ROYAL SOCIETY OF NEW SOUTH WALES.

JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

1880.

VOL. XIV.

EDITED BY

fill in set.

A. LIVERSIDGE,

Professor of Chemistry and Mineralogy in the University of Sydney.

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

AGENTS FOR THE SOCIETY:

Messrs. Trübner & Co., 57, Ludgate Hill, London, E.C.

SYDNEY: THOMAS RICHARDS, GOVERNMENT PRINTER

1881.

NOTICE.

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

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NOTICE.

All Donations presented to the Society are acknowledged by letter, and in the printed Proceedings of the Society.

The Smithsonian Institute, Washington, U.S.A., and Messrs. Trübner & Co., 57, Ludgate Hill, London, have kindly undertaken to receive and forward parcels of books and printed matter intended for the Society.

Donations to the Building Fund.

Original List.

	£	s.	d.
Abbott, Thomas R.	3	0	0
Abbott, W. E.	1	1	0
Bartels, W. C. W.	5	0	0
Belfield, A. H.	3	3	0
Bensusan, S. L.	2	2	0
Bennett, G. F.	1	0	0
Bladen, Thomas	2	2	0
Bolding, H. I., P.M.	5	0	0
Bowen, G. M. C.	2	2	0
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Brazier, John, C.M.Z.S (two donations)	5	5	0
Brodribb, W. A., F.R.G.S.	10	10	0
Brown, Thomas	5	0	0
Burnell, Arthur	2	2	0
Campbell, Allan, L.R.C.P.	5	0	0
Campbell, The Hon. Alex., M.L.A.	20	0	0
Clarke, Rev. W. B., M.A., F.R.S., &c.	5	5	0
Christie, W.	5	5	0
Colyer, J. U. C.	2	2	0
Croudace, Thomas	3	0	0
De Salis, The Hon. L. F., M.L.C.	10	0	0
De Salis, L. W., jun.	10	0	0
Dight, A.	5	5	0
Dixon, W. A., F.C.S.	1	1	0
Docker, Ernest B., M.A.	3	3	0
Fairfax, J. R.	20	0	0
Fairfax, Edward	10	10	0
Flavelle, John	5	0	0
Flavelle Bros. and Roberts	5	0	0
Frazer, The Hon. John, M.L.C.	20	0	0
Gilliatt, H. A.	1	1	0
Graham, The Hon. W., M.L.C.	5	0	0
Griffiths, F. C.	5	0	0
Gurney, Professor, M.A.	10	0	0
Harrison, L. M.	10	0	0
Hay, The Hon. John, M.A., M.L.C.	20	0	0
Heron, Henry (two donations)	12	12	0
Henry, James	3	3	0
Holt, The Hon. Thos., M.L.C.	10	0	0
Horton, Rev. Thomas	2	0	0
Hume, J. K.	3	3	0
Hume, F.	5	5	0
Hunt, Robert, F.G.S.	5	5	0
Jones J. A., L.R.C.P.	1	1	0
Jones, P. Sydney, M.D., F.R.C.S.	10	10	0
Josephson, J. F., F.G.S., District Court Judge	20	0	0
Josephson, J. P.	3	3	0
Keep, J.	5	5	0
Keele, T. W.	3	3	0
Kinloch, J., M.A.	2	2	0

	£	s.	d.
Knox, Edward S.	20	0	0
Leibius, Adolph, Ph.D.	5	5	0
Lenehan, H. A.	2	2	0
Liversidge, Archibald, F.C.S., F.G.S., &c.	10	0	0
MacDonnell, William	5	0	0
MacKenzie, John, F.G.S.	5	0	0
Manning, Frederick N., M.D.	5	5	0
Martin, Rev. George	2	2	0
Merriman, James	5	5	0
Moir, James	3	3	0
Moore, Charles, F.L.S.	5	0	0
Morehead, R. A. A.	10	0	0
Mullens, Josiah, F.R.G.S....	10	0	0
Murray, W. G.	5	0	0
Myles, C. H.	2	2	0
Norton, J.	5	0	0
O'Reilly, W. W. J., M.D.	1	1	0
Paterson, Hugh	2	2	0
Rolleston, Christopher, C.M.G.	10	0	0
Russell, H. C., B.A., F.R.A.S., &c.	10	0	0
Scott, Rev. William, M.A.	5	0	0
Sharp, James B., J.P.	5	5	0
Sleep, J. S.	1	1	0
Smith, The Hon. J., C.M.G., M.D., LL.D.	5	0	0
Smith, Robert, B.A.	10	10	0
Suttor, W. H., J.P.	7	10	0
Tayler, W. G., F.R.C.S.	1	0	0
Tebbutt, John, F.R.A.S.	10	0	0
Thomas, H. A.	3	0	0
Toohey, J. T.	10	0	0
Trouton, F. H.	3	3	0
Tucker, G. A., Ph.D.	10	10	0
Voss, Houlton H.	10	10	0
Ward, J. W. (four donations)	9	4	0
Waterhouse, J., M.A.	2	2	0
Watt, A. J. (two donations)	6	6	0
Walker, Thomas, "Yaralla"	500	0	0
Webster, A. S.	10	0	0
Wilkinson, C. S., F.G.S.	5	5	0
Woolrych, F. B. W.	3	3	0
Wright, H. G. A., M.R.C.S.E.	5	5	0
	£1,064	14	0

1880.

	£	s.	d.
Bassett, W. F., M.R.C.S.	1	1	0
Berney, Augustus	1	18	0
Brodribb, W. A. (total donation, £12 10s.)	2	0	0
Brooks, Joseph	2	2	0
Cameron, John	2	2	0
Chard, J. S.	2	2	0
Codrington, J. F., M.R.C.S.	1	1	0
Collie, Rev. Robert...	2	2	0
Conder, W. J.	5	5	0
Cox, G. H.	5	5	0

	£	s.	d.
Daintrey, E. ...	5	5	0
Darley, C. W.	3	3	0
Dixson, Dr. Craig ...	1	1	0
Dixson, Dr. Thomas	1	1	0
Dixon, W. A. (total donation, £4 4s.) ...	3	3	0
Du Faur, E. ...	1	1	0
Evans, George	3	3	0
Fraser, Robert	2	2	0
Haege, Hermann ...	5	5	0
Heron, Henry (total donation, £17 12s.)	5	0	0
Hume, J. K. (total donation, £5 5s.) ...	2	2	0
Hunt, Robert (total donation, £6 6s.) ...	1	1	0
Inglis, James	1	1	0
Josephson, J. P. (total donation, £4 4s.)	1	1	0
Latta, G. J. ...	1	1	0
Leibius, Dr. ...	1	1	0
Liversidge, Professor	1	1	0
MacPherson, Rev. P., M.A.	2	2	0
Markey, James, M.R.C.S.	1	1	0
Marsden, Right Rev. Dr. ...	1	1	0
Moore, Chas., F.L.S.	1	1	0
Morehead, R. A. A. (total donation, £15)	5	0	0
Mullins, J. F. L. ...	3	3	0
Parrott, T. S.	1	1	0
Pittman, Edward F.	1	1	0
Poolman, F. ...	5	5	0
Quaife, Dr. ...	3	3	0
Quirk, Rev. D. Placid ...	1	1	0
Roberts, John	5	0	0
Russell, H. C., B.A. (total donation, £13 3s.) ...	3	3	0
Watt, Charles	2	2	0
Welch, E. W.	1	1	0
Weston, W. J.	2	2	0
Wilkinson, C. S., F.G.S. ...	1	1	0
Wilshire, J. F.	1	1	0
Woolrych, F. B. W. (total donation, £5 5s.) ...	2	2	0
Wright, H. G. A., M.R.C.S. ...	1	1	0
Young, L. H. G. ...	1	1	0
	£108	3	0

1881.

	£	s.	d.
Dixon, W. A. (total donation, £5 5s.) ...	1	1	0
E. Ross Fairfax (total donation, £21) ...	10	10	0
Griffiths, F. C. ...	5	5	0
Hirst, G. D. ...	1	1	0
Hunt, Robert (total donation, £7 7s.) ...	1	1	0
Leibius, Dr. (total donation, £7 7s.) ...	1	1	0
Liversidge, Professor (total donation, £12 2s.) ...	1	1	0
Moore, Charles (total donation, £7 2s.) ...	1	1	0
Smith, The Hon. J., C.M.G., M.D. (total donation, £6 10s.)	1	1	0
Wilkinson, C. S. (total donation, £7 7s.) ...	1	1	0
Wright, H. G. A., M.R.C.S.E. (total donation, £7 7s.)...	1	1	0
	£25	4	0

Annual Subscriptions promised.

	£	s.	d.
Dixon, W. A., F.C.S.	1	1	0
Hirst, G. D.	1	1	0
Hunt, Robert, F.G.S.	1	1	0
Leibius, Dr.	1	1	0
Liversidge, Professor	1	1	0
Moore, Charles, F.L.S.	1	1	0
Russell, H. C., B.A.	1	1	0
Smith, The Hon. J., C.M.G., M.D., LL.D.	1	1	0
Wilkinson, C. S., F.G.S.	1	1	0
Wright, H. G. A., M.R.C.S.E.	1	1	0

The Royal Society of New South Wales.

OFFICERS FOR 1880-81.

HONORARY PRESIDENT:

HIS EXCELLENCY THE RT. HON. LORD AUGUSTUS LOFTUS,
G.C.B., &c., &c., &c.

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HON. J. SMITH, C.M.G., M.L.C., M.D., LL.D., &c.

VICE-PRESIDENTS:

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H. C. RUSSELL, B.A., F.R.A.S., F.M.S., &c.

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DR. ADOLPH LEIBIUS.

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HIRST, G. D.
HUNT, ROBERT, F.G.S.
MONTEFIORE, E. L.
ROLLESTON, C., C.M.G.
WILKINSON, C. S., F.G.S.

ASSISTANT SECRETARY:

W. H. WEBB.

INDEX TO RULES.

RULES.

(*Revised October 1st,* 1879.)

Object of the Society.

I. The object of the Society is to receive at its stated meetings original papers on Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

Honorary President.

II. The Governor of New South Wales shall be *ex officio* Honorary President of the Society.

Other Officers.

III. The other Officers of the Society shall consist of a President, who shall hold office for one year only, but shall be eligible for re-election after the lapse of one year; two Vice-Presidents, a Treasurer, and one or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers and Council.

IV. The President, Vice-Presidents, Secretaries, Treasurer, and the six other Members of Council, shall be elected annually by ballot at the General Meeting in the month of May.

V. It shall be the duty of the Council each year to prepare a list containing the names of members whom they recommend for election to the respective offices of President, Vice-Presidents, Hon. Secretaries and Hon. Treasurer, together with the names of six other members whom they recommend for election as ordinary members of Council.

The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting.

Such list shall be suspended in the Society's Rooms, and a copy shall be sent to each ordinary member not less than fourteen days before the day appointed for the Annual General Meeting.

VI. Each member present at the Annual General Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible members not already included in it and removing from it an equivalent number of names, and he shall use this list with or without such alterations as a balloting list at the election of Officers and Council.

The name of each member voting shall be entered into a book, kept for that purpose, by two Scrutineers elected by the members present.

No ballot for the election of Members of Council, or of New Members, shall be valid unless twenty members at least shall record their votes.

Vacancies during the year.

VII. Any vacancies occurring in the Council of Management during the year may be filled up by the Council.

Candidates for admission.

VIII. Candidates must be at least twenty-one years of age.

Every candidate for admission as an ordinary member of the Society shall be recommended according to a prescribed form of certificate by not less than three members, to two of whom the candidate must be personally known.

Such certificate must set forth the names, place of residence, and qualifications of the candidate.

The certificate shall be read at the three Ordinary General Meetings of the Society next ensuing after its receipt, and during the intervals between those three meetings, it shall be suspended in a conspicuous place in one of the rooms of the Society.

The vote as to admission shall take place by ballot, at the Ordinary General Meeting at which the certificate is appointed to be read the third time, and immediately after such reading.

At the ballot the assent of at least four-fifths of the members voting shall be requisite for the admission of the candidate.

Fees.

IX. The entrance money paid by members on their admission shall be Two Guineas; and the annual subscription shall be Two Guineas, payable in advance; but members elected prior to December, 1879, shall be required to pay an annual subscription of One Guinea only as heretofore.

The amount of ten annual payments may be paid at any time as a life composition for the ordinary annual payment.

New Members to be informed of their election.

X. Every new member shall receive due notification of his election, and be supplied with a copy of the obligation (No. 3 in Appendix), together with a copy of the Rules of the Society, a list of members, and a card of the dates of meeting.

Members shall sign Rules—Formal admission.

XI. Every member who has complied with the preceding Rules shall at the first Ordinary General Meeting at which he shall be present sign a duplicate of the aforesaid obligation in a book to be kept for that purpose, after which he shall be presented by some member to the Chairman, who, addressing him by name, shall say :—"In the name of the Royal Society of New South Wales I admit you a member thereof."

Annual subscriptions, when due.

XII. Annual subscriptions shall become due on the 1st of May for the year then commencing. The entrance fee and first year's subscription of a new member shall become due on the day of his election.

Members whose subscriptions are unpaid to enjoy no privileges.

XIII. An elected member shall not be entitled to attend the meetings or to enjoy any privilege of the Society, nor shall his name be printed in the list of the Society, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligation signed by himself.

Subscriptions in arrears.

XIV. Members who have not paid their subscriptions for the current year, on or before the 31st of May, shall be informed of the fact by the Hon. Treasurer.

No member shall be entitled to vote or hold office while his subscription for the previous year remains unpaid.

The name of any member who shall be two years in arrears with his subscriptions shall be erased from the list of members, but such member may be re-admitted on giving a satisfactory explanation to the Council, and on payment of arrears.

At the meeting held in July, and at all subsequent meetings for the year, a list of the names of all those members who are in arrears with their annual subscriptions shall be suspended in the Rooms of the Society. Members shall in such cases be informed that their names have been thus posted.

Resignation of Members.

XV. Members who wish to resign their membership of the Society are requested to give notice in writing to the Honorary Secretaries, and are required to return all books or other property belonging to the Society.

Expulsion of Members.

XVI. A majority of members present at any ordinary meeting shall have power to expel an obnoxious member from the Society, provided that a resolution to that effect has been moved and seconded at the previous ordinary meeting, and that due notice of the same has been sent in writing to the member in question, within a week after the meeting at which such resolution has been brought forward.

Honorary Members.

XVII. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, and distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions: they may attend the meetings of the Society, and they shall be furnished with copies of the publications of the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

The number of Honorary Members shall not at any one time exceed twenty, and not more than two Honorary Members shall be elected in any one year.

Corresponding Members.

XVIII. Corresponding Members shall be persons, not resident in New South Wales, of eminent scientific attainments, who may have furnished papers or otherwise promoted the objects of the Society.

Corresponding Members shall be recommended by the Council, and be balloted for in the same manner as ordinary Members.

Corresponding Members shall possess the same privileges only as Honorary Members.

The number of Corresponding Members shall not exceed twenty-five, and not more than three shall be elected in any one year.

Ordinary General Meetings.

XIX. An Ordinary General Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m., on the first Wednesday in every month, during the last eight months of the year; subject to alteration by the Council with due notice.

Order of Business.

XX. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise:—

1—Minutes of the preceding Meeting.
2—New Members to enrol their names and be introduced.
3—Ballot for the election of new Members.
4—Candidates for membership to be proposed.
5—Business arising out of Minutes.
6—Communications from the Council.
7—Communications from the Sections.
8—Donations to be laid on the Table and acknowledged.
9—Correspondence to be read.
10—Motions from last Meeting.
11—Notices of Motion for the next Meeting to be given in.
12—Papers to be read.
13—Discussion.
14—Notice of Papers for the next Meeting.

Annual General Meeting.—Annual Reports.

XXI. A General Meeting of the Society shall be held annually in May, to receive a Report from the Council on the state of the Society, and to elect Officers for the ensuing year. The Treasurer shall also at this meeting present the annual financial statement.

Admission of Visitors.

XXII. Every ordinary member shall have the privilege of introducing two friends as visitors to an Ordinary General Meeting of the Society or its Sections, on the following conditions:—

1. That the name and residence of the visitors, together with the name of the member introducing them, be entered in a book at the time.
2. That they shall not have attended two consecutive meetings of the Society or of any of its Sections in the current year.

The Council shall have power to introduce visitors, irrespective of the above restrictions.

Council Meetings.

XXIII. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Absence from Meetings of Council.—Quorum.

XXIV. Any member of the Council absenting himself from three consecutive meetings of the Council, without giving a satisfactory explanation in writing, shall be considered to have vacated his office. No business shall be transacted at any meeting of the Council unless three members at least are present.

Duties of Secretaries.

XXV. The Honorary Secretaries shall perform, or shall cause the Assistant Secretary to perform, the following duties:—

1. Conduct the correspondence of the Society and Council.
2. Attend the General Meetings of the Society and the meetings of the Council, to take minutes of the proceedings of such meetings, and at the commencement of such to read aloud the minutes of the preceding meeting.
3. At the Ordinary Meetings of the members, to announce the presents made to the Society since their last meeting; to read the certificates of candidates for admission to the Society, and such original papers communicated to the Society as are not read by their respective authors, and the letters addressed to it.
4. To make abstracts of the papers read at the Ordinary General Meetings, to be inserted in the Minutes and printed in the Proceedings.
5. To edit the Transactions of the Society, and to superintend the making of an Index for the same.
6. To be responsible for the arrangement and safe custody of the books, maps, plans, specimens, and other property of the Society.

7. To make an entry of all books, maps, plans, pamphlets, &c., in the Library Catalogue, and of all presentations to the Society in the Donation Book.

8. To keep an account of the issue and return of books, &c., borrowed by members of the Society, and to see that the borrower, in every case, signs for the same in the Library Book.

9. To address to every person elected into the Society a printed copy of the Forms Nos. 2 and 3 (in the Appendix), together with a list of the members, a copy of the Rules, and a card of the dates of meeting; and to acknowledge all donations made to the Society, by Form No. 6.

10. To cause due notice to be given of all Meetings of the Society and Council.

11. To be in attendance at 4 p.m. on the afternoon of Wednesday in each week during the session.

12. To keep a list of the attendances of the members of the Council at the Council Meetings and at the ordinary General Meetings, in order that the same may be laid before the Society at the Annual General Meeting held in the month of May.

The Honorary Secretaries shall, by mutual agreement, divide the performance of the duties above enumerated.

The Honorary Secretaries shall, by virtue of their office, be members of all Committees appointed by the Council.

Contributions to the Society.

XXVI. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the Council of Management. It will be the duty of the Council to arrange for promulgation and discussion at an Ordinary Meeting such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Management of Funds.

XXVII. The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

All cheques shall be countersigned by a member of the Council.

Money Grants.

XXVIII. Grants of money in aid of scientific purposes from the funds of the Society—to Sections or to members—shall expire on the 1st of November in each year. Such grants, if not expended, may be re-voted.

XXIX. Such grants of money to Committees and individual members shall not be used to defray any personal expenses which a member may incur.

Audit of Accounts.

XXX. Tw Auditors shall be appointed annually, at an Ordinary Meeting, to audit the Treasurer's Accounts. The accounts as audited to be laid before the Annual Meeting in May.

Property of the Society to be vested in the President, &c.

XXXI. All property whatever belonging to the Society shall be vested in the President, Vice-Presidents, Hon. Treasurer, and Hon. Secretaries for the time being, in trust for the use of the Society; but the Council shall have control over the disbursements of the funds and the management of the property of the Society.

SECTIONS.

XXXII. To allow those members of the Society who devote attention to particular branches of science fuller opportunities and facilities of meeting and working together with fewer formal restrictions than are necessary at the general Monthly Meetings of the Society,—Sections or Committees may be established in the following branches of science:—

Section A.—Astronomy, Meteorology, Physics, Mathematics, and Mechanics.

Section B.—Chemistry and Mineralogy, and their application to the Arts and Agriculture.

Section C.—Geology and Palæontology.

Section D.—Biology, *i.e.*, Botany and Zoology, including Entomology

Section E.—Microscopical Science.

Section F.—Geography and Ethnology.

Section G.—Literature and the Fine Arts, including Architecture.

Section H.—Medical.

Section I.—Sanitary and Social Science and Statistics.

Section Committees—Card of Meetings.

XXXIII. The first meeting of each Section shall be appointed by the Council. At that meeting the members shall elect their own Chairman, Secretary, and a Committee of four; and arrange the days and hours of their future meetings. A card showing the dates of each meeting for the current year shall be printed for distribution amongst the members of the Society.

Membership of Sections.

XXXIV. Only members of the Society shall have the privilege of joining any of the Sections.

Reports from Sections.

XXXV. There shall be for each Section a Chairman to preside at the meetings, and a Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to the Hon. Secretaries of the Society, on or before the 7th of December in each year, a report of the proceedings of the Section during that year, in order that the same may be transmitted to the Council.

Reports.

XXXVI. It shall be the duty of the President, Vice-Presidents, and Honorary Secretaries to annually examine into and report to the Council upon the state of—

1. The Society's house and effects.
2. The keeping of the official books and correspondence.
3. The library, including maps and drawings.
4. The Society's cabinets and collections.

Cabinets and Collections.

XXXVII. The keepers of the Society's cabinets and collections shall give a list of the contents, and report upon the condition of the same to the Council annually.

Documents.

XXXVIII. The Honorary Secretaries and Honorary Treasurer shall see that all documents relating to the Society's property, the obligations given by members, the policies of insurance, and other securities shall be lodged in the Society's iron chest, the contents of which shall be inspected by the Council once in every year; a list of such contents shall be kept, and such list shall be signed by the President or one of the Vice-Presidents at the annual inspection.

Branch Societies.

XXXIX. The Society shall have power to form Branch Societies in other parts of the Colony.

Library.

XL. The members of the Society shall have access to, and shall be entitled to borrow books from the Library, under such regulations as the Council may think necessary.

Alteration of Rules.

XLI. No alteration of, or addition to, the Rules of the Society shall be made unless carried at two successive General Meetings, at each of which, twenty-five members at least must be present.

THE LIBRARY.

