lime in samples kept under different circumstances, unhydrated, and kept in air; hydrated and kept in air; hydrated and kept in water for a period of twelve months; with the dry cement there is hardly any change, showing that cement may be kept in a good condition for that length of time. The hydrated cement kept under water decomposes very little also—but when hydrated and kept in air, the decomposition and formation of carbonate of lime is very great.

How to distinguish between good and indifferent cement has received a good deal of criticism, and there are a few facts that have been gained by experience which to a certain extent upset some of the ideas that have been formed without sufficient data to work upon.

There is a very general impression that the stronger a cement is, during the first month, the better suited it is for general work; this is not so, a true Portland cement cannot be above a certain strength, and it is only by adding an excess of lime that the tensile and crushing strength can be raised, and then from time to time the cement is strained by the action of the lime.

In every case where there is a partial break-down as shown on diagrams 6 and 7, there is always a corresponding indication of free or feebly combined lime when tested. The development of heat while setting indicates free lime which slakes quickly.

Slower slaking lime is indicated by the cement cracking when allowed to set in cold water, and very slow slaking lime will show no indications at first except in hot water. The disintegrating effect of the hot bath is often due to unslaked silicate of lime, but when the silicate of lime is air slaked an abnormally high tensile strain is obtained in hot water; this silicate of lime when slaked can do no harm, but on the contrary will make an excellent hydraulic lime, hence the necessity of thoroughly air slaking cement likely to contain simple silicate of lime before use. When the cement contains free lime already slaked, the only indication at first is a large amount of carbon di-oxide that can be absorbed by a given quantity of cement; the limit for good cement is put down by the German Association of Cement Manufacturers at two milligrams in three grams.

The action of hot water on the briquettes might appear to be sometimes very contradictory, unless all the other indications are taken into consideration; the rule is that a normal cement will show approximately the same strength after seven days in hot water at 180° Fahr., as twenty-eight days in cold water at 65°. As already shown a certain small percentage of free lime will lower the strength of the neat cement but not always the mortar, on the other hand cement which has a buff surface, and bluish-grey section after drying, will give a tensile strength after seven days in hot water very much higher than twenty-eight days in cold water. A light grey section indicates defective burning, and if unslaked will always show defects in hot water.

On the table is a briquette two years old which contained a large quantity of slaked lime; the cement gave a high tensile strain at first, with a good progressive increase in strength, but set very slowly; it remained sound until the second year, when broken after two years in water, the result was an imperfect fracture, showing the formation of $CaCO_3$ internally.

The author also showed a specimen of hydraulic lime (silicate of lime) cracked by internal expansion after being exposed to the weather for twelve months, and the same silicate of lime when mixed with sand under the same conditions in weather, but perfectly sound, the voids being filled with $CaCO_3$.

The relation of cement containing unslaked free lime to the strength after twelve months in water will be understood by the following statistics: Taking the tests made by the Sewerage Department for three years 1891-92-93, the average tensile strength after twelve months of all test, (about two hundred), made during 1891 = 430lbs. per square inch for mortar in the proportion of three to one. And the percentage of tests that proved unsound in Deval's hot bath 3·3%. During 1892 the average tensile strain after twelve months dropped to 372lbs. and the tests unsound in Deval's hot bath rose to 5·1%. During the first half of 1893 the average tensile strain, twelve months is 304lbs. only, and the tests which disintegrated in Deval's hot bath 6·1%, besides about 10% which were partially disintegrated. This would show that cement as at present imported is very inferior to that imported three years ago; probably the present price of cement does not make it sufficiently remunerative for the manufacturers to take the proper care required for the manufacture of a sound cement.

The INTERPRETATION of CEMENT ANALYSES,
Including a new Method of Recording Results.

By W. M. Hamlet, F.C.S., F.I.C.

[*Read before the Royal Society of N. S. Wales, November 7, 1894.*]

During the past twenty years the value of cement testing by chemical analysis has declined somewhat in the estimation of the engineer and the practical man, owing partly to the ready means afforded by improved appliances for measuring the amount of strain any given cement-briquette can be made to bear; and partly owing to the difficulty encountered in the correct interpretation of the results of the chemical analysis.

Now, however, I venture to think there are signs of a revival of interest in the chemistry of Portland cement, which will doubtless lead towards a better appreciation of the minute structure and composition of this useful material.

To those who had not utterly discarded cement analyses as altogether useless, the good cements—that is, those cements that were found to survive the Deval bath and other severe physical tests—showed on analysis the following general results :—

58 – 62	per cent. of	lime
20 – 24	,,	silica
7½	,,	alumina
3½	,,	iron oxide
3 – 10	,,	subsidiary constituents

The bad or indifferent cements showed varying deflections from this standard, and contained notable quantities of magnesia, sulphates and other useless bodies.

A fresh impetus is given to the subject by Le Chatelier,* who proposes the equation now bearing his name, in which

* Recherches Experimentales sur la constitution des mortiers Hydrauliques.

$$M = \frac{CaO + MgO}{SiO_2 + Al_2O_3}$$

the value of M in a good cement never being found to exceed 3.

The formula, which it is proposed to call the Hydraulic Modulus, is the ratio of the sum of the bases to that of the acid-forming bodies and is now extended by including all the active bases and acidic radicles thus :—

$$M = \frac{CaO + MgO + K_2O + Na_2O}{SiO_2 + Al_2O_3 + Fe_2O_3}$$

and varies in value between 1·7 and 2·2. A good cement, satisfying all the physical tests gives a value lying within these limits.

Acting upon this basis the Russian Government now specify in their contracts that the hydraulic modulus shall not vary beyond these figures either way; it is also specified that the sum of the amounts of magnesia and sulphur tri-oxide shall not exceed 3%.

In order to ascertain for myself what results should be obtained from a known and well tried Portland cement, I asked Mr. De Lisle Roberts of the Public Works Department to give me a sample of a cement that had satisfactorily passed his most rigorous time and physical tests. That gentleman very kindly furnished me with a sample of a cement that had given him the following results on the neat cement :—

Tensile strain	after	3 days	... ...	607lbs.
,,	,,	7 ,,	... ...	702lbs.
,,	,,	7 ,,	(hot bath test)	758lbs.

Cement and Sand 1 : 3

Tensile strain after 7 days 235lbs.

Ditto, 7 days in hot bath 247lbs.

Provided with such a good cement I was anxious to see what the hydraulic modulus would be, accordingly the following complete analysis was made :—

CaO	62·70
SiO_2	21·75

SiO_2 (insol.)	0·25
Al_2O_3	7·61
Fe_2O_3	2·41
MgO	0·43
K_2O / Na_2O	1·00
S	0·12
SO_3	1·44
CO_2	1·25
C (from fuel)	·10
OH_2	·94
Chlorides	traces
	100·00

The value for M was found to be 2·004, and the sum of the sulphur tri-oxide and magnesia was 1·87, which comes well within the figures required by an undoubtedly good cement.

The object of the present paper is to give a more extended meaning and value to an analysis of a cement and to express as clearly as possible all the information that an analysis affords. In doing so it seems rather remarkable that this has not been done long ago, as it would have given greater confidence in judging of the value of a cement, and removed that perplexity that existed in the minds of both analyst and engineer in times past.

By analogy a cement resembles gunpowder, at least in one conspicuous feature, namely, that it may be regarded as* "a system in such a condition of chemical equilibrium that a variation of the condition involves a transformation of energy," so that when the gunpowder is fired, the nitrate, carbon and sulphur become resolved into simpler and more stable bodies.

In like manner the cement just awaits the gauging or addition of the water whereupon a transformation occurs, hydration taking place, resulting in the formation of certain definite and stable

* Threlfall in Watt's Dictionary of Chemistry, Vol. II., p. 530.

bodies, the phenomenon being known as the setting of the cement. The stable bodies are silicates, alumina and iron compounds which solidify together and resemble Portland stone, and hence the name given to the product known as Portland cement.

The particular kind of silicate formed is first the silicate of lime—calcium orthosilicate (Ca_2SiO_4)—formed by the combination of two molecules of lime with one molecule of silica.

This view accords with the analytical results obtained with Mr. Roberts' cement and is not taken for granted as some writers seem to have done, where one, two, three, and even four molecules of lime have been assumed to be the combining equivalent.

From a careful examination of the pats of neat cement the silicate appears to resemble, from the mineralogical point of view, a lime peridote, Ca_2SiO_4. The alumina acts as a body having feeble acid properties forming an aluminate of the composition 3 CaO, Al_2O_3, while the ferric oxide combines with one molecule of lime to form calcium ferrite CaO, Fe_2O_3. After proper setting these compounds, including the hydrate, form a dense stone-like substance of which the briquette, made with the cement in question and now exhibited, is an example.

On examination of a thin section of this briquette, made like any other rock slice, all these compounds are visible, including the magnesium silicate which is plainly seen when viewed with polarised light, the iron-lime compound or ferrite is quite plainly visible as well as the tabular crystal of calcium hydrate. The crystals of the calcium silicate have no action under the crossed nicols and appear most numerous in the crystalline cut section.

It is evident therefore that in Portland cement we have the basic bodies :—

$$CaO,\ MgO,\ K_2O,\ Na_2O,$$

and the acidic radicles :—

$$SiO_2,\ Al_2O_3,\ Fe_2O_3,\ SO_3,\ CO_2,$$

the percentages of which give us the elements for obtaining the hydraulic modulus of Le Chatelier.

In the valuation of cements, however, it becomes necessary to distinguish clearly between the essentials and non-essentials in its composition, in other words to be able to discriminate between the good and the bad constituents of the cement.

The essentials may be enumerated as

Calcium orthosilicate Calcium aluminate Calcium ferrite

The remaining constituents may be deemed non-essential although some among them may be decidedly injurious, and will if their quantity be excessive, sooner or latter bring about the disintegration of the concrete.

The possibility therefore of formulating an ideal cement from purely theoretical considerations may be brought into practical use and I would specify the type of a good cement to be one that will prove on chemical analysis to be constituted in harmony with the following scheme, the principle being, that there shall be the correct proportion of lime present to make the combination complete according to the demands of the law of chemical combination.

Essentials.	Calcium orthosilicate	60 – 75	per cent.
	Calcium aluminate...	18 – 20*	,,
	Calcium ferrite ...	2 – 5	,,
	Calcium hydrate ...	2 – 10	,,

Non-Essentials.	Insoluble silica	2 – 8% [not to exceed 10%]
	Sulphur trioxide†	
	Sulphur as sulphide	
	Free carbon	
	Magnesia‡	
	Soda	
	Potash	
	Moisture	
	Carbon di-oxide	

*The higher this figure appears, the quicker will be the cement in setting

† This and the magnesia together should not exceed 3 per cent.

‡ If the cement is to be used for harbours or submarine works, the magnesia should not exceed 1 per cent.

Now in order to state the results of an ordinary complete chemical analysis in terms of the type-analysis here set forth, it is necessary to apportion the lime to the acid forming bodies, thus the $SiO_2 \times 1{\cdot}858 =$ the amount of lime to form the orthosilicate. $Al_2O_3 \times 1{\cdot}641 =$ the lime for the aluminate, and $Fe_2O_3 \times 0{\cdot}3503 =$ the lime required to form ferrite, the respective logs. for these co-efficients are for the silica 0·26834; for the alumina 0·21582; for the iron oxide $\bar{1}{\cdot}54444$. Applying these numbers to the sample analysed we find the lime apportioned thus:—

for the silica	40·41
„ alumina	12·51
„ iron oxide	·84
„ carbon di-oxide ...	1·62
„ sulphur trioxide ...	1·01
„ sulphur as sulphide ...	·21
	56·60

Now the total lime shown by analysis is 62·70 (the mean of two different estimations by different methods)

$$62{\cdot}70 - 56{\cdot}60 = 6{\cdot}10$$

the lime is thus accounted for by actual combination to within 6% and this is the free and unappropriated lime which will change into hydrate on setting and will become in due time a varying mixture of carbonate and hydrate; and further, as this unappropriated lime is capable of becoming wholly hydrated at the time of setting it may be safely reckoned that the cement will stand all the physical tests, there being no inimical compounds to modify this action; it will therefore follow that if this lime be in the condition I have assumed it to be, and if we cause it to combine with carbon di-oxide, the quantity of carbon di-oxide so combined when subtracted from the balance in our calculation, ought to satisfactorily account for the whole of the lime in the cement analysed. Accordingly, a given quantity of the cement was treated with pure ammonium carbonate and ignited, making of course the necessary corrections for loss on ignition of the raw cement. The amount of carbon di-oxide taken up by the free lime was found to be 4·4 per cent. The theoretical quantity of lime that will unite with 4·4% carbon di-oxide is 5·6%, which nearly coincides with the remainder 6·1%, the difference being only half a per cent. and within the personal error of the experimenter.

The 5·6% of lime will, I have said, form hydrate, and in making concrete will unite at the surfaces of clean sharp sand to form calcium metasilicate $CaHo_2 + SiO_2 = CaSiO_2 + OH_2$,* thus the free lime within due limits in a properly constituted cement must act as a cementing agent and prove a good feature in a sound cement, the danger lies in the presence of free lime and free magnesia together, exerting differing degrees of hydration and causing the cement or concrete to bulge, swell, and crack. Compared with the ideal type analysis, this good sample furnished by Mr. Roberts stands as follows :—

Essentials	Orthosilicates ...	62·16	
	Alumina...	20·12	
	Ferrite ...	3·25	
	Hydrate...	7·40	= 92·93
Non-Essentials	... ...		7·07†
			100·00

It is interesting to compare these results with those obtained from a cement that had failed to pass the usual tests. The chemical analysis of this cement was as follows :—

CaO	58·96
SiO_2...	23·72
Al_2O_3	9·17
Fe_2O_3	1·98
MgO	·40
K_2O, Na_2O	2·41

* The water of course gradually disappearing as the age of the concrete increases.

† Objectionable compounds = 1·99.

SO_3	1·78
CO_2	·90
OH_2...	·43
Loss and undetermined ...	·25
	100

It will be seen that the cement contained 58·96% of lime.

The hydraulic modulus was 1·79 by which it would pass as a good cement, but on apportioning the lime to the different acid-forming radicles it was found that these required 62·18% of lime, so there was not enough lime in the cement to enable the constituents to combine with each other.

Lime wanted	62·18
Lime in the cement ...	58·96
Deficiency	3·22

and hence the failure in the cement; and yet by adding carbon di-oxide to the raw cement, it was found to take up as much as would represent 3% of lime.

These results point to the conclusion that the value of a Portland cement cannot be appraised by mere inspection of the figures given by chemical analysis, but by calculating the necessary quantities of lime distributed among the various acid radicles in the proportions required by theory, one is enabled to discriminate between good and bad cements, which cannot be done in all cases by the calculation of the hydraulic modulus.

In conclusion I desire to thank my assistant Mr. Doherty and Mr. Petrie for their valuable help in the analysis and preparation of microscopic sections of the cements examined.

A CHART OF CIRCUMPOLAR STARS.

By H. C. Russell, B.A., C.M.G., F.R.S.

[With Plate XL.]

[*Read before the Royal Society of N. S. Wales, July 4, 1894.*]

Circumstances have frequently brought under my notice the difficulties felt by amateurs in finding, on the ordinary star charts, the several stars which they may see in the heavens, and hence I have designed a chart of southern circumpolar stars, which I thought would be more convenient and easy for them to use than the star charts previously published. I have also introduced some results from my own work which seemed desirable additions to the information usually given; these will be referred to later.

For the ordinary amateur's use, too much has been attempted on the best star charts. He wants to recognise the visible stars in their relative positions, and not to have the chart crowded by details which only come to him in later studies. The smallest star put in is of 6·5 magnitude, and should be visible to good eyes on a fine night. It is possible that some stars are visible which are not in the catalogues and which will therefore not be found here. Great care was taken in selecting sizes for the star spots which would make it easy for the eye to pick up the bright stars, and in order still further to aid in this ease in using the chart, each star to the fifth magnitude inclusive has projecting rectangular bars, the number of which at once decides the magnitude, and all stars of 5·5 to 6·5 magnitude are simply round spots. The abreviations used are all shown on the chart for easy reference, and on the outer rim a series of dates by which to set the chart. If any date is set vertically over the centre of the chart, then at 8 p.m. of that date, the stars bear the same relation to the horizon and the points of the compass (when looking south), as they do when one looks at the stars themselves.

All the star clusters which one could see under favourable circumstances with a three inch telescope have been put in,—for the selection of these our own photographs were very useful—all are distinctly marked by the letter C in a circle. It is hoped that the ease with which these may be found will be a convenience to many. The star positions have been computed and plotted for the epoch 1900, so that the chart will be available for some years without serious errors from precession.

The intention is to have the chart printed on thin or translucent paper, which may be placed on a circular piece of glass or other translucent material, so that it can readily be turned round in a holder in accordance with the instructions on its margin, when it is desired to get the stars on it into the positions then occupied by the stars in the heavens. This method of mounting is not new, but has been too much neglected, and I have adopted it because I think it will be a most important aid to the beginner, who as a rule gets very much confused by having to look at a star chart bound up in a book and placed the wrong way, and then mentally turn it round into the position in which he sees the stars in the heavens. In use it will be found exceedingly convenient to have some sort of frame or box which the star chart can be placed upon close to a lamp, and if much use is to be made of it there is a decided advantage in having a box which will hold the lamp and the chart in the most convenient position. It is an advantage to have the chart neither vertical nor horizontal, but in a position midway between these two, so that when one is in the ordinary position for reading, the chart is at right angles to the line of sight, and therefore in the most convenient position to use. Provision should also be made for turning the star chart round and settting it in any desired position.

The original drawing measures thirty inches in diameter, and the greatest care has been taken in plotting the stars in their exact positions, and in making every detail as clear and sharply defined as possible, and the lettering is on such a scale that everything can be read, even when the chart is photographically reduced to a diameter of six inches, and if a magnifier is used, the chart may be reduced to three inches diameter and retain every detail sharply defined.

The computations for the positions of the stars have been carefully made and verified, and then compared with those on existing star charts, and when any difference was found, great care was exercised to ascertain the correct position, and it is satisfactory to be able to state that this process resulted in finding confirmation of our positions.

In some cases the star magnitudes are uncertain, because the best authorities differ; in these cases the magnitudes given in the Argentine General Catalogue have been taken.

The form of the Magellan Clouds have been put in from actual photographs taken to the scale of the map, and only the brighter parts are shown—the parts most interesting to the possessors of small telescopes—they look very different from what is put to represent them in other star charts of this region, but these are certainly the forms of the brighter parts. Some slight changes appear in the Milky Way. To my eyes and those of the assistants in the Observatory, the great rift said to begin at Alpha Centauri really extends and includes Beta Centauri, only it is not so dark between these stars. Again the Milky Way clearly encloses the northern parts of Crucis. I have followed the usual course in showing the Coal Sack dark, also in regard to the great rift in Argo, although my photographic examination of these regions shows them to be full of stars.

It will seem to many that there was no need to add to the number of charts of southern circumpolar stars. Nothing for instance, could be better than the one published by the late Mr. Proctor, for the classes he meant it for—students and observers, *i.e.*, those who know something about the stars or have teachers—there is a wider circle who know less, and these I have endeavoured to reach.

A MAP SHOWING THE AVERAGE MONTHLY RAINFALL IN NEW SOUTH WALES.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[With Plate XXXIX.]

[Read before the Royal Society of N. S. Wales, November 7, 1894.]

It will be remembered that just twelve months since I brought before the Society a Pictorial Rainfall Map giving the result of many years of observation condensed into a few figures, and showing the average rainfall on each square degree of New South Wales. I have now the pleasure of bringing under your notice another pictorial rain map, this time showing for each square degree of this Colony the average quantity of rain which falls in every month of the year. This is the first time such a map has been prepared, and it conveniently answers questions of great importance in agriculture, and so far as I am aware, these questions are more fully answered by this map than by any map or publication for any other country.

At first sight the map looks like a confused mass of figures, but that impression disappears as soon as the method of arranging the figures is understood. In the first place each square degree in the Colony is treated as quite independent of all the others, and the average rainfall in that degree for each month of the year was calculated from the rainfall records in it. The quantities of rain in each month are then expressed in the usual way in inches and hundredths of an inch, and the months of the year are arranged in four rows, each row covering a quarter of the year, thus the first row in each degree reads January, February, March; the second April, May, June; the third July, August, September; the fourth October, November, December.

Now let us assume we want to know what rain to expect in each month in some particular place; say Bourke, we refer to the map and find it is situated in a degree in which the average rainfall for January is 2·63″, for February 2·00″, for March 2·06″, for

April 1·37″, for May 1·56″, for June 1·35″, for July 1·23″, for August 0·97″, for September 1·16″, for October 1·22″, for November 1·21″, for December 1·57″. January is thus seen to be the wettest month with 2·63″, and August the driest with 0·97″.

One reference to the map shows that this mechanical arrangement of the figures gives the desired information in much less space, and is much easier to read than in any ordinary tabular form. Let us for the sake of comparison take another degree, that in which Lismore is situated, and the corresponding monthly rainfalls stand out in remarkable contrast with those for Bourke. In January they have 8·50″, February 8·64″, March 12·74″, April 7·82″ May 6·73″, June 4·17″, July 4·58″, August 4·32″, September 3·83″, October 3·75″, November 3·88″, December 4·96″; while here, the wettest month, March, has 12·74″, and the driest October 3·75″.

In the northern districts west of Bourke, January is the wettest month of the year, and the half year January to June has much more rain than the second half. Eastward of Bourke February begins to claim with January the highest rainfall, and the proportion of rainfall for the second half of the year is much better; and from Walgett eastward, February is generally the wettest month until we reach the highest lands where the rainfall is very much greater than it is at Bourke, and then January again takes the lead for quantity of rain.

On the northern coast March is the wettest month, with January February, and April in many places nearly equal, and although there is much more rain on the coast in the latter half of the year, the first half still maintains it superiority as to quantity. In the extreme west of the central districts about Broken Hill, Wilcannia and Menindie, May is the wettest month, and the rainfall in the second half of the year is better than the first in some cases. Eastward from this area for two hundred miles east of the River Darling, the wettest month oscillates between January and February, and in these districts there is a noteworthy increase in the quantity of rain generally, and in the first half of the year particularly, and also in what may be called the wheat growing months October and November, thence further east to the high lands the rainfall of the second half of the gradually becomes greater than that of the first half, and in some cases includes the wettest month, the fall during October, November, and December being favourable to wheat growing. Still in the central districts, but east of the mountains, February, March, and May by turns represent the wettest month, and the latter half of the year has an abundant rainfall.

In the southern districts west of Balranald, May or October is the wettest month, and the latter half of the year has a good rainfall. In Riverina, between Balranald and Urana, May is in all places the wettest month, while the rain of the latter half of the year is about equal to, and in some cases better than during the first half. From Urana eastward to the mountains, the wettest month on the Lachlan is January. In the district indicated by Temora, Wagga Wagga, Albury, Urana, the wettest month is in some places October, and the rainfall in the latter half of the year is equal to, or in some places greater than that of the first half of the year. On the highlands here as in the north, January is the wettest month, and January, February, March, October, November and December have much more rain than the other six months.

It is needless to go into greater detail; the information is designed to be read in detail on the map, where locality as well as quantity of rainfall are given in the most convenient form for reference, and the suitability of the rainfall for wheat growing and other purposes can be seen at a glance. For instance it would be folly to try and grow wheat in the extreme north-western districts, not only because the rainfall is much below the quantity (20 inches per annum) which is required for that purpose, but also because of the fact that the bulk of the rainfall is in the first half of the year. These relations gradually improve in every direction, east, south-east and south as we leave the north-west, and reach their most favourable relations in eastern Riverina, where the rainfall is specially favourable for wheat growing.

On a New VELOCITY RECORDER and its Application to Anemometry and other Purposes.

By J. Alfred Griffiths, B.Sc., Wh.Sch., M.I.Mech.E.

[With Plate XLI.]

[*Read before the Royal Society of N. S. Wales, November 7, 1894.*]

(Abridged for Publication.)

In recording a continuously growing function on a travelling band of paper by a pen moving at right angles to the paper, the inconvenience arises when the experiment is continued for extended periods, of the pen travelling far beyond the limits of any reasonably sized sheet. This has hitherto been obviated, either, (1) by limiting the experiment or record to the extent of the sheets of paper which are changed frequently; (2) by recording some derived function of more limited range or periodic character, from which the original functions may be deduced; or (3) by various devices for causing the pen to periodically return to zero and commence a fresh portion of record on a band of paper of limited width.

Many devices* have been used in previous recording meters, and (notably for anemometers) it has been the practice for the rotating wind-vane to move the pen by continuous motion which is interrupted at the end of fixed periods of space when the pen returns to the zero line, producing a saw-tooth diagram, each tooth of which indicates the passage of so many miles of wind. When the space interval is made sufficiently small with respect to the extent of speed variation, the pitch of adjoining teeth is fairly constant over short intervals, and the average speed may be measured by counting the number of teeth between each time vertical.

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* See Prof. H. S. H. Shaw, on "Measurement of Velocity"—Proc. Inst. C.E., Vol. LXIX., page 369.

Tylor on "Recording Water Meters,"—Proc. Inst. M. E., 1886.

In other instruments, such as Osler's Anemometer and Moscrop's Engine Recorder,* instead of the pen moving proportionately to the increment of space, the pen takes up a position indicating the velocity of motion, and only moves when the velocity changes; but in such instruments the inertia of the mechanical parts seriously interferes with the perfection of the record.

In the writer's instrument both these principles are involved. The pen is moved by the prime variable, and the length of the line measured perpendicular to the motion of paper measures the time integral. One pair of axles in the train moving the pen carry friction rollers, which can be periodically separated or recoupled by tripping clockwork. Thus instead of the saw-teeth on the diagram measuring equal intervals of *space*, they indicate equal intervals of *time*, and consequently the strokes are of varying length, the length of each being an exact measure of the time integral during one interval. If this lifting period be made indefinitely small, and at the same time the vertical scale of the pen's motion be increased in inverse proportion, the lines will be very close together, and their envelope will be the differential coefficient of the main function, that is, will exactly measure the speed or velocity of the prime motion. In practice the period is not indefinitely small, and the *actual length* of the line gives the *total space* moved in the lifting interval, and also the *average velocity* during that interval, and the interval may be made small enough to give the differential curve with sufficient exactness for most purposes.

The mechanism designed for this purpose by the writer may be almost indefinitely varied in detail according to circumstances, but requires three essential parts:—

First, an axle or roller moving continuously with the prime motion, and continuously tending to move the pen at right angles to the motion of the paper.

Second, a clock to measure the time interval and to advance the paper band with a regular motion, which may be continuous or intermittent.

* English Patents, 1321 of 1881 and 6965 of 1884.

Third, a tripping or disengagement action, whereby the pen is periodically detached from the prime mover and returned to zero, where it is again coupled to the prime mover; the interval of time between the uncoupling and recoupling being made as small as possible with respect to the differentiating interval, but it must be sufficient for the pen to travel back to zero, and to settle at rest on the zero line after the little shock and vibration consequent thereon.

By making the motion of the paper *intermittent* (Figs. 1, 3, and 4) so that during the lifting of the pen it is at rest, and that during the fall of the pen it makes a movement, the diagram becomes a series of parallel lines. If, as in the writer's machines, a glass capillary pen is used, the line from the up stroke (being drawn comparatively slowly), is distinct and its intensity may be easily regulated; but the down stroke is made so fast that very little ink has time to flow though the capillary point, and the lines are so faint that they do not interfere with the up strokes. By using very carefully made pens, such diagrams have been drawn with as many as one hundred and forty lines per inch, but the least dust or filament on the pen will cause the lines to coalesce into a shading when the lines are closer than about fifty per inch.

If the paper moves continuously, (Fig. 2) then the up strokes are irregularly curved according to the changes in the prime motion, and if the differentiating interval is not less than about $\frac{1}{30}$ inch on the paper, the nature of such changes is to a considerable extent visible in the up stroke. The down stroke is a very faint line almost vertical and barely visible.

If the instrument is to be a fixture in a factory or observatory, the best clock for the purpose is a pendulum clock, with gravity or remontoire escapement, driven by a weight, or with Mr. Russell's double pendulum, so that ample power may be provided for the tripping gear without affecting the rate. In the experimental instruments constructed by the writer, exact time keeping has been sacrificed to portability, and spring driven clocks with lever escapements are used. Ordinary clock trains were adapted to these instruments, but in the illustration (Fig. 5) a more carefully designed instrument is shown, which may be used for many purposes.

The three parts of the mechanism are fixed in one frame, and in the illustration the front plate is supposed to be removed, and with it the ordinary dial work on the hour arbor C. The large sector N moves with a long range outside the back plate, has a steady axis of the full breadth of the frame at the base and rests at zero against the stop P, a light spring assisting and balancing its return stroke. The motion of the prime mover is communicated to the pulley T by a cotton thread from any convenient rotating part, and by the worm S drives the wheel R and the friction roller Q bearing against the sector N, and continually drags the pen Y away from zero. The front pivot of the arbor of Q bears in the front plate of the clock, and the wheel R (of one hundred teeth) remains continually in gear with the worm S. The back pivot of R Q however is carried in a swinging bearing attached to a branch of the lever V W which is centred in cocks so as to clear the wheel R and the sector N. A light spring holds down the lever W and presses the roller Q against N, except when the lever end W is lifted by the revolution of the snail K. If the motion of T is speeded too fast for the size of the paper, at the upper limit of the pen stroke the roller Q passes over the clearance Z and grinding is avoided.

The tripping train* B, G, H, K, is driven from the inner end of the mainspring, and the time train† A, C, D, E, F, from the outer end of the spring, and winding may be done at any time between the tripping moments without stopping the action. Separate springs might be used for the two trains, but a single spring ensures a constant proportion between the power available to lift the lever I J and the friction at the main tripping pallets L.

On the snail arbor K is an arm K L (shown dotted), with a detent pin at its end gearing alternately with one of two pallets L

* The numbers may be :— $\frac{\text{Mainspring}}{\text{B=84 teeth}} \times \frac{8}{\text{G=64}} \times \frac{8}{\text{H=60}} \times \frac{8}{\text{snail K}}$

† $\frac{\text{Mainspring}}{\text{A=84 teeth}} \times \frac{25}{\text{C=64}} \times \frac{8}{\text{D=60}} \times \frac{8}{\text{E=48}} \times \frac{6}{\text{scape, 15 teeth}}$

on the tripping lever I J. When the clock allows the lever I J to fall the detent is released, the snail K makes a nearly complete revolution and comes to rest with its point holding up the lever V W, so that the friction roller Q is out of contact with the sector N, and then the pen falls to zero. As soon as the notch I in the scape-cam lifts the tripping lever, the snail completes its revolution and the roller Q again takes hold and begins to lift the pen.

On each of the time arbors C, D, E, F, is a notched wheel or cam (shown shaded), all the cams being arranged in one plane, and close alongside is the tripping lever I J, so that by removing or placing certain pins opposite each cam its time of falling may take place regularly at the period of one revolution of any of the time arbors. The *lifting* of the striking lever however, must be done by the quickest moving cam, viz., that on the scape arbor, so that the pause during which the pen is uncoupled may be reduced in duration. Hence a fairly heavy balance is needed to control the very strong mainspring required to do the work of lifting the striking lever. The cam plates should be fixed on friction collets so that they may be easily adjusted to any alteration of the clock dial, and to ensure that the notches come opposite the pins in the tripping lever I J at the proper times. This tripping lever is close inside the back plate and all or any of the pins may be unscrewed from the back to alter the differenting period to suit the particular experiment in hand.

The intermittent motion is transmitted to the drum by bevils on the arbor G, which are so geared that the drum moves one revolution for six turns of G, and for three hundred and sixty of K; thus as the circumference of the drum is about eight inches, there will be about forty-five lines per inch, and an octavo-sheet will contain a record lasting from one hour to fifteen days, according as the lever I J is allowed to drop at the time intervals corresponding to the arbors F, E, D, or C of ten seconds, one minute, seven and a half minutes or one hour.

The length of the line drawn by the pen being dependent solely on the number of revolutions of the shaft T S, it is convenient to ascertain the *absolute scale* by rotating T by hand for 10—20—30 etc. revolutions, and moving the drum a little by hand at the end of each ten turns. This eliminates the possibility of error in determining the radius of the sector and friction roller, and also the effect of obliquity of the pen clip. As the length of pause depends solely on the notch at I, it is the same whether the drops take place once per hour or at any of the faster intervals, and may be only one to two seconds when the ten-second cam does the lifting, but the scale used in measuring the diagram must allow for this pause, when its magnitude is a sensible fraction of the whole interval. The *special scale* of speeds to be used for any particular experiment depends on the time interval and pause. In the illustration the proportions of roller and sector are such that on the absolute scale about one hundred revolutions of T equal one inch. If, for example, the recorder is coupled to the prime motion under test, so that T makes say two revolutions for each one of the prime motion, and the tripping takes place once per minute with two seconds pause, then fifty-eight on the absolute scale will correspond to thirty revolutions per minute of the prime mover, and the vertical width of the paper (five inches) will allow of velocities up to about three hundred revolutions per minute being recorded.