1. During the Session, the Library shall be open for consultation and for the issue and return of books between 4 and 6 p.m. on the afternoon of each Wednesday, and between 7 and 10 p.m. on the evenings of Monday, Wednesday, and Friday, and during the recess (January to end of April) on Wednesdays, from 4 to 6 and 7 to 10 p.m.

2. No book shall be issued without being signed for in the Library Book.

3. Members are not allowed to have more than two volumes at a time from the Library, without special permission from one of the Honorary Secretaries, nor to retain a book for a longer period than fourteen days; but when a book is returned by a member it may be borrowed by him again, provided it has not been bespoken by any other member. Books which have been bespoken shall circulate in rotation, according to priority of application.

4. Scientific Periodicals and Journals will not be lent until the volumes are completed and bound.

5. Members retaining books longer than the time specified shall be subject to a fine of sixpence per week for each volume.

6. The books which have been issued shall be called in by the Secretaries twice a year; and in the event of any book not being returned on those occasions, the member to whom it was issued shall be answerable for it, and shall be required to defray the cost of replacing the same.

Form No. 1.

ROYAL SOCIETY OF NEW SOUTH WALES.

Certificate of a Candidate for Election.

Name

Qualification or occupation

Address

being desirous of admission into the Royal Society of New South Wales, we, the undersigned members of the Society, propose and recommend him as a proper person to become a member thereof.

Dated this day of 18 .

FROM PERSONAL KNOWLEDGE.	FROM GENERAL KNOWLEDGE.

Signature of candidate

Date received 18 .

*** This certificate must be signed by at least three members, to two of whom the candidate must be personally known.

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,

Sir, Sydney, 18 .

I have the honour to inform you that you have this day been elected a member of the Royal Society of New South Wales, and I beg to forward to you a copy of the Rules of the Society, a printed copy of an obligation, a list of members, and a card announcing the dates of meeting during the present session.

According to the Regulations of the Society (*vide* Rule No. 9), you are required to pay your admission fee of two guineas, and annual subscription of two guineas for the current year, before admission. You are also requested to sign and return the enclosed form of obligation at your earliest convenience.

I have, &c.,

To

Hon. Secretary.

Form No. 3.

ROYAL SOCIETY OF NEW SOUTH WALES.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of New South Wales, and to observe its Rules and By-laws, as long as I shall remain a member thereof.

Signed,

Address

Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,

Sir, Sydney, 18 .

I have the honour to inform you that your annual subscription of for the current year became due to the Royal Society of New South Wales on the 1st of May last.

It is requested that payment may be made by cheque or Post Office order drawn in favour of the Hon. Treasurer.

I have, &c.,

To Hon. Treasurer.

Form No. 5.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,

Sir, Sydney, 18 .

I am desired by the Royal Society of New South Wales to forward to you a copy of its Journal for the year 18 , as a donation to the library of your Society.

I am further requested to mention that the Society will be thankful to receive such of the very valuable publications issued by your Society as it may feel disposed to send.

I have the honour to be,
Sir,
Your most obedient servant,

Hon. Secretary.

Form No. 6.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,

Sir, Sydney, 18 .

On behalf of the Royal Society of New South Wales, I beg to acknowledge the receipt of and I am directed to convey to you the best thanks of the Society for your most valuable donation.

I have the honour to be,
Sir,
Your most obedient servant,

Hon. Secretary.

Form No. 7.

Balloting List for the Election of the Officers and Council.

ROYAL SOCIETY OF NEW SOUTH WALES.

Date..................

BALLOTING LIST for the election of the Officers and Council.

Present Council.	Names proposed as Members of the new Council.	
	President.	
	Vice-Presidents.	
	Hon. Treasurer.	
	Hon. Secretaries.	
	Members of Council.	

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address.

Name ....

....

Titles, &c. ....

....

Address ....

....

....

Date ....

To the

Hon. Secretaries,

The Royal Society of N. S. W.,

37, Elizabeth-st., Sydney.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

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

Elected.		
1877		Abbott, Joseph Palmer, Wentworth Court, Elizabeth-street.
1877	P 1	Abbott, Thomas Kingsmill, P.M., Gunnedah.
1877	P 1	Abbott, W. E., Glengarry, Wingen.
1877		Adams, Francis, A.J.S. Bank, Sydney.
1864		Adams, P. F., Surveyor General, Kirribilli Point, St. Leonards.
1878		Alexander, George M., 48, Margaret-street.
1874		Alger, John, Macquarie-street.
1870		Allen, The Hon. Sir George Wigram, M.P., Speaker of the Legislative Assembly, 124, Elizabeth-street North.
1868		Allerding, F., Hunter-street.
1873		Allerding, H. R., Hunter-street.
1856		Allwood, Rev. Canon, B.A. *Cantab.*, Vice-Chancellor, University of Sydney, Woollahra.
1876		Alston, John Wilson, M.B. *Edin.*, Mast. Surg. *Edin.*, 455, Pitt-street.
1877		Anderson, A. W., Oriental Bank, Sydney.
1877		Anderson, H. C. L., M.A., Sydney Grammar School.
1876		Armstrong, W. D., Surveyor General's Office.
1878		Archer, W. H., F.I.A., Australian Club.
1879		Arnheim, E. H., Royal Mint, Sydney.
1876		Atchison, Cunningham Archibald, C.E., North Shore.
1873		Atherton, Ebenezer, M.R.C.S. *Eng.*, O'Connell-street.
1873		Austen, Henry, Hunter-street.
1876		Backhouse, Benjamin, "Ithaca," Elizabeth Bay.
1878		Backhouse, Alfred P., M.A., "Ithaca," Elizabeth Bay.
1877		Baker, Hon. E. A., Minister for Mines, Mining Department.
1878		Balfour, James, Union Club.
1876	P 4	Barkas, Wm. James, Lic. R. Col. Phys. *Lond.*, M.R.C.S. *Eng.*, Warialda.
1878		Barker, Francis Lindsay, 130, Pitt-street.

Elected.		
1879		Barraclough, William, 2, Yurong-street.
1875		Bartels, W. C. W., Union Club.
1876		Bassett, W. F., M.R.C.S., *Eng.*, Bathurst.
1878		Bayley, George W. A., Railway Department, Phillip-street.
1880		Beattie, Josh. A., Lic. K. & Q. Coll. Phys., *Irel.*, Lic. R. Coll. Sur., *Irel.*, Parramatta.
1875		Bedford, W. J. G., M.R.C.S. *Eng.*, Staff Surgeon.
1868		Beilby, E. T., Pitt-street.
1875		Belgrave, Thomas B., M.D. *Edin.*, M.R.C.S. *Eng.*, 153 Elizabeth-street.
1877		Belfield, Algernon H., Eversleigh, Armidale.
1875		Belisario, John, M.D., Lyons' Terrace.
1876		Benbow, Clement A., 24, College-street.
1869	P 2	Bensusan, S. L., Exchange, Pitt-street.
1877		Bennett, George F., C.M.Z.S., Toowoomba, Queensland.
1878		Berney, Augustus, H. M. Customs, Sydney.
1878		Bestic, Edwin Henry, L.R.C.S., *Irel.*, L.R.C.P., *Edin.*, Arthursleigh-terrace.
1878		Black, Reginald James, Bank of New South Wales, Sydney.
1878		Black, Morrice A., F.I.A., Actuary, Mutual Provident Society.
1880		Blackmann, C. H. E., 267, George-street.
1877		Bladen, Thomas, William Henry street, Ultimo.
1872		Bolding, H. J., P.M., Newcastle and Union Club.
1879		‡Bond, Albert, Bell's Chambers, Pitt-street.
1874		Bowen, George M. C., Keston, Kirribilli Point, North Shore.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, Lyons' Terrace.
1871	P 1	Brazier, John, C.M.Z.S., Corr. M.R.S., Tas., 82, Windmill-street.
1868		Brereton, John Le Gay, M.D. *St. Andrew's*, L.R.C.S. *Edin.*, Domain Terrace.
1879		Brindley, Thomas, Nepean Cottage, Bourke-street, Redfern.
1876		Brodribb, W. A., M.L.A., F.R.G.S., Double Bay.
1878		Brooks, Joseph, F.R.G.S., Hope Bank, Nelson-st., Woollahra.
1876		Brown, Henry Joseph, Newcastle.
1880		Brown, John Studd, Dubbo.
1876		Brown, Thomas, Eskbank, Bowenfels, and Australian Club.
1877		Bundock, W. C., Australian Club.
1876		Burn, James Henry, 93, Palmer-street, Woolloomooloo.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street North.
1877		Burnell, Arthur, Survey Office.
1878		Burnett, Robt. H., C.E., Railway Department.
1875		Busby, The Hon. William, M.L.C., "Redleaf," South Head Road, Woollahra.
1880		Bush, Thomas James, Gas Works, Sydney.
1878		Butterfield, George, Survey Office.
1876		Cadell, Alfred, Vegetable Creek, New England.
1876		Cadell, Thomas, Wotonga, East St. Leonards.
1880		Caird, George C., Lillingstone, Ocean-street, Woollahra.
1876		Campbell, Allan, L.R.C.P., *Glasgow*, Yass.

Elected.		
1876		Campbell, The Hon. Alexander, M.L.C., Woollahra.
1868		Campbell, The Hon. Charles, M.L.C., Clunes, South Kingston.
1872		Campbell, The Hon. John, M.L.C., Clunes, South Kingston.
1879		Cameron, John, surveyor, Barringun, *viâ* Bourke.
1879		Campbell, Revd. Joseph, B.A., "Edgarville," Botany-street, Surry Hills.
1870		Cane, Alfred, 110, Victoria-street.
1876		Cape, Alfred J., "Torfrida," Elizabeth Bay.
1876		Chandler, Alfred, 185, Pitt-street.
1879		Chard, J. S., District Surveyor, Armidale.
1878		Chatfield, William, 69, Pitt-street.
1878		Chisholm, Edwin, M.D., M.R.C.S., L.S.A., &c., Ashfield.
1876	P 1	Christie, Wm., L.S., Hawthorn Lodge, Glen Innes.
1877		Clarke, William, E. S. & A. C. Bank, Pitt-street.
1874		Clay, William French, M.A., *Cantab.*, M.D. *Syd.*, M.R.C.S. *Eng.*, Fellow of St. Paul's Col., North Shore.
1876		Clune, Michael Joseph, M.A., Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 12, College-street.
1876		Codrington, John Fredk., M.R.C.S., E.; Lic. R.C. Phys., L.; Lic. R.C. Phys., *Edin.*, Orange.
1878		Collie, Revd. Robert, The Manse, Wellington-street, Newtown.
1878		Colquhoun, George, 3, Mona-terrace, Rushcutters' Bay.
1880		Colyer, Henry Cox, M.A., Clinton, Liverpool-street, Darlinghurst
1876		Colyer, John Ussher Cox, A.S.N. Company, Sydney.
1856		Comrie, James, Northfield, Kurrajong Heights.
1876		Conder, Wm., Survey Office, Sydney.
1878		Cottee, Wm. Alfred, Spring-street.
1880		Cox, The Hon. George Henry, M.L.C., Mudgee, and Union Club, Sydney.
1859	P 1	Cox, James, M.D. *Edin.* C.M.Z.S., F.L.S., Hunter-street.
1865	P 2	Cracknell, E. C., Superintendent of Telegraphs, Telegraph Office, George-street.
1869		Creed, J. Mildred, M.R.C.S. *Eng.*, Scone.
1870		Croudace, Thomas, Lambton.
1877		Cunningham, Andrew, Lanyon, Queanbeyan.
1873		Daintrey, Edwin, "Æolia," Randwick.
1876		Dalgarno, John V., Telegraph Office, George-street.
1876		Dansey, George Frederick, M.R.C.S. *London*, Cleveland-street, Redfern.
1875		Dangar, Frederick H., "Greenknowes," Darlinghurst.
1876		Darley, Cecil West, Newcastle.
1877		Darley, F. M., M.A., Union Club, Sydney.
1879		Davenport, Samuel, Adelaide, South Australia.
1878		Dean, Alexander, J.P., Elizabeth-street.
1877		Deck, John Field, M.D., 251, Macquarie-street.
1856		Deffell, George H., Bayfield, Woolwich Road, Hunter's Hill.
1878		De Lissa, S., 3, Barrack-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., Cuppercumbalong, Lanyon.
1875		De Salis, L. W., junr., Strathmore, Bowen, Queensland.
1873		Dibbs, George R., M.P., 131, Pitt-street.
1876		Dight, Arthur, Richmond.

Elected.		
1875	P 7	†Dixon, W. A., F.C.S., Fellow and Member Inst. of Chemistry of Gt. Britain and Irel., Lecturer on Chemistry, School of Arts; Chemical Laboratory, School of Arts, Sydney.
1880		Dixson, Craig, M.B., C.M., *Edin.*, M.R.C.S., *Eng.*, 2, Clarendon Terrace, Elizabeth-street.
1880		Dixson, Thomas, M.B., C.M., *Edin.*, 111, Victoria-street.
1876		Docker, Ernest, M.A. *Sydn.*, Carhullen, Parramatta.
1879		Docker, Wilfred L. Craigstone, William-street South.
1876		Douglas, James, L.R.C.S. *Edin.*, Hope Terrace, Glebe Road.
1879		Dowling, Neville, Wallace-street, Woollahra.
1876		Drake, William Hedley, Fellow of the Inst. of Bankers, Lond., Colonial Bank of New Zealand, Nelson, N.Z.
1873		Du Faur, Eccleston, F.R.G.S., Lands Office.
1876		Eales, John, Duckenfield Park, Morpeth.
1876		Egan, Myles, M.R.C.S. *Eng.*, 2, Hyde Park Terrace, Liverpool-street.
1874		Eichler, Charles F., M.D. *Heidelberg*, M.R.C.S. *Eng.*, Bridge-street.
1876		Eldred, W. H., 119, Castlereagh-street.
1878		Ellis, Thomas Augustus, C.E., City Engineer, Newcastle.
1876		Evans, George, Como, Darling Point.
1876		Evans, Owen Spencer, M.R.C.S. *Eng.*, Darling-street, Balmain.
1877		Fache, Charles James, Cleveland House, Redfern.
1877		Fairfax, Edward R., 177, Macquarie-street.
1868		Fairfax, James R., *Herald* Office, Hunter-street.
1880		Ferguson, James W., 35, Rialto Terrace, Darlinghurst.
1880		Finlayson, David, Manager, Union Bank.
1876		Firth, Rev. Frank, Wesleyan Parsonage, St. Leonards.
1874		Fischer, Carl F., M.D., M.R.C.S., *Eng.*; L.R.C.P., *Lond.*; F.G.S.; F.L.S.; F.R.M.S.; Member Imp. Botanical and Zoological Society, Vienna; Corr. Member Imp. Geographical Society, Vienna; 251, Macquarie-street.
1876		Fitzgerald, R. D., F.L.S., Surveyor General's Office.
1856		Flavelle, John, George-street.
1880		Forbes, Alexr. Leith, M.A., Dept. of Public Instruction.
1863		Fortescue, G., M.B. *Lond.*, F.R.C.S., F.L.S., Lyons' Terrace.
1879		Foreman, Joseph, M.R.C.S. *Lond.*, L.R.C.P. *Edin.*, Lithgow.
1877		Fraser, A. C., 235, Albion-street.
1878		Fraser, Robert, 12, Barrack-street.
1875		Frazer, Hon. John, M.L.C., York-street.
1878		Fuller, Francis John, Market Buildings, Hunter-street, Newcastle.

Elected.		
1879		Gabriel, C. Louis, care of Dr. J. J. Hill, Lambton.
1880		Gardiner Rev. Andrew, M.A., Rensdale, Pyrmont Bridge Road.
1877		Garnsey, Rev. C. F., Christ Church Parsonage, Sydney.
1868	P 1	Garran, Andrew, LL.D., *Sydney Morning Herald* Office, Hunter-street.
1877		Garvan, J. P., East St. Leonards.
1878		Gedye, Charles Townsend, "Eastbourne," Darling Point.
1878		George, Hugh, *Sydney Morning Herald* Office.
1876		George, W. R, 360 George-street.
1879		Gerard, Francis, Occupation of Lands Office.
1878		Giblin, Vincent W., Australian Joint Stock Bank, Sydney.
1876		Gilchrist, W. O., Greenknowes, Potts's Point.
1875		Gilliat, Henry Alfred, Australian Club.
1876		Gillman, Thomas Henry, B.A., C.M., M.D., Queen's Univ. *Irel.*, Mast. Surg. Queen's Univ. *Irel.*, Carlton Terrace, Wynyard Square.
1876	P 1	Gipps, F. B., 134, Pitt-street.
1878		Goddard, William C., The Exchange, New Pitt-street.
1859		Goodlet, John H., George-street.
1876		Goode, George, M.A., M.D., M. Ch., Trin. Coll., *Dub.*, Enfield House, Camden.
1876		Graham, Hon. Wm., M.L.C., Stratheam House, Waverley.
1873		Greaves, W. A. B., Armidale.
1878		Griffiths, Frederick C., Macquarie-street.
1877		Griffiths, G. Neville, The Domain, Sydney.
1877		Gurney, T. T., M.A. *Cantab.*, late Fellow of St. John's College, Cambridge, Professor of Mathematics and Natural Philosophy, University of Sydney.
1880		Haege, Hermann, 127, Pitt-street.
1864		Hale, Thomas, Gresham-street.
1878		Hall, Richard T., care of W. H. Quodling, Esq., Public Works Department.
1880		Halligan, Gerald H., C.E., Marrickville
1874		Hardy, J., Hunter-street.
1877		Hargrave, Lawrence, 94, Upper William-street.
1877		‡Harrison, L. M., Macquarie Place.
1878	P 2	Hart, Ludovico, Wemyss-street, Stanmore.
1878		Haviland, E. Cyril, 15 Bridge-street.
1877	P 1	Hawkins, H. S., M.A., Balmain.
1874		Hay, The Hon. Sir John, K.C.M.G., M.L.C., A.M. *Aberdeen*. President of the Legislative Council, Rose Bay, Woollahra.
1876		Heaton, J. H., *Town and Country* Office, Pitt-street.
1875		Helsham, Douglass, Heaton, Homebush.
1877		Henry, James, 754, George-street.
1878		Herborn, E. W. L., "Flinton," Glebe Point Road.
1878		Herborn, Eugene, "Flinton," Glebe Point Road.
1880		Hern, Charles E., "Ellora," Queen-street, Woollahra.
1876		Heron, Henry, solicitor, 49, Hunter-street.

Elected.		
1878		Hewett, Thomas Edward, The Observatory, Sydney.
1879		Higgins, R. G., Clifford, Potts's Point.
1879		Hills, Robert, Elizabeth Bay.
1880		Hill, Jno. James, J.P., L.R.C.P.E., L.F.P., and S.G.L.M., Lampton, Newcastle.
1880		Hill, Jos. Higham, M.D., Univ. *Brussels,* F.R.C.S., *Edin.,* &c., Kensington, Glenmore Road.
1879		Hitchins, Edwd. Lytton, Florence, Victoria-street, Darlinghurst.
1877		Hindson, Lawrence, Exchange Buildings, Pitt-street.
1876	P 2	†Hirst, Geo. D., 379, George-street.
1878		Hodgson, Rev. E. G., M.A. *Oxon.*, S.C.L , Vice-Warden of St. Paul's College, University.
1880		Hodgson, Wilfred, M.D., 67, Regent-street.
1868		Holt, The Hon. Thomas, M.L.C., Sydney.
1876		Holroyd, Arther Todd, M.B. *Cantab.*, M.D. *Edin.*, F.L.S., F.Z.S., F.R.G.S., Master-in-Equity, Sherwood Scrubs, Parramatta.
1870	P 1	Horton, Rev. Thomas, Ina Terrace, Woollahra.
1879		Houison, Andrew, B.A., M.B.C.M., 128, Phillip-street.
1877		Hume, J. K., Cooma Cottage, Yass.
1878		†Hunt, Robert, F.G.S., Associate of the Royal School of Mines, London, Deputy Master of the Royal Mint, Sydney.
1876		Icely, Thos. R., Carcoar.
1879		Inglis, James, Redmyre.
1877		Innes, Sir J. George L., Knt., Darlinghurst.
1880		Iredale, Lancelot, A.F., Goolhi, Gunnedah.
1878		Jackson, Arthur Levett, Government Printing Office.
1876		Jackson, Henry Willan, M.R.C.S. *Eng.*, Lic. R. C. Phys., *Edin.*, 130, Phillip-street.
1880		Jackson Robert, 89, Pitt-street North.
1879		Jarvie, Rev. A. Milne, Univ. Council, *Edin.*, Scots' Church, Sydney.
1879		Jefferis, Rev. James, LL.B., "The Retreat," Newtown.
1876		Jenkins, Richard Lewis, M.R.C.S., Nepean Towers, Douglas Park.
1874		Jennings, P. A., Sir, K.C.M.G., Edgecliffe Road, Woollahra.
1877		Jennings, W. E., B.A., Mining Department, Sydney.
1876		Jones, James Aberdeen, Lic. R.C. Phys. *Edin.*, Booth-street, Balmain.
1876		Jones, Richard Theophilus, M.D. *Sydn.*, L.R.C.P. *Edin.*, Ashfield.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, College-street.
1877		Jones, Edward Lloyd, 345, George-street, Sydney.
1874		Jones, James, Bathurst-street.
1877		Jones, Griffith Evan Russell, B.A , *Syd.*, 382, Crown-street, Surry Hills.

Elected.		
1879		Jones, John Trevor, 356, Liverpool-street.
1879		Johnson, James W., "Brooksby," Double Bay.
1863		Josephson, Joshua Frey, F.G.S., District Court Judge, Enmore Road, Newtown.
1876	P 1	Josephson, J. P., Assoc. Mem. Inst. C.E., 253, Macquarie-street North.
1878		Joubert, Numa, Noumea.
1873		Keele, Thos. Wm., Harbours and Rivers Department, Phillip-street.
1877		Keep, John, Broughton, Leichhardt.
1879		Kemmis, Rev. Thomas, St. Mark's Parsonage, Darling Point.
1873		Kennedy, Hugh, B.A. *Oxon.* Registrar of the Sydney University.
1874		King, Philip G., William-street, Double Bay.
1877		Kinloch, John, M.A., Hurlstone College, Ashfield.
1878		Knaggs, Saml. J., M.D., Newcastle.
1874		Knox, George, M.A., *Cantab.*, King-street.
1875		Knox, Edward, 24, Bridge-street.
1877		Knox, Edward, jun., "Fiona," Double Bay.
1877		Kopsch, G., Telegraph Department.
1878		Kretschmann, Joseph; care of Mr. Moss, Hunter-street.
1878		Kyngdon, F. B., 221, Darlinghurst Road.
1878		Kyngdon, Fred. H., M.D. *Aberdeen;* L.S.A., *L.;* M.R.C.S., *E.;* C.M., *Aberdeen*, North Shore.
1876		Langley, W. E., *Herald* Office, Sydney.
1874	P 1	Latta, G. J., Hawthorne, Crystal-street, Petersham.
1876		Laure, Louis Thos., M.D. Surg. Univ. *Paris*, 138, Castlereagh-street.
1880		Leask, John L., M.B.C.M. *Edin.*, "Terra Bella," Pyrmont Bridge Road.
1859	P 5	†Leibius, Adolph, Ph. D., *Heidelberg*, F.C.S.; Fel. Inst. Chemistry of Gt. Brit. and Irl.; Senior Assayer to the Sydney Branch of the Royal Mint, *Hon. Secretary.*
1874		Lenehan, Henry Alfred, Sydney Observatory.
1872	P 21	†Liversidge, Archibald, F.C.S.; Fel. Inst. Chemistry of Gt. Brit. and Irl.; F.G.S.; F.L.S.; F.R.G.S.; Assoc. Roy. Sch. Mines, *Lond.;* Mem. Phy. Soc. London; Mem. Mineralogical Soc. Gt. Brit. and Irel.; Cor. Mem. Roy. Soc. Tas.; Cor. Mem. Senckenberg Institute, Frankfurt; Cor. Mem. Soc. d'Acclimat. Mauritius; Hon. Fel. Roy. Hist. Soc. Lond.; Mem. Min. Soc. of France; Professor of Chemistry and Mineralogy in the University of Sydney, *Hon. Secretary*, Union Club.

Elected.

1875 Living, John, Marsaloo, North Shore.
1874 Lloyd, George Alfred, F.R.G.S., "Scottforth," Elizabeth Bay.
1879 Loftus, His Excellency The Right Hon. Lord Augustus, G.C.B., &c., &c., &c., *Hon. President*.
1876 Lord, The Hon. Francis, M.L.C., North Shore.
1877 Lord, George Lee, Kirketon, Darlington.
1878 Low, Hamilton, H.M. Customs.
1880 Low, Andrew S., Merrylands, Granville.

1876 M'Carthy, W. F., solicitor, Pitt-street.
1876 M'Culloch, A. H., jun., 165, Pitt-street.
1874 M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1878 MacDonald, Ebenezer, Oriental Bank, Sydney.
1859 MacDonnell, William, 312, George-street.
1868 MacDonnell, William J., F.R.A.S., George-street.
1877 MacDonnell, Samuel, 312, George-street, Sydney.
1876 M'Kay, Dr., Church Hill.
1880 M'Kinney, Hugh G., Assoc. Mem. Inst. C.E., "Seaton," Point Piper Road, Paddington.
1876 MacLaurin, Henry Norman, M.A., M.D. Univ. *Edin.*, Lic. R. Coll. Sur. *Edin.*, No. 155, Macquarie-street.
1878 ‡MacPherson, Rev. Peter, M.A., 241, Carlingford Terrace, Albion-street, Sydney.
1872 Mackenzie, John, F.G.S., Examiner of Coal Fields, Newcastle.
1874 Mackenzie, W. F., M.R.C.S., *Eng.*, Lyons' Terrace.
1876 Mackenzie, Rev. P. F., "Friendville," Paddington.
1880 Mackenzie, R., The Exchange Corner.
1876 Mackellar, Chas. Kinnard, M.B., C.M., *Glas.*, Lyons' Terrace.
1878 Maitland, Duncan Mearns, junior, "Afreba," Stanmore Road.
1873 Makin, G. E., Berrima.
1880 Manfred, Edmund C., Montague-street, Goulburn.
1877 Mann, John, Neutral Bay.
1873 P 5 Manning, James, Milson's Point, North Shore.
1876 Manning, Frederick Norton, M.D. Univ. *St. And.*, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Gladesville.
1869 Mansfield, G. A., Pitt-street.
1878 Markey, James, L.R.C.S., *Irel.*, L.R.C. Phys., *Edin.*, Regent-street.
1878 Marklove, Robert J., 52, Pitt-street.
1880 Marano, G. V., M.D. Univ. *Naples*, Clarendon Terrace, Elizabeth-street.
1872 Marsden, The Right Rev. Dr., Bishop of Bathurst, Bathurst.
1876 Marsh, J. M., Edgecliff Road, Woollahra.
1876 Marshall, George, M.D. Univ. *Glas.*, Lic. R. Coll. S. *Edin.*, Lyons' Terrace.
1876 Martin, Rev. George, Parramatta.
1879 Masters, Edward, Lurlei, Marrickville.
1875 Mathews, R. H., Singleton.
1879 Matthews, Robert, Tumut-street, Adelong.
1877 Merriman, James, Miller's Point.

Elected.		
1879		Meslée, E. Marin de la, Surveyor General's Office.
1868		Metcalfe, Michael, Bridge-street.
1873		Milford, F., M.D. *Heidelberg*, M.R.C.S. *Eng.*, 3, Clarendon Terrace, Hyde Park.
1876		Millard, Rev. Henry Shaw, Newcastle Grammar School.
1875		Moir, James, Margaret-street.
1875		†Montefiore, E. L., Macleay-street.
1878		Montefiore, Octavius L., Belgian Consul, Gresham-street.
1850	P 3	†Moore, Charles, F.L.S., Director of the Botanic Gardens, Botanic Gardens, *Vice-President.*
1879		Moore, Fred. H., Exchange Buildings.
1850		Morehead, R. A. A., 30, O'Connell-street.
1872		Morgan, Cosby William, M.D. *Brussels*, L.R.C.P. *Lond.*, Newcastle.
1876		Morgan, Allan Bradley, M.R.C.S. *Eng.*, Lic. Mid. Lic. R. Coll. Phys. *Edin.*, Ashenhurst, Burwood.
1876		Morgan, T. C., L.R.C.S. *Edin.*, M.K. & Q. Coll. Phys. *Ireland*, 55, Castlereagh-street.
1865	P 1	Morrell, G. A., C.E., Pitt-street.
1877		Morris, William, F.F.P.S. *Glas.* & F.R.M.S.L., 5, Carlton Terrace, Wynyard Square, Sydney.
1880		Moses, David, "Aurovida," Forest Lodge.
1879		Mountain, Adrian C., City Surveyor, Town Hall.
1877		‡Mullens, Josiah, F.R.G.S., 34, Hunter-street.
1879		Mullins, John, F.L., M.A., 211, Macquarie-street.
1865		Murnin, M. E., Eisenfels, Nattai.
1876		Murray, W. G., 52, Pitt-street.
1876		Myles, Chas. Henry, Wymela, Burwood.
1873		Neill, William, City Bank, Pitt-street.
1879		Neill, W. J. Walter, City Bank, Pitt-street.
1874		Neill, A. L. P., City Bank, Pitt-street.
1879		Newman, W., care of Messrs. David Jones & Co., George-street.
1878		Newton, John, "Prudho," Darling Point.
1876		Nilson, Aroid, Department of Mines.
1873		Norton, James, Hon., M.L.C., solicitor, Spring-street.
1875		Nott, Thomas, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Ocean-street, Woollahra.
1878		Nowlan, John, Union Club and West Maitland.

Elected.	
1880	Oakes, Arthur W., M.B., C.M., L.R.C.P., L.R.C.S., *Edin.*, "Chiswick," Ocean-street, Woollahra.
1879	O'Connor, Dr. Maurice, 223, Victoria-street.
1878	Ogilvy, James L.,Oriental Bank, Sydney.
1877	Olley, Rev. Jacob, Manly.
1875	O'Reilly, W. W. J., M.D., M.C., Q. Univ. *Irel.*, M.R.C.S., *Eng.*, Liverpool-street.
1880	Paling, W. H., "Wonden," Cambridge-street, Petersham.
1875	Palmer, J. H., Legislative Assembly.
1880	Palmer, Joseph, 133, Pitt-street.
1876	Parrott, Thomas S., C.E., Ashfield.
1878	Paterson, Hugh, junr., 229, Macquarie-street.
1877	Paterson, James A., Union Bank, Pitt-street.
1878	Paterson, Alexander, M.D., M.A., "Hillcrest," Stanmore Road.
1877	Pedley, Perceval R., 48, Wynyard Square.
1877	Perkins, Henry A., Pembrook, Johnson-street, Balmain.
1856	Phillip, H., Pacific Insurance Company.
1876	Pickburn, Thomas, M.D. *Aberdeen*, Ch. M., M.R.C.S. *Eng.*, 40, College-street.
1879	Pittman, Edwd. Fisher, L.S., Department of Mines.
1879	Pockley, Thos. F. G., Commercial Bank, Singleton.
1878	Poolman, F., Colonial Sugar Refining Co., Bridge-street.
1878	Potts, J. H., Victoria-street, Ashfield.
1862	Prince, Henry, George-street.
1876	Quaife, Fredk. Harrison, M.D., Mast. Surg. Univ. *Glas.*, Hughenden, Queen-street, Woollahra.
1876	Quirk, Rev. Dr. J. A., O.S.B., LL.D., *Syd.*, St. Joseph's, Newtown.
1878	Quirk, Rev. D. Placid, M.A. *Syd.*, Post Office, Cook's River.
1876	Quodling, W. H., Burwood.

Elected.		
1865	P 1	‡Ramsay, Edward, F.L.S., Curator of the Australian Museum, College-street.
1876		‡Ratte, F., G.P.O., Sydney.
1874		Read, Reginald Bligh, M.R.C.S., *Eng.*, Coogee.
1877		Read, Richard, M.D., Singleton.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Castlereagh-street.
1876		Reece, J. D., Surveyor General's Office.
1878		Reid, George H., M.L.A., Barrister, Elizabeth-street.
1870		Renwick, Arthur, M.D. *Edin.*, B.A. *Sydn.*, F.R.C.S, *E.*, M.L.A., 295, Elizabeth-street.
1880		Riddell, C. E., Union Club.
1856		Roberts, J., George-street.
1868	P 3	Roberts, Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. Vienna, Bridge-street.
1878		Roberts, William, Australian Club.
1871		Robertson, Thomas, solicitor, 91 Pitt-street.
1856	P 6	†Rolleston, Christopher, C.M.G., Auditor General, Castlereagh-street.
1880		Rome, Robert, Union Club.
1878		Rose, W., Union Club.
1865		Ross, J. Grafton, 24, Bridge-street.
1876		Rowling, Dr., Mudgee.
1864	P 21	†Russell, Henry C., B.A. *Syd.*, F.R.A.S., F.M.S., Hon. Mem. S. Aust. Inst., Government Astronomer, Sydney Observatory, *Vice-President.*
1875		Sahl, Charles L., German Consul, Consulate of the German Empire, Wynyard Square.
1876		Saliniere, Rev. E. M., Glebe.
1876		Samuel, The Hon. Saul, C.M.G., M.L.C., Gresham-street.
1880		Sandy, James, "Rothgael," Croydon Road, Ashfield.
1876		Schuette, Rudolf, M.D., Univ. *Göttingen,* Lic. Soc. Apoth. *Lond.*, 10, College-street.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Hon. Mem. Roy. Soc. Vic., The Parsonage, Queanbeyan.
1880		Scrivener, Charles Robert, Berlin Cottage, Fotheringham-street, Stanmore.
1876		Sedgwick, Wm. Gillett, M.R.C.S., *Eng.*, Newtown.
1877		Selfe, Norman, C.E., M.I.C.E., Rockleigh, Balmain.
1876		Sharp, James Burleigh, J.P., Clifton Wood, Yass.
1876		Sharp, Henry, Green Hills, Adelong.
1878	P 1	Sharp, Revd. W. Hey, M.A. *Oxon.*, Warden of St. Paul's College, University.
1879		Shepard, A.D., Adelong.
1875		Sheppard, Rev. G., B.A., Berrima.
1878		Skinner, J. H., B.A. *Oxon.*, Grammar School, Sydney.
1875		Slade, G. P., solicitor, Bridge-street.
1877		Slattery, Thomas, Premier Terrace, 169, William-street, Woolloomooloo.

Elected.		
1877		Sloper, Fredk. Evans, 360, Liverpool-street.
1852	P 5	†Smith, John, The Hon., C.M.G., M.D., LL.D., *Aberdeen*, M.L.C., F.C.S., Hon. Mem. Roy. Soc. Vic., Professor of Physics and Chemistry in the University of Sydney, 193, Macquarie-street, *President*.
1878	P 1	Smith, Marshall, Glanville-street, Glanville, South Australia.
1875		Smith, Robt., M.A. *Syd.*, solicitor, Spring-street.
1874		Smith, John M'Garvie, Hunter-street.
1876		Smith, R. S., Surveyor General's Office.
1878		Smith, E. E., Fevereaux, Roslyn-street, Upper William-street, North.
1876		Southey, H. E., Oaklands, Mittagong.
1879		Spry, James Monsell, Union Club.
1872	P 1	Stephen, George Milner, B.A., F.G.S., Mem. Geol. Soc. of Germany; Cor. Mem. Nat. Hist. Soc., Dresden; F.R.G.S. of Cornwall; Pyrmont Bridge Road.
1879		Stephen, Septimus, South Kingston.
1879		Stephen, Alfred F. H., Pyrmont Bridge Road.
1857		Stephens, William John, M.A. *Oxon.*, 233, Darlinghurst Road.
1876		Stopps, Arthur J., Surveyor General's Office.
1878		Street, John Rendell, Birtley, Elizabeth Bay Road.
1876		Strong, Wm. Edmund, M.D., *Aberdeen*, M.R.C.S., *Eng.*, Liverpool.
1874		Stuart, Alexander, M.L.A., Sydney.
1876		Stuart, Clarendon, Upper William Street South.
1876		Suttor, Wm. Henry, M.L.A., Cangoura, Bathurst.
1879		Tarrant, Harman, M.R.C.S., Elizabeth-street.
1874		Taylor, Chas., M.D. *Syd.*, M.R.C.S., *Eng.*, Parramatta.
1879		Taylor, Chas. Lamb, M.R.C.S., 14, College-street.
1876		Tayler, William George, F.R.C.S., *Lond.*, 219, Pitt-street.
1862	P 9	Tebbutt, John, F.R.A.S., Observatory, Windsor.
1878		Tennant, E. G., M R.C.S., Bourke-street, Dubbo.
1879		Thomson, Dugald, 20, Charlotte Place.
1870	P 1	Thompson, H. A., Adelaide, S.A.
1875		Thompson, Joseph, Bellevue Hill, Double Bay.
1877		Thompson, Thos. James, Pitt-street, Sydney.
1876		Thomas, H. Arding, Narellan.
1878		Thomas, F. J., Hunter River N.S.N. Co., Market-street.
1876		Tibbits, Walter Hugh, M.R.C.S. *Eng.*, "Carlisle," Petersham.
1876		Toohey, J. T., Melrose Cottage, Cleveland-street.
1873		Trebeck, Prosper N., George-street.
1879		Trebeck, P. C., George and Margaret Streets.
1876		Trouton, F. H., A.S.N. Company's Offices, Sydney.
1877		‡Tucker, G. A., Ph. D., Superintendent, Bay View Asylum, Cook's River.
1868		Tucker, William, Clifton, North Shore.

Elected.

1875 Tulloh, W. H., "Airlee," Greenwich Point Road, North Shore.
1875 Turner, G., 3 Fitzroy Terrace, Pitt-street, Redfern.

1876 Voss, Houlton H., J.P., Goulburn.

1879 Walker, H. O., Australian General Assurance Co., 129, Pitt-street.
1867 Walker, Philip B., Telegraph Office, George-street.
1870 Wallis, William, Moncur Lodge, Potts's Point.
1867 Ward, R. D., M.R.C.S. *Eng.*, North Shore.
1877 Warren, William Edward, M.D., M.R.C.S., 281, Elizabeth street, Sydney.
1876 Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, 121, Elizabeth-street.
1876 Waterhouse, J., M.A. *Syd.*, "Waima," Cavendish-street, Stanmore.
1876 Watson, C. Russell, M.R.C.S., *Eng.*, Camden Terrace, Newtown.
1877 Watt, Alfred Joseph, Ashfield, Parramatta Road.
1859 Watt, Charles, Government Analyst, New Pitt-street.
1876 Waugh, Isaac, M.B., M.C., *T.C.D.*, Parramatta.
1876 Webster, A. S., Union Club.
1867 Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1878 Welch, Edward Wm., *Sydney Morning Herald* Office, Pitt-street.
1878 Westgarth, G. C., solicitor, Pitt-street.
1877 Weston, W. J., Union Club.
1879 ‡Whitfield, Lewis, B.A. (Sydney Univ.), Grammar School.
1874 White, Rev. James S., M.A., LL.D., *Syd.*, Gowrie, Singleton.
1875 White, Hon. James, M.L.C., "Cranbrook," Double Bay.
1877 White, Rev. W. Moore, A.M., LL.D., T.C.D., 1, Lawrening Terrace, Elizabeth-street.
1879 Wilshire, F. R., P.M., Berrima.
1879 Wilson, F. A. A., Alfred-street, St. Leonards.
1876 Windeyer, W. C., M.A., *Syd.*, M.L.A., King-street.
1876 P 1 Wise, George Foster, Immigration Office, Hyde Park.
1874 †Wilkinson, C. S., F.G.S., Government Geologist, Department of Mines.
1876 Wilkinson, Henry Toller, Department of Mines.
1878 Wilkinson, Rev. Samuel, 5, Argyle Terrace, Pitt-street, Redfern.
1880 Wilkinson, Robt. Bliss, 12, Spring-street.
1878 Wilshire, James Thompson, C.P.S., Scone.
1876 Williams, Percy Edward, Treasury.

Elected.		
1878		Wise, Henry, Savings' Bank, Barrack-street.
1873		Wood, Harrie, Under Secretary for Mines, Department of Mines.
1879		Woodhouse, E. B., Mount Gilead, Campbelltown.
1877		Woods, T. A. Tenison-, Phillip-street, Sydney.
1876		Woolrych, F. B. W., Wilson-street, Newtown.
1872		†Wright, Horatio G. A., M.R.C.S., *Eng.*, Wynyard Square, *Hon. Treasurer.*
1878		Wright, Rev. Edwin H., St. Stephen's, Bourke.
1879		Young, John, Town Hall, George-street.
1878		Young, Lamont H. G., F.G.S., Assoc. R.S. Mines, Oaklands, Mittagong.

Honorary Members.

Limited to Twenty.

1875		Agnew, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart Town.
1875		Barlee, His Excellency F. P., C.M.G., Governor of Honduras.
1879		Bentham, George, F.R.S.,V.P.L.S., C.M.G., The Royal Gardens, Kew.
1875		Bernays, Lewis A., F.L.S., F.R.G.S., Brisbane.
1876	P 1	Cockle, His Honor Sir James, late Chief Justice of Queensland, M.A., F.R.S., London.
1879		Darwin, Dr. Charles, F.R.S., M.A., F.G.S., F.L.S., &c., &c., Beckenham, Kent.
1876		De Köninck, Prof., M.D., Liège, Belgium.
1875		Ellery, Robert F., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.
1875		Gregory, Augustus Charles, C.M.G., F.R.G.S., Geological Surveyor, Brisbane.
1875		Haast, Dr. Julius von, Ph. D., F.R.S., F.G.S., Professor of Geology, Canterbury College, and Director of the Canterbury Museum, Christchurch, New Zealand.
1875	P 1	Hector, James, C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington.
1880		Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., Director of the Royal Gardens, Kew.
1879		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'Coy, Frederick, F.G.S., Hon. F.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.
1875	P 2	Mueller, Baron Ferdinand von, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S., Government Botanist, Melbourne.
1879		Owen, Professor R., C.B., M.D., D.C.S., LL.D., F.L.S., F.G.S., V.P.Z.S., &c., &c., The British Museum, London, W.C.

Elected.		
1875		Schomburgh, Dr., Director of the Botanic Gardens, Adelaide, South Australia.
1878		Walker, Thomas, Yaralla, Concord.
1875		Waterhouse, F. G., F.G.S., C.M.Z.S., Curator of the Museum, Adelaide, South Australia.
1875	P 9	Woods, Rev. Julian E. Tenison-, F.G.S., F.L.S., Hon. Mem. Roy. Soc., Victoria, Hon. Mem. Roy. Soc., Tasmania, Hon. Mem. Adelaide Phil. Soc., Hon. Mem. New Zealand Institute, Hon. Mem. Linnean Soc., N.S.W., &c., Union Club, Sydney.

Corresponding Members.

Limited to Twenty-five.

1880	P 1	Clarke, Hyde, V.P. Ethnological Institution, London.
1879	P 2	Etheridge, Robert, junr., F.G.S., &c., The British Museum.
1880		Ward, Sir Edward, K.C.M.G., Major-General, R.E., Cannes, France.
1880		Miller, F. B., F.C.S., Melbourne Mint.

Obituary, 1880.

1869		Bode, Rev. G. C.
1876		Freehill, Bernard Austin.
1859		Hill, Edward S., C.M.Z.S.
1874		Nichol, D.
1873		Rogers, Rev. Edward, Rural Dean.
1874		Vessey, Leonard A.
1861		Paterson, Hugh.

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, to men of science, whether resident in Australia or elsewhere.

1878. Professor Richard Owen, C.B., F.R.S., The British Museum.

1879. Mr. George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.

1880. Professor Huxley, F.R.S., The Royal School of Mines, London.

1881. Professor F. M'Coy, F.R.S., The University of Melbourne.

ANNIVERSARY ADDRESS.