Two experimental recorders have been constructed by the writer, the first (made in Brisbane in June 1893), had great range of adaptability, and was correspondingly troublesome in adjustment. Its periods varied from four seconds to eight minutes, and there were also two sets of friction rollers. The lines on the diagram could be spaced either at one hundred and forty lines per inch, giving a shaded diagram, or at fifty per inch separating the lines. The second instrument (made in Parramatta in August 1884), was specially modified for anemometry. The differenting period is one hour with a pause of four and a half seconds, which is negligable in comparison with one hour. The drum is driven continuously, and revolves in a week, the paper moving one inch and a quarter per day, the verticals being spaced about twenty per inch. At this scale, the secondary changes of speed inside of each hour are fairly indicated by the varying inclination of the strokes. The driving shaft T S is placed vertically and coupled directly to a Robinson's wind gauge by a vertical wire, which makes one revolution to thirty of the cups. The wire may be of any length so that the gauge may be on a pole on a tall building, and the recorder under cover in the building below. As ordinary winds seldom exceed thirty miles per hour, yet are stated to occasionally exceed one hundred, the pen gear is modified so as to give a varying scale. Thus at 0 to 5 m.p.h. the scale is about five miles per inch, diminishing to half that between 20 and 30 m.p.h., and so on, the extreme motion being to record 100 m.p.h. By this device ordinary winds are recorded on a very open scale, and yet exceptional gales can be included in a band of the moderate width of five inches. This is accomplished by separating the pen-lever OM from the sector N, and coupling them by a link* the relative centres being so arranged that the angular velocity ratio changes continuously and evenly from about *two to one* at 1 m.p.h., to *equality* at about 25 m.p.h. and vanishing at 100 m.p.h.

The diagrams from these instruments are difficult to reproduce by printing, particularly those shaded diagrams produced by very close ruling. Figs. 1 to 4 illustrate some records produced with fairly wide time scales.

Fig. 1 (*a* and *b*) are modified records of the velocity imparted to a Morse telegraph ribbon by a clock mainspring, *a* when controlled by a Siemen's frictional governor, and *b* when controlled by a plain rectangular fan or fly (1·3″ × ·85″). In the former case *a* the speed of the roller over which the ribbon runs commences at about sixty revolutions per minute and steadily falls to zero, the whole run lasting only about seventeen and a half minutes. With the frictional governor the period of one unwinding of the spring is extended to forty-five minutes, and the roller speed is fairly

* See Rankine—"Machinery and Millwork," page 312, article 273.

even, commencing at eighteen and ending at fifteen revolutions per minute.

In the diagram *b* the thread from the paper roller to shaft T S was led to a larger pulley than in diagram *a*, hence the difference in the vertical scales. In both diagrams the envelope of the vertical strokes is a fairly even curve of a somewhat parabolic outline, with minor irregularities due to variations in the train and spring friction.

Fig. 2 is a portion of record extending over three days (4 – 6 October, 1894) taken at Parramatta with the special recorder for wind, and showing the daily wave in a marked manner, as well as some of the more prominent irregularities inside of each hourly average. During this experiment the wind gauge was coupled to both recorders, and Fig. 3 is a duplicate of the same record from 4 p.m. to midnight on the 5th October, taken with a four minute period instead of one hour, and giving the minute changes in greater detail.

Fig. 4 is a short example of one hour taken 19 October, with an eighty second period, and showing that with wind there is no such thing as uniform velocity, even for a few seconds, but that however small the period be made yet succeeding intervals always show great and irregular changes of velocity. This has been tested, both in calms and gales, down to intervals so short as four seconds.

The instruments may be used for recording any class of velocity, such as the motion of a railway train or steamship, the fluctuations of steam engine speed on various duties, or the variations of current or potential in electrical transmission of power or light.

THE GEOLOGY OF LIMEKILNS, BATHURST DISTRICT.

By W. J. Clunies Ross, B.Sc.

(Communicated by J. H. Maiden, F.L.S., &c.)

[With Plate XLII.]

[Read before the Royal Society of N. S. Wales, August 1, 1894.]

The locality known as Limekilns is situated about sixteen miles north-east of Bathurst. The existence of beds of limestone there has long been known, and, as the name of the place indicates, the stone was formerly used for lime burning, although at present little, if any, is quarried for that purpose. One of the limestone beds contains some small caves, which are occasionally visited, and a short list of fossils from the place is given by Rev. J. M. Curran, in his paper on the Geology of Bathurst.* A few months ago attention was drawn in the daily papers to the occurrence of a variegated marble at a place called "Fernbrook," which is close to Limekilns. The discovery of this ornamental stone, or at any rate the recognition of its suitability for decorative work, is due to my friend Mr. W. Roberts, Government Clerk of Works for the Western District, who carefully examined all the limestones in the Bathurst district, with a view to the utilisation of some of them in Government buildings. The favourable opinion which he formed of the Fernbrook stone has been fully endorsed by all who have seen polished specimens, and it is generally admitted to be equal in beauty to any imported stone. As it is obtainable in good sized blocks and easily polished, there is considerable probability that it will be extensively used in the near future. Geologically speaking, it is not a true marble, if we confine that term to limestones which have undergone complete metamorphism, accompanied by the obliteration of all fossils. True saccharine

* 'A Contribution to the Geology and Petrography of Bathurst, New South Wales.'—*Proc. Linn. Soc. N.S.W.*, Ser. 2, Vol. vi., p. 173 - 234.

marble exists at various places around Bathurst, but the Fernbrook limestone is decidedly rich in fossils, although it has no doubt undergone considerable alteration since it was first formed.

The Limekilns area as a whole appears never to have been systematically examined geologically, and, as it has already yielded a considerable variety of fossils, while many more will probably be obtained as the various beds are opened out, a short account of the stratigraphy of the district may be of interest. A summary of the character of the limestone will be given as a preliminary, and also some notes on the other marbles and limestones found around Bathurst.

Petrography of Bathurst Limestones.

A series of specimens is exhibited herewith, which will show the great variety of ornamental stone existing in this district. Taking the Fernbrook stone first, we find it extremely varied in appearance, scarcely two specimens being alike. It exhibits all shades of colour, from pure white to deep red, occasionally passing into a bluish slate colour and even to black. In many instances it appears to be brecciated, consisting of angular fragments cemented together by calcite. In other cases it is compact but with various shades of red in blotches and streaks, while sections of fossils sometimes show out in a striking manner. When tested with acids, it effervesces freely, but when dissolved leaves a moderate amount of insoluble residue, while the solution is found to contain a good deal of magnesium in addition to calcium. I have not yet made a thorough quantitative analysis of the stone.

The Fernbrook stone has probably resulted from the alteration of limestones similar to those occurring in the neighbourhood, but these, in the main, are of very different appearance, consisting of massive limestones of a bluish tint, mostly rather dark when broken or polished, but weathering to a lighter colour. Several places are already known, however, where they also become red, remaining massive and generally differing in appearance from the variegated stone. The term "Fernbrook" is usually applied to the variegated variety, which is all that has hitherto been quarried, and it will be used in that sense in this paper.

Preparations are, however, being made to open up quarries in some of the other beds, and it is likely that the name of Fernbrook marble will eventually be used to denote all the ornamental stone obtained from the Limekilns area. This appears to be desirable, since Fernbrook is a more euphonious name and also more definite than Limekilns. Leaving Limekilns for a time, we find no more limestone for a considerable distance, but near Green Swamp, about twelve miles south, there is a small bed, and there are also one or two others in the neighbourhood, all on the same line of country. Taking a line more to the west, the rocks in all cases striking nearly north and south, we find, near Wyagdon, a very fine, close grained marble, pure white with greenish or black veins (No. 12). This stone has been obtained as yet only at the surface, but promises well, if opened up. It dies out if followed south before reaching the granite, but on the other side of Bathurst, near the old copper mining centre of "Cow Flat," there is a similar but coarser grained marble, white with bluish veins (No. 13). These marbles, being situated on what appears to have been the axis of greatest metamorphism of the district, have been completely altered, and are never likely to yield fossils.

Proceeding still farther south, however, we find at Rockley, about twenty-two miles from Bathurst, a very rich limestone country. Some beds are crinoidal and make a very ornamental stone when polished (No. 16); other beds are ordinary bluish limestone of no particular beauty, but about a mile from the township, at a place called Jumper's Flat, there is a saccharine marble of a warm cream colour (No. 15). This is a very pretty stone, but does not appear to have been utilised except to a limited extent for lime burning. Beyond Rockley, again to the south, a magnesian limestone occurs at Bunnamagoo. This rock appears at first sight to be a coarsely crystalline ordinary limestone, but it does not effervesce in cold acids, and may be classed as a dolomite (No. 17).

Other localities in the district where beds of limestone occur might be cited, as for instance, between Limekilns and Sunny Corner, but enough has been said to prove that there is a great variety of stone, suited for building and ornamental purposes, within a radius of twenty miles from Bathurst. It would, in fact, be difficult to name any locality where so complete a series of limestones and marbles, coarse grained and fine grained, fossiliferous and unfossiliferous, of all colours—white, black, red, blue, grey, and variegated, could be obtained.

A polished slab and several small specimens, Nos. 1 to 5, from Fernbrook are shown, also samples of the other beds at Limekilns Nos. 6 to 10 and 14. For comparison, a specimen of ornamental stone from Kaloola, near Orange is added. This limestone carries fossil corals.

Stratigraphy of the District.

In a paper contributed to the Geological Society of London, and recently published in the Quarterly Journal,* I have sketched the geology of the Bathurst District, as I understand it. In order, however, to make the mode of occurrence of the Limekilns rocks clear, it will be necessary to traverse part of the ground alluded to in the paper.

Let us set out from Bathurst, height about 2,200 feet above sea level, on a journey to Limekilns, and note the geological features of the country. We at first travel over low hills of granite, capped with drift near the village of Kelso, descending again to the Wimburndale Creek. This creek or rivulet follows roughly the junction of the granite and slate for some distance, crossing and recrossing the boundary several times. On the Limekilns road, however, one has to travel for about a mile and a half beyond the creek before reaching the junction. Just beyond the creek the ground rises, and some fifty feet above its present level, a thick bed of coarse drift occurs, marking the former level

* 'The Geology of Bathurst, N. S. Wales.'—*Quart. Journ. Geol. Soc.*, Vol. L., pp. 105 – 119.

of the stream and proving that the creek is an old one. The road reaches a height of about three hundred feet above Bathurst and then descends to Clear Creek, where we are again at about the level of the city. Here, the rocks consist of micaceous schists, passing to less altered slates higher up the creek; dykes of felstone also come in and pebbles of Devonian rocks, Brachiopod Sandstone, may be picked up showing the existence of beds of Devonian age near the head of the creek. Where the Limekilns road crosses, the granite does not show out, but is probably not far from the surface, as it may be found between this point and Peel. Beyond Clear Creek, the road runs roughly north east for about two miles, then nearly due north for about the same distance, steadily rising the while, and being roughly parallel to a small creek known by the unpoetical name of "Bread and Butter." Passing beyond this, it makes a wide bend around a place marked *Limekilns* on the official map of the parish of Jesse, but which is some distance from the locality usually so called; nor does there appear to be any limestone in the neighbourhood, although there may once have been kilns for lime burning in the vicinity. The highest point on the road is about eight hundred feet above Bathurst, and it then descends rapidly to Limekilns proper. Near the top there is a quarry for road metal which offers a good opportunity of taking the dip and strike of the black slates which make up almost all the hill. I found them to strike S.S.E.—N.N.W., dip E.N.E. 35°.

On reaching the foot of the hill, we find ourselves opposite the "Rising Sun" Inn, kept by Mr. Thomas Tobin. This forms a good starting point for examining the Limekilns area, and numerous determinations by aneroid give the altitude of the road in front as just about five hundred feet higher than Bathurst. Standing at the door of the inn we look towards the valley of Cheshire Creek, or Jesse Creek as it is sometimes called about here, a tributary of the Wimburndale. The back of the house looks up a broad valley dividing the hills down which we have just come from those containing the limestone, which are farther on. Near Cheshire Creek, however, there is a thick bed of limestone in which the caves already mentioned are situated. They have been explored but are of no great extent, running for about a quarter of a mile, principally as low passages, but with a few more lofty chambers. The walls are encrusted with calcite "formation" similar to that at the Jenolan Caves, and there are a few stalactites, mostly dull in appearance and showing little of the beauty of those at the Jenolan. The caves terminate in a moderately lofty chamber from which most of the limestone appears to have been dissolved out; the roof and floor being of black earth. There is a good deal of earthy mud in the caves, but no bones appear to have been found.

The cave limestone is almost entirely made up of fossil corals, and is capped in places by a conglomerate of limestone pebbles. It seems to die out before reaching Cheshire Creek where the rocks are schistose in character. An observation in the caves gave the strike as N.N.W.—S.S.E., dip W.S.W. at a low angle. The limestone at the surface may be followed along the strike for a considerable distance. It crosses the Diamond Creek and afterwards the Sofala road, retaining the same character all the way.

Returning to Tobin's and travelling along the road in front, we find at about two hundred yards away a road branching off on the right hand side, nearly at right angles, which leads to Palmer's Oakey and Sunny Corner. The main road bends to the west of north, and the cave limestone is reached about one and a half miles from the inn; the road shortly after dividing, one branch going to Sofala, the other to the Upper Turon. At the junction of the Palmer's Oakey and Sofala roads the black slates are well seen, dipping apparently nearly N.W. at about 20°, but it is difficult to be quite sure about the true bedding planes. To reach the other outcrops of limestone one has to follow the Palmer's Oakey road for about half a mile, it running east and west, when it bends to the north, crosses Diamond Creek and begins to rise steadily. In a short distance we find a thick band of bluish limestone crossing the road. This is similar in appearance to that at the caves, but less distinctly fossiliferous, although the corals are of the same genera and apparently the same species. This limestone strikes about N.N.W.—S.S.E., like the other, and may be followed on the right hand side of the road towards the Diamond Creek, but gives place to slates, much tilted up, before the creek is reached; on the left it continues for at least two miles. After crossing the outcrop the black slates come in again and there is no more limestone on the road for about two miles. A short distance back from the road, however, there is a very fine outcrop of limestone, forming a bold escarpment, and apparently dipping into the hill, that is, about E. The rock is very massive and compact, mostly of the usual bluish tint, but in places becoming red, and near the base of the escarpment there is a seam of brown haematite, which seems to be a pure ore, but its thickness has not been tested. The base of the limestone escarpment is about eight hundred feet above Bathurst and the top at least one thousand feet. It is capped by beds of grit, quartzite, and impure limestone. The limestone and grits contain *Rhynchonella pleurodon* and other fossils. The grits clearly belong to the well known Brachiopod Sandstone series, and the quartzites are quite similar to those obtainable anywhere to the east of Bathurst where the ground rises to one thousand feet above the city. At Limekilns they have been followed to a height of one thousand two hundred feet, and the top of the hill was not reached. They have the usual dip, about E.S.E. 20°. At other places the quartzites and grits reach a height of two thousand feet above Bathurst, but, as they dip easterly, the base is found lower down as we proceed in that direction. There can be little doubt that they are unconformable to the limestone, from which they are separated by a thin band of slate, and are of very different age.

The Palmer's Oakey road bends to the north-east and at about three miles from Tobin's one reaches the Fernbrook quarries. These are situated in a mass of limestone with a gentle slope, at a height of about eight hundred and fifty feet. Only two small quarries have been opened as yet, to a depth of about ten feet. The band of stone appears at first to be a combination of that which forms the escarpment, but between the two a very different rock comes in. This is a rather coarse-grained quartz-felspar-porphyry. It seems clearly to be intrusive, but in one specimen shows the impression of a crinoid stem ; this may have been caught up by the rock when intruded.

The Fernbrook rock is much broken up by irregular joints into large blocks. It appears likely that it was shattered by the intrusion of the quartz-porphyry and the fragments afterwards cemented together. The iron present in the limestone, or introduced from outside, has no doubt become peroxidised and imparted the red colour to much of the rock. The irregular distribution of the colour, which gives its characteristic appearance to the marble, may be due to small differences of texture modifying the deposition of the iron. Very few of the corals, so common in the other beds, can be seen in polished specimens of Fernbrook stone, but on the other hand, fossil cephalopoda are tolerably abundant. They are not usually very evident on rough specimens but when ground and polished show out remarkably well ; there often being several species represented on the same piece of stone. It is only within the last few months that I have been on the look out for cephalopoda especially, and I have not had much opportunity for collecting specimens, but I have already found several which are now exhibited (Nos. 1, 2, 3, 4). So far I have not found a single cephalopod in either of the other beds.

PALÆONTOLOGY.

The fossils hitherto found at Limekilns include hydro-corallines, corals, crinoids, brachiopoda, and cephalopoda. One new coral has already been described and named *Phillipsastrea Currani*, after the Rev. J. M. Curran, by Mr. R. Etheridge, Junr.* I have placed two parcels of fossils from the locality in Mr. R. Etheridge's hands. These have not yet, I believe, been systematically examined, but representatives of the *Stromatoporidæ*, *Favo-*

* Records Geol. Surv. N.S.W., Vol. II., Pt. iv., 1892, p. 166, Pl. xi.

sitidæ, and *Cyathophyllidæ* are certainly present among them. The brachiopoda include *Spirifer*, *Orthis*, and *Strophomena*. A specimen of the latter genus was thought by Mr. Etheridge to be near to, or identical with, *S. corrugatella*, an Upper Silurian fossil which is mentioned by Professor Hutton as occurring in the Takaka system, Baton River series, of New Zealand.* The brachiopods and corals appear to indicate an Upper Silurian age for the limestone beds, but I have not yet obtained a recognisable specimen of *Pentamerus Knightii*, which occurs in so many of the limestone beds of this Colony. A specimen from Molong (No. 19) is exhibited, herewith, which may add another to the list given by Mr. Etheridge of localities where this fossil occurs.† Once or twice I thought I was on its track at Limekilns, but hitherto it has eluded me. The cephalopoda promise to be very interesting. When I sent my last parcel to Mr. Etheridge I had only obtained two specimens. One of these he considered to be a section of an *Orthoceras*, the other as possibly *Gomphoceras*. The specimens now exhibited show examples of *Orthoceras* and *Gomphoceras* almost certainly, possibly *Cyrtoceras*, or one of the other curved forms, and a specimen having apparently a beaded siphuncle which may indicate affinities to *Ormoceras*. I hope to make a good collection of these fossils which will be worthy of description by Mr. Etheridge or some other competent palæontologist.

The slates accompanying the limestones, as well as those on the Bathurst road, are disappointing. They do not appear to be much altered, and some of them effervesce slightly with acids, but hitherto not a trace of a fossil has rewarded the most diligent search. I do not despair, however, of finding some.

The Devonian rocks have not yet been carefully examined, but they are so similar to the beds near Glanmire, on the Wimburndale and Gulf Creeks (see map), that nothing very different from

* The Geology of New Zealand, by Capt. F. W. Hutton—*Quart. Journ. Geol. Soc.*, Vol. XLI., (1865) p. 199.

† Records, Geol. Surv. N.S.W., Vol. III., pt. ii., 1892.

the fossils in those beds is likely to be found. The present list from Limekilns only includes *Rhynchonella pleurodon*, *Chonetes*, near to *C. Hardrensis;* and a plant remain hardly sufficiently definite to name. From Glanmire we have in addition *Spirifer disjunctus*, a rugose coral, possibly a *Zaphrentis*, *Lepidodendron australe*, and another plant impression having the appearance of a stem of a *Calamite* or *Phyllotheca*, certainly not a *Lepidodendron*, but again not distinct enough to be identified definitely. Careful search and description of the fossils will probably add considerably to this rather meagre list.

Summary.

The Limekilns area is principally interesting geologically from the fine exposures of Silurian Limestone, rich in fossils, which occur there. What are believed to be Silurian rocks cover an immense area around Bathurst, but they are for the most part completely barren of fossils, so that for the determination of their age one would have to depend on their similarity of character to beds in other parts of the Colony, at all times an unsatisfactory kind of evidence, were it not for the existence of occasional beds of limestone. Many of these, however, have undergone so much alteration that they are useless to the palæontologist. The Limekilns beds, being removed from the area of extreme metamorphism, have retained their fossils in a very satisfactory state of preservation and are therefore valuable. Four distinct outcrops of limestone occur, which may be numbered 1, 2, 3, and 4, as on the map. Whether these are all separately formed beds is uncertain at present. Very possibly there may be one or more faults, as, for instance, between 2 and 3, and there is little doubt that there has been a good deal of disturbance of the beds, with fracturing in places. The strike of the beds remains tolerably regular, but the dip, where obtainable, appears to vary a good deal, both in direction and amount. In this the limestones agree with the Silurian slates, which at several places in the same area show fracture and contortion.

It is often said that the limestones of the colony exist for the most part in lenticular masses. The Limekilns beds may have that character, but it is doubtful. The cave stone (No. 1) and that on the Palmer's Oakey Road (No. 2), can be followed for several miles, and the outcrop seems to vary little in breadth, so that, if they are lens shaped, they must have a very large radius of curvature. All the beds seem to terminate rather abruptly to the south, but their limits to the north are uncertain, since the colours on the map only indicate the extent to which they have been followed up by the writer. Bed No. 3, which exists as a massive escarpment two hundred feet in height, gives the impression of being possibly lenticular, but this also is uncertain.

Another point of interest at the Limekilns is the capping of Devonian rocks which is found on the highest part of the limestone and which appears to be the termination of those beds to the north, for at any rate a long distance, since the hills beyond Cheshire Creek are of no great height, and the junction line of the Devonian and Silurian rocks seldom falls much below one thousand feet above Bathurst all along the hills which bound the Bathurst plains to the east. If one is not aware of this, the Devonians may be missed altogether in examining the country, as they have generally been denuded away from the valleys and lower hills. This is especially observable on the Sydney road on which one has to travel a long way before meeting Devonian rocks, although they cap the hills at the side.

Limekilns may become the centre of an important industry, when the arrangements now being made to work the quarries on a large scale are completed. We may all wish success to this new colonial industry, but whether commercially prosperous or or not there are certain to be many interesting geological facts brought to light which will well repay investigation.

In conclusion, I desire to acknowledge my indebtedness to Mr. W. Roberts for the polished slab of Fernbrook marble, as well as for several other valuable specimens. Also to Mr. W. Pascoe for grinding and polishing many of the specimens now exhibited.

Notes on the Maps and Section.

Map No. 1, on a scale of two inches to the mile, is intended to indicate the principal geological features of the country between Bathurst and Limekilns. The topographical details have been inserted mainly from the parish maps. The geological lines are drawn from my own observations and are subject to correction after further work, especially as to the limits of the Silurian and Devonian about the head of Clear Creek—a rather rough country which I have not yet examined carefully.

The section along the line A B (*Plate* 42) is on a horizontal scale three times that of the map. The vertical scale is about one inch to two hundred feet. The heights are reckoned from the level of Bathurst, as a datum line, but it is not shaded below the level of Cheshire Creek, since it is impossible to predict with any confidence the arrangement of the rocks at a distance from the surface. No doubt the granite underlies the area, but at what depth one cannot say. The line of juncture between the granite and Silurian varies much around Bathurst. Thus, on the Limekilns road it is about two hundred and fifty feet above, and on Clear Creek, near Peel, about fifty feet below Bathurst; while on the Sydney road the granite appears at about seven hundred feet above Bathurst, near Yetholm.

List of Specimens.

No.	Locality.	Description.
	Fernbrook ...	... Polished slab, to illustrate the character of the stone.
1.	Fernbrook ...	... Section of Cephalopod, probably *Gomphoceras.*
2.	,, ...	... Section of Cephalopoda. *Orthoceras, Gomphoceras*, and, possibly, *Ormoceras* present.
3.	,, ...	... Section of Cephalopoda. *Orthoceras,* possibly *Cyrtoceras.*
4.	,, ...	... Section, part of large Cephalopod.

No.	Locality.	Description.
5.	Fernbrook	Sample of Marble.
6.	Limekilns	Fossil Coral. *Phillipsastrea.*
7.	,, ...	,, ,, *Favosites.*
8.	,, ...	,, ,, *Cyathophyllum.* (?)
9.	,, ...	Dark Limestone, with Coral, &c.
10.	,, ...	,, ,, with red markings.
11.	Palmer's Oakey Rd., beyond Fernbrook	Crinoidal Limestone.
12.	Wyagdon	Saccharine Marble.
13.	Near Cow Flat ...	,, ,, coarse grained.
14.	Limekilns	Red Limestone.
15.	Jumper's Flat, near Rockley	Cream coloured, fine grained Marble.
16.	Near Rockley ...	Crinoidal Limestone.
17.	Bunnamagoo, S. of Rockley	Magnesian Limestone.
18.	Kaloola, near Orange	Coloured Limestone. (For comparison. Outside Bathurst District.)
19.	Molong	Fossil *Pentamerus Knightii.* (?)
20.	Green Swamp, near Bathurst... ...	Limestone.

SOME STONE IMPLEMENTS USED BY THE ABORIGINES OF NEW SOUTH WALES.

By R. H. MATHEWS, Licensed Surveyor.

[With Plate XLIII.]

[*Read before the Royal Society of N. S. Wales, September 5, 1894.*]

THE following aboriginal stone implements are exhibited on the table to-night, viz :—stone hatchets, stone knives, a stone used as a mill for grinding seeds of grass, &c., and a stone pounder.

Hatchets.—Some of the hatchets exhibited have been artificially chipped into their present form before being ground,—but that they have been formed from weathered rock fragments is evident from parts of the original decomposed surfaces being still visible on portions of the implements which have not been chipped. In other words, they have not been quarried from a mass of rock.

Some of them are naturally denuded rock fragments found on the surface of the ground, and picked up by the natives on account of their convenient shape and adaptability for taking a cutting edge. Others have evidently been well rounded water-worn pebbles of the requisite size and shape, found in the bed of some creek or river, and ground to an edge at one end.

No. 1 (*Plate* 43, fig. 1) is a chipped pebble of igneous rock which appears to be of the nature of dolerite : it is five inches long, three and one-eighth inches wide, and about one and one-quarter inch through at the thickest part, and has been ground to a good cutting edge. It is a perfect specimen of the native hatchet. The other hatchets exhibited, Nos. 2 to 9, consist of the following kinds of stone respectively :—diorite, felspar-porphyry, fine grained granite, porphyry, highly altered sedimentary rock, clay-slate, and andesite.

Grinding.—The hatchets, or tomahawks, were ground and sharpened on sandstone rocks, in places near water, to facilitate the grinding ; and the groovings in the rock surface made by rubbing the hatchets upon them, can be seen in numerous localities in different parts of the country. The grooves are from half an inch to an inch deep, three or four inches wide, and of variable length—none of them being very long. The appearance of these grooves on the rock surface is delineated in *Plate* 43, fig. 3. The blacks also frequently carried with them a flat piece of sandstone, or other suitable rock, from five to six inches long, three or four inches wide, and about an inch thick, which they used as a whetstone to sharpen the edges of their tomahawks. These sharpening stones are grooved on one side—sometimes on both—by repeated use, in the same manner as the larger rocks. We do not often see these whetstones in collections, although they are as plentiful as the hatchets; the reason being, I think, that they are not so easily distinguished on the ground, and are passed by unobserved where a hatchet would be seen and picked up.

Handles.—The handle was made either of a tough vine, or part of half a sapling of suitable thickness, which had been split longitudinally down the middle, and placed in hot ashes to make it flexible. The piece of vine, or wood, was doubled, and in the loop thus formed the axe head was gripped, and secured with cord made from the bark of certain trees, or strong sinews of the kangaroo's tail. A gum which exudes from the stems of certain trees was applied to the binding to keep it secure in its place. This gum or resin was warmed at the fire, and worked till it was soft enough for use. In some cases a suitable piece of wood was obtained, and split at one end so as to receive the head of the hatchet, which was then fastened by cord and gum as just stated. The handle tapered almost to a point at the end to be held in the hand; this was done so that it might be of use in pushing it under the edges of bark in stripping, to force it off the tree, or for similar purposes. Brough Smyth states that the natives of the northern tributaries of the Darling River did not in all cases attach handles to their stone hatchets, but sometimes used them by holding them in the hand.

Use.—These stone hatchets were used to cut saplings employed in the building of gunyahs, &c., and for stripping bark from trees, for various purposes. They were also used in cutting notches in trees for the purpose of climbing; in cutting holes in the boles and hollow branches of trees to get out opossums and other animals, or to obtain the honey out of native bees' nests. In cutting these holes, the natives always chopped with the grain of the wood, instead of across it as a European would do, widening the aperture laterally until it was large enough for the purpose required. This method was adopted because it was easier to remove the chips in that way than by cutting across the grain, which would have been difficult with these primitive tools. One of these holes, which are always of an oval shape, is illustrated in *Plate* 43, fig. 4.

Knives.—The next exhibits are a number of aboriginal stone knives of various sizes, and different kinds of stone. These were obtained by me in the County of Hunter, by digging into the earthen floors of rock shelters which have been used by the natives as camping places. They were found at depths varying from a few inches to about two feet. They are all more or less interesting, especially the three largest ones, Nos. 10, 11, and 12, which are of a somewhat unusual type, and appear to have been used in skinning and dressing animals. No. 10, (*Plate* 43, fig. 2) is a piece of claystone, four and a half inches long by three inches wide, and an inch three-eighths in thickness at the widest part, having one of its longer margins ground on both sides to form a cutting edge. This edge is irregular and sinuous, and could not have been ground on a rock in the same way as the hatchets; this applies to the concave side of the edge, at any rate, which must have been ground by a stone held in the hand, or on a convex surface of a rock. My friend Mr. R. Etheridge, Junr., the Government Palæontologist, informs me that they are somewhat rare, and are well worth collecting. Nos. 11 to 13 are stone knives similar to No. 10, but not so large.

No. 14 is a fragment of some crystalline rock, apparently diorite, five and half inches long, four and three-quarters inches wide at the widest part, and one and a quarter inch thick, ground to a rough edge, and perhaps used for chopping up the carcases of animals, splitting bones to obtain the marrow, breaking firewood, &c. No. 15 is the same kind of stone as the last mentioned, but much smaller, found in the same excavation. This fragment was apparently chipped ready for grinding, but left unfinished.

Nos. 16 to 20 are fragments of stone, found in the same localities as the knives, and were probably used in cleaning and ornamenting the skins of animals, in tattooing, or for any purpose where a sharp cutting edge was required. These fragments were either broken off larger pieces by percussion, or were procured by lighting a fire on a suitable rock, and then pouring water upon it, resulting in the flaking off of pieces. Portable stones, of the requisite hardness and fineness of grain, could be heated in the fire, and then cast into water, which would cause them to fracture, from the fragments of which suitable pieces could then be obtained. These fragments are chiefly diorite and quartz.

Millstones.—No. 21 is a water-worn, oval shaped pebble of quartzite, seven and a half inches long, six and three-quarter inches broad, and two inches thick, which has been used by the aborigines as a mill for grinding seeds, &c. Well-defined circular hollows have been worn in each side by repeated use of another stone. A nick has been made in each end, no doubt for the purpose of fixing the stone firmly in position while in use.

No. 22 is a specimen of the stone pounder, or "upper millstone," held in the hand of the operator.

Barter.—Hatchets, and the stone for making them, as well as sharpening stones and millstones, were amongst the articles of barter at the great meetings which were held for the initiation of the youths of the tribes. At the conclusion of these ceremonies, before the people dispersed, a kind of fair was held, when natives in whose country stone was plentiful would barter these things with other people for reeds for making spears, rich plumage of birds, &c., usually found in the level country where suitable stone is scarce—or for any other articles brought by the various tribes for the purpose of exchange.

A PERLITIC PITCHSTONE FROM THE TWEED RIVER, NEW SOUTH WALES, WITH REMARKS ON THE SO-CALLED PERLITIC STRUCTURE IN QUARTZ.

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[With Plates XLIV. - XLVI.]

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THE specimens from which this rock is described were brought to Mr. G. W. Card, A.R.S.M. of the Mines Department, Sydney, by a prospector under the impression that the phenocrysts of yellow quartz were tin-stone. Mr. Card drew my attention to to them, and, as they appeared to be of an interesting character, we decided to publish conjointly an account of them. I regret that Mr. Card has been unable to find time to carry out this arrangement, and so the task of describing the specimens has devolved upon me.

MACROSCOPICAL CHARACTERS.

In external appearance the rock presents a black glassy matrix uniformly studded with numerous phenocrysts of quartz and felspar averaging two to three mms. in diameter. The ferro-magnesian constituent is only apparent under magnification. The glassy matrix is black (colourless in thin sections), with a semi-vitreous lustre and a conchoidal fracture somewhat interrupted by the perlites which stand out on a fractured surface. The perlitic structure is remarkably well developed, and is best seen on a finely ground surface of the rock, over which a glass slip has been cemented with canada balsam. The cracks appear as light coloured lines on a black ground, the lighter material filling the cracks being transparent and of about the same refractive index as the surrounding glass, so that in thin sections the perfection of the structure is not so distinctly evident.

The Quartz occurs in rounded grains, which however, in many cases, can be recognized as more or less corroded bi-pyramidal crystals. In parts they are yellowish in colour owing to numerous cracks which are filled with a ferruginous staining material. These cracks are generally spheroidal and cause the crystals to break up into small grains with curved faces.

The Felspar is chiefly sanidine in glassy tabular crystals showing the usual transverse cracks and frequently simple twinning. A certain amount of plagioclase (albite) is present in smaller grains.

Microscopical Investigation.

Thin sections of the rock appear clear and fresh where not affected by weathering, and but little secondary alteration is visible either in the glass or in the phenocrysts; the latter, however, have undergone more or less corrosion by the molten magma.

The quartz grains are chiefly remarkable for the numerous strongly curved cracks which traverse them. In sections these cracks are sometimes rudely concentric for portions of their length, but more generally exhibit a number of curves abutting abruptly against one another. Occasionally these cracks include portions of the glassy matrix. Cracks quite similar to these have recently been claimed to be 'perlitic,' and if 'perlitic' simply implies that a crack is curved and may reasonably be inferred to be due to contraction on cooling, then the majority of these cracks are undoubtedly perlitic. I hope to show later on that typical perlitic cracks present well marked characteristic features, which give them the right to be considered as forming a distinct and definite rock-structure, and which features are markedly different to those exhibited by the cracks in the quartz.

Inclusions are not numerous, and so far as I have observed are all glassy. In sections at right angles to the vertical axis these inclusions are hexagonal in shape with slightly curved sides which may be due to action by the re-fusion of the contained glass. This glass contains minute crystallites, occasionally one or two needle-shaped crystals and invariably a small bubble with a dark border.

The Felspars are clear and fresh, but are in parts much corroded and contain great numbers of cavities filled with glass. Some of these take the shape of the host but the majority are irregular in shape, generally connected with one another and with the external glass. These latter doubtless owe, at least their present form to to secondary action. They frequently contain rounded or ring-shaped bodies of an isotropic material which varies in colour from pale green to dark brownish-green, and in places become opaque from the presence of a dark brown or black powder (probably magnetite). They are all doubtless secondary secretions of iron-silicates introduced along cracks and planes of solution in the felspar. The monoclinic felspar is sanidine, which occurs in large single grains, generally simply twinned. The triclinic felspar is much less in amount, in small grains two or three of which are sometimes aggregated together. The lamellar twinning is well marked and the extinction angles agree closely with those of an albite.

The Hypersthene occurs in small distinct grains of prismatic habit which usually do not exceed 1 mm. in length. No trace of any other ferro-magnesian mineral is to be observed. The grains though considerably corroded do not appear to have yielded any secondary alteration products (save possibly a little magnetite). In very thin sections they appear to be made up of an aggregation of minute rods parallel to the vertical axis. In thicker sections only a somewhat fibrous arrangement is visible in parts, but there is a strong cleavage in the same direction and a rough cracking at right angles. The grains are distinctly pleochroic, and the following scheme shows their relation to the type mineral.

Pleochroism : a = reddish-yellow, b = yellow, c = green, principal cleavage 010 which is also the optic-axial plane. $\mathfrak{a} = a$ and is the acute bisectrix, the optical sign is therefore negative.

The metallic inclusions so characteristic of some hypersthene are not present, but there are comparatively large crystals of magnetite included as well as numerous small zircons and a few apatite prisms. In addition to these there are a number of prismatic cavities whose lengths are parallel to the vertical axis, and which appeared to be filled with glassy material.

Crystals of magnetite similar to those included in the hypersthene are scattered through the rock, but are most numerous around the grains of hypersthene, while some are partially in the hypersthene and partially in the glass. These facts seem to indicate strongly that the magnetite was originally contained as inclusions in the hypersthene and has been set free by partial solution of the latter.

Though the phenocrysts are traversed by numerous cracks no apparent dislocation of the pieces has taken place, and this, in conjunction with the fact that many of the cracks pass out into the surrounding glass affords strong evidence that this cracking took place subsequently to the cessation of flow.

The glassy matrix is transparent and colourless in thin sections and thoroughly vitreous, but at the same time filled with innumerable microlites and crystallites, which under a one inch objective, appear as minute twisted black lines. These by their varying concentration serve to indicate the excellent lines of flow and vortex motion in the magma. Under high magnifying powers the minute bodies which are so densely distributed through the glass may be divided into two classes, the proportion between which varies in different parts (*Plate* 45, fig. 2). One of the classes consists of plagioclase felspar microliths, and is most typically represented by straight rod-like bodies terminated by crystalline faces and traversed by one or more cracks which sometimes appear parallel to one of the end faces (*Plate* 46, fig. 1). These minute rods, which average about ·02 mms. in length, are crystalline and react on polarized light. Their extinction angles, though difficult to measure with any approach to accuracy, vary from 0° to about 25° with the longer axis. They are doubtless lime-soda felspars rich in lime and the elongation is probably parallel to the axis '*a*.' Less perfect forms occur having forked terminations, while others resemble a dice box in shape. All the individuals of this class lie with their longer axes parallel to the lines of flow.

The other class consists of true crystallites, and is mainly represented by a form which I believe is uncommon. This is built up of a central axis, generally strongly curved, along which are ranged rows of globulites. Two rows of globulites are always visible, and sometimes a third can be detected, and leads one to surmise that a fourth row is present on the under side. The globulites are somewhat ovoid in shape and are occasionally composite. Frequently a portion of the axis projects free at one end, and it may then be seen to be serrated suggesting the partial fusion of a single row of globulites (*Plate* 46, fig. 2).

A form described by Zirkel as consisting of rows of cuneiform grains placed axially along a central line appears to be akin to that here described, and I think the designation 'granular axiolite,' which he uses may serve very well for the latter.

The individuals are always distinct and average a greater length (·05 mms.) than the microliths mentioned above. They are much contorted and curve about independently of the lines of flow except in places where there has been considerable differential motion in the current as in going round some of the larger crystals. No evidence of transition of the crystallites into the microliths is observable. Isolated globulites are rare, and margarites can occasionally be detected. In order to explain the fact that these crystallites are generally much curved, and in all directions to the flow I would suggest that in the flowing mass there were numerous minute whirls or eddies, and that these elementary bodies had not attained sufficient rigidity to resist their distorting action up to the cessation of flow. This is supported by the fact that these bodies are straightened out along the lines of flow where there was a strong set, and on the other hand become broken up where the motion appears to have been turbulent.

Accessory minerals.—A few slender prisms of apatite are present and some short prismatic grains of zircon. These may have been derived, along with the magnetite from the hypersthene. A few grains of a blue doubly-refracting mineral occur associated with the zircons which may possibly be sapphire.

Chemical and Mineralogical Constitution.

Sp. gr. = 2·47. The bulk analysis of the rock gave the follow ing results :—

SiO_2	=	75·51	per cent.
Al_2O_3	=	14·30	„
Fe_2O_3	=	1·01	„
CaO	=	1·81	„
MgO	=	·24	„
K_2O	=	2·89	„
Na_2O	=	1·21	„
H_2O	=	2·84	„
		99·81	

The alkalis were further determined in some of the glassy matrix from which the phenocrysts were separated, and gave the following:

K_2O	·78	per cent.
Na_2O	1·14	„

showing that the porphyritic felspars are rich in potash, while the glass is relatively rich in soda.

The relative volumes of the constituents were approximately determined by drawing several sections and cutting out and weighing the the pieces. After multiplying by the specific gravities of the minerals the mean of six sections gave the following result:

Quartz...	... 5·11	per cent.
Sanidine	... 14·94	„
Albite ...	... 2·07	„
Hypersthene	... 1·90	„
Glass ...	... 73·14	„
Water. .	... 2·84	„
	100·00	

The water being deducted from the percentage of glass. From these figures we can deduce that the glass contains 80·27% of SiO_2 and that its sp. gr. = 2·44. Assuming that the above figures are fairly accurate, it follows that there is not enough K_2O to completely satisfy the sanidine, which will therefore contain some

Na_2O (1·3%); while similarly, the albite will contain 1·9% of CaO, the bulk of the CaO being in the glass and in the lime-soda microliths. Figures derived in this way cannot of course be trusted very far, but they are interesting from their general agreement with the conclusions of microscopical observation.

A few words may not be out of place here as to the nomenclature of this rock. The well defined and abundant phenocrysts form a striking feature, and recall the appearance of vitreous members of the Dacite group, and this suggestion is somewhat furthered by the presence of hypersthene as the sole ferro-magnesian constituent. The high percentage of SiO_2 however, combined with the excess of potash over soda, and the fact that the majority of the porphyritic felspars are sanidine, necessitates the rock being placed in the acid group. It therefore becomes a quartz-felspar-pitchstone.

I am not aware that hypersthene has before been observed in so acid a rock.

In certain rhyolites intergrowths of enstatite and bronzite have been occasionally noticed in monoclinic pyroxenes. These latter are seldom conspicuously developed in the more acid lavas, and may usually be referred to the less ferruginous varieties. The presence therefore of hypersthene in this rock as a distinct constituent and in well marked grains, is, I think, worthy of special note.

Perlitic and other Cracks.

It would not be necessary to more than allude to the perlitic structure, so well exhibited in the glass of this rock, were it not that certain cracks similar to those in the quartz crystals have been claimed to be perlitic also.* In view of this it may be advisable to consider somewhat in detail the nature of the cracks to which the term perlitic is applied, and as a starting point I will first describe the structure which may be easily produced with great perfection in canada balsam. This artificial structure is admitted to resemble very closely the perlitic cracking of lavas

* The Occurrence of Perlitic Cracks in Quartz, W. W. Watts, M.A., F.G.S. —*Q.J.G.S., Aug.* 1*st,* 1894.

and is probably quite analogous if we remember that one is produced in a thin layer of substance and the other in the interior of a solid mass. In fact we may consider the artificial structure as a two-dimensional phase of the natural structure. Certain points of difference follow from this, to which I will allude later on.

As the method of producing the structure in canada balsam does not appear to be very generally known, I may perhaps be permitted to refer to one or two points in connexion with it. If a layer of balsam be spread on a polished slip of glass (or a cover glass) and heated until it becomes distinctly yellow in colour and then plunged into cold water, the balsam will be found to be traversed by numerous fine cracks which may be described as polygonal. In this case perlitic cracks are not developed, or only to a very slight extent. If however, the surface of the glass slip be first uniformly ground and the process repeated, the balsam will be found to exhibit, in addition to the polygonal cracks, very beautiful perlitic structure—the perlites occupying the interspaces between the polygonal cracks. If, instead of plunging the slip into water it be laid on a piece of glass the cracking takes place more slowly, and may be watched under the microscope. In this case the polygonal cracks make their appearance first, and then each individual perlite springs suddenly into existence, producing the impression of a tremor in the little mass of balsam. The higher the balsam is heated and the more quickly it is cooled the smaller is the interval of time between the two sets of cracks, until it becomes imperceptible to the eye.

In the structure so produced we may notice the following points (*Plate* 45, fig. 4.)

First, that the perlites always occur in the interspaces of a set of polygonal cracks and are formed subsequently to the latter, though the interval of time may be very small.

Second, each perlite is formed of segments of one or more spirals like curves—the radius of curvature tending to diminish as the curve is followed round. (Allowance must be made for distortion according to the shape of the polygonal interspaces). This spiral character can be clearly seen, and as a consequence the curves are not closed. Occasionally a curve may divide tangentially into two, or two may join into one, due doubtless to want of homogeneity or to a local disturbance.

Before applying these observations to the perlitic structure of a mass of rock, it will be necessary to try and form some conception of what I would call, the ideal perlitic surface. We have an approach to one section of this surface shown in the layer of balsam as a spiral curve, and we may take the external shape of a perlite to be spheroidal and that the outer surface completely encloses all the inner turns. It is evidently not possible to have a surface every section of which will be a spiral, and we are forced to assume that the surface is rolled spirally on an axis, each turn enclosing the previous ones, and all the turns touching each other tangentially where the axis intersects them. We have approximations to such a surface in the foraminifera *nummulites* and *fusulina*, the former being generally compressed and the latter drawn out along the axis.

A section of such a surface at right angles to the axis will give a spiral (*Plate* 46, fig. 3). A section passing through the axis will give a figure something like fig. 4, all the curves touching at two points on the axis. When the section passes through only one of these points we get fig. 5, and when it does not cut the axis between these points we get curves like fig. 6.

So far I have assumed this surface to be a continuous one. But even in the canada balsam the spirals are only segments, and therefore represent portions of a surface or surfaces similar to the ideal one. Again, in the balsam the curves all represent sections of the surface at right angles to the axis consequently the balsam may be considered as a section through a number of perlites whose axes are all parallel to each other and at right angles to the section. To such a group of perlites I may perhaps be permitted to apply the term 'polarized perlites,' and this arrangement is undoubtedly due to the mode of production on a plane surface of ground glass.

In a mass of lava on the other hand there is no such directive influence at work, so that the perlites would lie with their axes in all directions, and if they are surfaces similar to the ideal one, we should get the sections exhibited in figs. 3 to 6. As a matter of fact we do get figures closely resembling some of these in sections of perlitic rocks, but the majority of the curves in the natural structure are considerably different, and we are led to inquire what modifications of the ideal surface is likely to occur in a natural glass, and whether such modification will yield curves similar to those most frequently observed. The most obvious factor of disturbance will be a want of homogeneousness, which will I presume, be admitted to be a feature of natural glassy magmas.

The probable effect of this factor will be to produce a less symmetrical surface, and one in which the different turns—instead of being all rolled on one axis—are rolled on different axes. (The axis being the line joining the points of contact of any turn with the surrounding turn). For instance, if the axes of the turns in fig. 4, be displaced in the plane of the paper, we get curves of the type shown in fig. 7. If they are displaced in other directions as well, curves similar to figs. 8, 9, 10, must result with considerable variations in detail. To these considerations we must add the fact that the curves are frequently segmental or intermittent, and that the different segments may represent portions of more than one surface. These last set of curves bear a striking resemblance to those which may be observed in sections of perlitic rocks. Types approaching the previous more regular curves may also be observed but not frequently. In confirmation of these remarks I refer to the photograph of perlitic cracks (*Plate* 45, fig. 3), and to the drawings of actual perlites (Figs. 11 to 15).

If these suggestions as to the nature of perlitic structure are admitted to fairly represent its true character, I may be allowed to define it as follows :—Perlites are cracks of more or less irregularly spiralloid character, occurring in the interspaces between sets of polygonal cracks ; in section these appear as rudely concentric curves which are frequently in contact at various points.

Perhaps the most obvious characteristic is that the curves constituting a perlite never meet otherwise than tangentially, while another striking feature is the fact that the curves are so frequently segmental, the crack ending abruptly in the medium, and even curving round so as to run parallel with an adjacent crack instead of splitting into it. These are points which may be of use in determining whether any particular set of cracks are of a perlitic nature or not.

Before concluding these remarks I feel tempted to offer a suggestion as to the origin of this unique structure. It has been suggested, and I think generally admitted, that it is the result of contraction of the magma due to cooling. This however does not carry us very far, for everyone is familiar with countless instances of materials cooling, contracting, and splitting up under the strain, without giving rise to a semblance of perlitic structure. Even amongst volcanic glasses—the natural home of perlites—the range of the structure is extremely limited in comparison with the extent of apparently suitable magmas which have been examined.

In experimenting with canada balsam, the fact that the structure is easily produced when a ground surface of glass is used, and is only poorly and with difficulty produced on a polished surface suggests at once that the friction of the roughened surface plays an important part. Its effect will be a resistance to the natural contraction of the balsam, giving rise to a state of tension among the molecules. On a smooth surface of glass this tension exists only to a slight extent, and as soon as the polygonal cracking takes place, the strain is relieved and nothing further occurs. With the ground surface it is different, and two cases present themselves. First, when the balsam has not been very highly heated (and is therefore not very brittle) and is cooled slowly. In this case the polygonal cracks appear first, and the perlites spring into existence after an appreciable lapse of time. It is evident here that the balsam in the interspaces of the polygonal cracks remains under strain owing to friction, that the strain is towards the centre of each area and increases with the fall of temperature.

At some instant a rupture occurs and the fissure travels round with a diminishing radius of curvature as the shock travels towards the centre. Hence the spiral character of the cracks. In the second case, when the balsam has been highly heated the two sets of cracks occur simultaneously as far as the eye can tell, which may be due to the fact that the balsam is in such a condition of strain that the shock caused by the formation of the polygonal cracks, sends a vibration towards the centre of each interspace sufficient to cause the perlitic cracking of the highly strained balsam.

In order to apply these remarks to a mass of cooling lava we must seek for some agency capable of inducing the molecular tension which is supplied by the friction of the ground glass in the experiment. If we consider a stream of lava it is evident that the surface exposed to the air and those in contact with the ground become comparatively cool and hard, while the interior remains still viscous. This internal portion continues to part with its heat and consequently to contract. It will also experience a resistance to contraction, depending for amount on the ability of the external portions to withstand deformation. The result will be molecular separation along certain surfaces which may—as in the canada balsam—take the form of polygonal and perlitic cracks. Doubtless these only occur where there are some particular relations between the strain and the viscosity, or brittleness, of the medium. The various conditions necessary to induce a sufficient strain and to allow of the adjustment of such relations may well lead to the sparing development of the structure. I am not aware that up to the present the range of perlitic structure in rocks in which it occurs has been carefully studied.

To return now to the rock which I have been describing, we find there a glassy matrix full of undoubted perlites, and a number of quartz grains exhibiting various curved cracks. These latter are so similar in character to those figured by Mr. Watts in the paper above referred to, that I may be allowed to treat them in common. Apart from a general dissimilarity to the perlitic cracks it seems to me that they differ also in two important particulars: First, they do not lie in the meshes of a set of polygonal cracks, but on the contrary are often seen to be continuous with some of the polygonal cracks of the matrix. Second, instead of being segmental or touching each other tangentially they are almost invariably closed by abutting abruptly against each other.

These I consider to be important distinctions, and I cannot imagine anyone, who can view the two sets of cracks side by side, calling them by the same name, save on an extremely general basis of classification.

As I have not been able to obtain a photograph exhibiting the perlitic cracks and those in the quartz side by side, I have endeavoured to reproduce in canada balsam a structure similar in essential points to that of the rock. The result is shown in (*Plate* 45, fig. 4) and was obtained as follows:—

Small round pieces of polished cover glass were cemented on to a ground glass, a layer of balsam was spread over this and heated to a certain point and suddenly cooled. The result, as shown, was polygonal and perlitic cracks in the balsam overlying the ground glass and curved and sometimes concentric cracks in that overlying the polished pieces. It will I think be admitted that these latter cracks resemble in character those in the quartz grains and that they are quite distinct from the undoubted perlites.

There are a few other points in connexion with this matter to which I must allude. If a curved crack which lies mainly in the quartz encloses also a portion of the glass, one or more concentric cracks, representing an imperfect perlite cut off by the quartz, may be present in the enclosed glass. Again, if a perlite is adjacent to a crystal one or more of the cracks may traverse the crystal (*Plate* 45, fig. 1). Or, if a small crystal occupies the centre of a perlite, one or more of the cracks may traverse the crystal. These cases however do not prove that perlitic cracking will occur in the crystal *per se*.

There is another case which is probably of frequent occurrence and of which I have an example beside me at the present moment in a glassy basalt containing phenocrysts of olivine. Certain curved cracks surround the grains of olivine, but are elsewhere absent. They lack the even curvature of perlitic cracks, but, waiving this point, it is evident that they depend on the olivines for their existence, and do not prove that the magma would *per se* have yielded perlites. It appears to me that this case is on a par with the lithoidal variety of rock referred to by Mr. Watts (*Op. cit.* p. 373). These cracks, said by the author to be perlitic, surround the quartz grains. But, as in the former case, I should consider these cracks as doubtfully perlitic, and due to the contraction of the quartz, I am still unconvinced that an originally lithoidal groundmass has been found exhibiting of itself perlitic structure.

As Mr. Watts points out, quartz possesses a peculiar advantage towards yielding perlitic structure in having no cleavage, and, if such a medium cannot produce anything better than has been brought forward up to the present, it appears to me extremely improbable that a crystalline aggregate, consisting of individuals with various cleavages and different coefficients of contraction, would be able to develop so delicate a structure.

Reference to Plates.

PLATE XLIV.

General view of the rock × 15 diameters. Showing several grains of quartz with curved cracks, a large sanidine twin, and some small grains of magnetite and hypersthene.

PLATE XLV.

Fig. 1 × 30 diameters. A curved crack in the quartz on the right passes out into the glass through a crystal of felspar and round a grain of magnetite. This encloses a perlite, the outer curve of which is visible passing through the felspar.

Fig. 2. × 500 diameters. Showing the straight felspar microliths and the curved 'granular axiolites.'

Fig. 3. × 10 diameters. The perlitic structure of the rock photographed from a polished surface.

Fig. 4. Imitation of the structure of the rock in Canada balsam. The central patch which represents a piece of quartz shows some incipient perlitic cracks in addition to the curved cracks, but nothing like them is present in the quartz of the rock.

PLATE XLVI.

Fig. 1. Drawings of types of microliths.
Fig. 2. 'Granular axiolites.'
Figs. 3, 4, 5, 6. Sections of 'Ideal Perlitic Surface.'
Figs. 7, 8, 9, 10. Conjectural modifications of above.
Figs. 11, 12. Perlites from the Meissen Pitchstone, Saxony.
Figs. 13, 14, 15. Perlites from the present rock.

ON GREEN-PRODUCING CHROMOGENIC MICRO-ORGANISMS IN WOOL.

By T. P. Anderson Stuart, M.D.,
Professor of Physiology in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, November 7, 1894.*]

In the beginning of this year I received from my friend Mr. Charles Binnie of Fordee Station, near Quirindi, a parcel of wool with green patches, and Mr. Binnie asked me to tell him the nature of the discolouration. On submitting the discoloured wool to microscopical examination, nothing could at first be discovered, but at length little highly refracting bodies were seen on the surface of the hair, which led me to suspect that they were micro-organisms of some sort, and at once 1 set about cultivating them if possible. For a long time no success followed, but at length my assistant, Mr. Robert Grant, to whom I am indebted for much careful work in this matter, told me that he thought something was growing on the culture medium. And so it proved, and at length we succeeded in obtaining an abundant crop of an organism which tinted the culture medium with the exact colour of the wool, could be transferred from one artificial culture medium to another, and to normal wool itself, and everywhere produced the same beautiful green pigment, specimens of which are now upon the table. Since the original specimen was submitted to me several other specimens from different parts of the Colony have been sent to me by the Chief Veterinary Inspector of the Board of Health, Mr. Stanley, and all have yielded the same results.

The organism is a bacillus, and in the specimens of wool examined, were associated varying quantities of a streptococcus and a large coccus. After much trouble the bacillus and the streptococcus have been obtained pure, and it is the bacillus and not the streptococcus which produces the pigment. It is an actively motile, aërobic (and facultative anaërobic) and liquefying bacillus about one micro. in length. In various culture media it grows at the temperature of the room, but more rapidly in the incubator. In gelatine plate-cultures colonies are rapidly developed which give to the medium a deep green colour. At the end of two or three days liquefaction commences around each colony, and in about a week the gelatine is completely liquefied.

In gelatine thrust cultures development is most abundant near the surface, and the liquefaction is thus at first in the form of a funnel, but later on all the upper part of the medium is liquefied and rests upon the lower unliquefied part at a horizontal plane of separation. The surface of the liquefied part is covered with a yellowish-green film: at the plane preparation a quantity of this same film rests upon the unliquefied part and the entire mass exhibits a fluorescent green colour.

Surface cultures on nutrient agar are at first by reflected light white, by transmitted light deep brown. The green colour appears in about ten hours, and in thirty hours the whole of the agar shows the beautiful fluorescent green colour. The bacillus grows well in dextrose agar—in thrust cultures small dirty white globular colonies appear along the needle-track. On potato a rather dry yellowish-green or brown layer is formed. Old cultures gradually lose the fluorescent green colour and take on a dark olive-green, and finally a brown non-fluorescent colour takes its place.

To prove that this bacillus is the real cause of the green colouration in the wool submitted to me, normal wool from the fleece was inoculated with pure cultures from the tube, and in about a fortnight the characteristic colour made its appearance.

All the specimens of green wool have had a very characteristic odour, reminding one of the smell of woollen garments that have been put away in a wardrobe in a damp state. This smell is present likewise in the cultures, and even in the alcoholic solution of the pigment.

The pigments are two in number, a blue soluble in chloroform; a light green or yellow soluble in ether. They are both soluble in benzine and absolute alcohol. When the solution is carefully tested with an aqueous solution of iodine, a green colour is manifested at the junction of the two liquids, and with strong nitric acid also a green colour is developed at the interface—this green is intensified on the addition of ammonia. Acids change the colour to red. Both are bleached by light. The pigments are probably of the nature of a "lipochrome."

As to the effect of the growth of the organism on the quality of the wool, beyond the discolouration which has not been favourably viewed by the wool-classer, I have not made out any injury to the staple. The organism grows upon the surface of the strands and possibly in the abundant organic and foreign matter found in all fleeces, as shown by the simple statement that about a half of its weight is lost when wool is scoured. I do not think therefore, that pastoralists need mind these discolourations. As to a remedy—if one is required—I know of none better than the ordinary mineral poison sheep dips in common use in the Colony, although it is worth noting that while some of the specimens hail from sheep which had not been dipped, others had been dipped with "Cooper's Dip"—an arsenical preparation.

As to the origin of the organism, there can be little doubt: this bacillus is a aprophyte commonly distributed more or less all over the world. What wonder then if having entered a fleece with the dust and dirt already referred to, and finding there moisture, warmth, food and shelter, it should grow and multiply. It is just what one would expect under the conditions.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, MAY 2, 1894.

Annual General Meeting.

Prof. T. P. Anderson Stuart, M.D., President, in the Chair.

Sixty members and nine visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st, March, 1894, was presented by the Hon. Treasurer, and adopted:—

GENERAL ACCOUNT.

Receipts.		£ s. d.	£ s. d.
Subscriptions	One Guinea	159 12 0	
	Two Guineas	447 4 0	
	Arrears	16 16 0	
	Advances	1 1 0	624 13 0
Entrance Fees			79 16 0
Parliamentary Grant on Subscriptions received during 1893			500 0 0
Rent of Hall			24 13 6
Sundries			4 13 8
Total Receipts			1233 16 2
Balance on 1st April, 1893			59 13 0
			£1293 9 2

Payments.	£ s. d.	£ s. d.
Advertisements	34 4 6	
Assistant Secretary	250 0 0	
Books and Periodicals	117 19 8	
Bookbinding	20 12 7	
Freight, Charges, Packing, &c....	10 0 10	
Furniture and Effects	4 1 0	
Gas	30 9 5	
Carried forward	£467 8 0	

Payments—*continued.*	£	s.	d.	£	s.	d.
Brought forward	467	8	0			
Housekeeper	10	0	0			
Insurance	9	10	0			
Office Boy	24	12	8			
Petty Cash Expenses	12	14	7			
Postage and Duty Stamps	35	15	0			
Printing	41	16	9			
Printing and Publishing Journal	347	10	7			
Rates	32	12	6			
Refreshments and attendance at Meetings ...	21	6	0			
Repairs	14	3	6			
Stationery	7	1	1			
Sundries	5	6	3			
Total Payments				1029	16	11
Transfer to Building and Investment Fund...				200	0	0
Balance on 31st March, 1894				63	12	3
				£1293	9	2

BUILDING AND INVESTMENT FUND.

Receipts.	£	s.	d.
Transfer from General Account	200	0	0
Interest on Fixed Deposit	35	14	4
Amount of Fund on 1st April, 1893	892	16	1
	£1128	10	5

	£	s.	d.
Fixed Deposit in Union Bank	1128	10	5
	£1128	10	5

CLARKE MEMORIAL FUND.

Receipts.	£	s.	d.
Interest on Fixed Deposit	13	4	9
Amount of Fund on 1st April, 1893	330	16	8
	£344	1	5

	£	s.	d.
Fixed Deposit in Union Bank	344	1	5
	£344	1	5

ABERCROMBY FUND.

Receipts.	£	s.	d.
Amount received from the Hon. Ralph Abercromby to be offered as Prizes for Competitive Essays on various phases of Australian weather	100	0	0
Interest on Fixed Deposit	4	10	0
	£104	10	0

	£	s.	d.
Fixed Deposit in Union Bank	104	10	0

Audited, P. N. TREBECK.
W. C. W. BARTELS.

Sydney, 13th April, 1894.

H. G. A. WRIGHT, *Honorary Treasurer.*
W. H. WEBB, *Assistant Secretary.*

Messrs. P. R. Pedley and E. L. Montefiore were appointed Scrutineers for the election of officers and members of Council.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year:

Honorary President:
HIS EXCELLENCY SIR R. W. DUFF, P.C., G.C.M.G.

President:
Prof. THRELFALL, M.A.

Vice-Presidents:
F. B. KYNGDON.
CHARLES MOORE, F.L.S., F.Z.S.
Prof. T. P. ANDERSON STUART, M.D.
Prof. WARREN, M. INST. C.E., WH. SC.

Hon. Treasurer:
H. G. A. WRIGHT, M.R.C.S.E., &c.

Hon. Secretaries:
Prof. T. W. E. DAVID, B.A., F.G.S.
J. H. MAIDEN, F.L.S., F.C.S.

Members of Council:
C. W. DARLEY, M. INST. C.E.
JAMES GRAHAM, M.A., M.D.
J. W. GRIMSHAW, M. INST. C.E.
W. M. HAMLET, F.C.S., F.I.C.
G. H. KNIBBS.
H. A. LENEHAN, F.R.A.S.
Prof. LIVERSIDGE, M.A., F.R.S.
E. F. PITTMAN, ASSOC. R.S.M., F.G.S.
H. C. RUSSELL, B.A., C.M.G., F.R.S.
HARRIE WOOD, J.P.

The following gentlemen were duly elected ordinary members of the Society:

Kelly, Walter MacDonnell, L.R.C.P., L.R.C.S. *Edin.*, L.F.P.S. *Glas.*; 30 College Street, Hyde Park.

McMillan, William, M.L.A., Merchant; York Street.

The certificates of four new candidates were read for the second time, and of two for the first time.

The names of the Committee-men of the different Sections were announced :—

Section H.—Medical.

Chairman—Dr. Shewen.

Secretaries—Dr. G. E. Rennie and Dr. C. J. Martin.

Committee—Professor Anderson Stuart, M.D., Dr. W. Chisholm, Dr. P. Sydney Jones, Dr. McCormick, Dr. Purser, Hon. Dr. MacLaurin, M.L.C.

Three Meetings will be held, viz.—June 15th, August 17th, and October 19th, 1894, at 8·15 p.m.

Section K.—Engineering.

Chairman—R. R. P. Hickson, M. Inst. C.E.

Secretary—J. W. Grimshaw, M. Inst. C.E.

Treasurer—D. M. Maitland, L.S.

Committee—Prof. Warren, M. Inst. C.E., Wh. Sc., W. F. How, M. Inst. C.E., J. M. Smail, M. Inst. C.E., T. H. Houghton, Assoc. M. Inst. C.E., C. O. Burge, M. Inst. C.E.

Past Chairman *ex officio* Members of Committee for three years : Cecil W. Darley, M. Inst. C.E., H. Deane, M.A., M. Inst, C.E.

Meetings held on the Third Wednesday in each month, at 8 p.m.

The Chairman announced that the Committee of the Abercromby Fund had awarded the prize of £25 offered for the best essay on "Southerly Bursters" to Mr. H. A. Hunt, of the Sydney Observatory.

Ninety-four volumes, four hundred and eighty-nine parts, twenty-four reports, twenty-four pamphlets, five hydrographic charts, nineteen meteorological diagrams, and one atlas of geological charts, received as donations since the last meeting were laid upon the table and acknowledged.

Prof. T. P. Anderson Stuart, M.D., then read his address.

A vote of thanks was passed to the retiring President, and Prof. Threlfall, M.A., was installed as President for the ensuing year.

Prof. Threlfall thanked the members for the honour conferred upon him.

WEDNESDAY, JUNE 6, 1894.

Charles Moore, F.L.S., Vice-President, in the Chair.

Twenty-six members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of four new candidates were read for the third time, of two for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Baker, Richard Thomas, F.L.S., Assistant Curator, Technological Museum, Sydney.

Marshall, Fredk. William, M.B., C.M., 195 Elizabeth Street.

Simpson, Benjamin Crispin, Civil Engineer, 113 Phillip St.

Taylor, John M., M.A., Science Lecturer and Assistant Training Master, Fort Street Training School, "Eastbourne," Alfred Street, North Sydney.

The Chairman announced that the Council had subscribed amongst themselves for an enlarged portrait, on porcelain, of the late Dr. Leibius, the cost of which (£8 8s., including frame) had been defrayed, with the exception of a balance of about 35s. The Council thought that it would be advisable to procure a companion portrait of the late Mr. Robert Hunt, C.M.G., to replace the rough crayon drawing in the Library, and it was proposed to send circulars to the members of the Society asking those who felt disposed, to contribute ; the subscription would be limited to five shillings.

Eleven volumes, one hundred and forty-one parts, ten reports, ten pamphlets and one hydrographic chart, received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "Notes on some Minerals and Mineral Localities in the Northern Districts of New South Wales," by D. A. Porter.
2. "On the Magnetic Susceptibilities of Specimens of Australian Basalts," by Prof. A. W. Rücker, F.R.S. (Communicated by Prof. Threlfall, M.A.)

3. "Boleite, Nantokite, Kerargyrite, and Cuprite from Broken Hill, N. S. Wales," by Prof. LIVERSIDGE, M.A., F.R.S.
4. "From Number to Quaternion," by G. FLEURI. (Communicated by H. C. RUSSELL, B.A., C.M.G., F.R.S.)
5. "New Orbit of the Double Star β 416 = Scorpii 185," by Prof. S. GLASENAPP, Imperial Observatory, St. Petersburg. (Communicated by H. C. RUSSELL, B.A., C.M.G., F.R.S.)
6. "On the Value of Gravity at the Sydney Observatory," by E. F. J. LOVE, M.A. (Communicated by H. C. RUSSELL, B.A., C.M.G., F.R.S.)
7. "Preliminary Notes on the Pharmacology of *Carissa ovata*, R.Br. var. *stolonifera*, Bail." by Thomas L. BANCROFT, M.B. *Edin.* (Communicated by J. H. MAIDEN, F.L.S.)
8. "On the Almandine Garnets from the Hawkesbury Sandstone at Sydney," by HENRY G. SMITH.
9. "On a Natural Mineral Spring at Bungonia," by the Rev. J. MILNE CURRAN, F.G.S.

Some remarks were made by Mr. H. C. Russell, the Chairman and the Author.

WEDNESDAY, JULY 4, 1894.

Prof. THRELFALL, M.A., President, in the Chair.

Twenty-seven members and eight visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two new candidates were read for the third time, of two for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Cameron, Alexr. Mackenzie, Journalist, Walgett, N.S.W.

Symonds, John, Draftsman, Sewerage Branch, Department of Public Works, Parramatta Park.

Twenty-four volumes, sixty-eight parts, one report, and three pamphlets received as donations since the last meeting, were laid upon the the table and acknowledged.