By Mr. CHARLES MOORE, F.L.S., Vice-President,
Director of the Botanic Gardens.

[*Delivered before the Royal Society of N.S.W., 12 May, 1880.*]

IN addressing you this evening, I am happy in being able to congratulate my fellow members on the prosperous condition of the Society, financially and otherwise, on this its fifty-ninth anniversary, *i.e.*, if we date from the year 1821, when the first Society of the kind was established, by the name of the Philosophical Society; or the thirtieth annual meeting, if we consider this Society established in the year 1850. The Society formed in 1821, as most of you have learned from a former address, had but a brief duration, arising mainly from disunion among the few members who composed it, of whom, it is sad to state, there is now not a survivor. Let us earnestly hope that the same cause will not in any way affect us, as it is very certain that if any antagonistic feelings should again arise among the members, we should soon cease to be useful as a body, and ere long, I fear, die out from sheer inanition. Since the re-establishment of the Society in 1850, although it has undergone many vicissitudes, and changed its name more than once, it has yet been continuous under some form, and the members hitherto have always been animated by a unity of spirit and good fellowship, which I sincerely trust will be continued. Of those who joined the Society in 1850, Mr. R. A. Morehead and myself are now the only members who have not severed our connection with it. As will be readily imagined, the Society since its establishment has not always been in a flourishing condition—it has had its seasons of success and times of depression. Until within the last few years its greatest prosperity was from 1856 to about 1863. The income was then so much greater than the expenditure that the Council were able to invest surplus funds in Government debentures to the extent of some hundreds of pounds, but a reaction took place for which it was difficult to account, and the debentures had to be sold one after the other to meet current expenses, and when the last debenture had to be realised into cash, it was gravely suggested that the best thing to do with the remaining funds was to at once pay off all liabilities and bring the affair to an end. Fortunately this suggestion was not carried into effect. Better counsels prevailed, and fresh efforts were made to attract the attention of the more thoughtful and enlightened of our fellow-colonists, and the result has been that the Society is now in possession of the fine building in which we are assembled, and a library of no mean pretentions, consisting of some of the best scientific standard works and scientific periodical literature of the day, as well as the transactions of the many learned Societies with which we are now in correspondence.

To what cause are we indebted for this satisfactory state of our affairs? I state it advisedly that, if not wholly, it is largely due to the energy displayed by our indefatigable Honorary Secretaries, Professor Liversidge and Dr. Leibius, both of whom have devoted a greater amount of time and labour in organising and working out the details of the Society than is generally understood. The extensive correspondence now carried on is sufficient to occupy the time of one person, but when, in addition to this, these gentlemen have to attend general meetings of the Society and Council, to take minutes of the proceedings of such meetings, and to make abstracts of the papers read at the ordinary general meetings, and to be in attendance here in the afternoon of each Wednesday during the session, as well as the multitudinous matters which they have to attend to in connection with the sectional and monthly meetings, a fair idea may be gained of the obligations we are under to them.

It is to be regretted that so few papers were read at the general meetings during the last session, but let us hope that more vitality will be evinced in that which is now commencing. The papers read were as follows :—June 4 : On the "Gem Cluster in Argo," by H. C. Russell, B.A., F.R.A.S., &c. June 4 : "The International Geological Congress at Paris," by Professor Liversidge, F.G.S., &c. September 3 : Lecture on "The Geology of New Zealand," by Dr. Hector, C.M.G., F.R.S., &c. October 1 : "On the Languages of Australia in their connection with those of Mozambique and the South of Africa," by Hyde Clarke, Esq., V.P., Ethnological Institution. November 5 : On "Photography in its relation to Popular Education," by L. W. Hart, Esq. November 5 : On "Description of Fossil Leaf (*Ottelia præterita*)," by Baron von Mueller, K.C.M.G., F.R.S., &c. December 3 : On "A Catalogue of Latitude Stars," by H. S. Hawkins, M.A. December 3 : Resumé of Paper on "Some remarkable Boulders in the Hawkesbury Beds," by C. S. Wilkinson, F.G.S. December 3 : "Remarks upon the Wentworth Hurricane in January," by H. C. Russell, B.A., F.R.A.S. Several papers were also read at the meetings of the Sections. In some of the Sections there was an activity exhibited among the members which is most creditable to them. The work done, particularly in that on literature and fine arts, and in that on astronomical and microscopical matters, appears from the records to have been considerable ; but very important subjects were also brought under consideration and well discussed in the chemical and other Sections; and I venture to hope that in all these, during the ensuing session, there will be an equal interest taken by the members as that shown by them previously. I will make one suggestion, viz., that the work of the several Sections should be confined as much as possible to practical details and conversational discussion, and that papers on any subject, excepting medical science, should be read at the monthly meetings, so that the members of the Society generally may have the opportunity of discussing their merits.

I cannot allow this occasion to pass without referring to the *conversazione* which was held in the hall of the University. It will, I think, be admitted by those who were fortunate enough to be present, that it was one of the most successful which has yet taken place. The magnificent hall, then beautifully decorated, was filled to overflowing by a brilliant assemblage of over 800, most of whom appeared to be deeply interested in the numerous objects exhibited, and gratified by the explanations given by those in charge of the different exhibits, which appeared to impart much valuable information. The interest of that evening was greatly enhanced by an exhibition of photographs of New Zealand scenery, given by Dr. Hector, C.M.G., F.R.S. These were largely magnified by the lime-light, and the remarks which that gentleman made as the photographs were presented to view were listened to with great attention and interest, and were evidently much appreciated. These *conversazioni*, while they give great pleasure to the lady friends and relatives of members, are nevertheless a heavy tax upon our resources, as the expenses which have to be incurred are very considerable; but I would hope that so long as they do not trench too deeply on our funds that they will be continued.

Since the close of our last session the great International Exhibition has taken place, and is now a thing of the past. It is scarcely within the province of this address to refer particularly to the multitudinous natural and artificial productions which were sent to the Exhibition, but as some of the raw and manufactured vegetable products may hereafter become of great commercial importance to this Colony as exports, I may be pardoned for drawing attention to a few of these. In the Court of Ceylon there were very many most interesting exhibits of this kind. It is said that on no former occasion was that wonderful plant, the cocoa-nut so well represented as it was here. It would seem as if it produced every imaginable requirement for man's sustenance, luxury, and domestic use. Curiously enough, although this tree abounds upon islands adjoining the eastern and northern parts of this continent, it has never yet, I believe, been found growing on any portion of it, excepting where it had been placed by man's agency. It is now planted extensively in Northern Queensland. In this Court, and in that of Madras, there were some fine specimens of the barks of various kinds of Chinchonas, the genus from which the quinine alkaloid is obtained. The Chinchonas are nearly all natives of Peru, but are cultivated at such elevations, both in Ceylon and Madras, as to justify the expectation that some of the most valuable kinds may yet be grown with success in the warmer parts of this country. In these Courts the variety of teas formed a most remarkable feature. From the many kinds of these exhibited it might have been supposed that they were the produce of so many different species, instead of all being obtained from one species and its varieties. Although a comparatively new industry in Ceylon, the adaptability of the climate for the growth of the tea plant is now well established. The cultivation of this plant in India, in which country there are at least three distinct varieties, was commenced in 1837, by plants introduced from China; but the native kinds are now largely planted and are known as the "Assam," the "Cachar," and the "Moinpaar," named after the districts in which they are found in a wild state. These, with the China and two or three hybrids, obtained by crossing with each other, furnished all the splendid exhibits of this kind at the Exhibition. The peculiarities of these teas as contrasted with those of China are their much greater strength and stronger aroma. In both Ceylon and India the tea plantations are at heights varying from five to seven thousand feet above sea level, where the maximum temperature is about 69° and the minimum temperature about 49°, the rainfall being about 49 inches. As these conditions are exactly similar to those which may be found on our Northern Coast ranges, it may be reasonably expected that at no distant period plantations of the tea plant will occupy a great extent of the slopes of these mountain ranges, and that tea will then become one of our best products for home use and one of the most valuable for export. There were other exhibits of this description, which it would be most advantageous to this country to procure. The most noticeable of these were—the indigo, the yield of *Indigofera tinctoria*; pith, a cellular substance obtained from the stem of *Æschynomene aspera*, and so much used in the manufacture of sun or pith hats; tapa cloth, which is the prepared inner bark of *Broussonetia papyrifera*; and, in the Japan Court, a fine collection of the seeds of plants employed in that country for agricultural and culinary purposes. This collection has been secured by me, and their merits will be tested during the ensuing season.

I would now speak of what has been done in more scientific matters:—At the Congress of geologists, held at Paris last year, Professor Liversidge was appointed Vice-President for Australasia. On that occasion certain propositions were agreed to, bearing on important geological matters to be discussed in the various countries of which there were representatives present, and the result of these discussions to be reported to a meeting of geologists to be held at Bologna in 1881. Professor Liversidge, as convener for Australia, endeavoured to arrange for a meeting of geologists in Sydney during the late International Exhibition, to discuss these propositions, but failed, as it was found impossible for the geologists of each colony to meet together at that time. Under the auspices of the Paris Congress a guide to the geological and mineralogical collections was published. M. Zeiller contributed the notes on the geological collections from New South Wales, sent by the Department of Mines. M. Zeiller, judging from the plant fossils, affirms the mesozoic age of our coal-beds, notwithstanding the occurrence of Glossopteris and Phyllotheca in the carboniferous beds, as exhibited in specimen 96, which he supposes came from the upper coal measure; but Mr. Wilkinson, F.G.S., our Geological Surveyor, informs me that he himself obtained this specimen from the Anvil Creek coal seam. The association of these plants with palæozoic marine fossils in this locality has also been most clearly demonstrated by the late Rev. W. B. Clarke in his fourth edition of "Remarks on the Sedimentary Formations," which valuable work was specially dedicated to this congress of geologists; also, in the magnificent collection exhibited at the recent Exhibition by the Department of Mines. Other specimens of Glossopteris from the Greta pit were shown, which were obtained by the late Mr. Clarke. From this evidence it is somewhat surprising that M. Zeiller should have called in question the palæozoic age of the Glossopteris and Phyllotheca.

The occurrence of gold in some serpentine rocks, which also contain veins of asbestos, near Gundagai, was communicated to the Society at one of the monthly meetings last session by Mr. Wilkinson, who attaches much importance to the discovery as being likely to lead to the finding of workable gold deposits in other localities where the auriferous drifts have evidently been derived from the disintegration of serpentine rocks. Mr. Wilkinson also brought under the notice of the Society the occurrence of some remarkable boulders of shale in the Hawkesbury formation. These boulders, from their angular shape and the singular manner in which they have been embedded in irregular and scattered heaps in the sandstone, suggest that their mode of disposition has been partly due to glacial action. Mr. W. J. Stephen, M.A., recently communicated to the Linnæan Society of this Colony the result of similar observations made by him when examining the Hawkesbury rocks in the southern district, thus supporting Mr. Wilkinson's views. I may add that the fossil plants which occur in the shale beds are in an exceptionally good state of preservation. It is also gratifying to me to be able to state that the late Rev. W. B. Clarke's valuable geological map will be shortly published by the Department of Mines.

In astronomical matters the year now closed has not been marked by any great or startling event ; but steady work has been done in the Colony by our astronomer, Mr. H. C. Russell, B.A., F.R.A.S., and by Mr. J. Tebbutt, F.R.A.S., in determining star places, measuring double stars, and observations of the planets and the two comets which have appeared ; the last one, of unusual brilliance, was almost concealed by clouds, and its great tail, some forty degrees long, excited a lively curiosity, which could not be gratified because of the impossibility of seeing the nucleus. One event has transpired in connection with astronomy since last we met which takes us back to the birth of our Society, for the Parramatta Observatory was founded at the same time, and there can, I think, be little doubt that it was the presence amongst the founders of a Governor known to be a friend of science which induced them to found the Society. Sir Thomas Macdougall Brisbane had brought out with him an astronomer (Mr. Charles Rumker), and assistant (Mr. James Dunlop), together with a complete equipment for an Observatory; and very soon after landing, in November, 1821, he had the building commenced close to his own residence, so that he might superintend and actually take a share in the Observatory work. The building was 27 feet on each side, and only one story high, and had a flat roof, sometimes used for a place from which to observe. There were two domes, 12 feet in diameter; and the instruments consisted of a $5\frac{1}{2}$-feet transit instrument, by Troughton; a 2-feet mural circle, by the same maker; a 16-inch repeating circle, by Reichenbach; a 46-inch achromatic telescope, on equatorial stand, by Banks; a clock by Hardy, and another by Bregnet. All these were carefully placed, and a great many observations taken, which formed the basis of a catalogue of 7,000 stars, and several papers published in the "Philosophical Transaction," 1828 and 1829. Mr. Rumker left the Colony in 1829, and Mr. Dunlop was appointed in his place, a position which he held until the Observatory was dismantled, in about 1841. After the instruments were removed the building was allowed to fall into decay, and at one time there was a prospect that even its site would be lost. In 1875, however, Mr. Farnell, M.L.A., had £150 placed on the Estimates and voted, for the purpose of erecting a monument to mark the site of the old Observatory, and during the past year the obelisk, a handsome grained white marble one, has been completed under the direction of the trustees appointed, viz., Messrs. J. S. Farnell, M.L.A., James Barnet, Colonial Architect, and H. C. Russell, Government Astronomer. The inscription on it reads:—"An Astronomical Observatory was founded here May 2, 1822, by Sir Thomas Macdougall Brisbane, K.C.B., Governor of New South Wales. This obelisk was erected in 1880 to mark the site of the transit instrument in that Observatory."

In meteorology the field is so wide that I will not attempt a sketch of what has been done generally. Suffice it to remark that in our own Colony a steady advance has been made; the number of observing stations is steadily increased, and now amounts to 152, and the great majority of additional observers are found in the interior, so filling up space which has been a complete blank to the meteorologist; and the statistics now collected are of the utmost value for the present and future investigation of our climate. The rain map for 1879 has added to it a diagram showing the state of the inland rivers during the year, so that the effect of the rains can be traced in the rivers. I must not forget to mention that, owing to Mr. Russell's exertions, a meteorological conference was called together by the Government, and met at the Observatory. The report has been published, and contains important suggestions and arrangements for the study of the meteorology of Australia generally. Amongst minor matters should be mentioned the completion at the Observatory of a new recording instrument, which writes on a small sheet of paper, 19 inches by 8 inches, a complete record of every change in the thermometer, the barometer, the direction and force of wind, and the rain, in fact it is a complete meteorological observatory in itself.

To my excellent and most learned friend, Baron von Mueller, K.C.M.G., great praise is due for his indefatigable labours in working out the botany of this continent. In addition to the large share which he had in the publication of the "Flora Australiensis," a work which in itself is a monument of patient industry and pre-eminent ability, he has lately published a valuable atlas of the genus Eucalyptus, of which six decades have been received by me. This is of the utmost importance to botanists, as the elaborate plates contain figures of the leaves, flowers, and fruits of the species which have been referred to. The sections given of the flower and fruit, and the descriptive letter-press, are such as to enable any one with slight botanical knowledge to determine with ease the particular species described. The Baron has also accumulated considerable additional material for a continuance or supplement of the flora. Much of this has been attained by the collections made by Mr Alexander Forrest, during his last exploring expedition through North-west Australia, and by Mr. John Forrest, during that gentleman's triangulation of the back country of Nichol Bay. From this last collection we learn the astonishing fact that out of upwards of 400 species which it contains there is not a single orchid amongst them. The Baron's report of the forest resources of Western Australia, of which there is a copy in the library of this Society, is a valuable contribution to our knowledge of the vegetable economical resources of that Colony, and as a labour of love that gentleman has published, at his own expense, an index to the first edition of the "Species Plantarum" of Linnæus. This work was published in 1753, and is exceedingly rare, and the index will be the more valuable as it is from the second edition of that published in 1762 and 1763 that quotations are made in the more recent descriptive works on botany. I would also refer to the botanical researches of Mr. Bailey, F.L.S., of Brisbane, who has done much, under considerable difficulties, in investigating the botanical resources of Queensland. His works on the grasses and ferns of that colony are most creditable and highly interesting productions; and in an address recently delivered by that distinguished geologist and naturalist, the Rev. J. E. Tenison-Woods, F.G.S., F.L.S., we learn that Mr. Bailey is now engaged in working up the lower order of the Australian flora. I must also advert to and award my tribute of praise to the ability and research displayed by Mr. R. D. Fitzgerald, our Deputy Surveyor General, in the publication of his work on Australian orchids. When it is considered that this gentleman, during the time unoccupied by his public duties, has furnished with his own hand carefully and accurately drawn figures of the complete plant, and sections of all parts of the flower, and has given an excellent diagnosis of all the species which he has so beautifully illustrated, some faint idea may be formed of the industry required in carrying out so far this very valuable work.

While making this brief and very imperfect reference to what has been and is being accomplished in botanical pursuits, I may be pardoned in drawing attention to the very great necessity which now and has long existed of ascertaining the uses and economic value of the Australian flora. The knowledge which we possess of the properties of the greater number of the plants of the Colony is most imperfect. How little, for instance, is known of the value of what are termed the salt bushes of this country. It is believed, and with good reason, that this class of plants possesses a medicinal property of great advantage to sheep, which not only relish but fatten on this food, particularly in seasons of drought. It has not been determined which are the most valuable of these plants, a list of which is herewith appended. It is generally considered that of these *Atriplex halimodes* and *Atriplex vesicaria* are the best, but these are only found in certain localities—those called cotton bushes, *Kochia aphylla* and *Kochia villosa* and also *Chenopodium nitrariaceum* as well as others, afford excellent pasturage, but this is all that is really known of these most interesting and useful plants. The same remarks which have been made respecting these plants may be applied to the grasses of this country. Although the names and affinities of these have been botanically determined, we have yet very much to learn as regards the comparative nutritive value which these individually possess. An attempt has been made by Baron von Müeller to fix accurately the percentage of albumen, gluten, starch, gum, sugar, and fibre of the best of these, as compared with the best kinds of English grasses; but this attempt has not been brought to a satisfactory conclusion, as the different kinds experimented on have not yet been obtained at different stages of development and from various soils, so that the mean of different analyses may be taken. This is a most praiseworthy effort on the part of the Baron, and it is well worth imitating by some of our practical chemists; but however valuable the information derived in this way may be, we must look to the occupants or owners of our sheep and cattle runs to practically learn the real value of these plants. Observations of this kind should be based upon some intelligent principle, and it should be carefully noticed the kind of situation, whether low or high, dry or damp, and the nature of the soil in which the different species succeed best, whether early or late in flowering, and the kind of stock that fatten best by feeding upon them. In very many parts of the Colony, particularly on the sheep runs, a good number of the best grasses have been entirely destroyed by being too closely eaten down, for instance the well-known kangaroo grass, *Anthistiria Australis*, originally the most generally distributed and most valuable native grass, almost wholly disappears on sheep runs, while on country stocked with cattle it thickens and improves in quality. During the past season I have had collections of grasses sent to me from the Darling and other partially or wholly unstocked parts of the country. Many of the most luxuriant and nutritive of these were general in former times in the more settled parts of the southern and western districts, but which, from the causes alluded to, are now rarely to be found. It is the native grasses that we must, I think, depend on to form our permanent pastures, as hitherto, with very few exceptions, the introduced plants of this class have failed, or only partially succeeded. Of these, so far as I am aware, the only permanent kinds are buffalo grass, *Stenotaphrum glabrum*, the couch of colonists, *Cynodon dactylon*, and perhaps the American prairie grass, *Bromus Schraderii*, which grows well in all parts of the Colony, while the two former will only flourish within the coast range. I would also urge on our stock-owners the importance of making careful observations relative to the value which may be attached to other kinds of fodder plants, so that on well-founded grounds the growth of the more durable and fattening kinds may be encouraged and those of poorer character allowed to die out.

For some years back various species of Eucalyptus, growing thickly over extensive areas extending from Camden southwards, have been dying off, and in a manner so regular as to appear to have been caused by human agency. From the repeated examinations which I have made of localities where this singular phenomenon has occurred, the only hypothesis which I can arrive at is, that the trees have been destroyed by fungus at the roots. In this conclusion I am borne out by the fact that the trees do not die over any large area simultaneously, but become affected in the first instance on one particular spot, and gradually die off, usually in a direction from north to south, and in belts of more or less width, leaving those growing on either sides of such belts entirely unaffected, for which no reason has yet been satisfactorily assigned. If it be a fungus which thus destroys these trees, the question arises why it does not spread laterally instead of proceeding in one direction; and to this I have no answer to give. It is certain that on the roots of the dead trees a minute fungus of a whitish colour has been observed, but a similar fungus growth is common on the roots of other dead trees which have perished by decay. The investigation of this subject is one to be commended to every man of intelligence who may have the opportunity of inquiring into it.

My attention has of late been frequently drawn to another strange occurrence, very different from the last, but almost as difficult to explain. Over many parts of the country lying between the Lachlan and the Murray River a species of *Frenela*, Mirb., locally called pine, is spreading so rapidly and so thickly as to seriously affect the grazing capabilities of station property generally. This tree bears cones, having small seeds, somewhat angular in shape and hard in substance, but not at all likely to be carried about by the agency of birds or animals of any kind. The country over which it is spreading so fast and in such profusion has long been occupied as sheep and cattle stations, but until the last few years no great increase of the tree had been noticed. As this new growth cannot have had a spontaneous existence, it can only be supposed that the seeds have been lying in the ground for a long and indefinite period. This is the only explanation which I can offer for the very extraordinary manner in which this tree is spreading. It is not one, I must admit, quite satisfactory to myself, as, unlike seeds of certain Acacias, those of Callitris readily vegetate when placed in the earth, nor does it appear that the ground has undergone any unusual change to cause the seeds to germinate.