The following papers were read :—

1. "A Chart of Circumpolar Stars," by H. C. Russell, B.A., C.M.G., F.R.S.
2. "Aboriginal Bora held at Gundabloui, Moonie River, in 1894," by R. H. Mathews, L.S.

   Some remarks were made by Dr. John Fraser, and the discussion postponed.
3. "Observations and Orbit Elements of Comet Gale 1894," by John Tebbutt, F.R.A.S.

   Some remarks were made by Mr. Walter Gale, F.R.A.S.
4. "On the Structure and Composition of some Australian Basalts," by the Rev. J. Milne Curran, F.G.S.

   The paper was illustrated by lantern slides, microscopic slides and specimens of basalt.

Mr. W. F. Gale, F.R.A.S., by means of the lantern, exhibited and explained some photographs of the Solar Eclipse of 1893.

Some remarks were made by the Rev. S. Wilkinson and the discussion postponed.

WEDNESDAY, AUGUST 1, 1894.

Prof. Threlfall, M.A., President, in the Chair.

Thirty-nine members and six visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two new candidates were read for the third time, of two for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Balsille, George, Schoolmaster, Sandymount, Dunedin, N.Z.

Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, "Hawerby," Meredith Street, Homebush.

The Chairman announced that the Society's Bronze Medal and £25 had been awarded to each of the following gentlemen :—

1. Mr. J. V. de Coque, for paper "On the Timbers of New South Wales, with special reference to their fitness for use in construction, manufactures, and other similar purposes."
2. Mr. R. H. Mathews, L.S., for paper "On the Aboriginal Rock Carvings and Paintings in New South Wales."

The Medals and cheques were then presented.

Twelve volumes, one hundred parts, seven reports, eight pamphlets, and two hydrographic charts, received as donations since the last meeting were laid upon the table and acknowledged.

The following papers were read :—

1. "Garbage Destructors," by Prof. Warren, M. Inst. C.E., Wh. Sc., and Dr. Ashburton Thompson.

   Some remarks were made by Messrs. C. Moore, J. J. Farr, and Dr. Ashburton Thompson.

2. "The Geology of Limekilns, Bathurst District," by W. J. C. Ross, B.Sc. (Communicated by J. H. Maiden, F.L.S.)
3. "The Territorial Divisions of New South Wales into Counties," by W. D. Campbell, F.G.S., &c.
4. "The Timbers of New South Wales," by J. V. De Coque.
5. "On the Aboriginal Rock Carvings and Paintings in New South Wales," by R. H. Mathews, L.S.

WEDNESDAY, SEPTEMBER 5, 1894.

Prof. Threlfall, M.A., President, in the Chair.

Twenty-eight members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two new candidates were read for the third time, of three for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Dick, James Adam, M.D., C.M. *Edin.*, "Catfoss," Belmore Road, Randwick.

Tidswell, Frank, M.B., M.Ch., Randwick.

The Chairman made the following announcements:—

1. That the General Monthly Meeting would be held on the 3rd of October instead of the 10th, as stated on the printed cards.

2. That the Council had decided to hold a Conversazione in the Great Hall of the University on the 5th December.

3. He drew attention to the meeting of the Australasian Association for the Advancement of Science to be held in Brisbane in January next.

Twenty volumes, one hundred and twenty parts, two reports, ninety pamphlets, five hydrographic charts, and sixteen meteorological diagrams received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "On some Stone Implements used by the Aborigines of New South Wales," by R. H. Mathews, L.S.

2. "Recent Researches in the Testing of Cement," by W. S. de Lisle Roberts.

   Some remarks were made by the Chairman, Messrs. Speak, Hamlet, W. D. Campbell, Prof. David, and the Author. It was resolved that the discussion be adjourned and resumed before the Engineering Section.

3. "A comparison of the Languages of Ponape and Hawaii," by the late Rev. E. T. Doane, with additional notes and illustrations by Sidney H. Ray.

Exhibits.

"The Structure of Gold Nuggets," by Prof. Liversidge, some remarks were made by Messrs. Benbow, Hamlet, and Prof. David.

Star and Cloud Photographs, also a Map of the locality where a Meteor fell near Sydney, in June last, by H. C. Russell, B.A., C.M.G., F.R.S. Remarks were made by Prof, David, and Messrs. Grimshaw and Benbow.

Stone Implements used by the Aborigines of New South Wales by R. H. Mathews, L.S.

Stone Hatchets from the Clarence River and Cobar, also Stereoscopic Views of Norfolk Island and Lord Howe Island by Judge Docker.

Specimens of Quartz and other Crystals showing fine gold &c., by C. A. Benbow.

WEDNESDAY, OCTOBER 3, 1894.

Prof. Threlfall, M.A., President, in the Chair.

Thirty-four members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three new candidates were read for the third time, of four for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Hunt, Henry Ambrose, Second Meteorological Assistant, the Observatory, Sydney.

Rowney, Geo. Henry, A.M.I.C.E., Civil Engineer, Sewerage Construction Branch, Public Works Department.

Tooth, Arthur William, Brewer, "Ilfracombe," Burwood.

The Chairman announced that the Council recommended the election of the following gentleman as an Honorary Member of the Society, viz. :—W. Baldwin Spencer, M.A., Professor of Biology, University of Melbourne.

The election was carried unanimously.

Fourteen volumes, seventy-eight parts, eight pamphlets, eleven reports, one hydrographic chart, and nineteen meteorological diagrams received as donations since the last meeting were laid upon the table and acknowledged.

The following papers were read :—

1. "Preliminary Note on the Occurrence of Gold in the Hawkesbury Sandstone" by Prof. Liversidge, M.A., F.R.S.

   Some remarks were made by Messrs. James Taylor, J. H. Maiden, C. Moore, the Chairman, and the Author.

2. "Current Papers," by H. C. RUSSELL, B.A., C.M.G., F.R.S.

Remarks were made by Messrs. P. N. Trebeck, C. Hedley, L. Whitfeld, Judge Docker, the Chairman, and the Author.

Mr. RUSSELL gave an account of the state of the work at Sydney at the present time with reference to astronomical photography.

EXHIBITS.

The Structure of Gold Nuggets, by Prof. LIVERSIDGE.

Three Standard Thermometers and a Specimen of Bismuth Etched by the Electrolytic Process, by Prof. THRELFALL.

WEDNESDAY, NOVEMBER 7, 1894.

Prof. THRELFALL, M.A., President, in the Chair.

Forty-four members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

It was resolved that Messrs. P. N. Trebeck, and F. B. Kyngdon be appointed Auditors for the current year.

The certificates of four new candidates were read for the third time, of two for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Carleton, Henry R., M.I.C.E., Civil Engineer, Birrell-st., Bondi.

Edgell, Robert Gordon, Draftsman, Roads, Bridges and Sewerage Branch, Public Works Department.

Fitz-Nead, A. Churchill, Assistant Engineer, Public Works Department, Roads and Bridges Office, Sydney.

Twenty-one volumes, sixty-two parts, four reports, and nine pamphlets received as donations since the last meeting were laid upon the table and acknowledged.

The following papers were read :—

1. "On a new Velocity Recorder," by J. ALFRED GRIFFITHS, B.Sc., Wh. Sc., M. I. Mech. E.

Some remarks were made by Mr. Russell.

2. "The Interpretation of Cement Analyses, including a new method of recording results," by W. M. HAMLET, F.C.S., F.I.C.

   A discussion ensued in which the following gentlemen took part, viz.:—Prof. Threlfall, Messrs. W. A. Dixon, F. B. Gipps, C. W. Darley, Prof. Liversidge, and the Author.

3. "A Perlitic Pitchstone from Tweed River, with remarks on the so-called perlitic cracks in Quartz," by W. F. SMEETH, M.A., A.R.S.M.
4. "A New Map showing Average Monthly Rainfall," by H. C. RUSSELL, B.A., C.M.G., F.R.S.
5. "Green-producing Chromogenic Micro-organisms in Wool," by Prof. T. P. ANDERSON-STUART, M.D.

   Remarks were made by Dr. W. C. Wilkinson and Mr. P. N. Trebeck.

EXHIBITS.

Rev. J. MILNE CURRAN, F.G.S., exhibited photographs and micro slides of trachytes from spurs of the Warrumbungle Ranges, Coonabarabran. He wished to place on record that there is a widespread distribution of true trachyte in the district named, and in this rock is noted the rare mineral nosean, noted now for the first time in Australia.

WEDNESDAY, DECEMBER 5, 1894.

A Conversazione was held in the Great Hall of the University under the management of a Committee composed of the Officers and Council of the Society.

The Hall and approaches were tastefully decorated with ferns, palms and rare pot plants kindly supplied by Mr. Charles Moore, F.L.S., Director of the Botanic Gardens.

The University grounds were illuminated with Chinese lanterns, thus lighting the way for the guests to visit the Medical School. the Chemical, Geological, Physical, Engineering and Biological Laboratories, in which experiments were conducted by the Professors and their assistants.

The Macleay Museum, Library, and the various Lecture Rooms were also thrown open to the visitors.

The guests numbered about six hundred.

Unfortunately His Excellency The Governor, was absent from town, and His Excellency Vice Admiral N. Bowden Smith, R.N., was unable to be present. Owing to an important sitting of the House, neither the Premier, the Hon. G. H. Reid, nor the other members of the Ministry could attend.

Catalogue of Exhitits.

The Laboratories in the University Grounds.

Chemical Laboratory (Prof. Liversidge, M.A., F.R.S.)—Photographs of sections of gold nuggets, native gold. Gold in quartz, calcite, serpentine, &c.

Physical Laboratory (Prof. Threlfall, M.A.)—Apparatus for measurement of high specific resistances. Collection of samples of the modification of sulphur of great purity. Appliances for investigating feeble magnetic properties.

Engineering Laboratory (Prof. Warren, M. Inst. C.E., Wh. Sc.)—The Engineering Laboratory with its apparatus and machinery was open, and the following experiments were made :—

1. A beam of iron-bark timber, twelve inches square, was broken on a span of fifteen feet, with a central load of thirty-seven tons. The machine was specially made for Prof. Warren by Messrs. Joshua Buckton & Co., of Leeds, and consists of one central hydraulic press for tension and compression pieces ten feet long, up to one hundred tons load ; two cross-breaking presses to test beams up to a span of fifteen feet, and one hundred tons central load. The machine is also arranged for torsion, and is provided with Wicksteed's autographic apparatus.

2. Two pieces of Vicker's axle steel were tested in the 100000 pounds machine made by Messrs. Greenwood & Batley, Leeds, and autographic diagrams were drawn by an apparatus made in the laboratory; Kennedy's extensometer was also shown on this machine.

3. The lever testing machine of 4000 pounds capacity for testing wire, cements, &c. was shown testing cement briquettes; this machine was made in the laboratory. A shot machine of 2000 pounds capacity made by Messrs. Fairbanks, America, was shown testing cement briquettes.

4. The experimental engine and boiler made by Messrs. Rustin & Proctor, was shown at work, with four indicators, two friction brakes, throttling calorimeter, Carpenter's separating calorimeter, thermometers, gauges, pyrometer, measuring tanks, water meter, weighing machines, &c.

5. The gas engine was used to drive the various machine tools in the work shop, and the pump working the accumulator.

6. Thurston's oil testing machine and Bolt's cylinder lubricant tester, made by Messrs. Bailey & Co., Salford, were exhibited.

7. Morin's transmission dynamometer with autographic recorder.

8. The collection of Kinematic models made by Schrōeder of Darmstadt.

Biological Laboratory (Prof. Haswell, M.A., D.Sc.)—Series of stages of chick embryos mounted on revolving stage. Section of a Calcareous Sponge. Zoophyte with budding medusæ at various stages. Tetrarhynchus—a parasite from the Groper fish. Emu chick from the egg. *Porpita*, (disc zoophyte). Microscopic Shells of *Radiolarians*. *Diachoris magellanica*, Bryozoan. *Velella*, (sail zoophyte). *Doliolum*. *Appendicularia*. *Amphioxus*. *Echinorhynchus*. Liver Fluke. *Phoronis*. *Vorticella*. Larva of *Echiurus*. Ephyra stage of Jelly-fish. Section of Rhizome of Bracken Fern. Various plant models and zoological diagrams were also exhibited.

Medical School (Prof. T. P. Anderson Stuart, M.D.)—The bacillus of diphtheria. The bacillus of green wool, &c. Certain effects of filtering water. Working models to illustrate action of the larynx, &c.

Geological Laboratory (Prof. T. W. E. David, B.A., F.G.S.)—A large Solar Microscope and Polariscope for projecting images of transparent slices of rocks and minerals on to the screen. Six Petrological Microscopes with transparent sections of minerals and rocks, the latter being of eruptive origin and occurring in the neighbourhood of Sydney, chiefly at Pennant Hills and at Prospect, near Parramatta.

The University Hall.

Department of Mines and Agriculture—Apparatus in use at the Department for milling small quantities of experimental wheats. Exhibits showing different varieties of grain grown in the Colony, and their milling products. Exhibits illustrating different points in the testing of flours &c. *Farinometer* for testing gluten. *Strength Burette*, &c. *Electriating apparatus* for separating mechanical constituents of soils.—(F. B. Guthrie, F.C.S.) Samples of strata from the Artesian Bores; samples of Artesian casing; photographs of Artesian Bores in New South Wales and Queensland—(J. W. Boultbee, Superintendent of Public Watering Places and Artesian Boring Branch). A collection of interesting mineralogical and palæontological specimens in show case.—(E. F. Pittman, Government Geologist).

Roads and Bridges Department—Models:—Monier Arch, 30 ft. span; Hinged Lift Bridge (Edgell and Holden's Patent); Rock Drill with self-acting feed; 90 ft. Standard Timber Truss Bridge (previous to 1892); ditto (1892); 160 ft. Standard Composite Truss Bridge—(R. R. P. Hickson, M. Inst. C.E., Engineer-in-Chief). Specimens of shells and pallets of *Teredo navalis* and timber destroyed by seaworms—(E. M. de Burgh, Assoc. M. Inst. C.E.).

Harbours and Rivers Department—Collection of Photographs—(C. W. Darley, M. Inst. C.E., Engineer-in-Chief.

Government Printing Office—Photographs:—Panorama of Harbour and City of Sydney; Sydney Harbour, from Tower of Post Office; the General Post Office, and numerous others; one frame showing the various stages of Bookbinding as executed at the Government Printing Office; five frames showing specimens (by Chromo-lithography) of Australian flora. Toned Bromides:—

Distinguished Colonists, New South Wales; Views—National Park; Principal Stair-case, General Post Office; New South Wales Soudan Contingent. Specimens of Electrotyping, Stereotyping and Type Founding:—Electrotype—Locomotive Return; (Nickelled) Certificate to sell Poison; Music Cantata (mounted); Aboriginal; (Nickelled) Lunacy Cheque; Passport; Locomotive; Restoring the Apparently Drowned; Certificate of Registration. Galvan's Plastique (Copy of original in Bronze) William Charles Wentworth. Electrotype—(Nickelled) Royal Arms (mounted); Telegram Form—front; (Nickelled) Sydney Exhibition; Supreme Court Cheque; (Glyphographic Process) Sleeping Car; Marine Board Seal and others. Stereotype—(curved) Railway Telegram; (curved) Daily Summary; Cloak Room Ticket Return and others. Electrotype, Medallion (Corneille). Stereotype—Season Ticket Issue; Instructions for Cleaning Small Arms, &c.; Telegram Label. Movable type, Registered Brands, Furniture. Stereotype—Return Military Form; Railway Returns and others. Electrotype, Medallion (Bossuet). Stereotype—Registrar Information; Railway Return; (curved) Abstract; (curved) Parcels Way Bill. Specimens of Printing and Bookbinding, 112 Vols. One show case containing specimens of Machine Ruling.—(Charles Potter, Government Printer).

Cox, Hon. G. H., M.L.C.—First edition of Capt. Cook's Voyages. Photographs (23) of Mulgoa and Mount Wilson.

Campbell, Rev. Joseph, M.A., F.G.S.—Collection of Minerals.

Curran, Rev. J. Milne, F.G.S. (on behalf of the Technical Education Branch, Department of Public Instruction)—Photographs (30) illustrating the Geology of New South Wales.

Docker, Judge—Stereoscopes and Stereographs.

George, W. R.—Photograph of Engraving of Men of Science living in the years 1807-8.

Hargrave, Lawrence—Model (3″ to the foot) of the 90 square foot Cellular Kite, the lowest of the series on which the exhibitor made an ascent, Nov. 12, 1894.

Makin, G. E.—Bacon's Essays (miniature edition) 1810. Old Prints of Grecian Statuary &c., 1787.

Russell, H. C., B.A., C.M.G., F.R.S.—Delivered a lecture on Star Photographs, showing the great power of the Star Camera to dive into the star depths, this was illustrated by means of a lantern.

Sinclair, S.—Books in various languages of the New Hebrides.

Smith, Charles W.—Photographs of Laanecoorie Weir, Loddon River, Victoria; Goulburn Weir, Victoria. Description of Goulburn Weir illustrated with photographs.

Statham, E. J., Assoc. Inst. C.E.—Collection of Stone Implements. Specimens of rocks, fossils, and minerals.

Suttor, Hon. W. H., M.L.C.—Microscope (Negretti and Zambra) and slides. Flinder's Voyages, with Capt. Hunter's autograph. Oxley's works. Capt. Cook's Maps and Illustrations published 1773.

Taylor, James, B.Sc., A.R.S.M.—Fuller's slide rule.

Townsend, G. W.—Microscope (Dick and Swift) and slides.

Wiesener, T. F.—Microscope, Telemeter Level, Tacheometer, Specimens of peculiar compound lenses, viz., Bifocal, Sphero-prismatic, Cylindrical.

Wilkinson, W. Camac, M.D.—Bacillus of Diphtheria (Behring's) Drumstick bacillus of Tetanus (Lockjaw). Pure cultures, various, ten common forms.

Wright, H. G. A., M.R.C.S.,E.—Microscope and slides. Longitudinal section of the leaf of the *Valisneria spiralis*, showing the circulation of the protoplasm in the cells. Micro-photographs (framed) of the Blow Fly.

PROCEEDINGS OF THE SECTIONS.

(IN ABSTRACT.)

ENGINEERING SECTION.

At the preliminary meeting held on April 11, the following officers were elected for the 1894 Session:—Chairman: Mr. R. R. P. Hickson, M. Inst. C.E. Hon. Secretary: Mr. J. W. Grimshaw, M. Inst. C.E. Hon. Treasurer: D. M. Maitland, L.S. Committee: Professor Warren, M. Inst. C.E., Wh. Sc., Messrs. J. M. Smail, M. Inst. C.E., W. F. How, M. Inst. C.E., Wh. Sc., C. O. Burge, M. Inst. C.E., and T. H. Houghton, Assoc. M. Inst. C.E., M.I. Mech. E.

A resolution was carried that past Chairmen be *ex officio* members of Committee for three years.

Regulations for printing the papers and discussions of the Section were passed.

The subscription to the printing fund was reduced to 10s., the credit balance being £10 7s. 7d.

Monthly meeting held May 16, 1894.

Mr. R. R. P. Hickson, in the Chair.

Twenty-nine members and visitors present.

The discussion of Mr. Selman's paper on "Oil Engines," was opened by the author and continued by Messrs. Campbell, Darley, Houghton, How, Stecher, Grimshaw, Maitland, and J. M. Smail, and adjourned.

Mr. W. A. Smith then read a paper on "Australian Hardwood for London Pavements."

Monthly meeting held June 20, 1894.

Mr. R. R. P. Hickson, in the Chair.

Twenty-two members and visitors present.

Some further remarks on Mr. SELMAN's paper on "Oil Engines," were made by Mr. Bell, after which the author replied to the discussion.

The discussion of Mr. SMITH's paper on "Australian Hardwood for London Pavements" was opened by the author and continued by Prof. Warren, Messrs. Darley, Haycroft, Smail, Allen, Davis, Hickson, Selman, Grimshaw, and How, and adjourned to next meeting.

Monthly meeting held July 18, 1894.

Mr. R. R. P. HICKSON, in the Chair.

Twenty-two members and visitors present.

The adjourned discussion of Mr. SMITH's paper was resumed by Messrs. Darley, Roberts, Wilshire, Mollinson, Hickson, Selman, Maitland, Grimshaw, and King, and replied to by the author.

Monthly meeting held August 15, 1894.

Mr. J. M. SMAIL, in the Chair.

Twenty-three members and visitors present.

The discussion of Prof. WARREN's and Dr. ASHBURTON THOMPSON's paper on "The Destruction of Garbage," was opened by Prof. Warren, and continued by Messrs. Richards, Farr, Haycroft, Houghton, Trevor Jones, Smail, Campbell, and Noble, and adjourned to next meeting.

Monthly meeting held September 19, 1894.

Mr. R. R. P. HICKSON, in the Chair.

Twenty-seven members and visitors present.

The discussion of Prof. WARREN's and Dr. ASHBURTON THOMPSON's paper on "The Destruction of Garbage," was resumed by a communication received from Mr. Henson, followed by Messrs. Houghton, Richards, Haycroft, Seaver, De Montemas, Dr. Thompson, and then adjourned to next meeting.

Monthly meeting held October 17, 1894.

Mr. R. R. P. Hickson, in the Chair.

Twenty-eight members and visitors present.

The adjourned discussion of the paper on "The Destruction of Garbage" was resumed by Messrs Webster, How, Houghton, Smail, Tournay-Hinde, Docker, De Montemas, and replied to by the authors.

A paper communicated by Mr. E. M. de Burgh, entitled "Notes on Cylinder and Pile Foundations for Bridges over New South Wales Rivers," was taken as read, to allow of it being printed for discussion at the succeeding meeting.

Monthly meeting held November 21, 1894.

Mr. R. R. P. Hickson, in the Chair.

Twenty-three members and visitors present.

The discussion of Mr. de Burgh's paper "Notes on Cylinder and Pile Foundations for Bridges over New South Wales Rivers," was opened by the author and continued by Messrs. Haycroft, B. C. Simpson, and Prof. Warren, and then adjourned to the next meeting.

Monthly meeting held December 19, 1894.

Prof. Warren, in the Chair.

Twenty-three members and visitors present.

The adjourned discussion of Mr. de Burgh's paper was resumed by Messrs. Burge, Darley, Vicars, Houghton, Smail, Wells, Bowman, Grimshaw, B. C. Simpson, and Prof. Warren, and replied to by the author.

During the Session the Section visited by invitation, the North Shore Electric Tramway, the Government Cement Testing Rooms and the Municipal Cement Testing Rooms.

Thirty-eight subscriptions to the printing fund have been received amounting to £22 10s., in addition to which £12 11s. 6d. has been received from the sale of publications, while the disbursement for printing amounted to £27 14s. up to date.

MEDICAL SECTION.

At the provisional meeting held on April 27th, 1894, the following officers were elected :—Chairman : Dr. A. Shewen. Committee : Hon. Dr. MacLaurin, Professor Anderson Stuart, and Drs. Chisholm, Sydney Jones, MacCormick, and Purser. Secretaries : Drs. G. E. Rennie and C. J. Martin.

It was agreed to hold only three meetings during the year as in 1893.

First meeting June 15, 1894, at 8·15.

Dr. A. Shewen in the Chair.

Dr. Thomas Evans exhibited a patient suffering from a cyst in the anterior chamber of the eye, which he believed to be a hydatid cyst.

Dr. Angel Money read a short paper on "Clinical Symptomatology of Cerebral Tumours," and Dr. Fiaschi read a paper on "The Surgical Treatment of Cerebral Tumours."

At the discussion which followed Drs. Sydney Jones, Crago, Schwarzbach, Jenkins, C. J. Martin and Rennie took part.

Second meeting August 17, 1894, at 8·15.

Dr. A. Shewen in the Chair.

Dr. F. R. Tidswell read a paper on "Sewer-gas and its relation to the Spread of Disease."

Drs. MacLaurin, Goode, Milford, Quaife, Wilkinson, Chisholm, and the Chairman discussed the paper.

Owing to the lateness of the hour the further business was postponed until the next meeting.

Third meeting October 19, 1894, at 8·15.

Dr. A. Shewen in the Chair.

Dr. Sydney Jones drew the attention of the members present to the recent death of Sir Alfred Stephen, and proposed :—

"That a letter of condolence signed by the Chairman and Honorary Secretaries of this Section be sent to the family of the late Sir Alfred Stephen, conveying our deep sense of the great loss which this Colony has sustained by the death of their distinguished relative, and an assurance of the warm place which he occupied in our regard."

Dr. Milford seconded the motion, which was carried by acclamation.

Dr. Graham exhibited the brains from two patients who suffered from hydatid disease of that organ, and gave an account of the interesting features of the cases.

In connection with Dr. Graham's communication Drs. Fiaschi, Sydney Jones, Clubbe, Shewen, Chisholm, Milford, and Pockley made some remarks.

Dr. Shewen read a paper—"Experiments on the Pleural Cavity of a Sheep." The paper was discussed by Drs. Jenkins, Clubbe, Fiaschi, and C. J. Martin.

The meetings then closed for the year.

As on previous occasions the recent additions to the University Museum of Anatomy and Pathology were on view during the evening.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1894.

(The Names of the Donors are in *Italics.*)

TRANSACTIONS, JOURNALS, REPORTS, &c.

Aberdeen—University. Calendar for the year 1894-95. Catalogue of the Books added to the Library in King's College, Nov. 1891 to March 1894. *The University*

Adelaide—Observatory. Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory during 1886-7. *The Observatory*

Royal Society of South Australia. Transactions, Vol. xvii., Part ii. for 1892-93. *The Society*

South Australian School of Mines and Industries and Technological Museum. Annual Report, 1893. *The Director*

University. The Adelaide University Calendar for the Academical year 1894. *The University*

Agram—Meteorologisches Observatorium. Der Tornado bei Novska. *The Observatory*

Annapolis, Md.—United States Naval Institute. Proceedings, Vol. xix., No. 4, Whole No. 68, 1893; Vol. xx., Nos. 1 and 2, 1894. *U.S. Navy Department*

Auckland—Auckland Institute. Annual Report for 1893-94. *The Institute*

Austin—Texas Academy of Science. Transactions, Vol. i., No. 2, 1893. *The Academy*

Ballarat—School of Mines and Industries. Calendar 1894. *The Registrar*

Baltimore—Johns Hopkins University. Circulars, Vol. xiii., Nos. 108 - 114, 1893-94. *The University*

Batavia—Koninklijke Natuurkundige Vereeniging. Natuurkundig Tijdschrift voor Nederlandsch-Indië, Deel lii., Negende Serie, Deel i., 1893; Deel liii., Tiende Serie, Deel ii., 1893. *The Society*

Bergen—Bergens Museums. Bergens Museums Aarbog for 1892. *The Museum*

Berkeley—University of California. Bulletin of the Dept. of Geology, Vol. i., pp. 1 - 160. *The University*

Berlin—Association Géodésique Internationale. Comptes-Rendus de la Commission Permanente réunie a Genéve du 12 au 18 Septr., 1893. Comptes-Rendus des Seances de la Dixieme Conférence Générale à Bruxelles du 27 Sept. au 7 Oct. 1892. Rapport sur les Triangulations par Le Général A. Ferrero. *The Association*

BERLIN—*continued.*

Deutsche Meteorologische Station I. Ordnung. Ergebnisse der Meteorologishen Beobachtungen, Jahrgang IV., 1894. *The Station*

Gesellschaft für Erdkunde. Verhandlungen, Band XX., Nos. 8 – 10, 1893; Band XXI., Nos. 1 – 6, 1894. Zeitschrift, Band XXVIII., Nos. 3 – 6, 1893; Band XXIX., Nos. 1 – 2, 1894. *The Society*

Königlich Geodätisches Instituts. Jahresbericht des Direktors, April 1892 bis April 1893. Polhöhenbestimmungen im Harzgebiet ausgefuhrt 1887 – 1891. *The Institute*

Königlich Preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 26 – 38, 1 Juni – 27 Juli, 1893. *The Academy*

Königlich Preussische Meteorologische Instituts. Bericht, im Jahre, 1893. Ergebnisse der Beobachtungen an der Stationen II. und III. Ordnung im Jahre, 1893. Ergebnisse der Meteorologischen Beobachtungen im Jahre, 1890 durch W. von Bezold, Heft. III., 1890. Ergebnisse der Niederschlags-Beobachtungen im Jahre, 1892. *The Institute*

Naturwissenschaftlicher Verein. Abhandlungen, Band XIII., Heft. 1, 1894 and Extra-Beilage. *The Society*

BERNE—Département Fédéral de l'Interieur Section des Travaux Publics. Graphische Darstellung der Lufttemperaturen &c., Bl. 1 – 3, 1892-3. Graphische Darstellung der Schweizerischen hydrometrischen Beobachtungen, Bl. 1 – 16, 1893. Tableau graphique des observations hydrométriques suisses, Pl. I*a*, I*b*, I*c*, I*d*, II*a*, II*b*, II*c*, II*d*, III., IV., V*a*, V*b*, VI., 1892; Pl. I – XVI., 1893. Tableau graphique des températures de l' air et des hauteurs pluviales, Pl. 1 – 3, 1892. *The Department*

BIRMINGHAM—Birmingham and Midland Institute. Programme for Session 1894-95. Report of the Council for the years 1892, 1893. Results of Examinations and Award of Prizes 1893. "Aspects of Life," by Sir Edwin Arnold, M.A., K.C.I.E., &c. "The Movements of the Stars," by Sir R. S. Ball, LL.D., F.R.S. "The Political Value of History," by W. E. H. Lecky, LL.D., D.C.L. *The Institute*

Birmingham Philosophical Society. Proceedings, Vol. VIII., Part ii., Session 1892-93. Report to the Council, Oct. 19, 1893. *The Society*

BISTRITZ—Direction der Gewerbeschule. Jahresbericht, No. XVII., XVIII., 1891-93. *The Director*

BOLOGNA—R. Accademia delle Scienze dell'Istituto di Bologna. Memorie, Serie V., Tomo II., 1891. *The Institute*

BONN—Naturhistorischer Vereines der Preussischen Rheinlande Westfalens und des Reg.-Bezirks Osnabrück. Verhandlungen, Jahrgang L., Folge 5, Jahrgang X., 1893. *The Society*

BRISBANE—Chief Weather Bureau. Climatological Table, Sept. 1893. Meteorological Synopsis, Nov., Dec., 1892, Jan. – Oct., 1893. Table of Rainfall Oct. – Dec., 1892, Jan. – Sept., 1893. *Government Meteorologist*

Department of Agriculture. Botany Bulletin, No. 8, Dec. 1893; No. 9, Sept. 1894. Botany Abridged, by F. M. Bailey, F.L.S. *The Department*

BRISBANE—*continued.*

Geological Survey Office. Annual Progress Report of the Geological Survey for the year 1893. Deep Lead, Pentland, Cape River Gold Field, Report on the, by W. H. Rands, 1894. Report on Mount Morgan Gold Deposits by Robert L. Jack. Towalla and Mareeba Gold Fields, Report on the, by W. H. Rands, 1894. Ulam Gold Field, Report on, by A. Gibb Maitland. *The Government Geologist*

Natural History Society. Report of Meetings, April, June, July, Aug., 1894. *The Society*

Royal Geographical Society of Australasia. Proceedings and Transactions of the Queensland Branch, Vol. IX., 1893-94. ,,

Royal Society of Queensland. Proceedings, Vol. X., 1892-94. Index to Vols. VII., VIII., and IX. ,,

BRUNN—Naturforschende Vereines. Verhandlungen, Band XXX., 1891. Bericht der Meteorologischen Commission, Vol. X., 1890. ,,

BRUSSELS—Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Annuaire, 1892, 1893. Bulletins, 3me Serie, Tome XXII. – XXV., 1891-93. *The Academy*

BUCHAREST—Institutul Meteorologic al Roumâniei. Buletin Meteor. Anul II., Foaia 11 – 14, 1893 ; Jan. - June, 1894. *The Institute*

BUENOS AIRES—Instituto Geografico Argentino. Boletin, Tomo XIV., Cuadernos 5 – 8, 1893 ; 9 – 12, 1894. ,,

CAEN—Académie Nationale des Sciences, Arts et Belles-Lettres de Caen. Mémoires, 1892, 1893. *The Academy*

CALCUTTA—Asiatic Society of Bengal. Journal, Vol. LXII., Part i., Nos. 3, 4, Part ii., Nos. 3, 4, and Index, 1893 ; Part iii., Nos. 1 – 3, 1893 ; Vol. LXIII., Part i., Nos. 1, 2, Part ii., No. 1, Part iii., No. 1, 1894. Proceedings, Nos. 8 – 10, 1893, Nos. 1 – 6, 1894. Annual Address by the Hon. Sir C. A. Elliott, K.C.S.I., 7 Feb. 1894. *The Society*

Geological Survey of India. Records, Vol. XXVI., Part iv., 1893 ; Vol. XXVII., Parts i. – iii., 1894. Manual of the Geology of India, 2nd Edition, 1893. Memoirs, Palæontologia Indica, Ser. IX., Vol. II., Part i., 1893. *The Director*

CAMBRIDGE—Cambridge Philosophical Society. Proceedings, Vol. VIII., Part ii., 1893. Transactions, Vol. XV., Part iv., 1894. *The Society*

CAMBRIDGE (Mass.)—Cambridge Entomological Club. *Psyche,* Vol. VI., Nos. 211, 212, 1893 ; Vol. VII., Nos. 213 – 217, 1894. *The Club*

Museum of Comparative Zoölogy at Harvard College. Annual Report of the Curator for 1892-93. Bulletin, Vol. XXV., Nos. 2 - 7, 1893-94. *The Museum*

CAPE TOWN—South African Philosophical Society. Transactions, Vol. V., Part ii., 1886 – 1889 ; Vol. VII., Part i., 1893 ; Vol. VIII., Part i., 1890 – 1892. *The Society*

CHARLOTTEVILLE, Va.—Leander McCormick Observatory. Publications, Vol. I., Parts i. - iii., 1883-86 ; Part vi., 1893. *The Observatory*

CHRISTIANIA—Norske Gradmaalingskommission. Vandstands-observationer, Hefte v., 1893. *The Commission*

Norwegian North-Atlantic Expedition 1876 - 1878. Zoology, Ophiuroidea by James A. Grieg, 1893. *The Editorial Committee*

COLOMBO—Royal Asiatic Society. Journal of the Ceylon Branch, Vol. XI., No. 41, 1890; Vol. XIII., No. 44, 1893. Proceedings, 1889 - 1890. *The Society*

COPENHAGEN—Société Royale des Antiquaires du Nord. Mémoires Nouvelle Série, 1892. „

CORDOBA—Academia Nacionale de Ciencias. Boletin, Tomo XII., Entrega 1, 2, 1890-91. *The Academy*

CRACOVIE—Académie des Sciences. Bulletin International, Oct. Nov. Dec. 1893, Jan. 1894. „

DAVENPORT, Iowa—Davenport Academy of Natural Sciences. Proceedings, Vol. v., Part ii., 1885 - 1889. „

DENVER—Colorado Scientific Society. Geology of the Cripple Creek Gold Mining District, Colorado, by Whitman Cross, Ph.D. Nickel: the occurrence, geological distribution and genesis of its ore deposits, by Philip Argall. On Gold-bearing quartz by — Rickard, Discussion on paper. On the evidences of the formation of ore deposits by lateral secretion in the 'John Jay' Mine at Providence, Boulder Co., Colo. On the Nature of the Chemical Elements—Sixth Paper, The Distribution of the Atomic Weight by Charles Skeele Palmer, Ph.D. The mode of occurrence of gold in the ores of the Cripple Creek district by Dr. Richard Pearce, 1894. The Ore Deposits of Cripple Creek, Colorado, by R. H. F. Penrose Junr. The question of a standard of value, by O. G. Frost, 1893. The Solution of the Equations, $X^2+Y=7$ $X+Y^2=11$, by Francis T. Freeland. *The Society*

DIJON—Académie des Sciences, Arts et Belles-Lettres. Mémoires, 4e Série, Tome III., 1892. *The Academy*

DRESDEN—K. Säch. Statistische Bureaus. Zeitschrift, Jahrgang XXXVIII., Heft. 3 and 4, and Supplement, 1892. *The Bureau*

DUBLIN—Royal Dublin Society. Scientific Proceedings, N.S. Vol. VII., Part v., 1892; Vol. VIII., Parts 1 and 2, 1893. Scientific Transations, Ser. ii., Vol. IV., Part xiv., 1892; Ser. ii., Vol. v., Parts i. - iv., 1893. *The Society*

Royal Irish Academy. Proceedings, 3 Ser., Vol. II., Nos. 4 and 5; Vol. III., Nos. 1, 2, 1893-94. Transactions, Vol. XXX., Parts v. - xii., 1893-94. *The Academy*

EDINBURGH—Botanical Society of Edinburgh. Transactions and Proceedings, Vol. XIX., pp. 233 - 636, 1892-93. *The Society*

Edinburgh Geological Society. Transactions, Vol. VI., Part iv., 1892; Part v., 1893 and Roll of Members, 1893. „

Highland and Agricultural Society of Scotland. Transactions, 5 Ser., Vol. VI., 1894. „

Royal Physical Society. Proceedings, Vol. XII., Session 1892-93. „

EDINBURGH—*continued.*

Royal Scottish Geographical Society. *Scottish Geographical Magazine,* Vol. IX., Nos. 10 – 12, 1893, and Index; Vol. X., Nos. 1 – 8, 1894. Additions to Library, 1892-93. *The Society*

Royal Society of Edinburgh. Proceedings, Vol. XIX., Session 1891-92. Transactions, Vol. XXXVII., Part i., Session 1891-92; Part ii., 1892-93. ,,

Scottish Microscopical Society. Proceedings, No. 1, 1891. Session 1891-92, 1892-93. ,,

University. Supplement to the Edinburgh University Calendar, 1893-94. Calendar 1894-95. *The University*

FLORENCE—Società Africana. Bullettino della Sezione Fiorentina, Collezione Generale, Vol. IX., Serie 2, Vol. I., Fasc. 1 – 8, 1894. *The Society*

Società Entomologica Italiana. Bullettino, Vol. XXV., Trimestre 3, 4, 1893; Vol. XXVI., Trimestre 1, 1894. Resoconti di Adunanze e Bullettino Bibliografico, Anno XXVI., Statuto &c., 1894. ,,

Societá Italiana di Antropologia e di Etnologia. Archivio, Vol. XXIII., Fasc. 2, 3, 1893; Vol. XXIV., Fasc. 1, 1894. ,,

FORT MONROE—U.S. Artillery School. Journal of the United States Artillery, Vol. II., No. 4, 1893; Vol. III., Nos. 1 – 3, 1894. *The School*

FRANKFURT A/M.—Senckenbergische Naturforschende Gesellschaft. Abhandlungen, Band XVIII., Heft 2, 1894. *The Society*

FREIBURG (Baden)—Naturforschende Gesellschaft. Berichte, Band VII., Heft 1, 2, 1893. ,,

GEELONG—Gordon College Field Naturalists' and Science Association. *The Geelong Naturalist,* Vol. III., Nos. 2 - 4, 1893-94; Vol. IV., No. 10, 1894. Annual Report of the Gordon Technical College for 1893. *The College*

GLASGOW—Philosophical Society of Glasgow. Proceedings, Vol. XXIV., 1892-93. *The Society*

University. Calendar for the year 1894-95. *The University*

GÖTTINGEN—Königliche Gesellschaft der Wissenschaften und der Georg.-Augusts-Universität. Nachricten, No. 1 – 16, 1892; Nos. 1 – 21, 1893. Nachrichten, Math.-phys. Klasse Nos. 1, 2, 1894. *The Society*

GRATZ—Naturwissenschaftliche Vereins für Steiermark. Mittheilungen, Heft XXX., 1893. ,,

HAARLEM—Colonial Museum. Bulletin, Dec. 1893, Mar., May, July, 1894. Wekelijksche Courant de Nijverheid, Jahrg. I., Nos. 40 – 52, 1893; Jahrg. II., Nos. 1 – 26, 1894. *The Museum*

Musée Teyler. Archives, Ser. 2, Vol. IV., Part ii., 1894. ,,

Société Hollandaise des Sciences. Archives Néerlandaises des Sciences Exactes et Naturelles, Tome XXVII., Liv. 3 – 5, 1893-94; Tome XXVIII., Liv. 1, 2, 1894. *The Society*

HALIFAX, N.S.—Nova Scotian Institute of Science. Proceedings, and Transactions, Second Series, Vol. I., Part ii., Session 1891-92. *The Institute*

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EXCHANGES AND PRESENTATIONS

MADE BY THE

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* Exchanges of Publications have been received from the Societies and Institutions distinguished by an asterisk.

Africa.

1 TUNIS ... ... Institut de Carthage.

Argentine Republic.

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3 LA PLATA ... ...*Directeur-Général de Statistique de la Province de Buénos Ayres.
4 „ ... ...*Museo de La Plata. Provincia de Buenos Aires.

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8 GRATZ ... ...*Naturwissenschaftliche Vereins für Steiermark in Graz.
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14 „ ... ...*Kaiserliche Akademie der Wissenschaften.
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16 „ ... ...*K. K. Geographische Gesellschaft.
17 „ ... ...*K. K. Geologische Reichsanstalt.
18 „ ... ...*K. K. Gradmessungs Bureau.
19 „ ... ...*K. K. Naturhistorische Hofmuseum.
20 „ ... ...*K. K. Zoologisch-Botanische Gesellschaft.
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Belgium.

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29 MONS ... ...*Société des Sciences, des Arts et des Lettres du Hainaut.

Brazil.

30 RIO DE JANEIRO ...*Observatoire Impérial de Rio de Janeiro.

Chili.

31 SANTIAGO ... ...*Sociedad Cientifica Alemana.

Denmark.

32 COPENHAGEN ...*Société Royale des Antiquaires du Nord.

France.

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90 Freiburg (Baden)*Naturforschende Gesellschaft.
91 Giessen ... ...*Oberhessische Gesellschaft für Natur-und-Heilkunde.
92 Görlitz ... ...*Naturforschende Gesellschaft in Görlitz.
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MAURITIUS.

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241 GLASGOW ... ...*Geological Society of Glasgow.
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TASMANIA.

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VICTORIA.

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261 „ ...*Mining Department.
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266 „ ...*Royal Society of Victoria.
267 „ ...*University.
268 „ ...*Victorian Institute of Surveyors.
269 „ ...*Working Men's College.
270 STAWELL ... ...*School of Mines, Art, Industry, and Science.

WESTERN AUSTRALIA.

271 PERTH ... ...*Geological Survey of Western Australia.

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Italy.

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280 " ... ...*Società Italiana di Scienze Naturali.
281 Modena ... ...*R. Accademia di Scienze, Lettere ed Arti.
282 Naples ... ...*Società Africana d' Italia.
283 " ... ...*Società Reale di Napoli(Accademia delle Scienze Fisiche e Matematiche).
284 " ... ...*Stazione Zoologica (Dr. Dohrn).
285 Palermo ... ...*Reale Accademia Palermitana di Scienze Lettere ed Arti.
286 Pisa ... ... Reale Istituto Tecnico.
287 " ... ...*Società Toscana di Scienze Naturali.
288 Rome ... ...*Accademia Pontificia de Nuovi Lincei.
289 " ... ...*Biblioteca e Archivio Tecnico (Ministero dei Lavori Pubblico).
290 " ... ...*R. Accademia dei Lincei.
291 " ... ...*R. Comitato Geologico d' Italia.
292 " ... ...*R. Ufficio Centrale di Meteorologico e di Geodinamico.
293 " ... ...*Società Geografica Italiana.
294 Siena ... ...*R. Accademia dei Fisiocritici in Siena.
295 Turin ... ... Reale Accademia della Scienze.
296 " ... ...*Regio Osservatorio della Regia Università.
297 Venice ... ...*Reale Istituto Veneto di Scienze, Lettere ed Arti.

Japan.

298 Tokio ... ...*Asiatic Society of Japan (formerly in Yokohama).
299 " ... ...*Imperial University.
300 " ... ...*Seismological Society of Japan.

Java.

301 Batavia ... ...*K. Natuurkundige Vereeniging in Nederl Indië.

Mexico.

302 Mexico ... ...*Sociedad Cientifica "Antonio Alzate."

Netherlands.

303 Amsterdam ...*Académie Royale des Sciences.
304 " ...*Société Royale de Zoologie.
305 Harlem ... ...*Bibliothèque de Musée Teyler.
306 " ... ...*Colonial Museum.
307 " ... ...*Société Hollandaise des Sciences.

Norway.

308 Bergen ... ...*Museum.
309 Christian ... ...*Köngelige Norske Fredericks Universitet.
310 " ... ...*Videnskabs-Selskabet i Christiania.
311 Tromso ... ...*Museum.

Roumania.

312 Bucharest ...*Institutul Meteorologic al Roumăniei.

Russia.

313 Helsingfors ...*Société des Sciences de Finlande.
314 Kieff ... ...*Société des Naturalistes.
315 Moscow ... ...*Société Impériale des Naturalistes.
316 „ ... ...*Société Impériale des Amis des Sciences Naturelles d' Anthropologie et d' Ethnographie à Moscow (Section d' Anthropologie).
317 St. Petersburg ...*Académie Impériale des Sciences.
318 „ ...*Comité Géologique—Institut des Mines.

Spain.

319 Madrid ... ...*Instituto geografico y Estadistico.

Sweden.

320 Stockholm ...*Kongliga Svenska Vetenskaps-Akademien.
321 „ ...*Kongliga Universitetet.

Switzerland.

322 Berne ... ...*Société de Géographie de Berne.
323 Geneva ... ...*Institut National Genèvois.
324 Lausanne ...*Société Vaudoise des Sciences Naturelles.
325 Neuchatel ...*Société des Sciences Naturelles de Neuchatel.
326 Zurich ... ...*Naturforschende Gesellschaft.

United States of America.

327 Albany ... ...*New York State Library, Albany.
328 Annapolis (Md.) *Naval Academy.
329 Baltimore ...*Johns Hopkins University.
330 Beloit (Wis.) ...*Chief Geologist.
331 Boston ... ...*American Academy of Arts and Sciences.
332 „ ... ...*Boston Society of Natural History.
333 „ ... ... State Library of Massachusetts.
334 Brookville (Ind.)*Brookville Society of Natural History.
335 „ ... Indiana Academy of Science.
336 Buffalo (Ind.) ...*Buffalo Society of Natural Sciences.
337 Cambridge (Mass.)*Cambridge Entomological Club.
338 „ ...*Museum of Comparative Zoology at Harvard College.
339 Chicago ... ... Academy of Sciences.
340 Cincinnati ...*Cincinnati Society of Natural History.
341 Coldwater ... Michigan Library Association.
342 Davenport (Iowa)*Academy of Natural Sciences.
343 Denver ... ...*Colorado Scientific Society.
344 Fort Monroe (Va.)*United States Artillery School.
345 Hoboken (N.J.) ...*Steven's Institute of Technology.
346 Iowa City (Iowa) *Director Iowa Weather Service.
347 Jefferson City...*Geological Survey of Missouri.
348 Madison (Wis.)...*Wisconsin Academy of Sciences, Arts and Letters.
349 Minneapolis ...*Minnesota Academy of Natural Sciences.
350 Newhaven (Conn) *Connecticut Academy of Arts and Sciences.
351 New York ...*American Chemical Society.
352 „ ...*American Geographical Society.
353 „ ...*American Institute of Mining Engineers.
354 „ ...*American Museum of Natural History.

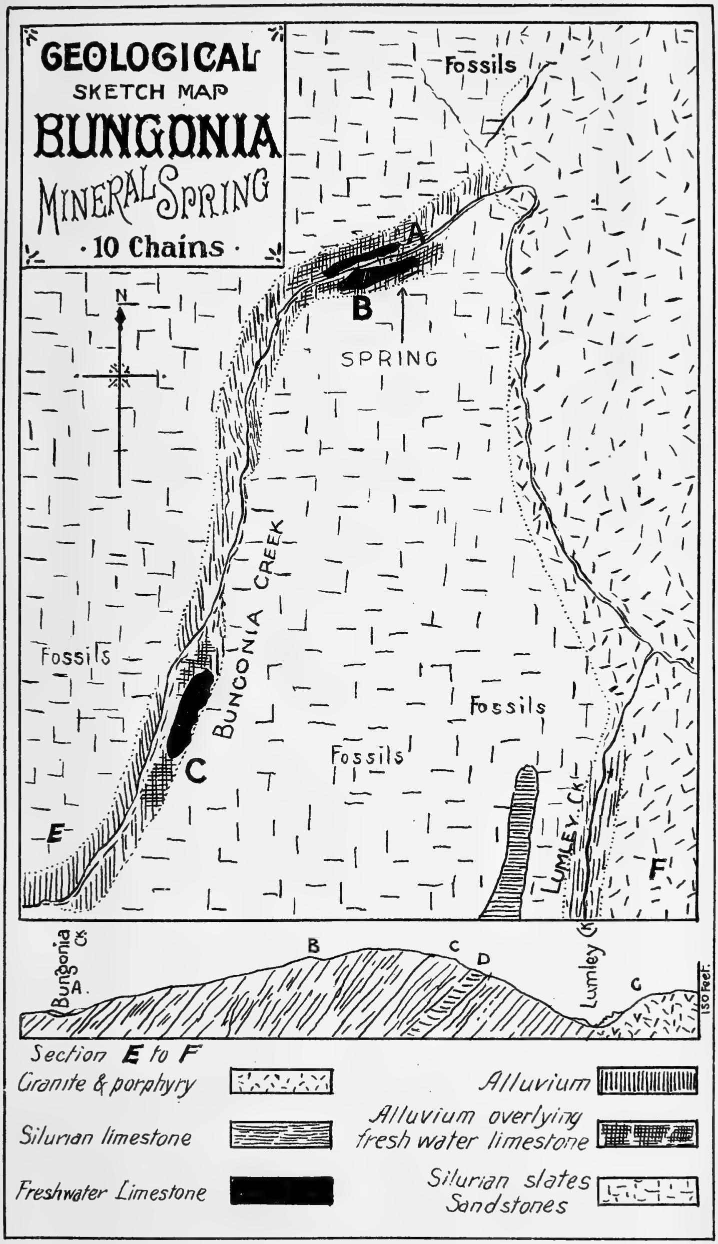
355 NEW YORK ...*Editor *Journal of Comparative Medicine and Veterinary Archives.*
356 „ ...*New York Academy of Sciences.
357 „ ...*New York Microscopical Society.
358 „ ...*School of Mines, Columbia College.
359 PALO ALTO (Cal.)...*Geological Survey of Arkansas.
360 PHILADELPHIA ...*Academy of Natural Science.
361 „ ...*American Entomological Society.
362 „ ...*American Philosophical Society.
363 „ ...*Franklin Institute.
364 „ ...*Geological Survey of Pennsylvania.
365 „ ...*Wagner Free Institute of Science.
366 „ ...*Zoological Society of Philadelphia.
367 ROCHESTER (N.Y.) *Geological Society of America.
368 SALEM (Mass.) ...*American Association for Advancement of Science.
369 „ ...*Essex Institute.
370 ST. LOUIS ... ...*Academy of Science.
371 „ ...*Missouri Botanical Garden.
372 SAN FRANCISCO ...*California Academy of Sciences.
373 „ ...*California State Mining Bureau.
374 SCRANTON (Pa.) ...*The Colliery Engineer Co.
375 WASHINGTON ... American Medical Association.
376 „ ...*Bureau of Education (Department of the Interior).
377 „ ...*Bureau of Ethnology.
378 „ ...*Chief of Engineers (War Department).
379 „ ...*Chief of Ordnance (War Department).
380 „ ...*Department of Agriculture, Library.
381 „ ...*Department of Agriculture, Weather Bureau.
382 „ ...*Director of the Mint (Treasury Department).
383 „ ...*Library (Navy Department).
384 „ ...*National Academy of Sciences.
385 „ ...*Office of Indian Affairs (Department of the Interior).
386 „ ...*Philosophical Society.
387 „ ...*Secretary (Department of the Interior).
388 „ ...*Secretary (Treasury Department).
389 „ ...*Smithsonian Institution.
390 „ ...*Surgeon General (U.S. Army).
391 „ ...*U. S. Coast and Geodetic Survey (Treasury Department).
392 „ ...*U.S. Geological Survey.
393 „ ...*U. S. National Museum (Department of the Interior).
394 „ ... U.S. Patent Office.
395 „ ...*War Department.

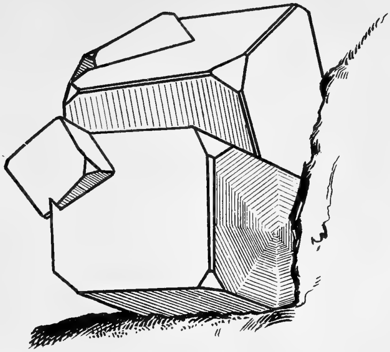
Number of Publications sent to	Great Britain	... ...	84
„ „	India and the Colonies	...	72
„ „	America	... ...	74
„ „	Europe	... ...	155
„ „	Asia, Africa, &c.	... ...	6
„ „	Editors of Periodicals	...	4
	Total	... ...	395

T. W. E. DAVID...... } Hon. Secretaries.
J. H. MAIDEN.......... }

The Society's House, Sydney, 31st December, 1894.

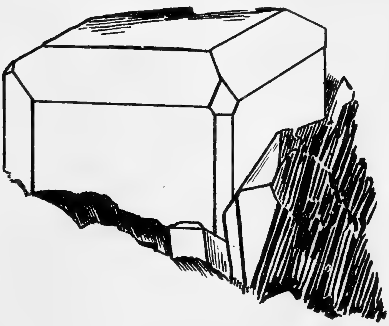
F. W. WHITE, Printer, 39 Market-st., Sydney.


GEOLOGICAL
SKETCH MAP
BUNGONIA
MINERAL SPRING
·10 Chains·
N
Fossils
A
B
SPRING
BUNGONIA CREEK
Fossils
C
Fossils
Fossils
E
LUMLEY CK.
F
Bungonia Ck
A.
B
C
D
Lumley Ck
G
150 Feet.
Section E to F
Granite & porphyry
Silurian limestone
Freshwater Limestone
Alluvium
Alluvium overlying fresh water limestone
Silurian slates Sandstones



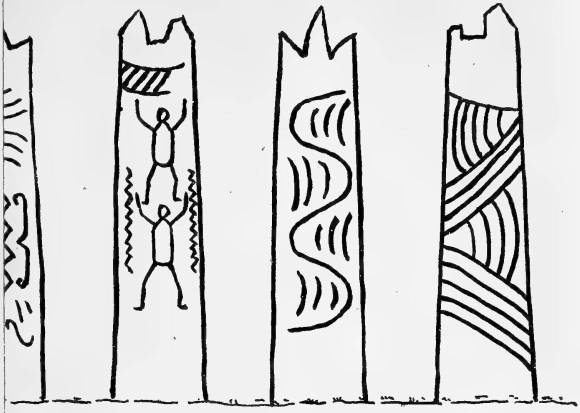
BOLEITE, enlarged 2½ dia.

KERARGYRITE.



CUPRITE. enlarged 2 dia.

Note on BOLEITE &c from BROKEN HILL N.S.W.
by A. Liversidge. M.A. F.R.S.



9 Fig. 10 Fig. 11 Fig 12

Fig 2 Fig. 13 Fig. 14 Fig 15

Scale - Figs. 1-7

Scale - Figs 8-15

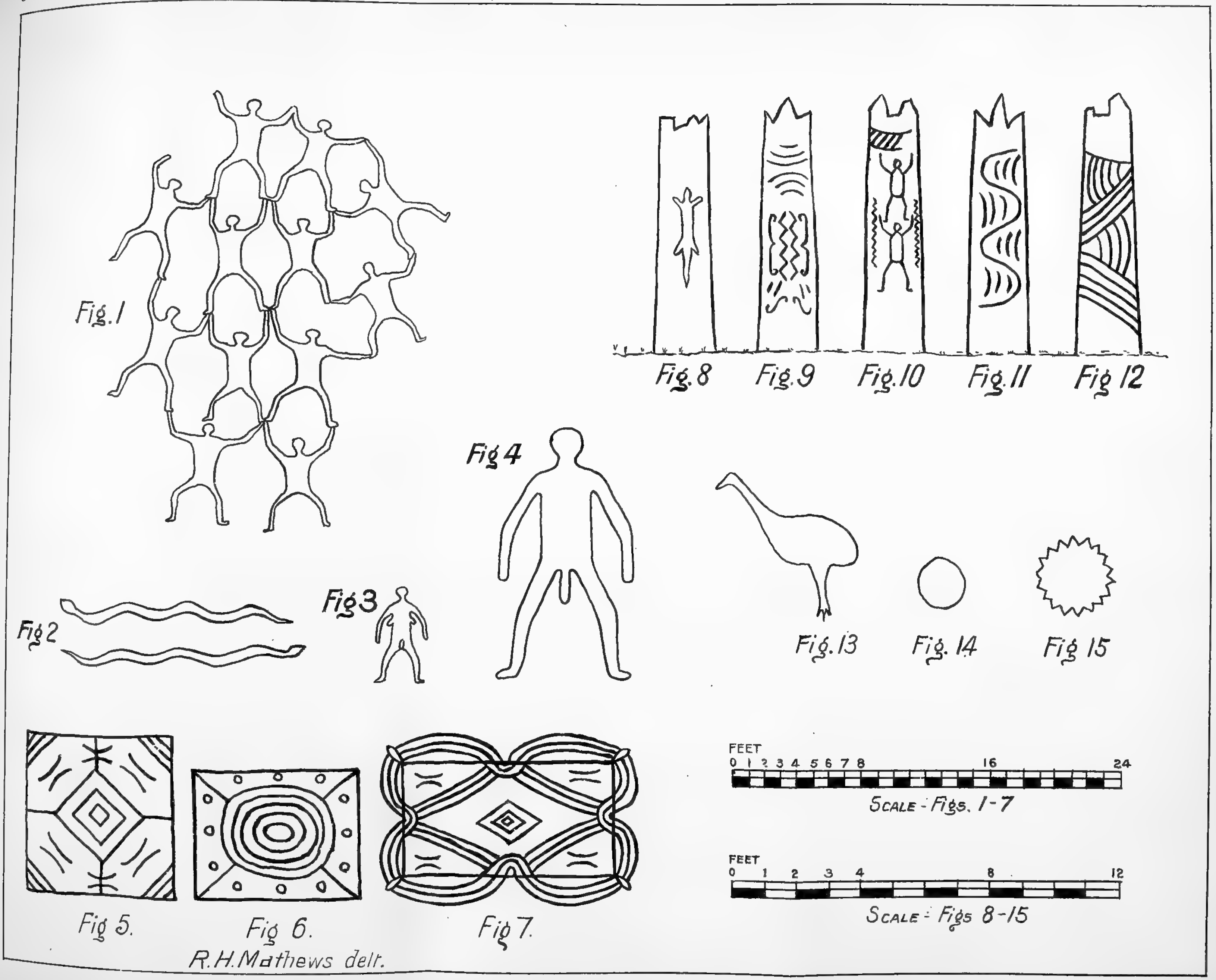
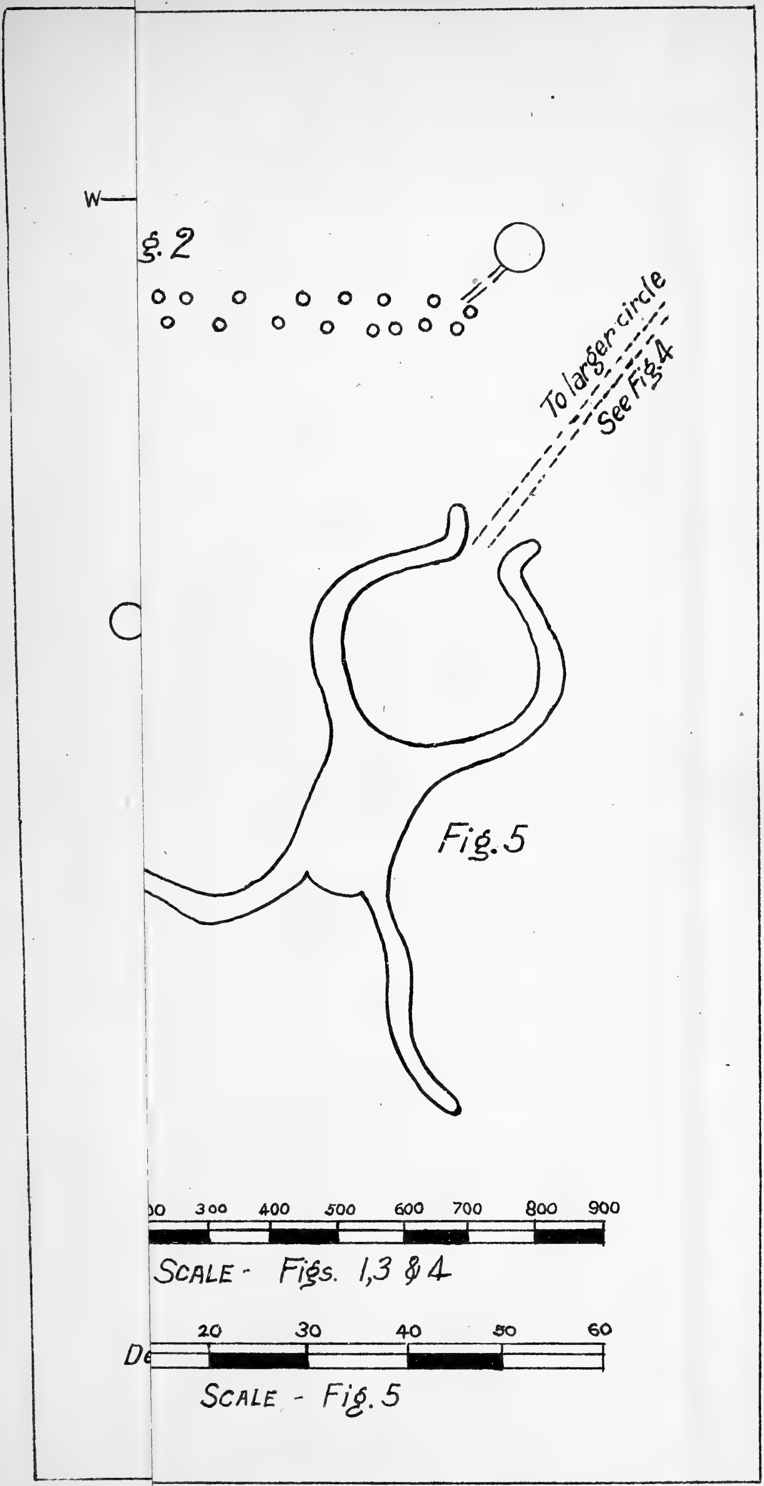
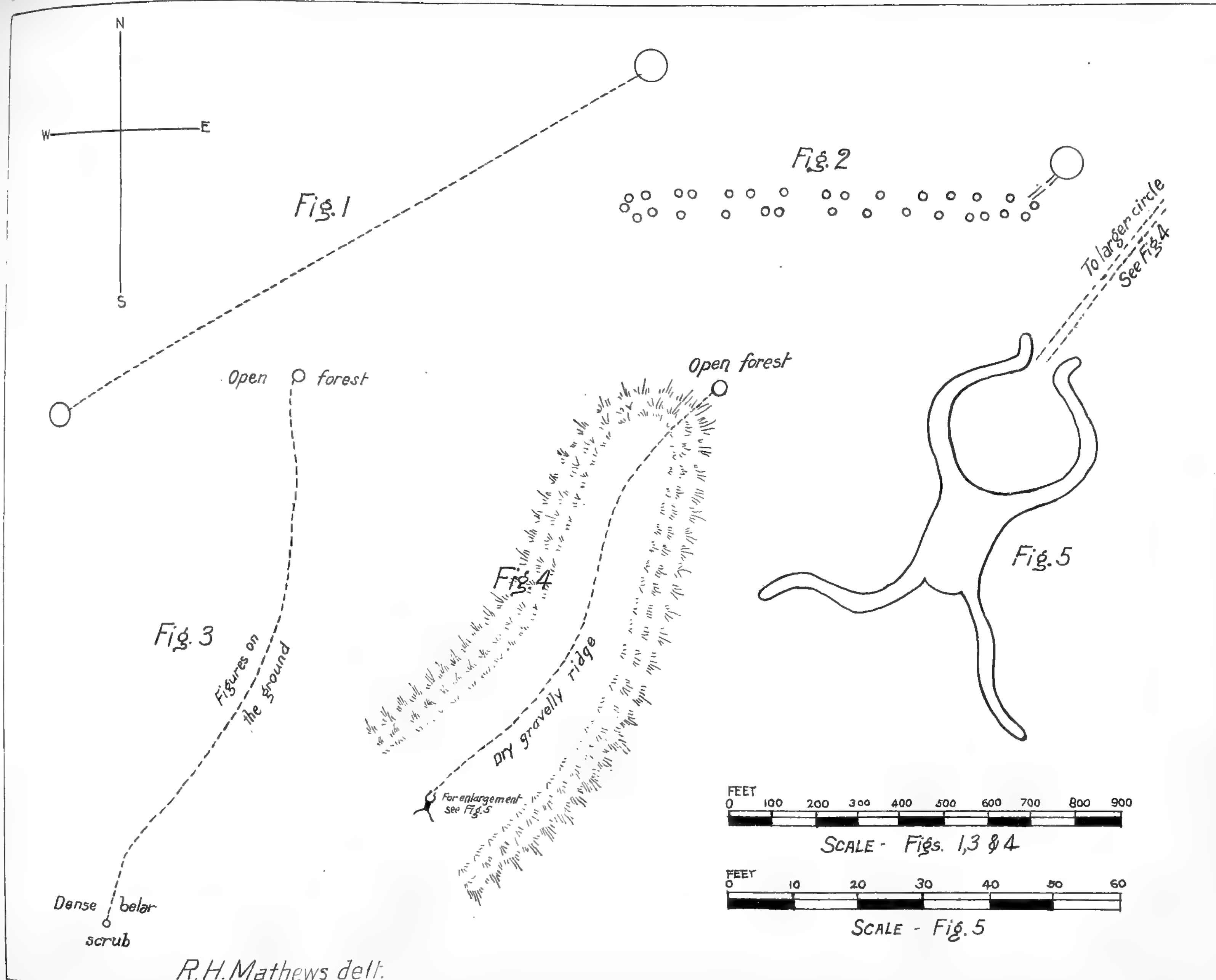
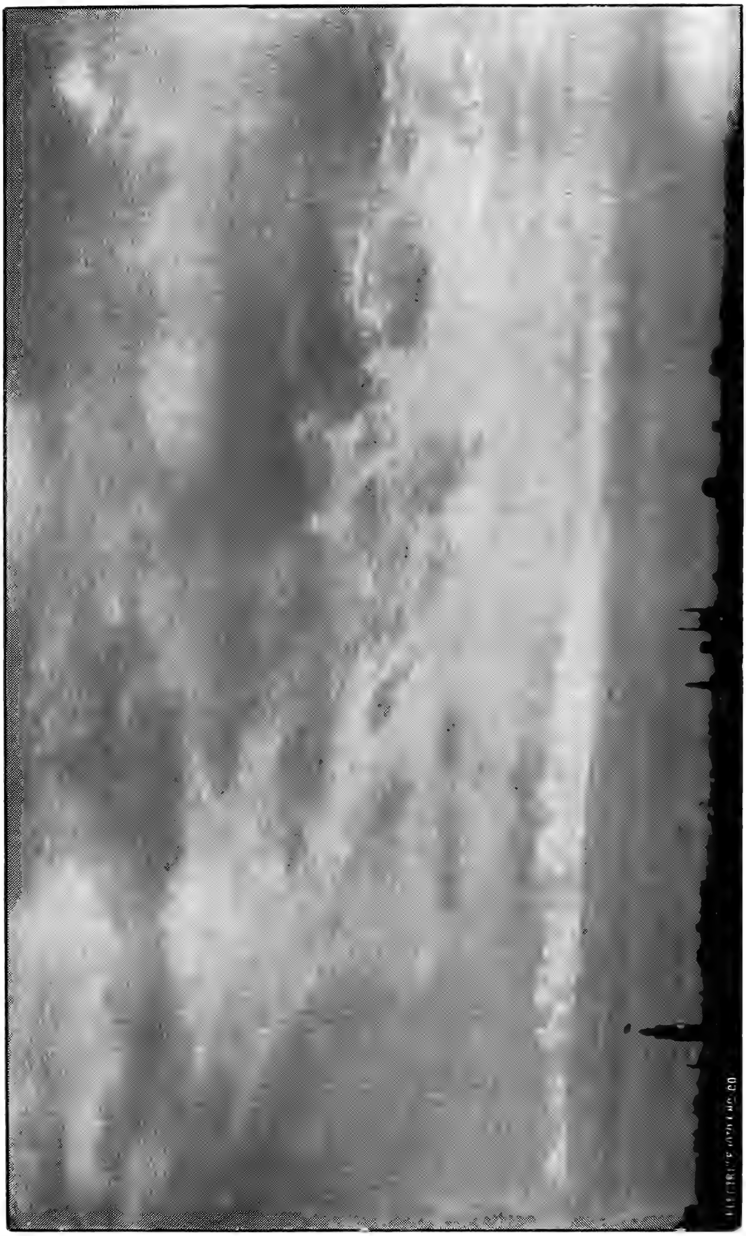


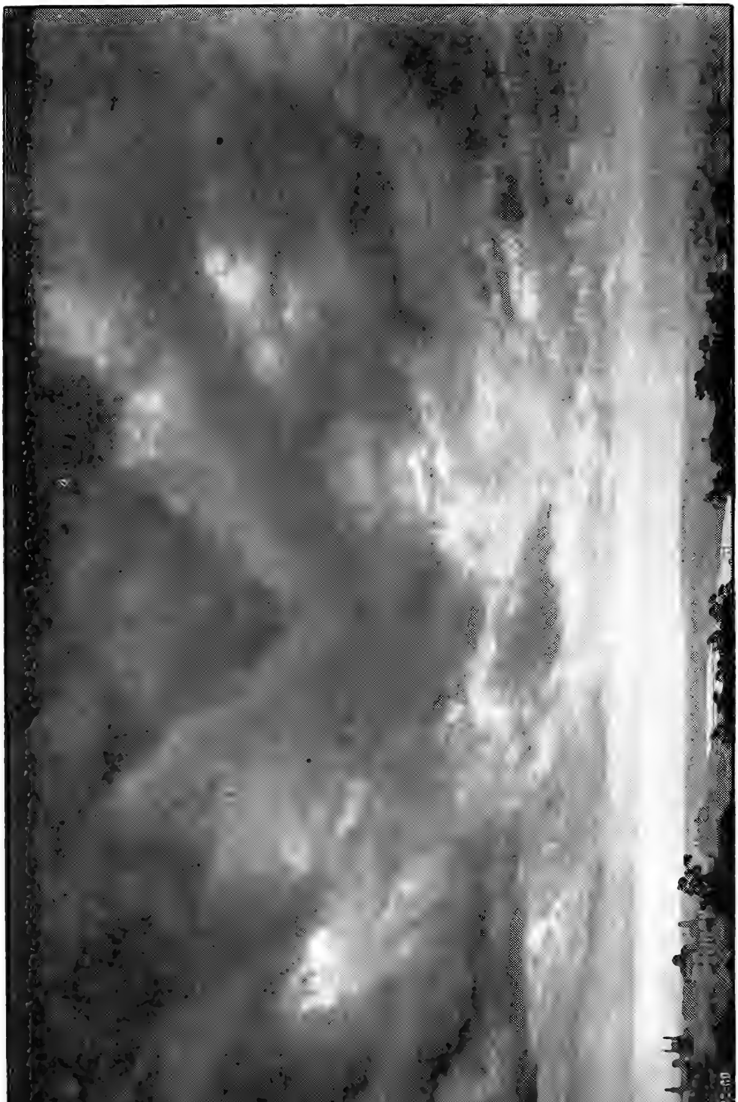
Fig. 1
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig 12
Fig 4
Fig 2
Fig 3
Fig. 13
Fig. 14
Fig 15
FEET
0 1 2 3 4 5 6 7 8 16 24
Scale - Figs. 1-7
FEET
0 1 2 3 4 8 12
Scale - Figs 8-15
Fig 5.
Fig 6.
Fig 7.
R.H. Mathews delt.