As yet absolutely nothing has been done in this Colony towards re-foresting any part of this country, and it is no easy matter to suggest a practicable plan by which this most desirable object could be accomplished. Valuable reserves have been made, however, in many well-timbered parts of the country, under the care and supervision of public officials. These reserves will preserve many excellent kinds of trees from being recklessly wasted, and most useful hereafter as a means of supplying seeds and plants of our best kinds of trees for the purpose of planting out future forests in the adjoining or other districts in situations where they may be expected to succeed. It is much to be regretted that reserves of this description were not made at an earlier period, for, had this been done, we should not have had to lament the loss and destruction of a class of vegetation as rich in numbers of species and as luxuriant in growth as can be found in any part of the world: I refer to the coast jungle forest extending from Shoalhaven in the south to the northern extremities of the Colony, which for the most part has been cleared. A quarter of a century ago the beautiful district of Illawarra, which is about 40 miles south of Sydney, was clothed with a dense mass of trees, shrubs, &c., with a foliage as rich and varied in appearance as could be found in any tropical country; and now, alas! with one especial exception of about 40 acres, nearly the whole of this magnificent vegetation has been destroyed, and the country turned into grazing paddocks. This especial exception is the property of a coal company, which fortunately has preserved the surface in its primitive condition, and on which can still be seen gorgeous masses of two different kinds of palms, called, locally, the bangalow and cabbage-tree palms; known botanically as *Seaforthia elegans*, and *Corypha Australis.* These, with three or four kinds of tree-ferns, viz.:—*Alsophila Cooperii*, *Alsophila Australis*, *Alsophila Macarthurii*, and *Dicksonia Antarctica*, and many climbing plants, and a dense undergrowth overtopped by species of Ficus, Eucalypts, and other tall trees, the trunks and branches of which are often clothed with an abundance of stag's-horn fern *(Platycerium Alcicorne)* and bird's-nest ferns *(Asplenium nidus)* and other similar plants, present to the eye a scene of beauty perhaps unequalled beyond the tropics. To the owners of this beautiful property the thanks of the community are due for preserving from destruction this now nearly the only remaining portion of the glorious natural vegetation which originally characterised the greater part of this lovely district. It may be assumed with some degree of certainty that within the last quarter of a century, from natural decay, ring-barking and clearing for cultivation, at least one-half of the timbered land of this country has been denuded of its forest vegetation. Looking at this fact from the point of view that climatic changes are largely affected by adding to or destroying to any considerable extent the forests of a country, it might have been expected that ere this time a very considerable diminution of our rainfall would have been experienced, but it is certain that this has not been the case, as statistics rather tend to show the reverse, nor have our principal rivers been diminished in volume of water. In support of this statement, I received from the Colonial Astronomer the accompanying diagram and letter:—

"I send you herewith diagram showing by vertical lines the rainfall for each year. For instance, the rainfall of 1840 was 48 inches, and is shown by the line under that year coming up to 48 inches, so on for each year. The straight horizontal line shows the mean of 40 years, and the short red lines show the means in periods of 5 years. You will at once see that the rainfall of the first 20 years was less than the second 20 years, for in the first 20 three of the red lines are below the mean, and one above; while in the second 20 three red lines are above the mean, and one below. I have thought of several ways of showing what you want, but this seems to be the best. Actual amounts in figures are also given. Lake George furnishes a good index of our seasons: when found, in 1820, it was very full; then it dried up, and now it has more water than ever before. If you look at page 182 of my book on the Climate of New South Wales, a copy of which I think you have (if not I will send one), you will find some notes about Lake George, which will interest you, *re* changes of climate.

"Yours very truly,
"H. C. RUSSELL."

Our late lamented Vice-President, the Rev. W. B. Clarke, read a most able paper on this subject shortly before his death, tending to show the good results as regards moisture and temperature which had arisen from planting trees in various countries. I am not now about to dispute the conclusions arrived at in that paper, but as a rule in discussing this matter too little consideration is given to the effect of natural agencies. There cannot be a doubt that the climate, rainfall, and vegetation of a country are all more or less influenced by geographical position. For instance, the average thermometer range of Western Australia is very similar indeed to that of this Colony; yet how very different is the vegetation. Here, within our coast ranges, moist, densely-wooded jungle forests prevail, in which a great profusion of ferns and several kinds of palms abound; there, for the most part, very little is to be seen but an apparently parched-up small-growing description of scrub, in which there is but very little trace of ferns. This remarkable difference in the coast flora of these two countries is wholly due to position and climate, for although the temperature of both places is almost identical, the rainfall is double in the former to what it is in the latter. The jungle forests, as I understand the term jungle to mean trees, shrubs, and climbing plants, and undergrowth intermingled into a dense mass, could not exist in so dry a country as Western Australia. It follows that there are natural laws which govern the rainfall of a country, and to alter these to any very appreciable extent is beyond the power of man. This opinion I know is a debatable one, and I shall be very pleased if any fellow member will take the subject up and endeavour to prove that I am in error. If the inference which I have drawn be correct, the partial destruction of our forests, present or future, will not alter to any great degree the rainfall or temperature of this climate.

I must now trespass on your patience for some minutes while I say a few words relative to certain views advocated by the illustrious Darwin in his work on "Insectivorous Plants." The opinions held by this author on this subject, and so powerfully enforced in the work referred to, have been accepted by very many of the most distinguished naturalists of the present day, and it may seem somewhat presumptuous in me to question some of the conclusions arrived at; but when any man, however great, ascends into the realm of uncertainty for arguments in support of his theory, he cannot be astonished at any effort which may be made to controvert them. I am in the unhappy position of being unable to acquiesce in the doctrine that the plants termed insectivorous, or those that are said to derive their nourishment from animal matter, captured through the agency of their leaves, were intended by nature to depend on, or benefit by, any such means for their support. Darwin does not claim to have originated this idea—it is, in fact, a very old one. In some of the early illustrated botanic works figures are given representing insects caught by the leaves of some of these plants. In the *Botanical Magazine* of 1804 there is an illustration of *Dionœa muscipula*,—the Venus fly-trap—showing a fly compressed between the lobes of its leaf, and of this there is a sketch on the table. That the leaves of this plant are sensitive, and the lobes will close upon each other by irritating the glandular hairs on the inner surface, is beyond doubt. In early days it was a favourite amusement of mine to test the irritability of these leaves, and to place flies upon them for nourishment; but the invariable effect of this was, if often repeated, to destroy the leaf and injure the plant, and of the many similar experiments which I have seen reported in the press as tried by practical cultivators, I cannot recollect an instance which had resulted in success. Then as regards the *Droseras* or sundews, several species of which are to be found growing around Sydney, there is no sufficient evidence adduced here or elsewhere to show that these plants derive any benefit from nitrogenous or animal matter under natural conditions. It is true that insects are often found caught by the tentacles or glandular hairs with which the leaves of these plants are clothed, but I have for many years past sought for proof of their animal-devouring properties, by examining them under all kinds of circumstances and in every possible situation, but all my investigations have failed to afford me the slightest grounds for believing that they absorb and assimilate nitrogenous matter as food. These plants seldom grow far apart, but are usually associated in masses, the smaller species on moist banks, and the comparatively large one, *Drosera dichotoma*, in marshy places; the last may be seen in profusion in the water reserve, and some of the former kinds on the North Shore, so that those who are curious about this subject have ample opportunities of judging for themselves; and if any unprejudiced observer will examine these plants, he will find, particularly among the smaller species, some with insects attached, but the great majority without a vestige of animal life about them; but in either case I can with confidence predict that he will not detect any difference in growth. This may seem a very summary way of disposing of this question, which has been so ably worked out by Darwin, who has shown that the glands of both the Dionœa and the Droseras have the power of secreting a viscid fluid, which, like the gastric juice of animals, has strong digestive properties capable of dissolving raw meat, and that they can absorb soluble nitrogenous matter, which is in itself a powerful argument in favour of the view that these plants prey upon insects. It is a plausible theory, but I am convinced a mistaken one. I have been induced to mention this last subject, as it was one not long since debated at one of the sectional meetings of this Society, on which occasion very contradictory opinions were expressed in regard to the views of Darwin.

[Diagram.]

DIAGRAM SHOWING RAINFALL IN INCHES AT SYDNEY FROM 1840 TO 1879.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

5e6-81

On the Longitude of the Sydney Observatory.

By John Tebbutt, F.R.A.S.

[*Read before the Royal Society of N.S.W., 2 June, 1880.*]

In June, 1878, I had the pleasure of reading before a General Meeting of the Royal Society of N.S.W. a paper on a proposed correction to the adopted longitude of the Sydney Observatory, and a few days subsequently I contributed to the Astronomical Section a supplementary paper on the same subject. The correction to the longitude, 10h. 4m. 45·74s. E., was based on the longitude of my own Observatory, derived from ten lunar occultations of stars and the difference of longitude of the two Observatories obtained from telegraphic signals. The assumed longitude of my Observatory was 10h. 3m. 15·70s. E., its correction from the ten occultations + 6·84s., the telegraphic difference of longitude + 1m. 28·83s., and the concluded longitude of the Sydney Observatory 10h. 4m. 51·37s. E. East longitude is here supposed to be positive. The occultations were all disappearances at the moon's dark limb, and the corrections of the moon's places were derived from the published observations at Greenwich alone. Since 1878 I have been enabled to extend my investigation to thirteen additional occultations, so that it now comprises altogether twenty-three occultation-phases, of which nineteen are disappearances at the dark, and four are reappearances at the bright, limb. For the occultations down to the close of 1875 the corrections of the Nautical Almanac places of the moon are obtained from the published observations at Greenwich, Radcliffe, and Washington, and for those in 1876 from MS. data kindly furnished to me by the Astronomer Royal and the Superintendent of the Washington Observatory. The moon's apparent right ascension and declination have, in each case, been interpolated with second differences from the hourly ephemeris of the Nautical Almanac and the corrections applied. The moon's horizontal parallax and her semi-diameter have likewise been interpolated with second differences, but no correction has been applied to the values so obtained. In the discussion I have adopted the geographical latitude of my Observatory as —33° 36′ 28·9″ and Bessel's ratio of the earth's semi-axes. —33° 25′ 53·0″ and 9·9995576 will, therefore, represent respectively the corresponding geocentric latitude and the log. earth-radius. In the subjoined table will be found certain data employed in the twenty-three determinations, together with the resulting individual corrections of the longitude of my Observatory. It will be seen that the mean of the twenty-three corrections is + 6·11s., and we have the derivation of the longitude of the Sydney Observatory as follows:—

	H.	M.	S.
Assumed longitude of my Observatory	10	3	15·70
Correction from the occultations			+ 6·11
Concluded longitude of my Observatory	10	3	21·81
Longitude of the Sydney Observatory east of mine		+ 1	28·83
Concluded longitude of the Sydney Observatory	10	4	50·64

I observe in the introduction to the Melbourne observations for 1871-5, recently issued from the press, that a comparison of the tabular errors of the moon's right ascension derived from the Melbourne observations in 1874 and 1875, with the errors derived from the Greenwich observations of the same dates, shows that the longitude hitherto adopted for the Melbourne Observatory from moon culminations requires no appreciable correction. The longitude of the Melbourne Observatory is 9h. 39m. 54·8s. E., and the telegraphic difference of longitude between Melbourne and Sydney is, I believe, 24m. 55·77s., so that, by this combination, we get 10h. 4m. 50·57s. E., as the longitude of the Sydney Observatory. Mr. Russell obtains directly from the Sydney moon culminations in 1863 and 1871-2-3-4 the value 10h. 4m. 50·81s. The agreement between the three results is remarkably close, and I think we may reasonably conclude that no more satisfactory result is likely to be obtained from a consideration of the moon's motions alone. I shall await with interest the confirmation of their accuracy by telegraphic connection with Europe.

Observatory, Windsor,
27 April, 1880.

Day and Year of Observation.	Star observed.	Observatory Mean Solar Time of Occultation Phase.			Phase of Occultation.	Adopted Apparent Place of Star.						Corrections to Moon's Tabular Places.		Concluded Correction to Longitude.
						R.A.			N.P.D.			R.A.	N.P.D.	
		h.	m.	s.		h.	m.	s.	°	′	″	s	″	s
18 April, 1866	B.A.C. 1468	6	14	36·2	D	4	38	27·73	71	30	46·8	+0·02	+0·1	+ 7·55
15 Oct., 1866	,, 6267	7	21	22·3	D	18	20	9·59	107	52	29·8	−0·16	+2·0	+14·27
27 Feb., 1868	μ Piscium	7	48	46·9	D	1	23	15·46	84	32	24·2	−0·06	−0·7	+10·04
2 March, 1868	m Tauri	10	11	27·2	D	4	59	39·31	71	32	14·8	+0·14	+0·1	+17·42
17 Feb., 1869	ξ' Ceti	8	3	32·6	D	2	6	2·76	81	46	18·5	+0·01	−0·4	+12·09
24 Feb., 1869	δ Cancri	8	0	49·3	D	8	37	15·19	71	22	7·1	−0·24	0·0	− 1·35
11 Feb., 1870	ζ Tauri	8	18	1·5	D	5	29	52·76	68	56	26·7	−0·14	+0·5	+ 3.51
30 Nov., 1870	ψ' Aquarii	10	7	52·2	D	23	9	6·54	99	47	33·5	−0·38	−0·6	+11·72
1 April, 1873	A′ Tauri	6	53	44·3	D	3	57	10·19	68	15	59·6	−0·42	+1·1	+ 5·45
2 Sept., 1873	σ Sagittarii	13	27	17·2	D	18	47	25·86	116	27	12·2	−0·49	+0·8	+ 6·79
27 Feb., 1874	ψ' Cancri	10	53	58·7	D	8	2	36·99	63	47	7·5	−0·61	−2·7	+ 9·61
30 May, 1874	δ Scorpii	11	36	34·9	D	15	52	55·21	112	15	53·1	−0·48	−3·8	+ 5·64
15 April, 1875	η Leonis	9	16	47·9	D	10	0	32·44	72	37	43·2	−0·56	−2·8	+ 3·06
22 May, 1875	3 Sagittarii	11	19	37·3	D	17	39	43·91	117	46	59·8	−0·52	−1·4	+ 3·10
7 Sept., 1875	Antares	7	11	17·7	R	16	21	46·78	116	9	24·7	−0·29	−0·6	+ 2·41
9 Sept., 1875	B.A.C. 6220	8	24	3·7	D	18	14	8·42	118	29	16·1	−0·29	−0·6	+ 7·81
2 June, 1876	Spica	12	34	7·2	D	13	18	41·83	100	31	5·6	−0·62	−4·8	+ 5·08
2 June, 876	Spica	13	39	5.2	R	13	18	41·83	100	31	5·6	−0·62	−4·8	− 0·83
3 July, 1876	Antares	12	14	41·0	D	16	21	51·55	116	9	34·0	−0·63	−2·1	+ 7·74
3 July, 1876	Antares	13	7	32·9	R	16	21	51·55	116	9	34·0	−0·63	−2·1	+ 3·91
28 Oct., 1876	λ Aquarii	7	50	21·6	D	22	46	12·16	98	14	1·8	−0·48	+3·4	+ 5·40
28 Oct., 1876	λ Aquarii	9	12	51·4	R	22	46	12·16	98	14	1·8	−0·48	+3·4	− 0·61
28 Oct., 1876	78 Aquarii	9	30	39·7	D	22	48	10·21	97	51	28·6	−0·48	+3·4	+ 0·74
												Mean	...	+ 6·11

NOTE.—The disappearance of m Tauri and 3 Sagittarii, and both phases of the occultation of Antares on 3rd July, 1876, were very unfavourable for longitude determinations.

Note on the Opposition-Magnitudes of Uranus and Jupiter.

By John Tebbutt, F.R.A.S.

[*Read before the Royal Society of N.S.W., 2 June, 1880.*]

In a note which I communicated to the Astronomical Section in May, 1878, I pointed out the gradual increase in the brightness of Uranus at each successive opposition, which increase will go on till the opposition of 1882, after which the planet's brightness will diminish. On the evening of 24th April, 1878, or sixty-seven days after the opposition, I found the planet to be of the $5\frac{1}{2}$ magnitude, the comparison being made by means of a small telescope with Nu (ν) Leonis. The star and planet were seen in the same field of view, and were estimated to be equal. On 18th March last, or twenty-one days after opposition, I compared the planet with B.A.C. 3621 and 3622. The comparison, which was made by means of the naked eye and also a small telescope, showed the planet to be about equal to the former but superior to the latter. The B. A. Catalogue gives $5\frac{1}{2}$ and 6 respectively as the magnitudes of the stars, so that Uranus may, at the recent opposition, be safely recorded as a star of the $5\frac{1}{2}$ magnitude. Some idea may be formed of its conspicuous character when it is stated that I determined pretty accurately its distance from Regulus and γ Leonis by means of an ordinary sextant. I may here draw attention to the circumstance that Jupiter will, at its opposition in October next, be very near its perihelion, and that the planet will in consequence be a very brilliant object. At each opposition near perihelion, which occurs every twelve years, it rivals Venus in brilliancy, and may be seen distinctly without a telescope in full sunlight. It was a splendid object in September and October, 1868.

Observatory, Windsor,
April 27th, 1880.

Some New Double Stars and Southern Binaries.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W., 2 June, 1880.*]

It is known to some of the members present this evening that I have for some time past devoted a considerable portion of my time to the examination of the double stars found in Sir John Herschel's Cape Observations. While doing this work I have frequently found double stars that he had overlooked; and I have occasionally devoted a fine evening to the search for close double stars, generally with some results in the form of interesting double stars. The number thus recorded has gradually increased until now it stands at 252. Of this list many are close doubles, probably too difficult for the optical means which Sir John Herschel had at his command, and which therefore escaped his search.

Excepting in the case of two or three, I have not published the positions of any of these stars, but they are now arranged in a catalogue to be sent to the Royal Astronomical Society for publication. There are, however, amongst them some that are favourably situated for observation just now, and I determined to place a list of these before you, in the hope that it may prove interesting to some of the members. In preparing the list I have been guided by the requirements of those who have telescopes of moderate power, so that some of the doubles are easy, and others very difficult, in fact, such as may be used as tests for instruments of higher power. It seems highly probable that at least one of these is a binary, and it will be interesting to watch the changes going on in this close double star. I would like to say, however, that the observer must not be too sanguine, otherwise he may be disappointed in finding relative motion in stars so rare. Yet, here and there, amidst the great mass of double stars, one will be found manifestly subject to the great law of gravitation, which is the ruling power in our solar system. In a study of this kind the greatest care is necessary to avoid being misled by errors of observation or of accident. I could refer to a published list of southern double stars in which several are set down as binaries, or probably in motion, the change in which is not real, but due to the causes mentioned. One curious instance in my own experience may illustrate this. On the 6th October, 1834, Sir John Herschel found a pretty double star, which is entered in his list as No. 3,416. The magnitudes were both 8, the distance between them 3″, and the angle of position 126° 1′. Two years later he examined the same star, and found the magnitudes the same, but the distance was then 6″, and the angle of position 128° 7′. Here seemed unmistakable evidence of motion, and when I turned the telescope to examine the star in 1870, by accidentally misplacing the telescope, only the diameter of the field of view, I found another star of the same general character, and which seemed to be Herschel's star, but the angle proved to be 192°, and the distance 23″. When examined, these three positions fitted (making allowance for probable errors) so nicely into an elliptical orbit that I felt sure here was a new binary. The distance seems large, but it has been proved that there may be a distance of 22″ between two stars in an orbital system, and here was but one second more. The slight difference in right ascension and declination did not attract much attention, because it is not uncommon to find such errors in the Cape catalogue. Subsequent observation, however, revealed no change in my star, and on searching more carefully I found Herschel's star, of which the distance proves to be 5″2, and the position angle 125° 38′, nearly a mean between Herschel's distances, and about the same angle, proving that no appreciable change has taken place in it since his time.

Of the new double stars which I propose to put before you to-night, 22 are in the constellation Crux, as shown in this map, which you will see has in some directions extended the limits of the constellation. For the purpose of showing you their relative positions with regard to other stars in that constellation, I have had this diagram prepared, which shows, first, the positions of the catalogued stars; second, Sir John Herschel's 25 doubles; and, thirdly, my own with a black circle round each. The first of these in R. A. 11h. 40m., dec. 57° 20′, is a very pretty double, of which the distance is 5″, both of the 9th magnitude, and yellow: at 11h. 59m., and dec. 61° 12′S. is a very pretty double star, both being of 8th magnitude, and distant 61° 12′ 9″. At 13h. 0m. is another double, very close indeed, of which the distance is probably not more than 0·5″. There are some twenty others in Crucis, which may be found in the list or map. I have been thus particular in giving the new doubles in Crucis, because I am anxious to record all the objects of interest which this beautiful constellation exhibits.

The other list containing stars has been extracted from the general list of 252 new ones, each having some peculiarity that would make it specially useful or interesting to the observer. One of these at 10h. 45m., dec. 58° 38′, when first found in 1874 was a very difficult double star, of which the distance was less than ½ a second. Perhaps an idea of the difficulty of seeing and measuring such a pair may be best conveyed to the non-observer by saying that in a large telescope (7¼ inches) the two images of the stars of this double, formed in the focus, would only be separated by a linear space of one four thousandth part of an inch. The angle and distance of this pair have gradually increased since 1874, until now the distance is over 1″, and there is reason to suppose that this will prove a binary system. Another star almost equally difficult is one easily seen by the naked eye: it is β *Muscæ*, the second brightest in the little constellation, under the foot of the cross. It proves to be a close double, and was divided by the large telescope first in April, 1878. The measured distance is only 0″54, and the angle of position 317° 16′. It forms a most beautiful object when seen under suitable optical power, and will serve as a capital test for defining power. Of the other stars in the list it is perhaps unnecessary to speak particularly. They are just a few out of the larger list, and may be interesting.

Binary Star.