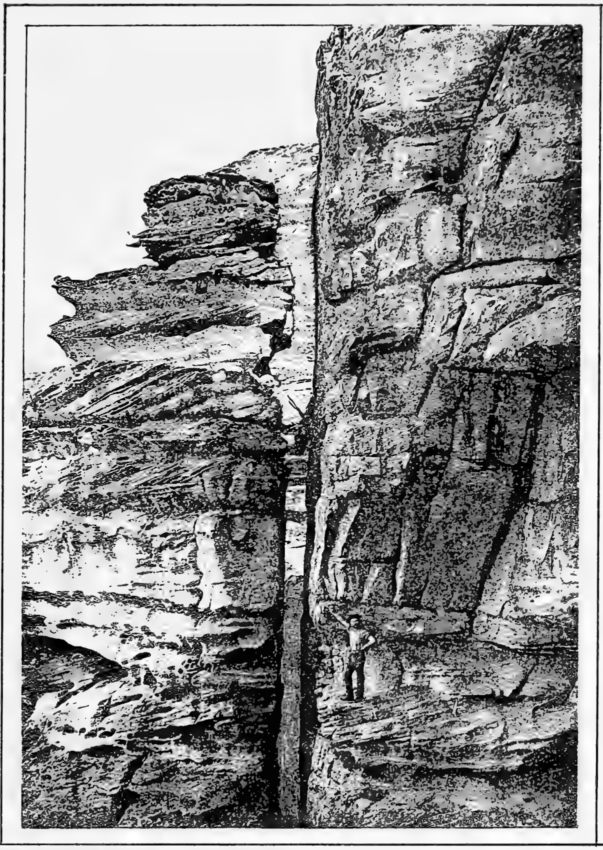
W
g. 2
To larger circle
See Fig. 4
Fig. 5
00 300 400 500 600 700 800 900
SCALE - Figs. 1,3 & 4
20 30 40 50 60
De
SCALE - Fig. 5

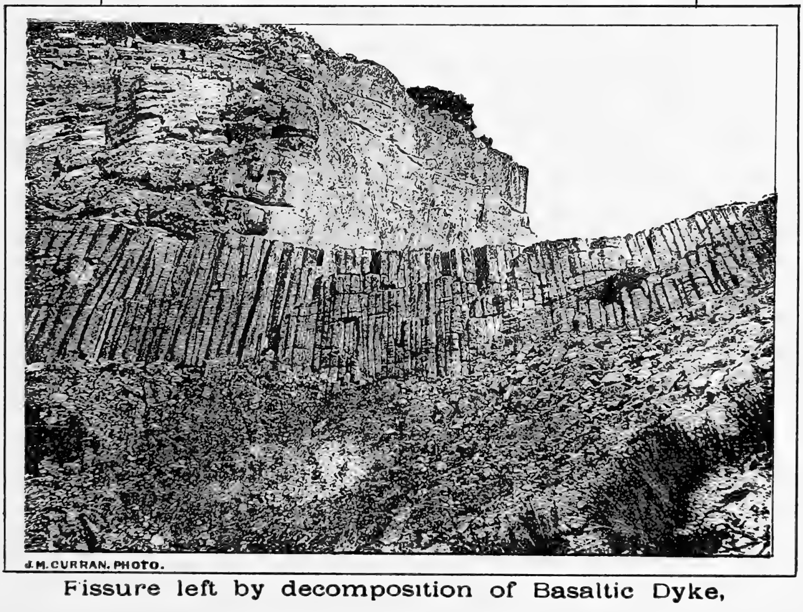


R. H. Mathews delt.





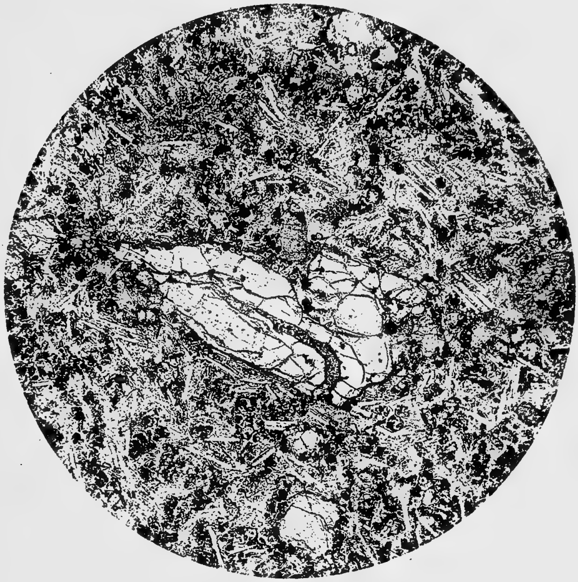


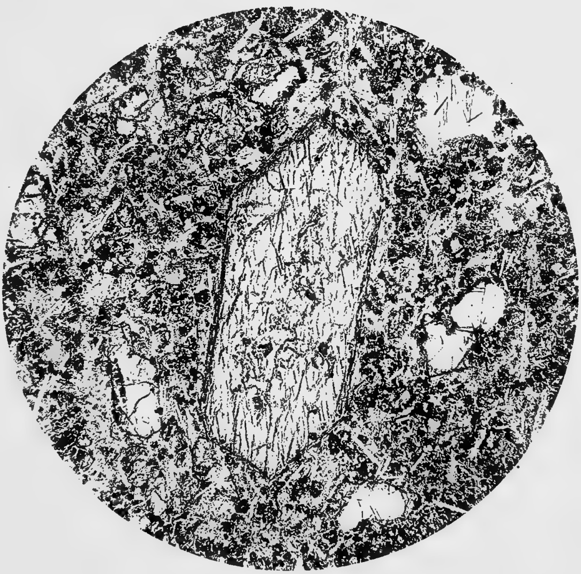


J.M. CURRAN. PHOTO.

Fissure left by decomposition of Basaltic Dyke, Bondi, Sydney, N.S.W.

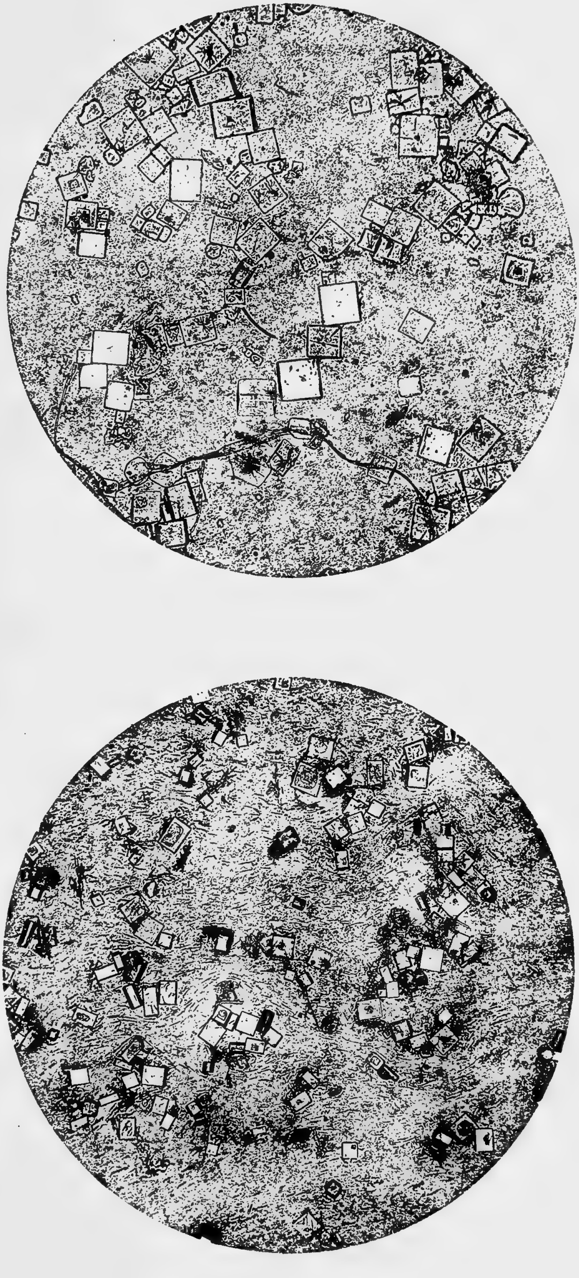
Columnar Sandstone, Bondi, Sydney, N.S.W.





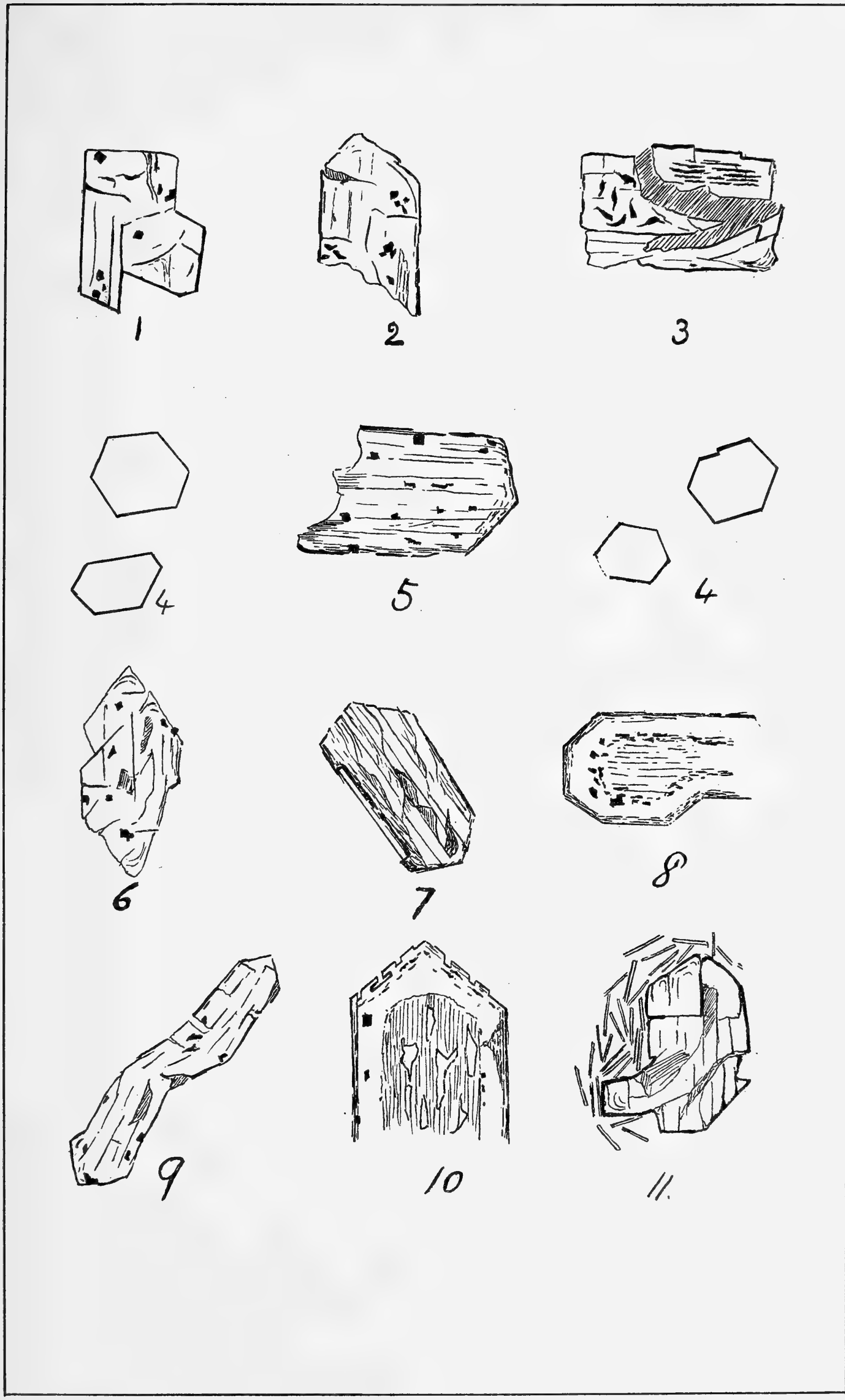
J. M. CURRAN, MICRO-PHOTO.

Microscopic Structure of Bondi Basalt X 30 diam.



J. M. CURRAN, MICRO-PHOTO.

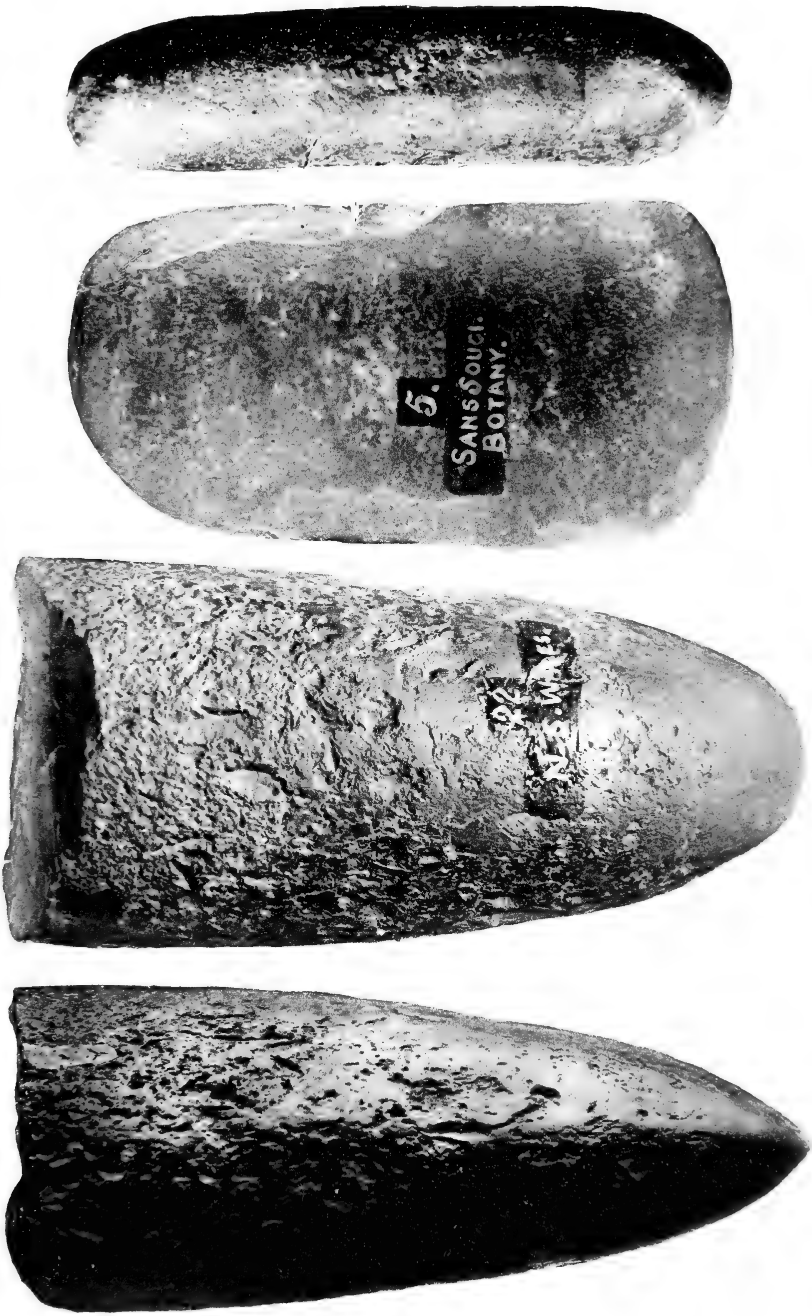
Sodium Chloride Crystals in Hydrochloric Acid Solution of Bondi Basalt. X 35.



Minerals in Bondi Basalt.

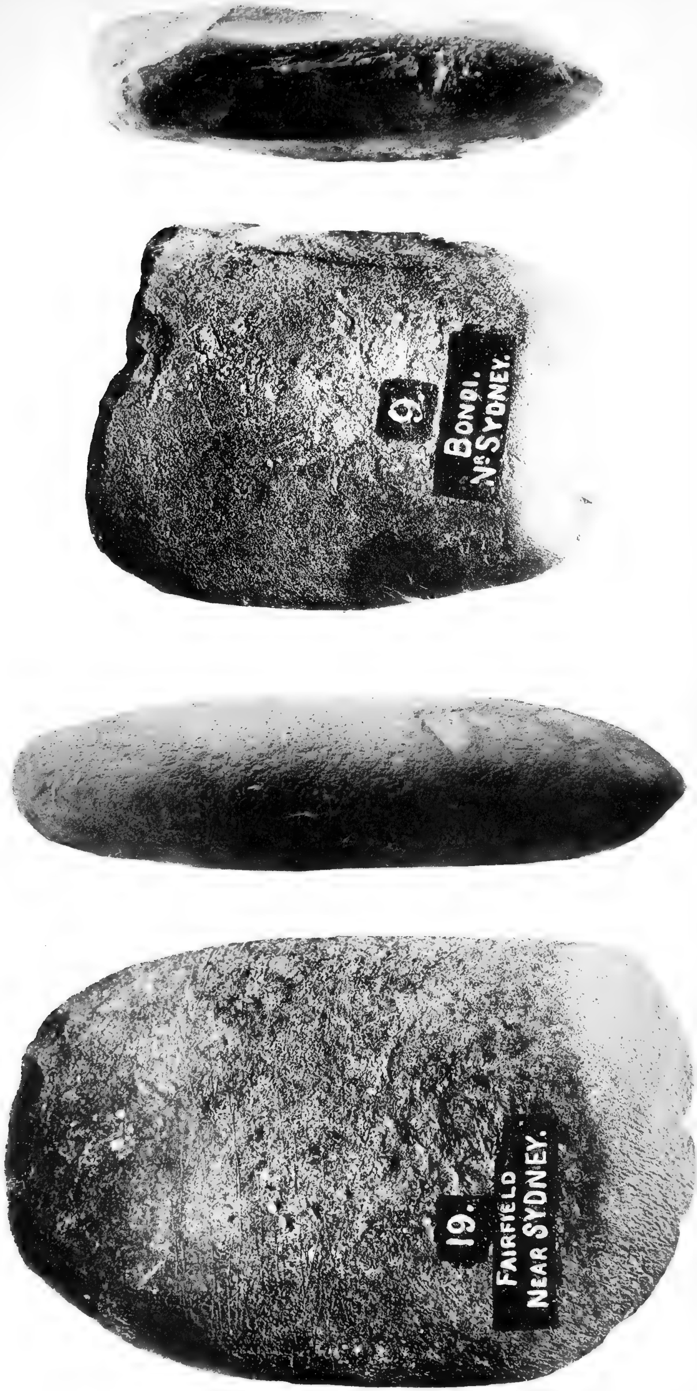
Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.



Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

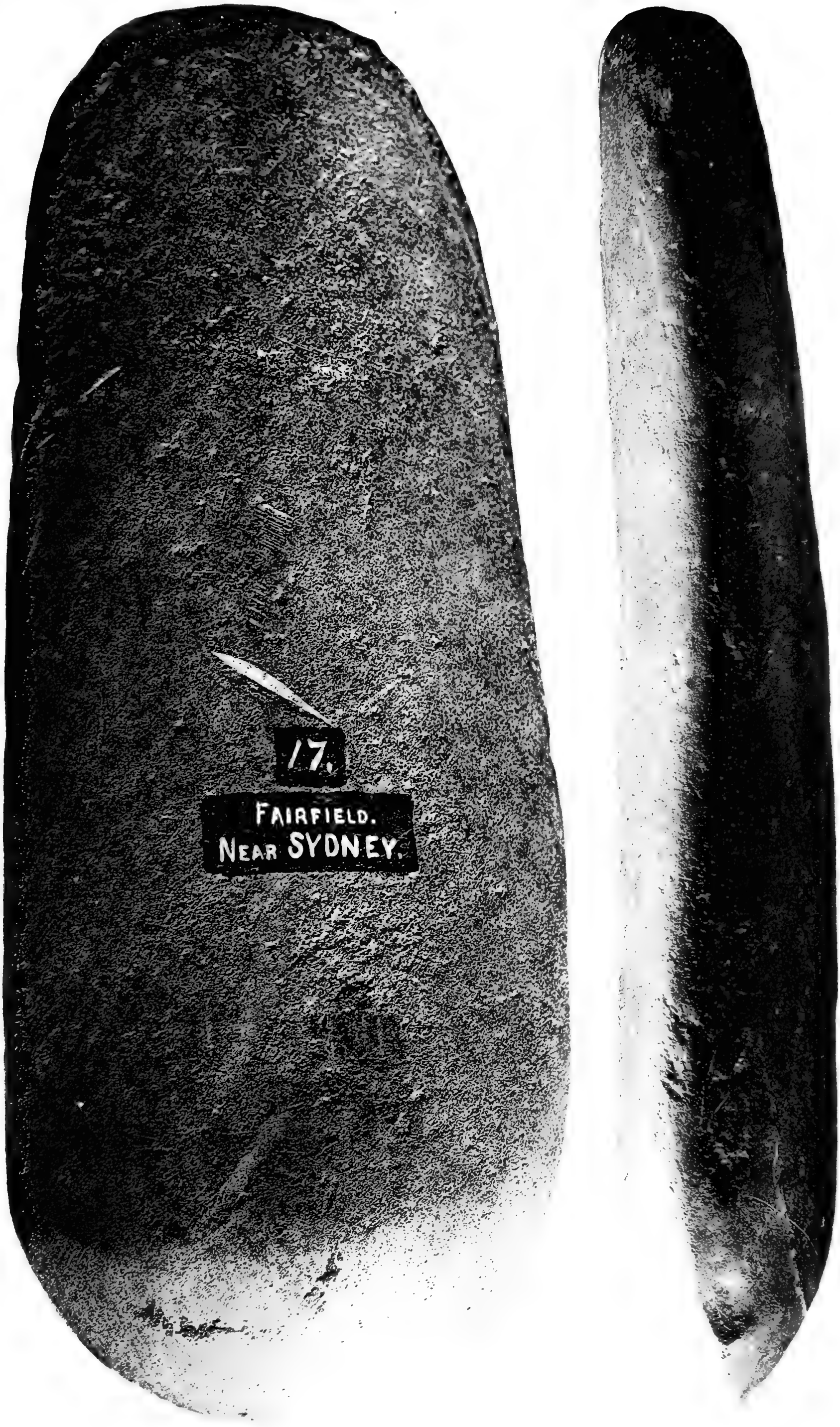


Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

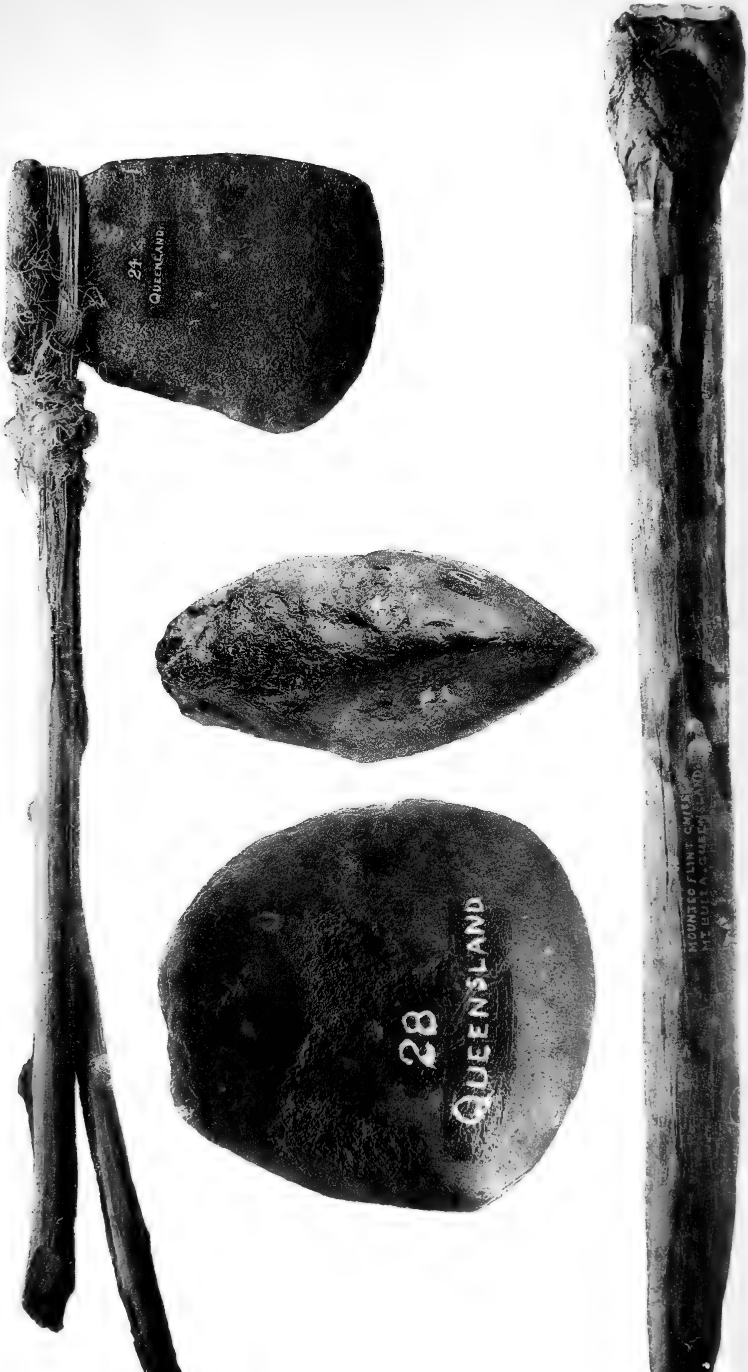
Australian and Other Stone Implements.

A. LIVERSIDGE, M.A., F.R.S.



Australian and Other Stone Implements. A. Liversidge M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.



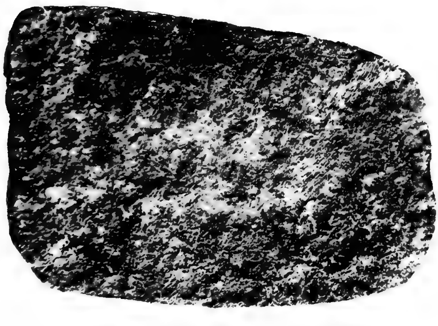
Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

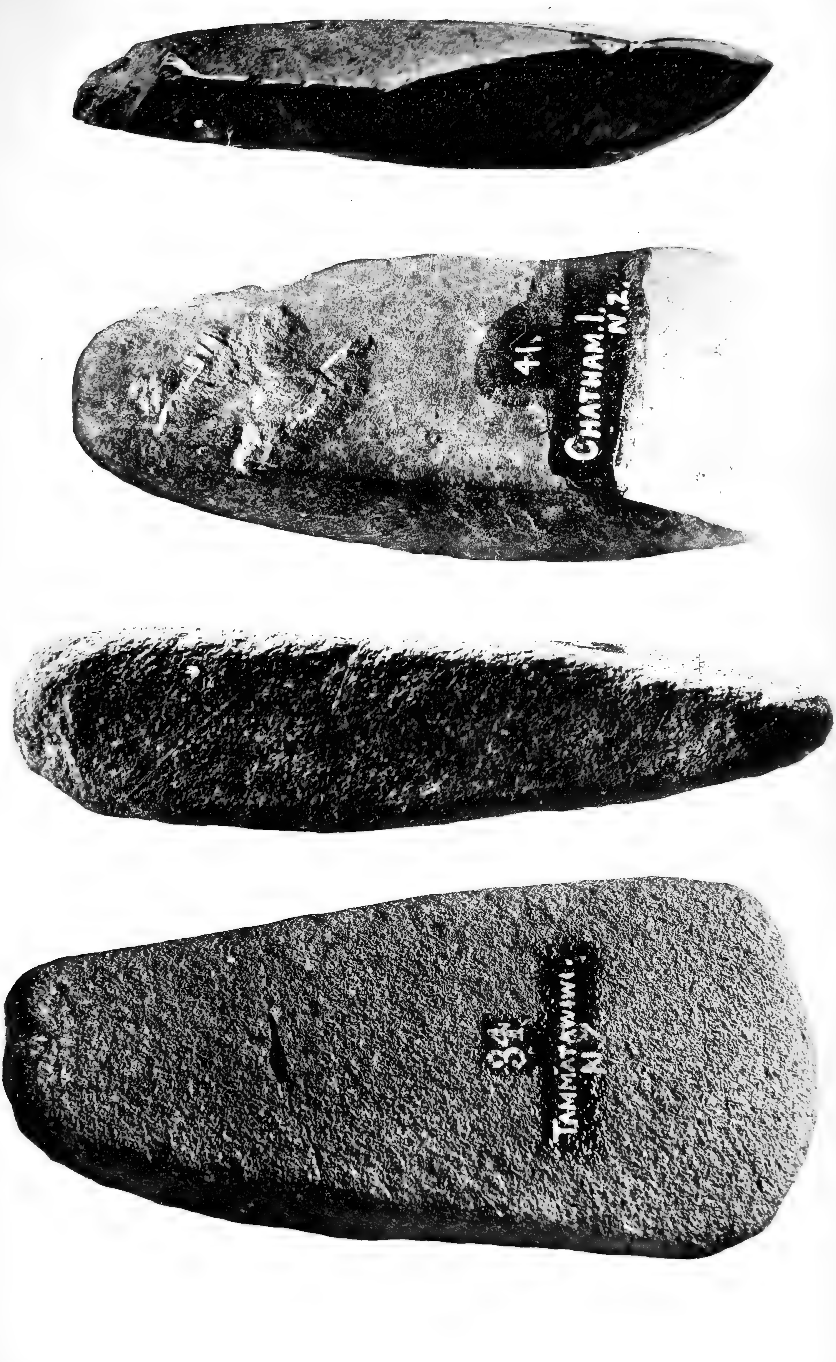
Section of No. 34, *Plate 26.*

44.—Jade Carving Chisel.