In the diagram are shown all the determined positions of the interesting binary star *p. Eridani*, one which has attracted considerable attention from the fact of its rapid motion. It will be seen that when the observations are corrected, so that all the measured angles are relieved of the uncertainty caused by the stars being of the same magnitude, they may be plotted into an ellipse. It must, however, be noticed that Dunlop's angle of position will not agree with the others until corrected, for an error probably due to the use of a reflecting telescope, for while he says the angle was in the *north following* quadrant, the work of all the other observers goes to show that it must have been in the south following quadrant, and I have so used it in the diagram. Dunlop's distance seems to be too small, and that it was so is probable because his instrument was small, and the distance only estimated. Captain Jacob, many years since, computed an orbit for this binary which seemed to satisfy the then existing observations; he made the period of revolution 123 years, and in making a second attempt reduced it to 107 years. The subsequent observations, however, including some of his own and those up to present date, go to prove that the longest of these periods is too short, and the period which seems to satisfy the observations best is 144 years. It is, I think, evident that Captain Jacob attached too much weight to Dunlop's distance, and by so doing reduced the computed period of revolution.

We have seen that the apparent orbit is an ellipse, and most of the observers agree in stating that the stars are of equal brilliance, and since they form a binary system they are at equal distances from the earth, and they must on theoretical grounds be of equal dimensions; but two such stars forming a binary system would revolve, not one about the other, but about the common centre of gravity, which, if the stars are equal, would be a point midway between them, so that this seems to be a well marked instance of this curious phenomenon, viz., two immense bodies revolving about a point in space, *i.e.*, about nothing; but this implies more, for while one star appears to us to be going round the other, both would, if we could refer their position to some fixed point, be found to have changed their places in proportion to their motion in their orbits. It so happens that these stars are now favourably situated for detecting such a change with the transit instrument, and they will be regularly observed for that purpose. But from an examination of the Cape and Madras catalogue it seems evident that the star taken as the fixed one is actually in motion. But the question may be viewed in another way; unless stars are connected in binary systems, the only test we have of their magnitude is the amount of light they send to us. Now, here we have two stars equal in light and therefore theoretically equal in size, and, as we have seen before, such an orbital pair will revolve about a common centre of gravity, and such a motion would appear to us as if one star went round the other in a circle, or, if the orbit were oblique to the line of sight, in an ellipse of which one star always occupied the focus. Now, all the observations go to show that if this is a binary the apparent orbit is an ellipse of which one star does not occupy the centre, and therefore, though equal in brilliance, one must be larger than the other.

It was my intention to have placed before you facts relating to several other southern binary stars, but the pressure of other engagements has rendered this impossible now, but I hope at no distant date to place before you some of the results of my observations of Sir John Herschel's doubles, and I may then include the information I am now obliged to defer. I may say, however, that the number of those which give certain evidence of being binary is small; perhaps, however, not smaller than might have been expected from previous experience, for it has been found that out of 11,000 double stars which were examined only 518 gave certain evidence of binary motion.

LIST OF NEW DOUBLE STARS IN THE SOUTHERN CROSS.

No.	R.A.	Dec. S.	Position Angle.	Distance.	Date of Discovery.	Mags.	Colours.	Remarks.
	h. m.	° ′	°	″				
1	11 40	57 20	4·778	5·07	1871·426	9 9	Both yellow.	
2	11 58	61 10	62·000	9·32	1880·402	10 10	....	Pretty pair.
3	11 59	61 22	147·900	14·40	1880·402	8 8	....	Triple, very pretty.
			19·167	24·84		8 9		
4	12 0	60 35	231·800	20·00	1880·426	......	....	A very remarkable cluster of stars, in which are no less than five conspicuous double stars within 10″ R. A. and 2′ in declination.
5	12 4	60 21	210·550	3·87	1880·426	9 10	....	A little north of ε Crucis and 80″ preceding it.
6	12 8	60 21	307·583	7·94	1880·426	10 11	....	In same field another about same size and following on same parallel; another, or perhaps two more, all good.
7	12 8	60 25	276·883	8·95	1880·426	11 11½	....	
8	12 14	59 34	31·750	12·06	1880·402	11 11	....	
9	12 21	60 12	134·583	2·99	1880·429	10 11	....	A number of 11th magnitude stars about.
10	12 22	61 8	270·467	2·43	1880·382	7 8	Both yellow...	The most northern of three stars nearly in a line; middle one 7th magnitude; bright orange yellow and has a distant companion.
11	12 27	57 10	40	6	1880·432	11 12		
12	12 31	57 30	100·700	20·00	1880·432	9½ 9½		
13	12 37	55 15	261·633	18·58	1880·432	9 9		
14	12 41	55 23	193·208	1·58	1878·278	9 10	Light yellow.	
15	12 59	61 3	109·400	5·55	1874·456	10 10½	White.	
16	12 59	59 14	19·256	0·63	1880·346	8 8	....	Very fine double.
	......	......	25·750	0·70	1880·426	8 8		

A few interesting Double Stars.

No.	R.A.	Dec. S.	Position Angle.	Distance.	Date of Discovery.	Mags.	Colours.	Remarks.
	h. m.	° ′	°	″				
1	10 40	48 55	54·633	2·81	....	3 10		
2	10 45	58 38	256·033	0·40	1874·188	7 8	....	A 7th magnitude star 4′ 30″ after the most northerly part of the cluster η Argus. Power used 333, very fine definition. Distance less than ½ a second. Telescope, 7½-in. Merz.
	......	.. ...	257·250	0·72	1876·128	7 8	....	7th magnitude, close double, following η Argus. Small star precedes. 11½-inch Schroeder telescope. Power used 400. Fair definition.
	......	......	261·417	0·95	1878·224	7 8	....	Aperture 9-in. Power 800. Good definition. Dark night. Observations taken before meridian passage. 11½-in. telescope.
	......	.. ...	258·817	1·15	1880·204	......	....	11½-in. telescope. This pair seems to be in motion.
3	10 50	58 27	55·217	1·80	1879·287	8 8½		
4	11 6	46 27	59·450	3·15	....	8 8		
5	12 38	67 17	317·267	0·54	1878·300	4 ...	....	A close double, β Muscæ; one of the closest I know.
6	13 20	57 25	169·983	3·99	1874·421	9½ 9½	....	Fine calm night. Very pretty bright pair. Power 140.
7	13 22	76 58	150 ±	12 ±	1871·451	7 10		
8	13 23	57 56	210 ±	1 –	1878·284	10 10	....	A very hazy-looking ill-defined pair; about the middle of a remarkable string of stars.
9	13 45	73 13	130 ±	10 ±	1871·432	9 9		
10	13 47	53 40	350 ±	2 ±	1878·284	9 9	Both yellow.	
11	13 50	77 50	165 ±	4 ±	1871·432	8½ 9		
12	14 27	46 8	291·375	5·50	1874·432	9 10	....	Power 140. Definition good. Fine double.

Discussion.

In answer to a question by a member respecting the diagram showing the changes of position of the double star *p. Eridani*, Mr. Russell explained that Dunlop, Herschel, Jacob, Powell, and himself, had all taken the components to be equal, and some ambiguity had hence arisen in regard to the direction of the line joining the two stars, or in other words the angle of position. Herschel had put it in the south following quadrant, while Jacob, Powell, and himself had placed it in the preceding quadrants; out of deference to Sir John Herschel he had added 180° to the angles of the three last, so that the diagram represented the companion star on the following side; there were not wanting, however, reasons for supposing that the more correct way would have been to add 180° to Herschel and Dunlop's positions; for this star had been observed at Madras, in 1840, when the direction of the line joining them would be nearly in a parallel of latitude, so that bisecting the image in the transit instrument would not appreciably affect the declination of either star. The observations at the Cape, in 1876, when the angle of position had become about 54° show when compared with those at Madras that one of the stars had moved 3·1 seconds of arc, while the other seemed to be fixed, and these observations prove that the change is in the preceding star, and therefore the angle of position should have been taken on the preceding side; for the purpose of the diagram, however, which was merely to show the motion, this is not material. Mr. Russell said he would like to direct attention to one possibility which the diagram reveals, viz., that this may not be a binary star at all, but merely one star passing another by reason of its proper motion. It will be seen that, excepting Herschel and Dunlop's observations, a straight line will satisfy the other observation better than any ellipse or curve that may be tried. Now Dunlop's distance was not the result of measure—it was merely an estimate made with most inadequate optical means, and the telescope, a small equatorial used by Sir John Herschel, was by no means, equal to those used by more recent observers; and a small error in distance, if it exists, the possibility of which no one would have more readily admitted than Herschel himself, would at once place this star out of the list of binaries; already the orbit computed by Jacob has proved too small to include the observations, and the period requires to be increased as we have seen to 144 years, and the uncertainty attending the early observations lends force to the supposition that we have here only the effect of proper motion.

[Two diagrams.]

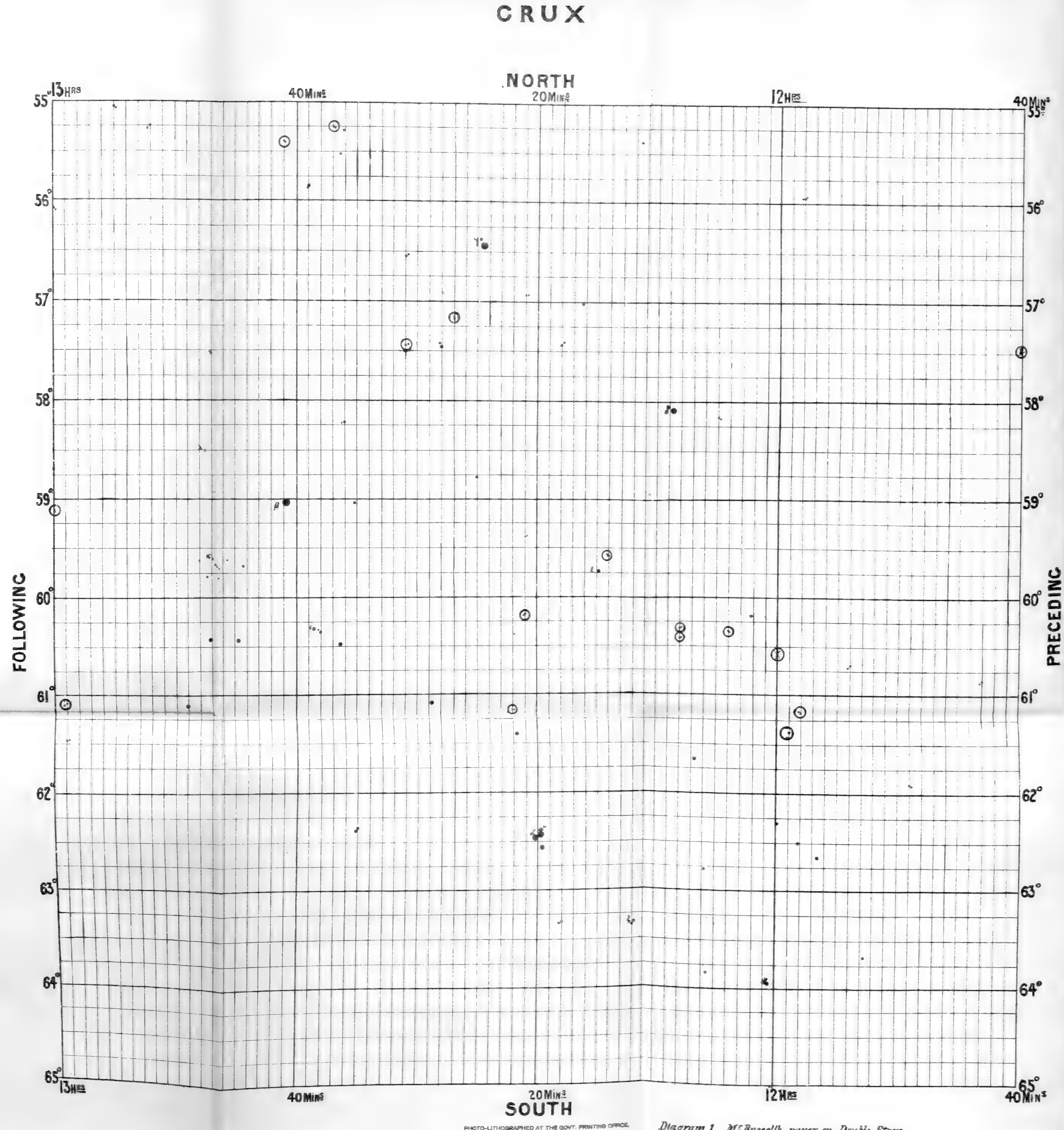
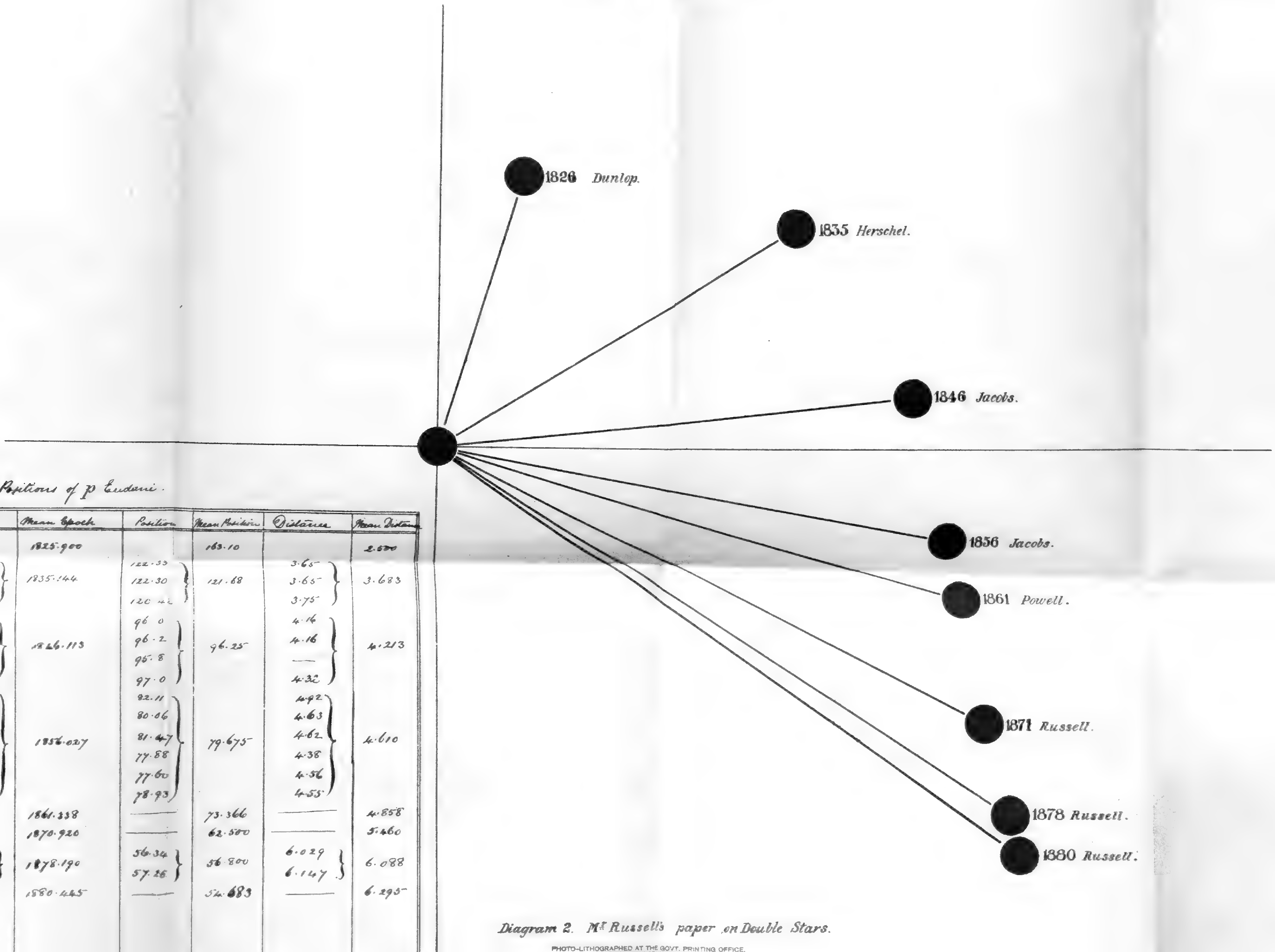


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

Diagram 1. Mr Russell's paper on Double Stars.

DIAGRAM SHEWING OBSERVED POSITIONS
OF
p ERIDANI.



Positions of p Eridani.

Observer	Epoch	Mean Epoch	Position	Mean Position	Distance	Mean Distance
Dunlop		1825·900		163·10		2·500
Herschel	1834·850		122·33		3·65	
"	1835	1835·144	122·30	121·68	3·65	3·683
"	1835·583		120·[illegible]		3·75	
Jacobs	1845·870		96·0		4·16	
"	1845·870	1846·113	96·2	96·25	4·16	4·213
"	1845·880		95·8		——	
"	1846·830		97·0		4·32	
Jacobs	1856·077		82·11		4·92	
"	1856·085		80·06		4·63	
"	1856·104	1856·027	81·47	79·675	4·62	4·610
"	1857·992		77·88		4·38	
"	1857·976		77·60		4·56	
"	1858·017		78·93		4·55	
Powell	——	1861·338	——	73·366	——	4·858
Russell	——	1870·920	——	62·500	——	5·460
" *	1878·164	1878·190	56·34	56·800	6·029	6·088
" *	1878·216		57·26		6·147	
" *	——	1880·445	——	54·683	——	6·295
*	Power 800					

Diagram 2. Mr. Russell's paper on Double Stars.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

On the Orbit-Elements of Comet I., 1880 (Great Southern Comet).

By J. Tebbutt, F.R.A.S.

[*Read before the Royal Society of N.S.W., 7 July, 1880.*]

The comet which forms the subject of the present paper was one of the grandest of modern times, and if we consider its probable identity with the great southern comet of 1843, we shall understand how interesting an object it must be to the astronomer. Owing to the low altitude of the comet during the first days of its visibility, and the persistently cloudy state of the horizon, it almost escaped unobserved in our Australian colonies. I myself saw the tail on several occasions, but only on one evening could I get a sight of the head, and then for a few seconds merely, between clouds. Fortunately the weather was more favourable at the Melbourne Observatory, and Mr. Ellery, and his valued assistant, Mr. White, succeeded in obtaining observations on the evenings of February 9th, 10th, 14th, 15th, 16th, and 17th, and these Mr. Ellery has very kindly communicated to me. On May 21st the *Observatory* for April 1st came to hand, from which I learned that communications had reached England from Mr. Gill, of the Royal Observatory at the Cape of Good Hope, and also from some private observers, respecting the comet. The observations sent, however, were very rough, and of no value for an accurate determination of the comet's orbit. In a paragraph of the same number of the *Observatory* it was also stated that Dr. Gould, of the Argentine National Observatory at Cordoba, had observed the comet. The following elements communicated by Mr. Hind had been computed respectively by Mr. Finlay, Chief Assistant at the Cape of Good Hope Observatory, and by Mr. Hind, from an observation by Dr. Gould on February 4th, and from rough places for February 10th and 15th, sent to England by Mr. Gill. These elements, placed in juxtaposition with those computed by Hubbard, for the great comet of 1843, appeared in the *Observatory* as follows :—

	Finlay.	Hind.	Comet, 1843.
Perihelion passage	1880, Jan. 27·55d	Jan. 27·6027d GMT	
Longitude of perihelion ..	280° 16′	279° 6′.8	278° 35′·1
Longitude of ascending node..	123 24·5	4 1·9	1 20·6
Inclination	75 12	35 39·8	35 38·2
Perihelion distance	0·008001	0·0059390	0·005511
Motion	Direct	Retrograde	Retrograde

Sun's radius, 0·004664 (sun's mean distance = 1).

Mr. Hind, in a letter to the Astronomer Royal, draws attention to the similarity of his orbit to that of the great comet of 1843, and says—"Can it be possible that there is such a comet in the system almost grazing the sun's surface in perihelion, and revolving in less than thirty-seven years? I confess I feel a difficulty in admitting it, notwithstanding the above extraordinary resemblance of orbits." It was also stated in the *Observatory* that, from rough places on February 10th, 13th, and 15th, Mr. Hind had previously found elements somewhat different from those which he communicated. Both sets differed *in toto* from Mr. Finlay's. The members of the Royal Society of N.S.W. will not fail to perceive the utter dissimilarity subsisting between the results given by Mr. Hind and Mr. Finlay, but this is not all, for now the *Astronomische Nachrichten* has come to hand, bringing more determinations of the orbit, varying as much from one another as those computed by the two astronomers already referred to. The following approximate determinations have appeared in that periodical up to April 8th, the latest date received :—

	Liais.	Copeland.	Gould.
Perihelion passage	Feb. 10 to 11	Jan. 26 ·5465d Berlin M. T.	Jan. 27·4185d Wash. M. T.
Longitude of perihelion ..	105°	256° 23′·9	280° 26′ 59″
Longitude of ascending node..	120	332 46 ·9	7 50 28
Inclination of orbit	60	46 25 ·4	35 5 30
Perihelion distance	0·08 to 0·10	0·038127	0·0052379
Motion	Direct	Retrograde	Retrograde

The elements given by M. Liais, Director of the Observatory at Rio Janeiro, somewhat resemble those arrived at by Mr. Finlay, but they are confessedly derived from very rough estimations of the positions of the comet's head. Considering now the very conflicting results which have reached us, I have thought that a determination of the orbit in Australia would not be without interest to our Society. In the *Herald* of the 26th May last, I announced that there was between the orbit given by Mr. Hind and the Melbourne observations a sufficient agreement to enable me to employ the former as a foundation for the correction of the latter for aberration and parallax, and that I would investigate an orbit from the observations so corrected and present it to the Society. This promise I now proceed to redeem. For the basis of my determination I have selected the observations of February 9th, 14th, and 17th. I have adopted the earlier groups of observations on the 9th and 17th, because they were taken at a considerable altitude. On the evening of the 14th three early comparisons were made of the comet with an anonymous star, whose accurate place has yet to be determined in the meridian. I am therefore obliged to reject the position depending on them and to adopt a position resting on a single comparison only with σ Sculptoris. This circumstance, it will be seen, is an unfortunate one. The three adopted apparent positions of the comet are as follows :—

Melbourne Mean Time.					R. A.			N. P. D.
	d.	h.	m.	s.	h.	m.	s.	
Feb.	9	9	9	30·5	23	41	6·73	123° 43′ 43″
,,	14	9	59	26·7	1	2	5·62	122 21 8
,,	17	8	57	29·8	1	41	9·51	120 21 43

Correcting these times and positions for aberration and parallax, and adopting the ecliptic as the fundamental plane, we get the following co-ordinates referred to the mean equinox of the beginning of the year :—

Feb. 8·97500d.	Greenwich M. T.	$\lambda = 341°\ 5'\ 34{\cdot}1''$	$\beta = -28°\ 49'\ 39{\cdot}5''$
,, 14·00948	,,	$\lambda' = 359\ \ 36\ \ 5{\cdot}6$	$\beta' = -35\ \ 31\ \ 0{\cdot}1$
,, 16·96621	,,	$\lambda'' = 9\ \ 57\ \ 7{\cdot}0$	$\beta'' = -37\ \ 37\ \ 18{\cdot}1$

The places of the sun have been taken from the British Nautical Almanac, have been duly corrected for aberration and reduced to the same equinox. The logarithms of the earth's radius vector have been taken from the same source. Assuming now the proportionality of the rectilinear instead of the parabolic sectors described by the comet to the times of description, I arrived at a value of the ratio of the curtate distances of the comet from the earth for the first and third observations, which, when Lambert's theorem was satisfied, gave a system of elements differing but little from that communicated by Mr. Hind. On correcting the assumption from which the ratio was derived I obtained another system differing considerably from the other. By a comparison of the residuals in longitude and latitude for the middle observation, as derived from these two systems, I deduced a corrected value of the ratio, which gave finally the following system of parabolic elements :—

Perihelion passage	1880, January 27·56330d G.M.T.	
Longitude of the perihelion	277° 22′ 53″·4	M.Equinox, 1880·0
Longitude of the ascending node	358 22 48 ·6	
Inclination of the orbit............	36 41 41 ·9	
Perihelion distance..................	0·0067243	
Heliocentric motion	Retrograde	

On recalculating the geocentric places from these elements, I obtained the following residuals, in the sense of *calculation minus observation* :—

Feb. 8.	$\Delta\lambda \cos\beta = -\ 5''{\cdot}2$	$\Delta\beta = +\ 0''{\cdot}5$
,, 14.	$\Delta\lambda' \cos\beta' = +\ 59{\cdot}7$	$\Delta\beta' = -\ 77{\cdot}6$
,, 16.	$\Delta\lambda'' \cos\beta'' = +\ 0{\cdot}5$	$\Delta\beta'' = +\ 0{\cdot}1$

It will be seen that the first and third positions are not perfectly satisfied by the elements, but I may state that owing to the small perihelion distance of the comet, the exceedingly small arc described by the comet between the extreme observations, and the very large anomaly in that arc, the calculation of the orbit is attended with great difficulty. I do not wonder at the conflicting sets of orbit-elements assigned to this body by the different computers whose results have reached the colony. My calculations have been effected by means of logarithms of seven decimal places, whereas, to do justice to the problem, logarithms of ten decimal places are absolutely necessary. The circumstances of the case are such that very small errors in the various stages of the computations become magnified in the final results. It appears from the figures given above that the residuals for the middle place are very large, and their ratio is such as to require a further slight correction of the adopted ratio of the curtate distances. Any attempt, however, to correct this ratio will not furnish residuals within the limits of probable errors of observation. It would seem, therefore, that the three positions cannot be satisfied on the hypothesis of parabolic motion, and that the orbit is elliptic. On comparing the elements which I have thus deduced with those computed by Hubbard for the great comet of 1843, one is at once struck with their close similarity. In the list of cometary orbits contained in Encke's Edition for 1847 of Olbers' *Abhandlung uber die leichteste und bequemste Methode die Bahn eines Cometen zu berechnen*, there are twelve determinations of the orbit of the comet of 1843, and these I now transfer to my paper, in order that the members may have the opportunity of comparing them with the results deduced for the late comet. I have roughly corrected the longitudes for the precession of the equinoxes since 1843.

Name of computer	Encke	Kendall & Walker	Kendall & Walker	Knorre	Nicolai	Plantamour
Perihelion passage, Paris, M.T.	Feb. 27d. 11h. 13m.	Feb. 27d. 10h. 39m.	Feb. 27d. 14h. 18m.	Feb. 27d. 10h. 24m.	Feb. 27d. 10h. 29m.	Feb. 27d. 10h. 27m.
Longitude of perihelion	279° 33′	278° 15′	281° 15′	278° 59′	279° 8′	278° 49′
Longitude of ascending node	4 46	2 26	16 28	2 19	2 9	1 22
Inclination of the orbit	35 13	35 34	34 20	35 35	35 36	35 46
Perihelion distance	0·00522	0·00702	0·00410	0·00579	0·00558	0·00581
Motion	R.	R.	R.	R.	R.	R

Name of computer	Santini	Clausen	Laugier & Mauvais	Laugier & Mauvais	Laugier & Mauvais	Valz
Perihelion passage, Paris, M.T.	Feb. 27d. 6h. 20m.	Feb. 27d. 3h. 44m.	Feb. 27d. 10h. 18m.	Feb. 27d. 9h. 39m.	Feb. 27d. 8h. 18m.	Feb. 27d. 10h. 19m.
Longitude of perihelion	277° 17′	278° 9′	279° 17′	279° 7′	278° 49′	278° 59′
Longitude of ascending node	4 31	350 40	2 41	1 15	358 23	360 0
Inclination of the orbit	35 15	38 31	35 31	35 46	36 21	35 40
Perihelion distance	0·00790	0·00708	0·00549	0·00568	0·00602	0·00520
Motion	R.	R.	R.	R.	R.	R.

On looking down the list one cannot fail to recognize the close resemblance between the elements which I present to the Society and the third orbit calculated by Laugier and Mauvais. But I wish also to draw the attention of the Society to the fact that these computers assign a period of thirty-five years in their orbit which so closely resembles mine, and this period it will be observed differs only two years from the interval between the appearance of the comet of 1843 and that of 1880. To their second orbit they assign a period of 175 years, and this it will be seen is commensurate with that of thirty-five years. Mr. Hind, in his Treatise on the Comets, edition of 1852, says :—"Several comets have been mentioned as probably identical with the great one of 1843, and in particular those of 1668 and 1689, which exhibited tails of unusual length. If it were one and the same comet that appeared in 1668, 1689, and 1843, the period of revolution could differ but little from twenty-two years. But independently of the *primâ facie* improbability of this short period, the evidence afforded by the history of comets in past ages is decidedly against it ; neither is the period of thirty-five years, suggested by some astronomers, more probable, for the comet of 1106, which was cited as strongly supporting this time of revolution, could not possibly have been the same as the comet of 1843, since historians agree in stating that it was observed for some time in the northern heavens, a circumstance perfectly irreconcilable with the elements of the latter body, which can only remain *about three hours* north of the ecliptic. Calculation shows that the paths of the comets of 1668 and 1689 might be tolerably well represented by the orbit of the comet of 1843, but equally well, in the former case, and much nearer in the latter, by numbers altogether different, so that we can come to no definite conclusion on the subject." Sir John Herschel, in his Outlines of Astronomy, edition, 1851, has the following among other remarks respecting the comet of 1843 :—"Although some of the observations of this comet were vague and inaccurate, yet there seem good grounds for believing that its whole course cannot be reconciled with a parabolic orbit, and that it really describes an ellipse. Previous to any calculation it was remarked that in the year 1668 the tail of an immense comet was seen in Lisbon, at Bologna, in Brazil, and elsewhere, occupying nearly the same situation among the stars, and at the same season of the year, viz., on the 5th of March and the following days. Its brightness was such that its reflected trace was easily distinguished on the sea. The head, when it at length came in sight, was comparatively faint and scarcely discernible. No precise observations were made of this comet, but the singular coincidence of situation, season of the year, and physical resemblance, excited a strong suspicion of the identity of the two bodies, implying a period of 175 years *within a day or two more or less.* This suspicion has been converted almost into a certainty by a careful examination of what is recorded of the older comet. Locating on a celestial chart the situation of the head, concluded from the direction and appearance of the tail, when only that was seen, and its visible place, when mentioned, according to the descriptions given, it has been found practicable to derive a rough orbit from the course thus laid down; and this agrees in all its features so well with that of the modern comet as nearly to remove all doubt on the subject. Comets, moreover, are recorded to have been seen in A.D. 268, 442–3, 791, 968, 1143, 1317, 1494, which may have been returns of this, since the period above mentioned would bring round its appearance to the years 268, 443, 618, 793, 968, 1143 1318, and 1493, and a certain latitude must always be allowed for unknown perturbations. But this is not the only comet on record whose identity with the comet of 1843 has been maintained. In 1689 a comet bearing a considerable resemblance to it was observed from the 8th to the 23rd of December, and from the few and rudely observed places recorded, its elements had been calculated by Pingré,* one of the most diligent inquirers into this part of astronomy. From these it appears that the perihelion distance of that comet was very remarkably small, and a sufficient though indeed rough coincidence in the places of the perihelion and node tended to corroborate the suspicion. But the inclination (69°) assigned to it by Pingré appeared conclusive against it. On recomputing the elements, however, from his data, Professor Pierce has assigned to that comet an inclination widely differing from Pingré's, viz., 30°4′, and quite within reasonable limits of resemblance. But how does this agree with the longer period of 175 years before assigned? To reconcile this we must suppose that these 175 years comprise at least eight returns of the comet, and that in effect a mean period of 21·875 years must be allowed for its return. Now it is worth remarking that this period calculated backwards from 1843·156 will bring us upon a series of years remarkable for the appearance of great comets, many of which, as well as the imperfect descriptions we have of their appearance and situation in the heavens, offer at least no obvious contradiction to the supposition of their identity with this. Besides those already mentioned as indicated by the period of 175 years, we may specify as probable or possible intermediate returns, those of the comets of 1733(?), 1689 above mentioned, 1559(?), 1537, 1515, 1471, 1426, 1405–6, 1383, 1361, 1340, 1296, 1274, 1230, 1208, 1098, 1056, 1034, 1012, 990, 925(?), 858(?), 684, 552, 530, 421, 245 or 247, 180, 158. Should this view of the subject be the true one, we may expect its return about the end of 1864 or beginning of 1865, in which event it will be observable in the southern

*Author of the "Cométographie," a work indispensable to all who would study this interesting department of the science.

hemisphere both before and after its perihelion passage." I have made these rather lengthy extracts in order to show the members what interest attaches to the comet of 1843. In connection with the closing remarks of Sir J. Herschel, I may say that a very fine comet did appear in the beginning of 1865, which was observed only in the southern hemisphere. It was at first generally supposed by the colonists to be the comet of which Sir J. Herschel speaks, but a determination of the orbit which I published at the time proved that the comet, although one of very small perihelion distance, was moving in an orbit quite different from that of the great comet of 1843. The results of my investigation of the orbit of the great southern comet of 1865, which are generally regarded by astronomers as the closest approximation yet obtained, will be found in the *Sydney Morning Herald* of May 6th, 1865, and likewise in the principal astronomical journals of Europe. From what I have stated, it is probable that the recorded observations of the comet of 1843 and of others which are supposed to be identical with it will again be ransacked in order to obtain, if possible, further evidence of identity. I am extremely anxious to refer to Pingré's *Cométographie*, Carl's *Repertorium der Cometen-Astronomie* and Cooper's *Cometic Orbits*, which invaluable works unfortunately I do not possess, nor do I think they are to be found in the library of the Sydney Observatory. And here I would take the opportunity of respectfully suggesting to those in authority the absolute importance of furnishing that young institution with copies of certain astronomical works in English, French, and German, without which no Observatory library can be said to be complete. A copious library for reference is as necessary to the practical astronomer as are his transit instrument, clock, and equatorial. I will now take leave of the more technical part of my subject, with an expression of the hope that the orbit-elements I have now presented to the Society may be found to be much more accurate than any which have yet reached the colony. At all events I believe they will be found sufficiently accurate to serve as provisional elements for the reduction of all the southern observations when they come to hand, and for the formation from them of normal places for a definitive determination of the orbit.

I shall now bring this paper to a close by offering a few interesting particulars respecting the movements of the comet in the parabolic orbit which I have calculated. For the linear distances of the comet from the sun and earth I have adopted Tupman's value of the mean equatorial horizontal parallax of the sun derived from the British observations of the late Transit of Venus, viz., 8″·8455, in the determination of which our Australian observations played so important a part. I have also assumed the equatorial semi-diameter of the earth as given by Airy in his "Treatise on the Figure of the Earth, Encyclopædia Metropolitana, 1849," viz., 20,923,700 English feet or 3,962·822 English miles. It appears now that towards the close of January the comet was rapidly approaching the sun from the regions lying south of the ecliptic. It proceeded, of course, with accelerated velocity towards that luminary, and at thirty-six minutes past 11 o'clock on the morning of the 27th (Sydney mean time) or just twenty-four hours before perihelion, it arrived at a point 9,584,500 miles from the sun's centre. At twenty-seven minutes past 10 o'clock a.m. on the 28th it crossed the plane of the earth's orbit at a distance of 1,074,600 miles from the same point. Its course now lay on the north side of the ecliptic, and sixty-nine minutes later it arrived in perihelion or that point of its orbit nearest to the sun. The distance between the sun's centre and the centre of gravity of the comet at this moment according to my elements was 621,380 miles. The semi-diameter of the sun at the earth's mean distance, resulting from twelve years' observations, 1836 to 1847, at the Royal Observatory, Greenwich, is 16′1″·82. If we adopt this value and execute the necessary calculation we shall find that at the instant of perihelion passage the comet's centre was actually only 190,480 miles distant from the sun's surface. The heat to which the comet was subjected at this point of its path in space must have been something beyond human conception, and the solar orb itself subtended an angle of 88°, or 165 times greater than its apparent diameter as seen from the earth. Sir John Herschel says that "the comet of 1680, whose perihelion distance was 0·0062, and which therefore approached the sun's surface within one-third part of his radius (more than double the distance of the comet of 1843) was computed by Newton to have been subjected to an intensity of heat two thousand times that of red hot iron,—a term of comparison indeed of a very vague description, and which modern thermotics do not recognize as affording a legitimate measure of radiant heat." After leaving perihelion the angular velocity of our comet gradually decreased, though its distance from the sun rapidly increased. At twenty-seven minutes past 1 o'clock in the afternoon of the 28th the comet passed from the north to the south side of the ecliptic, at a distance of 1,473,300 miles from the sun's centre. It thus appears that the comet was only *three hours* on the north side of the plane of the earth's orbit, and in this brief space of time it of course described an arc of 180°, or just one-half of its apparent path in the heavens as seen from the sun. I find by a rough calculation that if the perihelion passage had occurred on any date between March 1st and April 4th, or between August 28th and October 15th, there would have been a transit of the comet across the sun's disc as seen from the earth. The comet, during the interval I have described, was pursuing its path unseen from our planet, and it was not till the 1st day of February that its huge tail was detected from several parts of the southern hemisphere. On the evening of the 9th it was accurately observed at the Melbourne Observatory, but it had then receded to a distance of 53,885,000 miles from the sun, its corresponding distance from our planet being 62,205,000 miles. On the evening of the 17th the Melbourne observers obtained their last position, the comet having then increased its distance from the sun and earth to 75,293,000 and 69,508,000 miles respectively. This evening, July 7th, while I am reading this paper to the Society, it has attained to a distance of 301,000,000 of miles from the central luminary, and is therefore near the outer limits of the belt of minor planets. Assuming that our late visitor is the great comet of 1843 with a period of 37 years, it will ultimately reach its aphelion at a distance of 2,052 millions of miles or within the orbit of the planet Neptune, and will then commence its return journey towards the sun, and make its reappearance to the earth's inhabitants about the year 1917.

Having now given you as much information as lies in my power, I must take leave of my subject. I trust that in the course of a few weeks we shall receive from Europe information more accurate and detailed than that of which we are at present in possession.

The Observatory, Windsor,
June 26th, 1880.

Note on a New Method of Printing Barometer and other Curves.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W., 5 August, 1880.*]

The necessity for a convenient and expeditious method of printing barometer curves has long been felt by all who have had to publish weather maps, and I have therefore no hesitation in publishing what to me at least appears to be one method of meeting this want.

It is simple enough. The blanks for the curves containing lines at 29·4, 29·6, 29·8, 30·0, 30·2, and 30·4, and these crossed by vertical lines giving a column to each station, are cast ready for use, and, so soon as the barometers are reduced, the height at each station is marked in the column for that station, and a pen line is run through these points; the blank is then put under a fret-saw and the saw is run along the marked curve, and into the saw cut is placed a ribbon of soft metal, the edge of it marks the curve and serves as a printing surface. The whole of this may be done in less time than it has taken to describe it.

The advantages are obvious:—

In the first place, it gives a block which can be printed with ordinary type, and has therefore a great advantage over the lithograph system, in which the curve has to be printed after the map is otherwise complete.

Second: As soon as the barometers are reduced the printing block may be completed in from 8 to 10 minutes, and at once put into the press and printed at any required speed.

Third, as to cost: The blanks are only ⅛-inch thick, and when used can be melted again as often as may be required, and 5 minutes suffices to cut the groove and make it ready for printing.

In the lithograph method a new surface has to be made on the stone each day, and much time is lost in getting the printing adjusted on the prepared map, and then it is not applicable for the daily press.

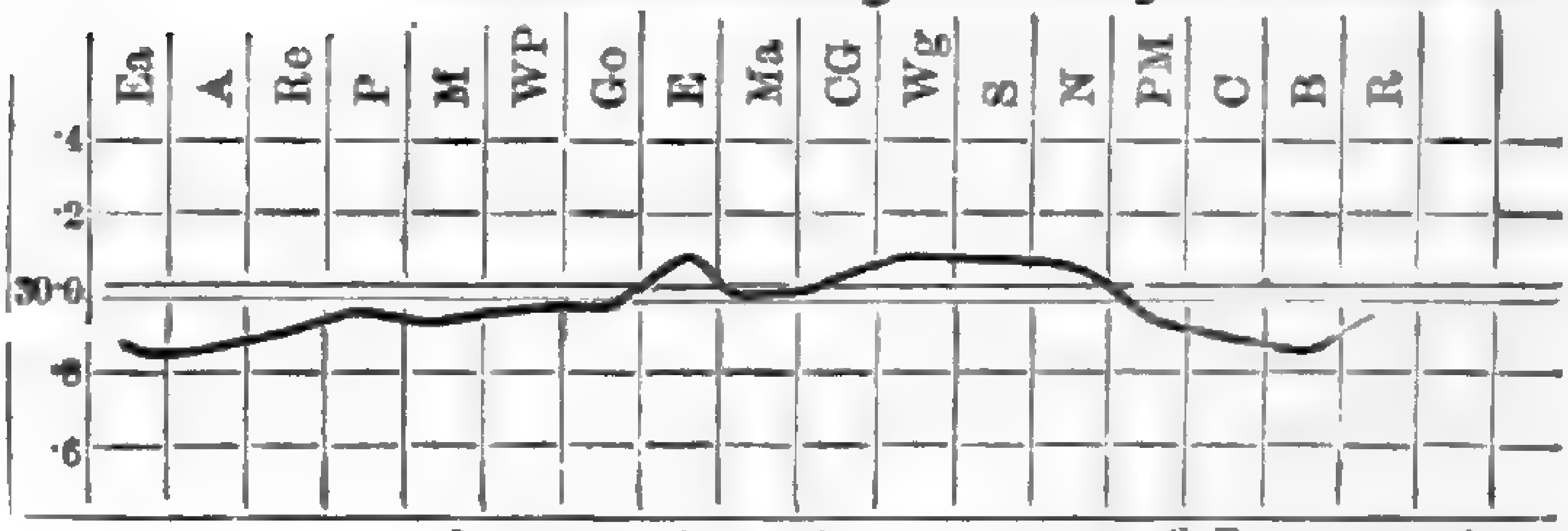
Fourth: By this system the blocks may be placed together for subsequent printing, as shown, so that the change in the barometers from day to day is seen at a glance.

It seems hardly necessary to suggest other uses, but no doubt many will be found for this method of preparing a block from which curves may be printed. But I would suggest here that for printing isobaric, isothermal and other lines, one engraving of the world or section to be illustrated being engraved it could be used as a mould from which to cast any required number, and upon each a different set of curves could be placed in this simple way.

[One diagram.]

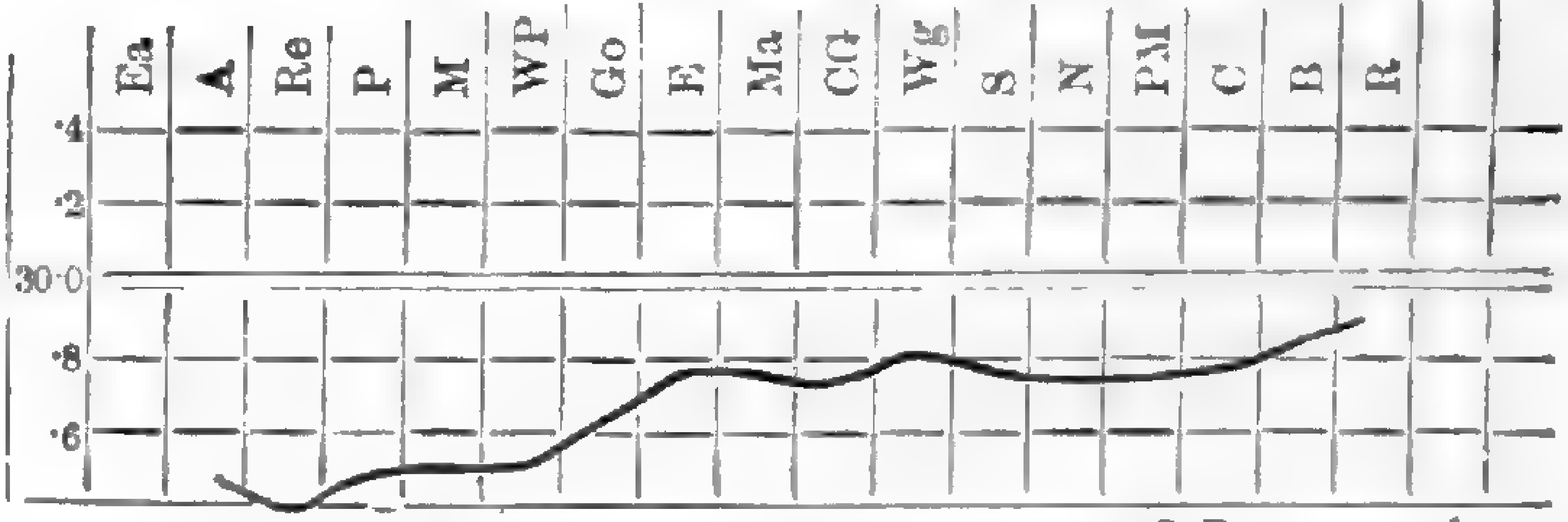
Curve showing state of Barometer.