Australian and Other Stone Implements.

A. Liversidge, M.A., F.R.S.

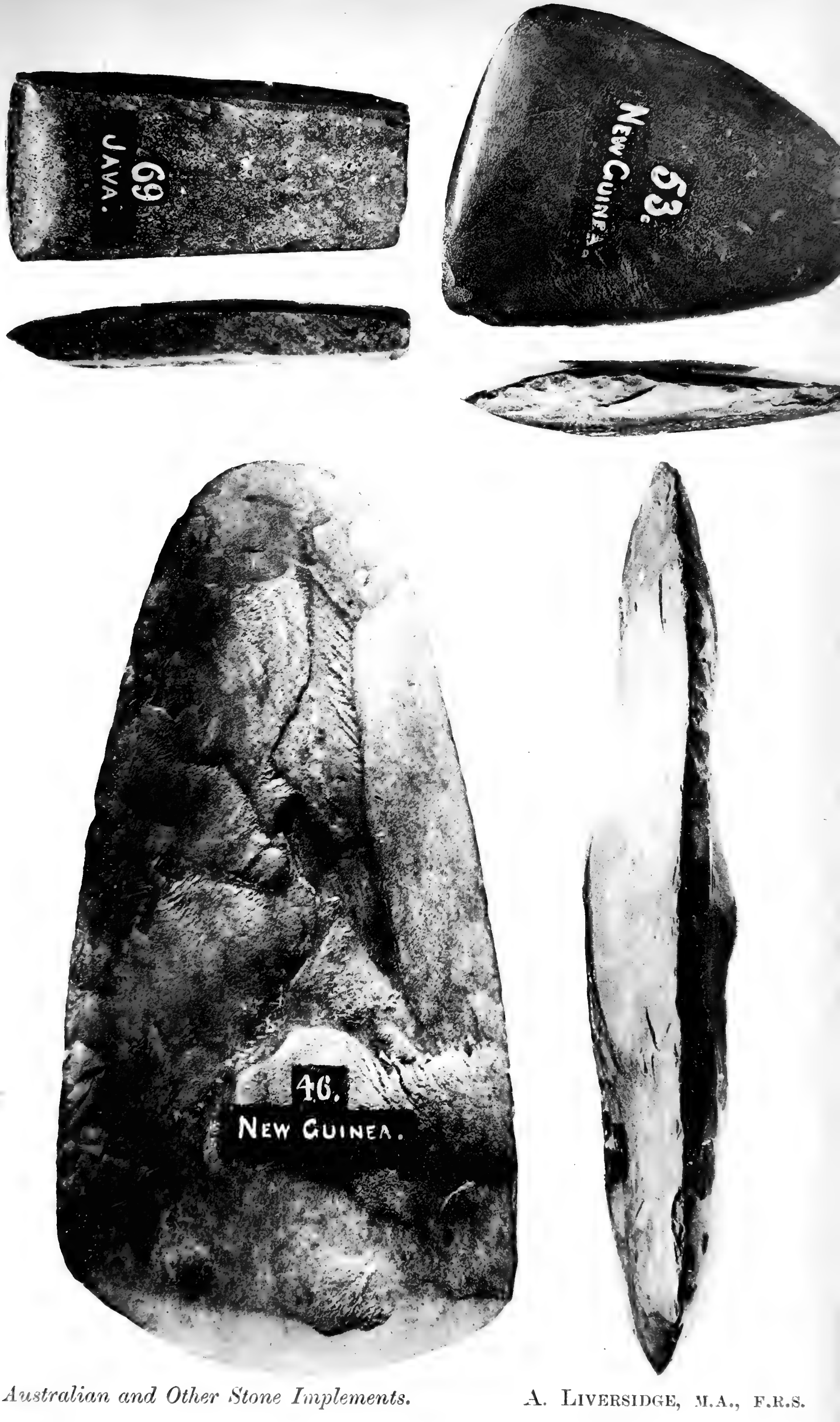


Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. Liversidge, M.A., F.R.

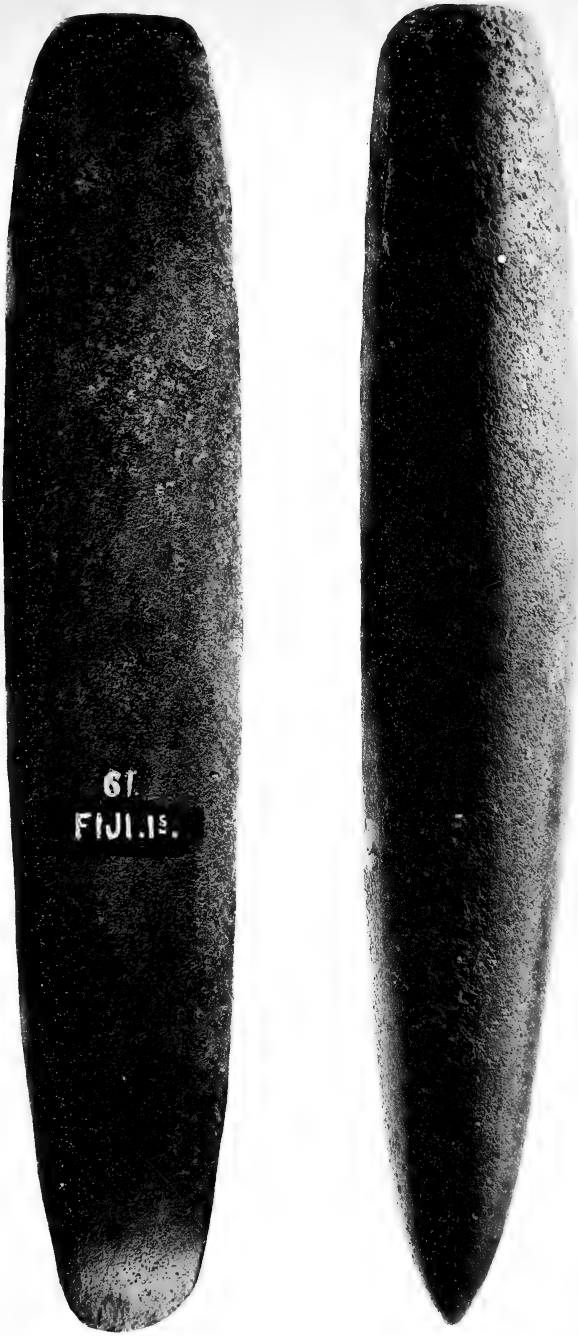


Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

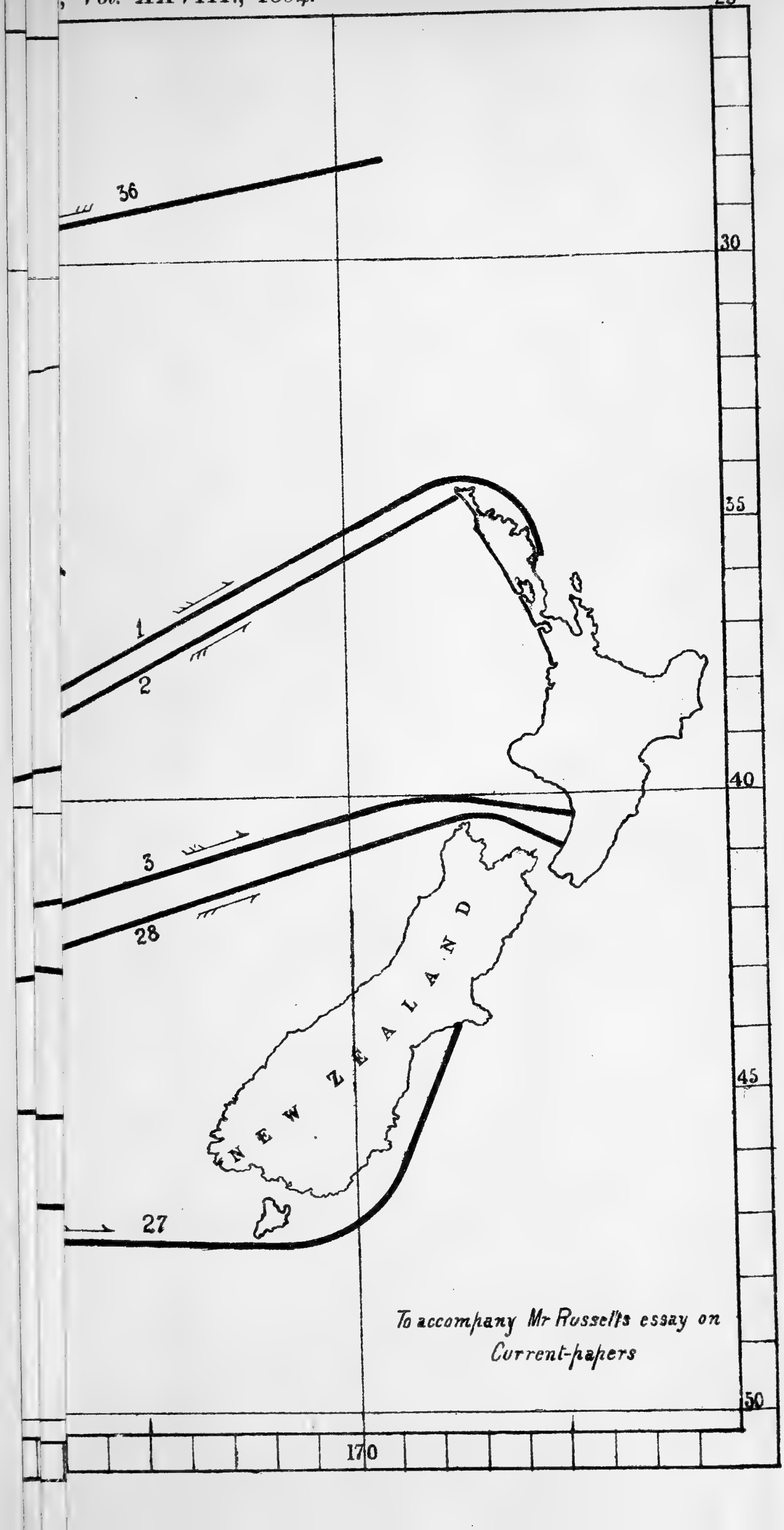
Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.



Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.

Australian and Other Stone Implements. A. LIVERSIDGE, M.A., F.R.S.


NEW BRITAIN
65
NEW BRITAIN


25
30
35
40
45
50
36
1
2
3
28
27
NEW ZEALAND
170
To accompany Mr Russell's essay on
Current-papers

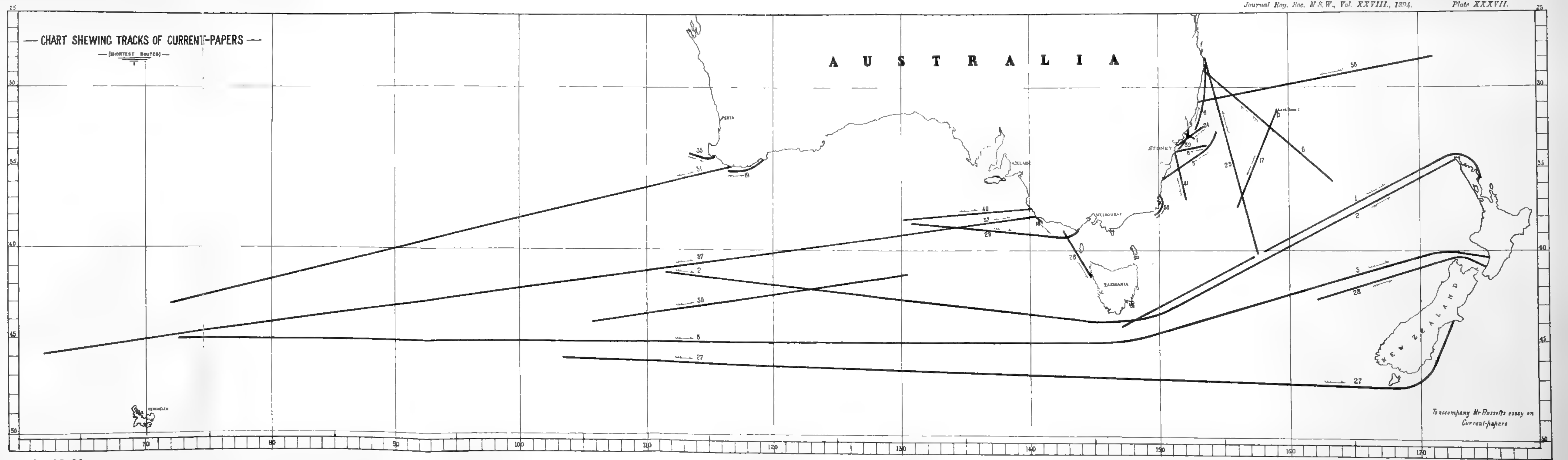
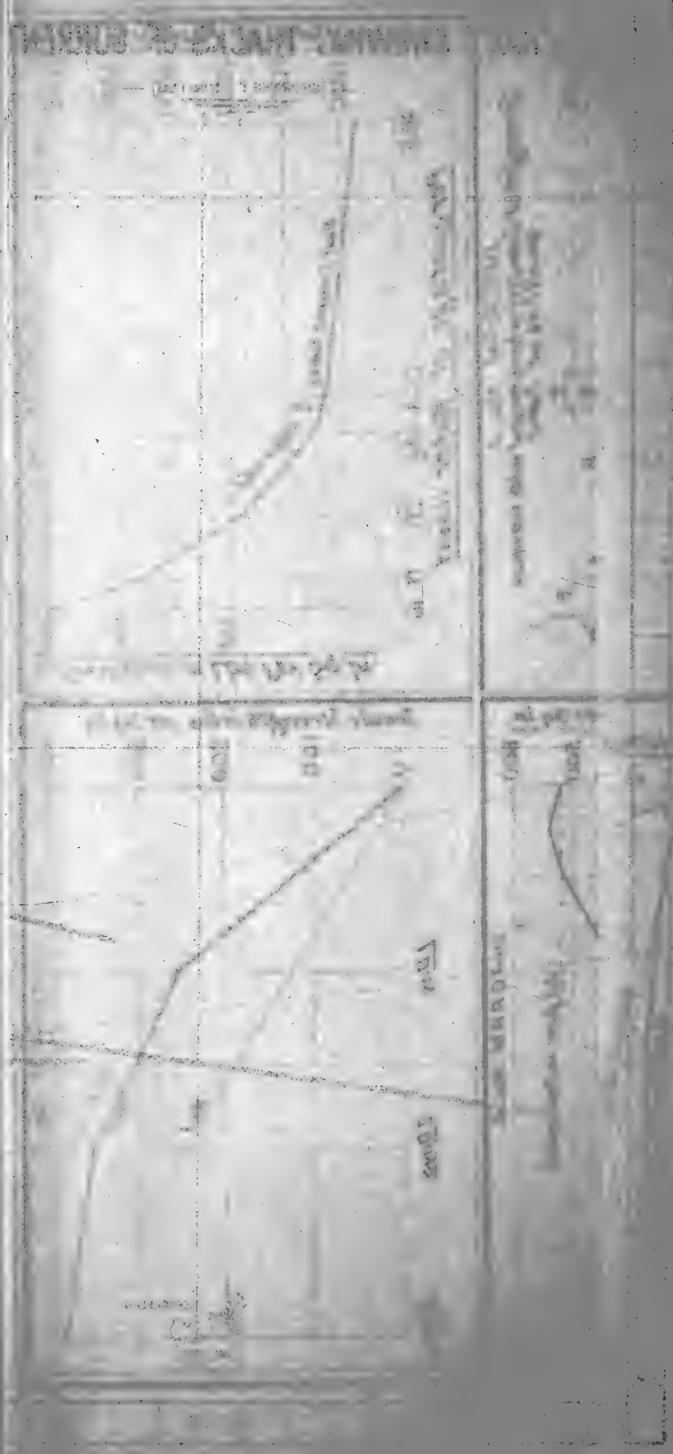


CHART SHEWING TRACKS OF CURRENT-PAPERS
(SHORTEST ROUTES)
AUSTRALIA
PERTH
ADELAIDE
MELBOURNE
SYDNEY
TASMANIA
NEW ZEALAND
KERGUELEN
To accompany Mr Russell's essay on Current-papers

12 a 145-94



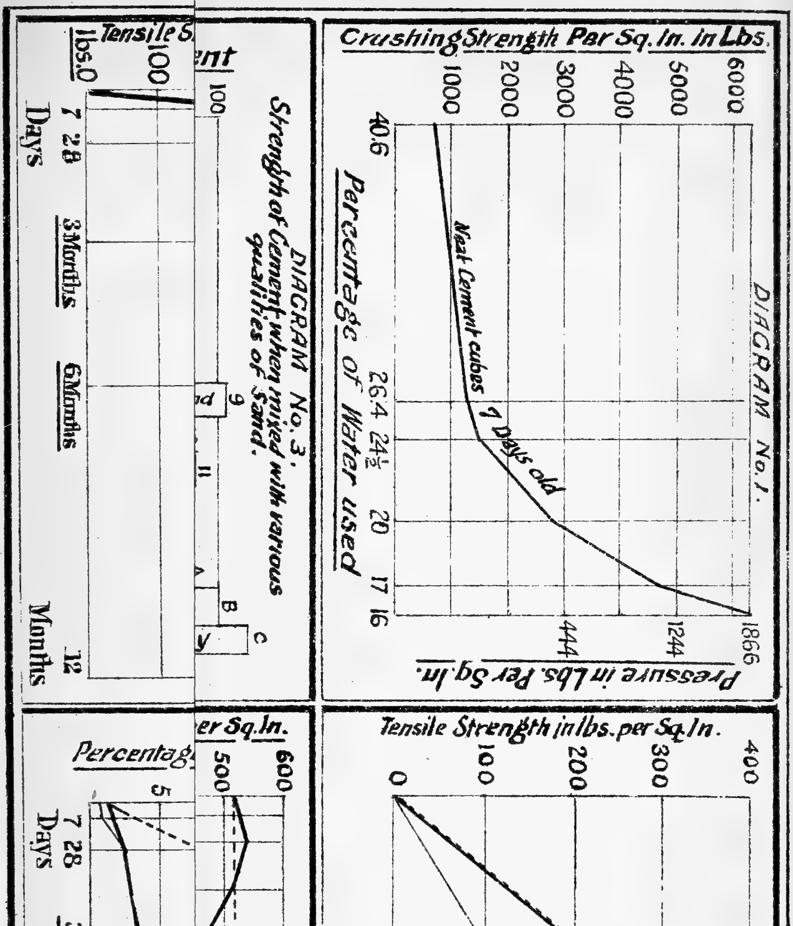


DIAGRAM No. 1.
Crushing Strength Per Sq. In. in Lbs.
1000
2000
3000
4000
5000
6000
Neat Cement cubes 7 Days old
40.6
26.4
24½
20
17
16
Percentage of Water used
444
1244
1866
Pressure in Lbs. Per Sq. In.
DIAGRAM No. 2.
Tensile Strength in lbs. per Sq. In.
0
100
200
300
400
1 Day
2 Days
3 Days
No. 1
No. 2
No. 3
DIAGRAM No. 3.
Strength of Cement when mixed with various qualities of Sand.
Tensile S
lbs. 0
100
Days
7
28
3 Months
6 Months
12
Months
DIAGRAM No. 4.
er Sq. In.
500
600
Percentag
5
28 Days in Cold water
Unhydrated
Hydrated and Kept in Water
Days
7
28
3 Months
6 Months
12
Months

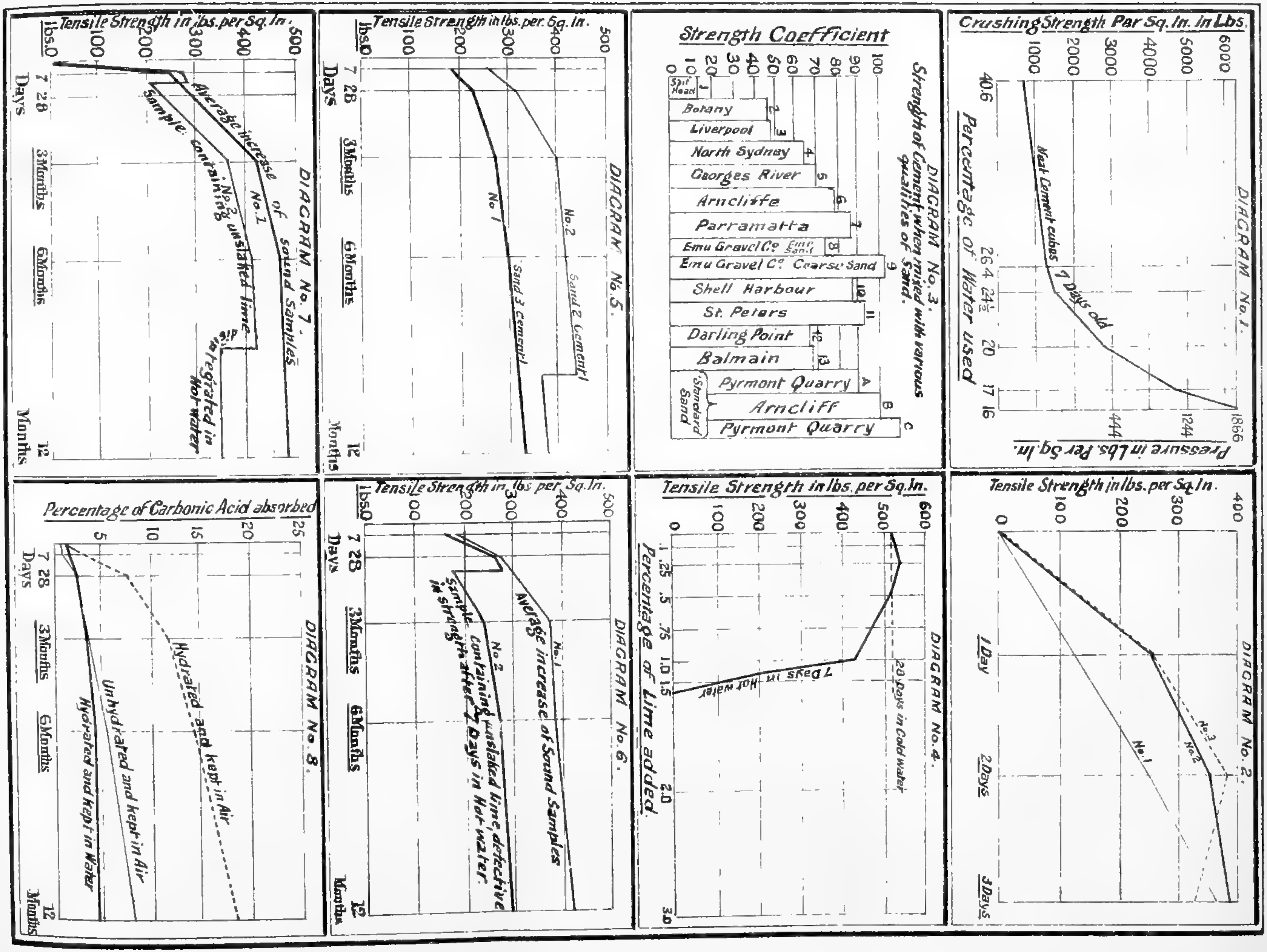
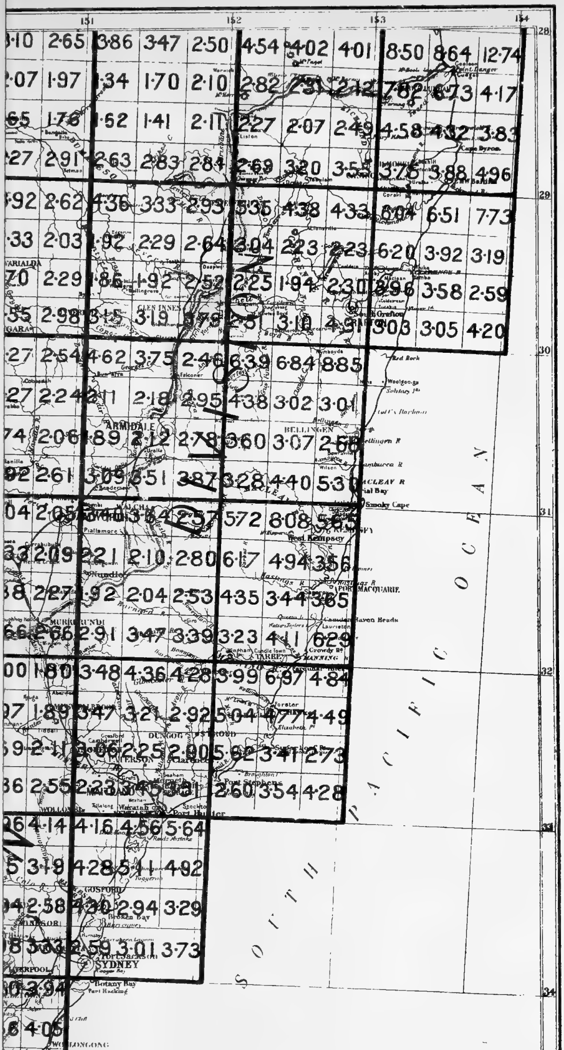


DIAGRAM No. 7.
Tensile Strength in lbs. per Sq. In.
Average increase of sound samples No. 1
Sample containing unslaked lime No. 2
disintegrated in Hot water
DIAGRAM No. 5.
Tensile Strength in lbs. per Sq. In.
Sand 3 Cement 1
Sand 2 Cement 1
DIAGRAM No. 3.
Strength of Cement when mixed with various qualities of Sand.
Strength Coefficient
Spit Head
Botany
Liverpool
North Sydney
Georges River
Arncliffe
Parramatta
Emu Gravel Co. Fine Sand
Emu Gravel Co. Coarse Sand
Shell Harbour
St. Peters
Darling Point
Balmain
Standard Sand
Pyrmont Quarry
Arncliff
Pyrmont Quarry
DIAGRAM No. 1.
Crushing Strength Per Sq. In. In Lbs.
Percentage of Water used
Neat Cement cubes 7 Days old
Pressure in Lbs. Per Sq. In.
DIAGRAM No. 8.
Percentage of Carbonic Acid absorbed
Hydrated and kept in Air
Unhydrated and kept in Air
Hydrated and kept in Water
DIAGRAM No. 6.
Tensile Strength in lbs. per Sq. In.
Average increase of Sound Samples No. 1
Sample containing unslaked lime, defective in strength after 7 Days in Hot water No. 2
DIAGRAM No. 4.
Tensile Strength in lbs. per Sq. In.
Percentage of Lime added.
7 Days in Hot water
28 Days in Cold water
DIAGRAM No. 2.
Tensile Strength in lbs. per Sq. In.
1 Day
2 Days
3 Days



MAP

OF

NEW SOUTH WALES

SHOWING AVERAGE MONTHLY RAINFALL FOR THE

YEARS PREVIOUS TO 1894.

Prepared in Sydney Observatory under the direction of H. C. Russell, Government Astronomer.

EXPLANATION.

In the upper left hand-corner the names of the months are given; this order is preserved throughout the map. Thus the average rainfall for the month of January in the square in which Cobar is found is 2·34 inches; February, 1·08 inches; March, 1·44 inches, and so on.

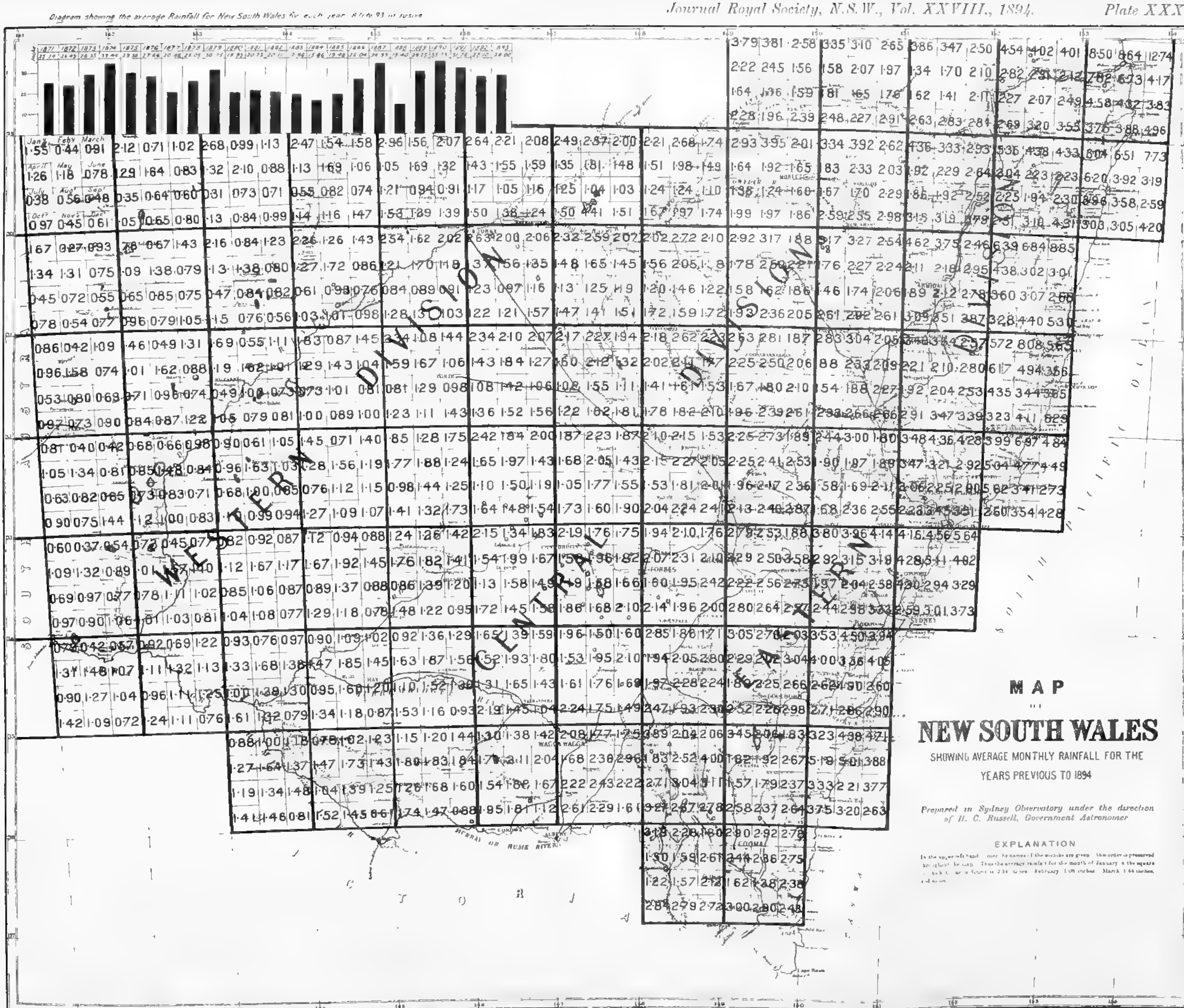
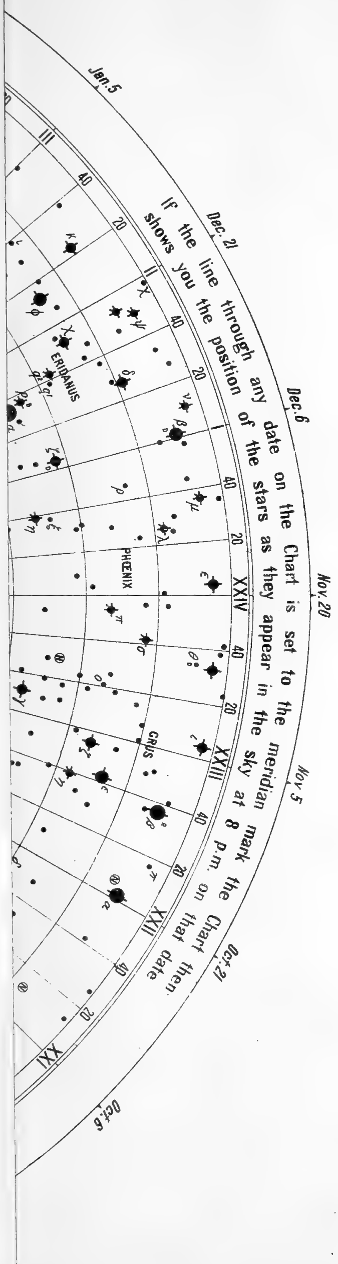


Diagram showing the average Rainfall for New South Wales for each year 1871 to 93 inclusive
WESTERN DIVISION
CENTRAL DIVISION
EASTERN DIVISION
MAP
OF
NEW SOUTH WALES
SHOWING AVERAGE MONTHLY RAINFALL FOR THE
YEARS PREVIOUS TO 1894
Prepared in Sydney Observatory under the direction
of H. C. Russell, Government Astronomer
EXPLANATION
FORBES
SYDNEY
WAGGA WAGGA
MURRAY OR HUME RIVER
COOMA
V I C T O R I A



Printed at the Department of Lands, Sydney, N.S.W. Jany 1895.
No of Lithograph 0.95-230

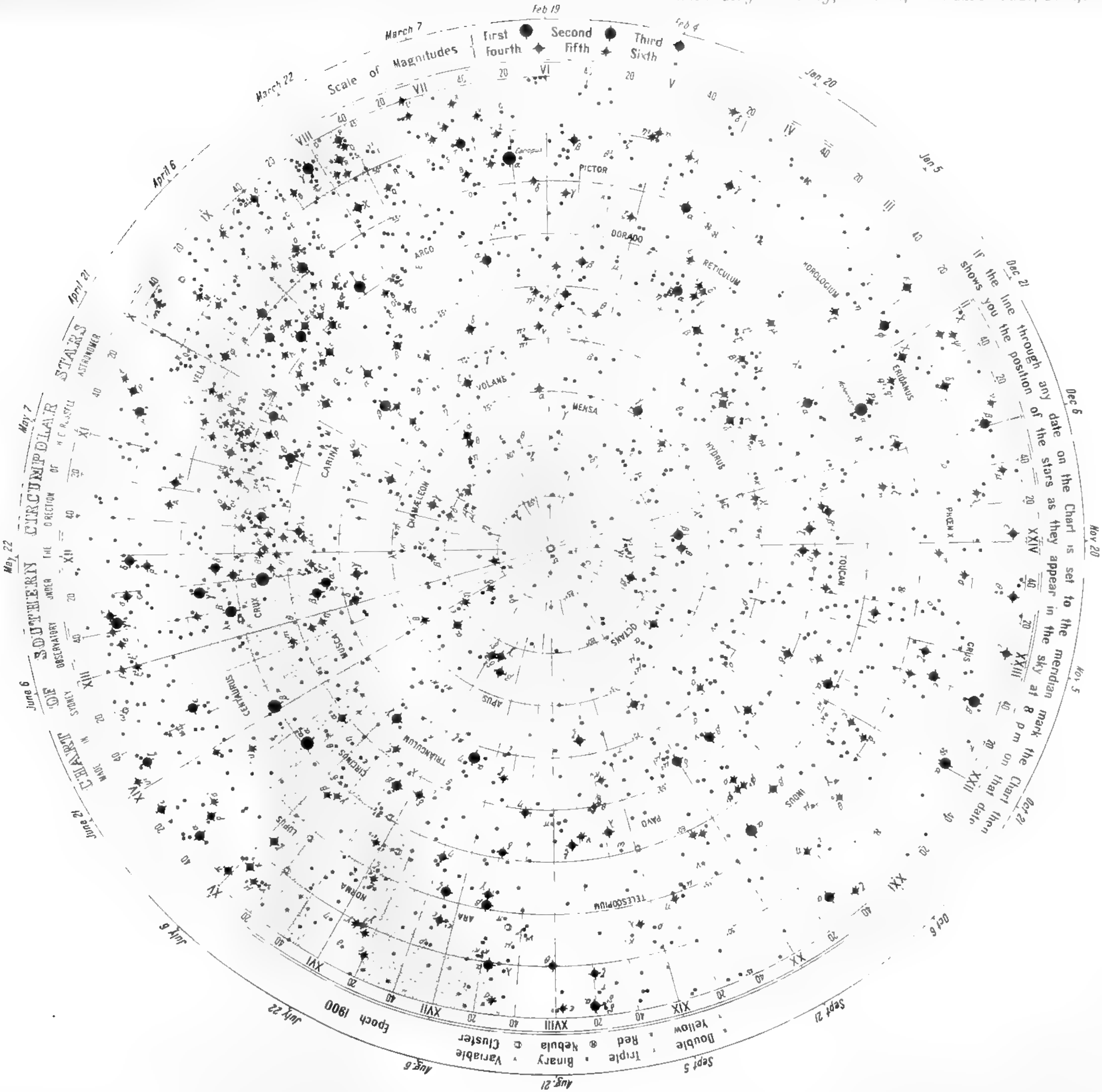


Chart of Southern Circumpolar Stars
made in Sydney Observatory under the direction of H. C. Russell Astronomer
Scale of Magnitudes
First Second Third
Fourth Fifth Sixth
If the line through any date on the Chart is set to the meridian mark the Chart then shows you the position of the stars as they appear in the sky at 8 p.m. on that date
Epoch 1900
Double Yellow
Triple Red
Binary Nebula
Variable Cluster
Feb 19
Feb 4
Jan 20
Jan 5
Dec 21
Dec 6
Nov 20
Nov 5
Oct 21
Oct 6
Sept 21
Sept 5
Aug 21
Aug 6
July 22
July 6
June 21
June 6
May 22
May 7
April 21
April 6
March 22
March 7
Canopus
Achernar
PICTOR
DORADO
RETICULUM
HOROLOGIUM
ERIDANUS
ARGO
VELA
CARINA
VOLANS
MENSA
HYDRUS
CHAMÆLEON
PHŒNIX
TOUCAN
OCTANS
GRUS
CRUX
MUSCA
CENTAURUS
APUS
TRIANGULUM
CIRCINUS
INDUS
PAVO
LUPUS
NORMA
ARA
TELESCOPIUM

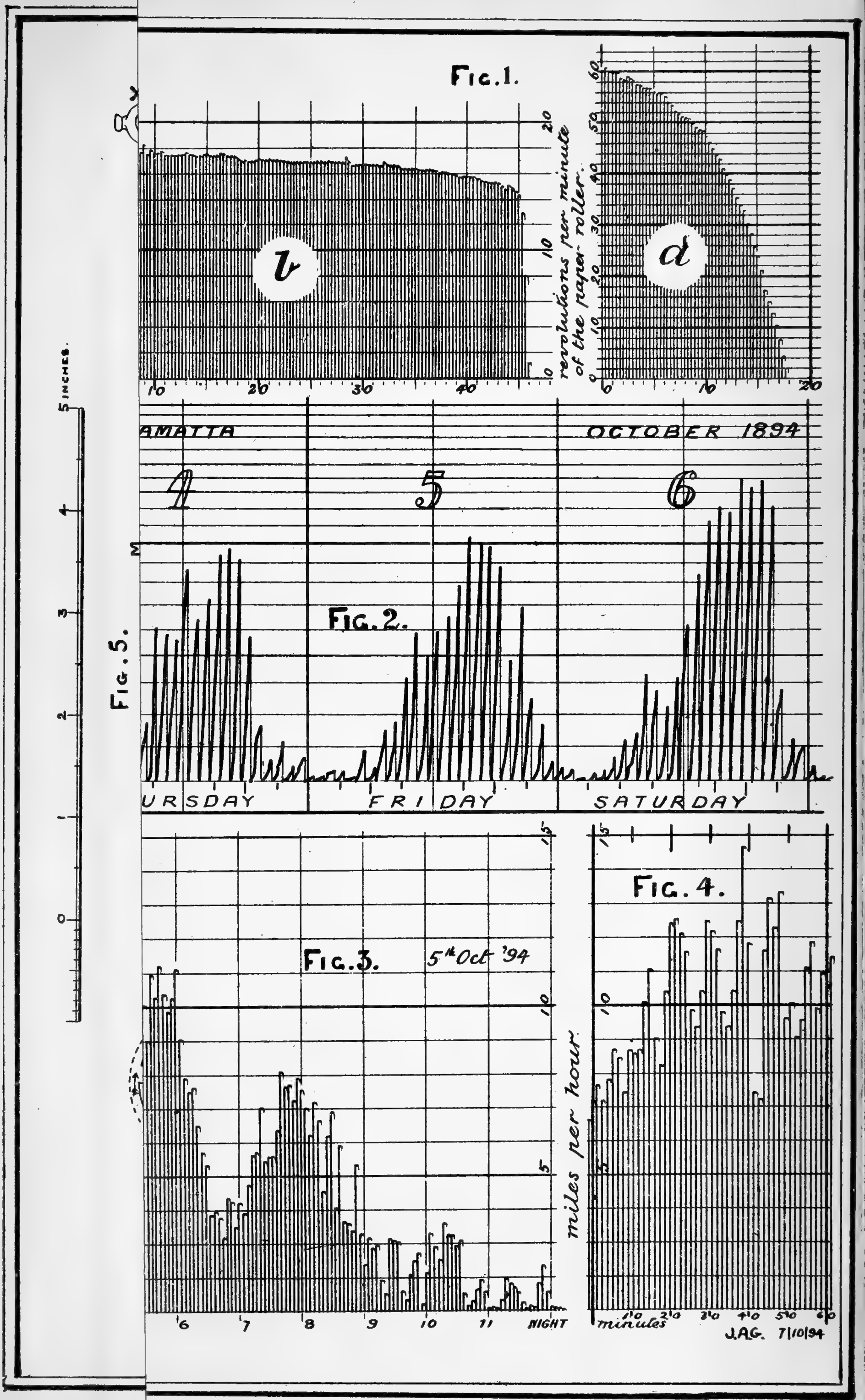


FIG. 1.
revolutions per minute of the paper roller.
b
d
AMATTA
OCTOBER 1894
4
5
6
FIG. 2.
URSDAY
FRIDAY
SATURDAY
FIG. 5.
5 INCHES.
FIG. 3.
5th Oct '94
NIGHT
miles per hour
FIG. 4.
minutes
J.A.G. 7/10/94

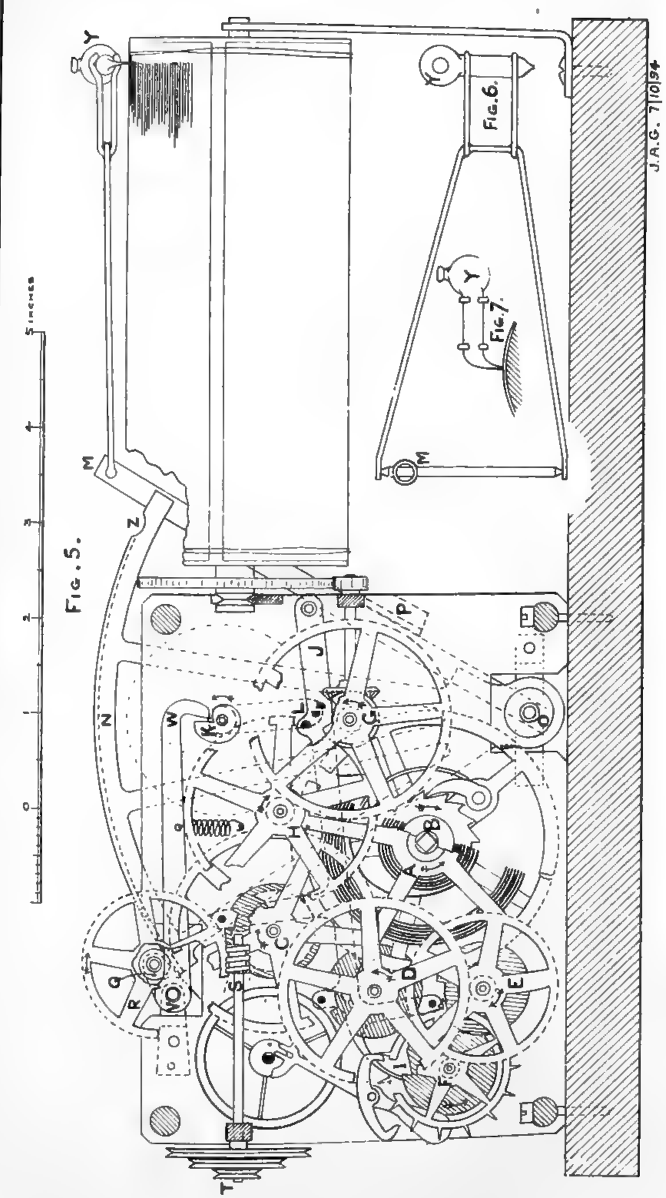


Fig. 5.
Fig. 6.
Fig. 7.
5 INCHES
J.A.G. 7/10/94

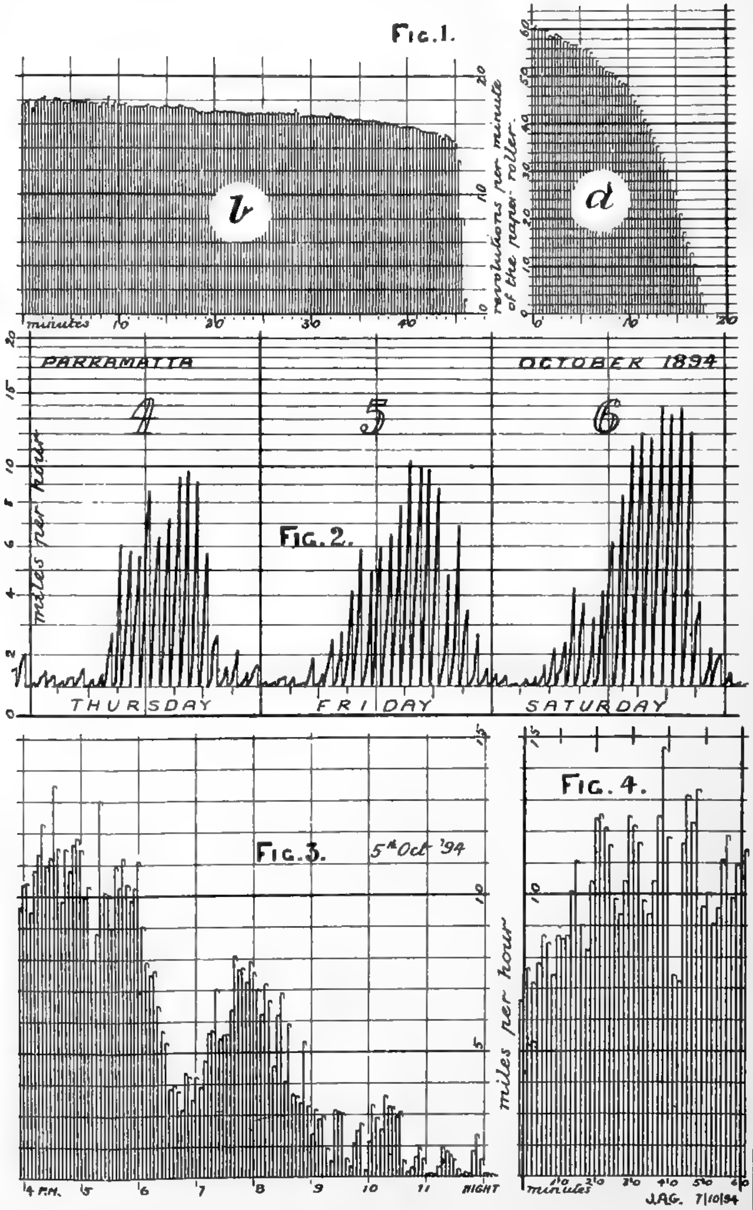
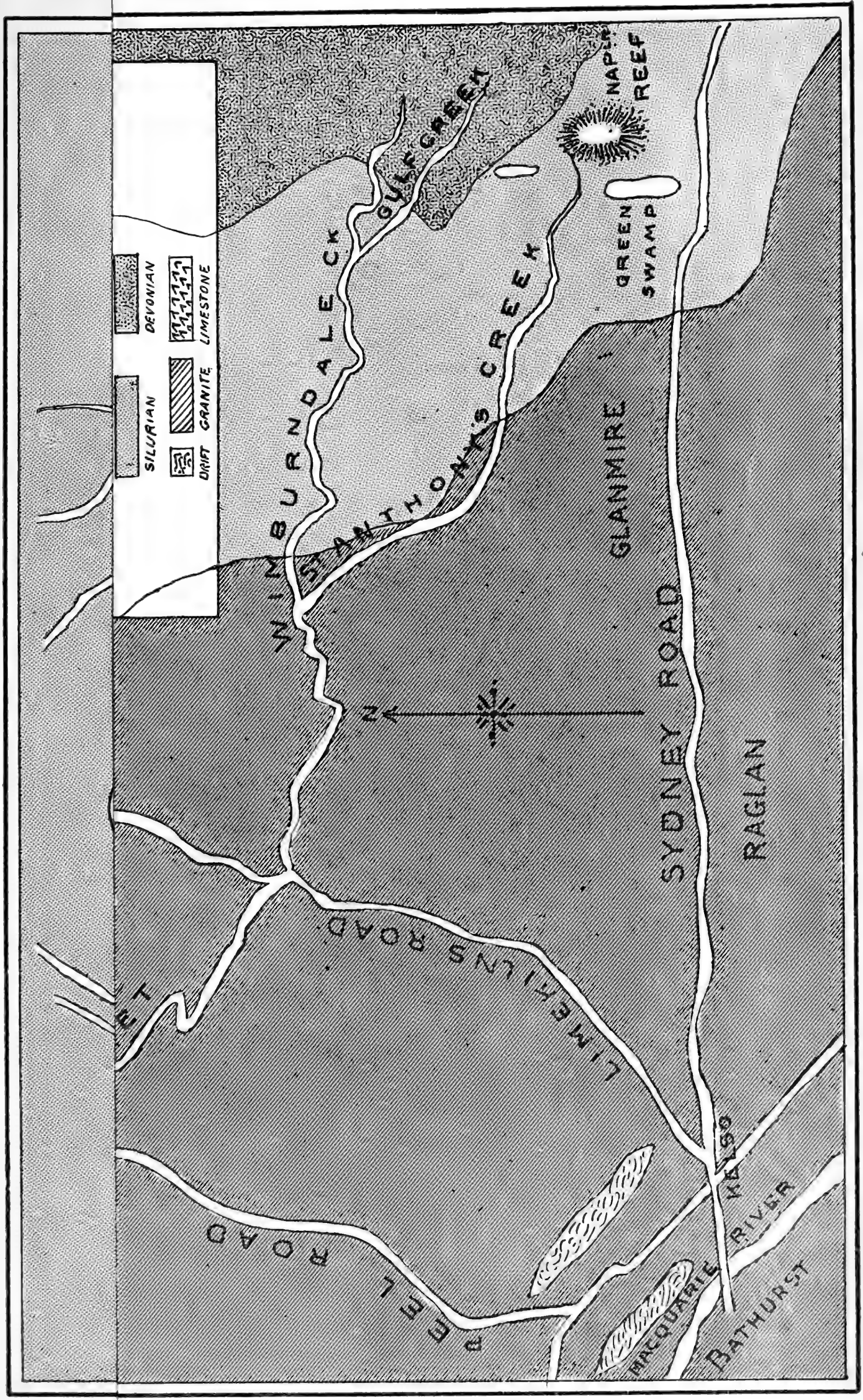
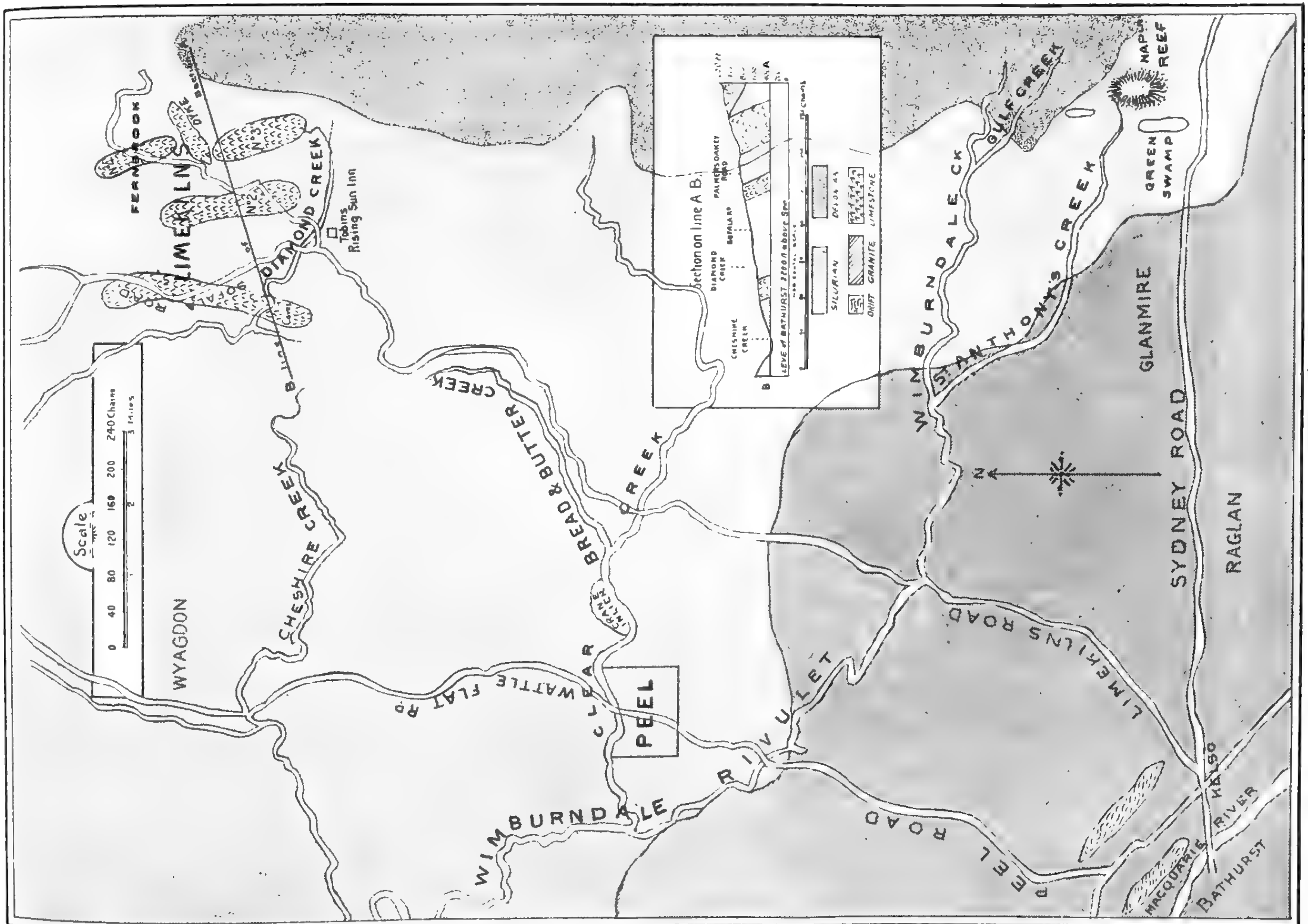
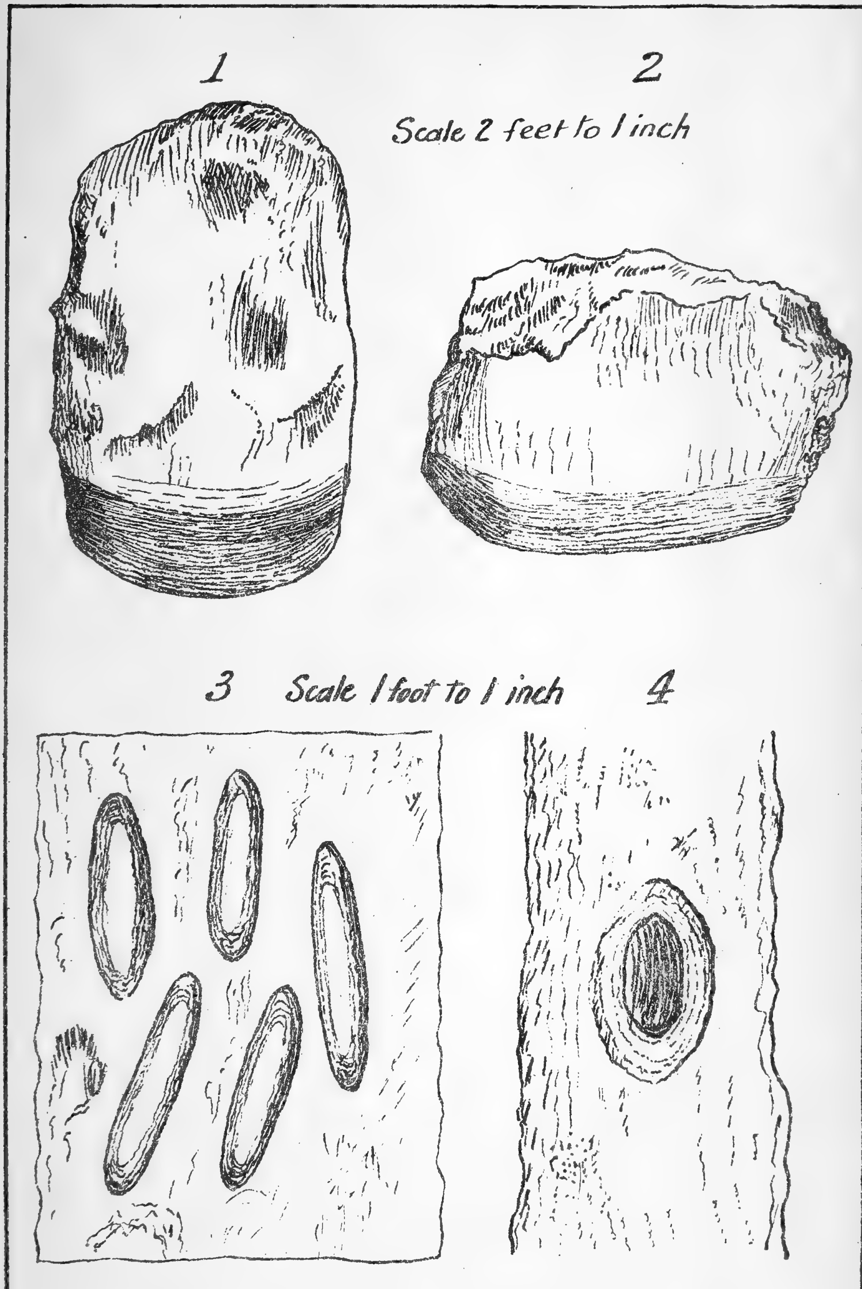
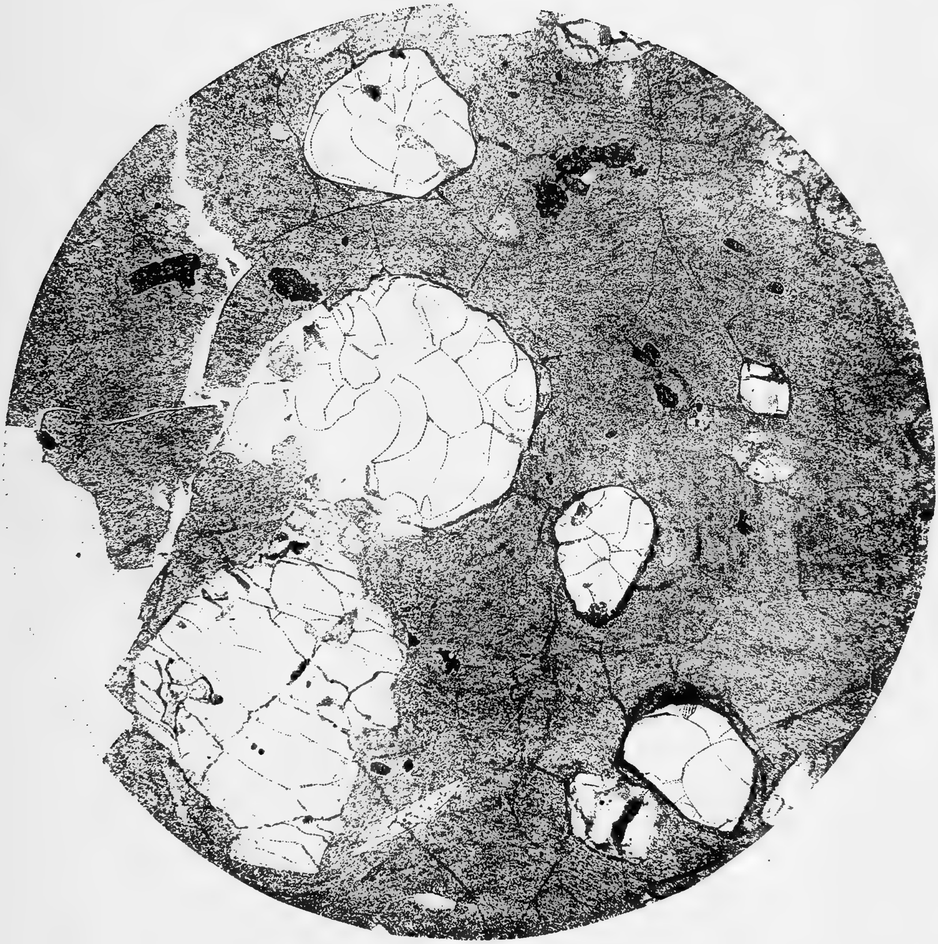


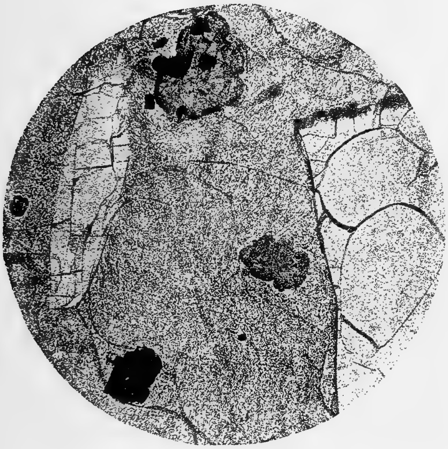
Fig. 1.
revolutions per minute of the paper roller.
minutes
b
a
PARRAMATTA
OCTOBER 1894
4
5
6
Fig. 2.
miles per hour
THURSDAY
FRIDAY
SATURDAY
Fig. 3.
5th Oct '94
4 P.M.
NIGHT
Fig. 4.
minutes
J.A.G. 7/10/94


SILURIAN
DEVONIAN
DRIFT
GRANITE
LIMESTONE
WIMBURNDALE CK
GULF CREEK
ST ANTHONY'S CREEK
NAPIER REEF
GREEN SWAMP
GLANMIRE
N
SYDNEY ROAD
RAGLAN
LIMEKILNS ROAD
KELSO
MACQUARIE RIVER
BATHURST


WYAGDON
CHESHIRE CREEK
BREAD & BUTTER CREEK
CLEAR
PEEL
WATTLE FLAT RD
WIMBURNDALE RIVULET
LIMEKILNS ROAD
PEEL ROAD
SYDNEY ROAD
RAGLAN
GLANMIRE
WIMBURNDALE CK
ST ANTHONYS CREEK
GULF CREEK
GREEN SWAMP
REEF
MACQUARIE RIVER
BATHURST
KELSO
DIAMOND CREEK
LIMEKILNS
FERNBROOK
Tobins Rising Sun Inn
Section on line A B.
SILURIAN
DEVONIAN
DRIFT
GRANITE
LIMESTONE
Scale
240 Chains
3 Miles


1
2
Scale 2 feet to 1 inch
3
Scale 1 foot to 1 inch
4
R. H. Mathews Delt.





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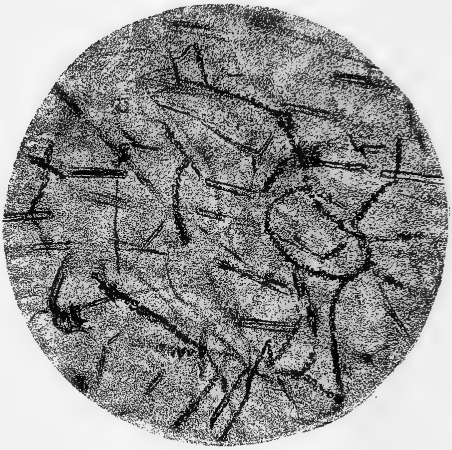

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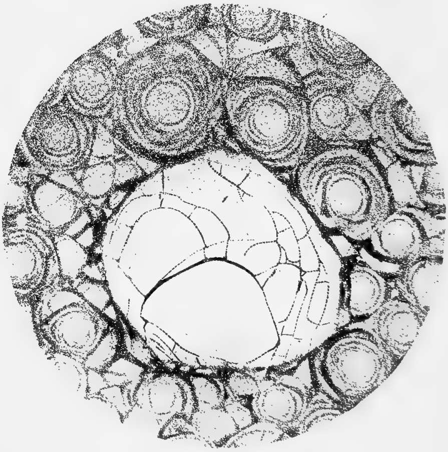

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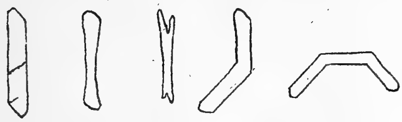


Fig. 1.

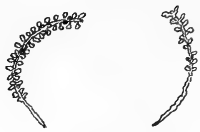
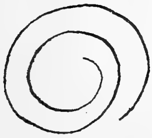


Fig. 2.



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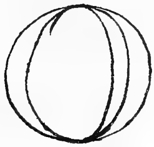

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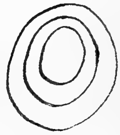

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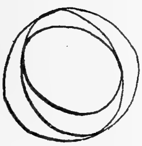

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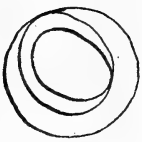

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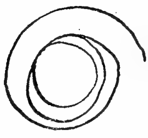

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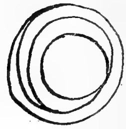

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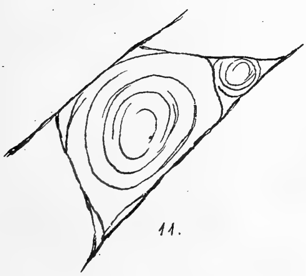

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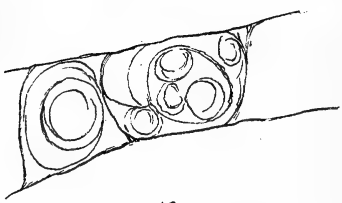

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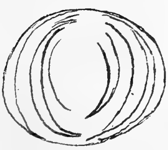

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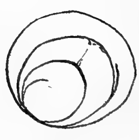

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