October 20th, 1880.
Generally cloudy.



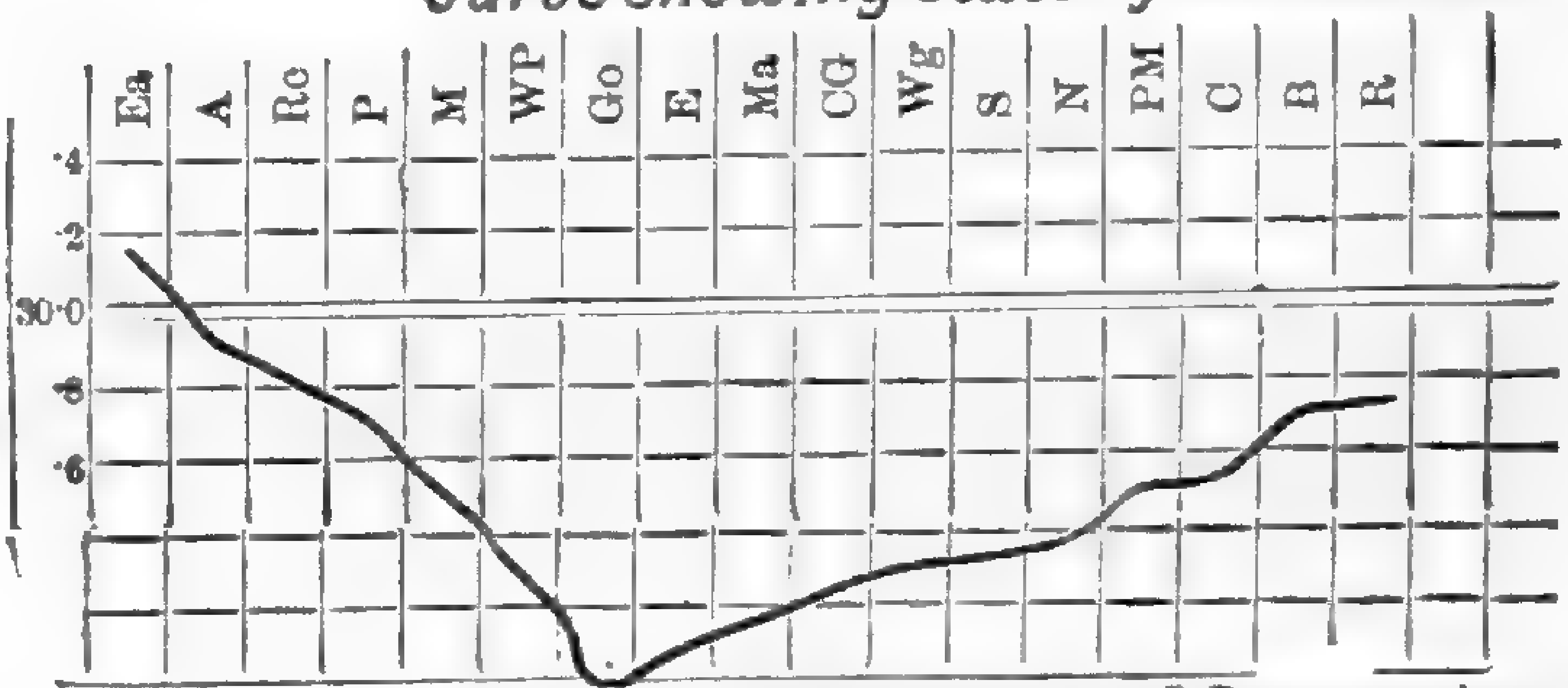
Curve showing state of Barometer.

October 21st, 1880.
Rain general; wind W.



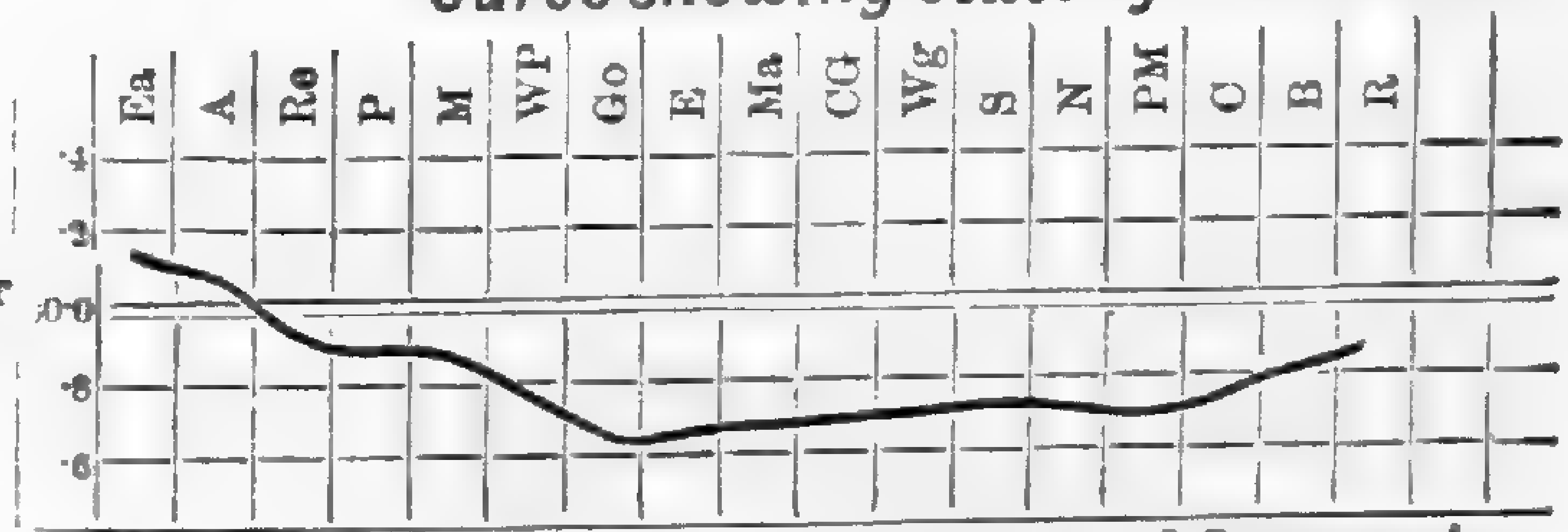
Curve showing state of Barometer.

October 22nd.
Some rain; strong S. to S.W. gale.
Barometer at Gabo, 29·20 inches.



Curve showing state of Barometer.

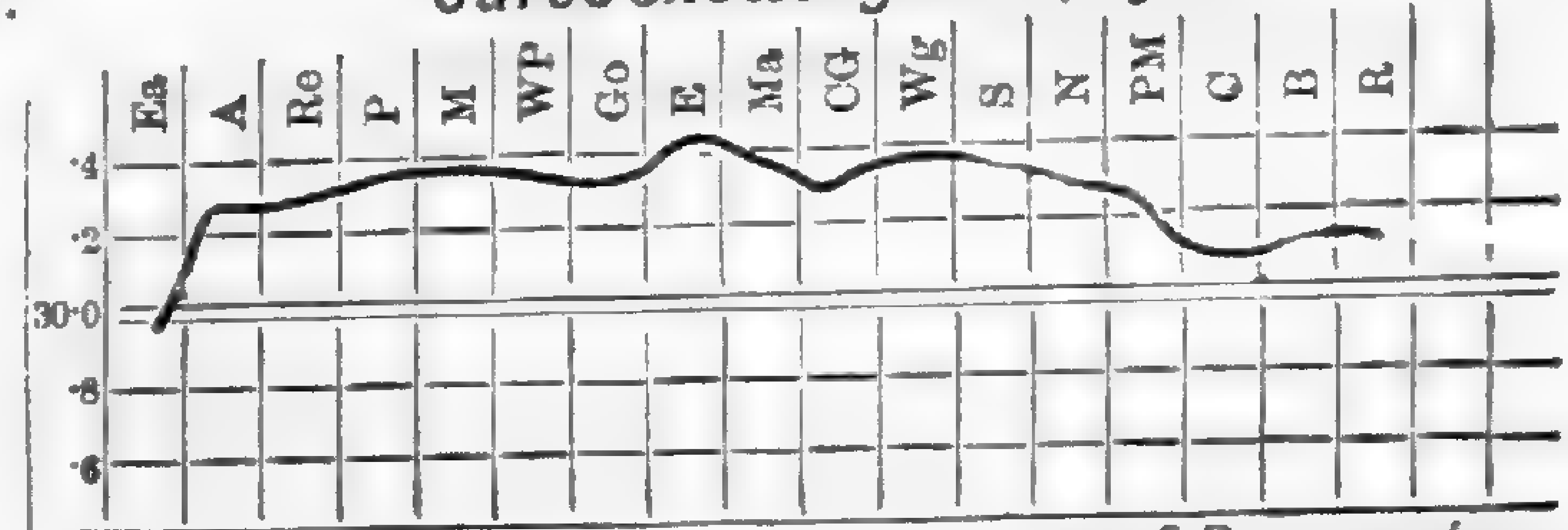
October 23rd.
Wind light; weather clearing.



October 24th—Sunday.

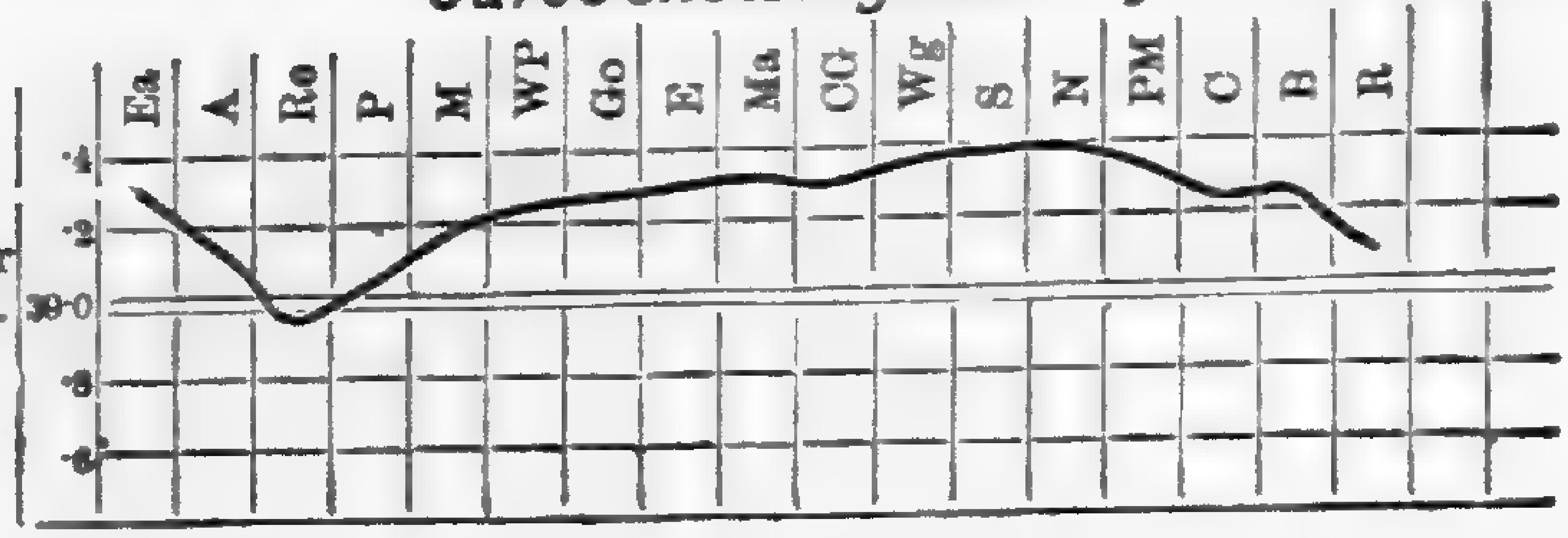
Curve showing state of Barometer.

October 25th.
Winds variable.



Curve showing state of Barometer.

October 26th.
Generally fine and clear with N. to N.E. winds.



Note upon a Sliding-scale for correcting Barometer Readings to 32° Fah. and Mean Sea Level.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W., 1 September, 1880.*]

Just eleven years since I had the honour of reading before this Society a description of the sliding-scale which I then designed and made for the purpose of doing away with the computation which had previously been necessary when the humidity of the air was required from readings of the dry and wet bulb thermometers. That sliding-scale has been a useful servant in Sydney and other observatories ever since, and has saved an amount of time which it would be difficult to estimate; but it only met one of the wants of the meteorological computer, and it seems strange, now that the other want of the computer is met by the sliding-scale for barometers, that I could not at that time see how to do what within the past few days has seemed so easy. I have often since then wished to find some convenient method of saving the time spent in correcting the readings of the barometers, where so many readings have to be corrected every day ; the time was a serious item, and long since I completed the design of a machine to meet my wants, but it did not promise such a saving of time as I desired, and it was therefore never made. Recently it occurred to me that it would be possible to construct a table from which every possible reading of the barometer could be obtained, corrected for each degree of temperature; and I had such a table computed, because even that would save a great deal of the time lost in correcting barometer readings for temperature. When this was done I saw that, by applying to that table a scale on which from a given zero a point was marked for each station at such a distance from the zero as to be equal to the altitude correction, I should get by inspection the reading corrected for temperature and altitude at one inspection.

The scale was made by taking a strip of paper and at one end putting a line marked 0. Any reading of the barometer at a station —say Bathurst, was then taken and corrected for temperature and altitude ; the 0 of the scale was then placed on the table so that the 0 line was on the given reading and the scale along the line of figures under the temperature of the shade thermometer, say 60°; the figures were then followed down until the corrected barometer or the nearest reading to it was found; opposite this a mark was made on the scale and "Bathurst" written on it. Now, whenever the same reading is received, the scale being placed as before, the marks opposite Bathurst would show the corrected reading; and since the readings in the columns increase at the rate of 0·01, any other reading being given with the same temperature, the same scale would serve to point out the corrected reading required.

The table thus prepared was placed upon a cylinder, so that any part of it could be immediately brought up for inspection, and the scales (some forty-six—one for each degree of temperature) were prepared, and promised a very great saving of time; but in looking at the table thus arranged I saw that it was possible to do away with all the figures except one column, and substitute a scale upon which one oblique line should represent the corrected reading of a barometer at a particular station for every possible temperature and variation in the atmospheric pressure. The result is the convenient sliding-scale represented in the annexed photo-lithograph. I will endeavour to explain to you how this was done. In the first place, a strip of paper, 25 inches long, and divided by cross lines one-tenth of an inch apart, was taken, and upon it were written all the readings of a barometer scale, from 28 inches to 30·40 inches, advancing by ·01 at a time. It was found necessary to begin at 28 inches, in order to reach the high stations. A second sheet of paper 22 inches by 8 inches, was then divided lengthwise by lines $\frac{1}{8}$ of an inch apart; at one end of them were written temperatures from 20° to 90°, and near the left-hand end a fine black zero line was drawn, crossing all of them. The mean barometer reading of a station—say Newcastle—was then taken, and corrected for index error for the temperature of 40°, and for altitude; the barometer scale on a strip of paper, described above, was then laid upon the line on the sheet of paper which was marked 40°, and the uncorrected barometer reading found on the strip of paper and made to coincide with the zero line. Looking along the scale, the reading corresponding to the "corrected" reading as by computation was found, and opposite, on the 40° line, a mark was made. Exactly the same process was repeated for the temperature 80°, care being in both instances used to apply, not only the temperature correction corresponding to these degrees, but the altitude correction as computed for the same degrees. A line was then drawn through these marks, and upon it the corrected readings of the barometer for any temperature and for any reading may be found by simply placing the scale on the given temperature line. A similar process was repeated for each station, and on this scale exhibited the lines for eighteen stations are marked without interfering with one another to any troublesome extent. The use of this scale has brought into prominence one of the little troubles of a meteorological computer. It is this. Suppose this morning Mount Victoria sends in a reading of his barometer 26·742, and air temperature 50°, and at Sydney the barometer read 30·021, and air temperature was 57°; now the question arises for which of these temperatures, or at what other, shall I compute the altitude correction. Theoretically, in computing altitude corrections it is assumed that the air is cooler in proportion to the elevation, and therefore the mean of the two should be taken; but in our practice this is found to be incorrect, and all the barometers will agree better if they are corrected for altitude at the temperature of Sydney, and the corrections are always therefore computed at the Sydney temperature. You will naturally ask why is theory wrong in this instance; probably the answer would be found in the usual condition of our atmosphere, which is that of having a warm wind overhead, and it may be mentioned that the mean temperature of Sydney is very near the same as that for the whole Colony when determined from seventy stations scattered all over it. Now, in using the sliding-scale, we follow the old rule of using the Sydney temperature, but when the readings are taken on this line, though they are affected by the right altitude correction, they are affected by the wrong correction for temperature, for the line is plotted as stated before, so that the temperature and altitude correction for each temperature are found on the same line; and since we use the Sydney temperature, the reading found is affected by the temperature correction for Sydney temperature, and not that of the thermometer at the station in question.

It is found impossible to provide for this difficulty in the sliding-scale; but it is met by adding to the reading found, 2½ times the difference between the thermometers when the upper thermometer is lower, and subtracting it when it is higher. It is evident that such a sliding-scale will not give the readings correct to 0·001 in., but it will to 0·01, which is more than sufficiently accurate for the purpose of daily weather maps; and if the third place of decimals is taken by estimation, the readings are found frequently to coincide with the computed readings.

I should mention here that as Kiandra, one of the meteorological stations, is at an altitude of 4,640 feet, it would be necessary to begin the scale at 25,000 inches, so that the sliding-scale would then be 3 feet 6 inches long, and the scale 4 feet. I found, however, that this was unnecessary for the purposes of the sliding-scale, and that just the same result was obtained if constant corrections of 1, 2, or 3 inches were made to the readings of the barometers, and the scale plotted accordingly.

SLIDING SCALE FOR CORRECTING BAROMETER READINGS

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE.
SYDNEY, NEW SOUTH WALES.

Thunder and Hail Storms in New South Wales.

By H. C. Russell, B.A., F.R.A.S.

[*Read before the Royal Society of N.S.W., 1 December, 1880.*]

When the Garden Palace or Exhibition building was in course of erection in 1879, the question was raised by a member of the Commission whether the risk from hail-storms was sufficient to call for some precaution against it in the construction of the building, and the question was referred to me for an answer. After a careful examination of all the available records up to the end of 1878, I addressed to the Commission a letter, the substance of which may be here quoted:—"After a careful examination of the recorded thunder and hail storms I cannot trace any period in their recurrence, except that they seem to be more numerous during the first year after a drought, as for instance in 1829-39-50 and 63. In accordance also with the above, it appears that they are not severe or numerous in wet years. As the present year (1879) may be fairly classed amongst these, the probability of a severe hail-storm is very remote, and would not I think justify the outlay necessary to provide special protection for the glass in the roof of the building."

The examination necessary to arrive at the answer involved some labour, and the tables and diagram will be of use in many ways, but specially with reference to the question of insurance against damage by storms. I have therefore determined to place them on record, without at present discussing the bearing of these statistics. There is only one point I would draw your attention to, and that is the great number of storms in the early part of November, or when the earth is passing through the November meteor stream.

The first table shows the date, place at which it occurred, and the intensity of each hail-storm; and the page given is the page in "Climate of New South Wales."

The second table gives the dates and characters of recorded storms; and the last table shows the number in each year.

The diagram presents the result of this examination in a convenient form. For the hail-storms the severity was estimated from the description in a scale 0 to 10, so that a long line shows a severe storm. For the thunder-storms the severity of the storm could not be estimated except in a few cases. The length of the line used for thunder-storms was therefore made uniform; and the number which in the course of years have occurred on the same day of the month is shown by adding one line to the other; as for instance, for the 10th of February seven storms are on record, the line is therefore made over seven spaces in the scale. This, as will be seen, is the heaviest record against any day of the year except 8th December, which has an equal number. The diagram shows clearly the preponderance of storms during the summer.

TABLE I.—RECORDED HAIL STORMS.

Page.	Year.	Month.		Place.	Character.	Coef.
60	1795	Dec.	5	Hawkesbury	*6 to 8 in. long	10
62	1797	Nov.	8	Sydney	Lark's eggs	7
62	1798	May	14	,,	6 in. circum.	10
64	1799	Nov.	15	Hawkesbury and Sydney	Severe	5
67	1804	Dec.	10	Sydney	Not severe	4
71	1806	Sep.	24	Hawkesbury	Severe(night)	5
72	1806	Nov.	9	Richmond Hb.	Severe	7
72	1806	,,	7	,,	,,	7
72	1806	,,	6	Hawkesbury	Light	4
75	1809	Sep.	13	Sydney	Moderate	4
76	1810	Oct.	6	,,	Severe	7
77	1812	Jan.	17	,,	Very severe	10
77	1812	Sep.	12	,,	,,	6
77	1812	Nov.	7	,,	Musket balls	5
78	1813	Mar.	10	Hawkesbury	Never equal'd	10
78	1814	,,	10	Sydney	Very severe	5
79	1814	Dec.	24	Bunbury Curran	Severe	6
79	1815	Oct.	1	Appin	Light	4
83	1818	Mar. &	21 & 23	Hawkesbury	2 severe ones	10
90	1823	Nov.	13	Wilberforce	Severe	5
90	1824	Jan.	1	Sydney	,,	6
90	1824	May	6	Prospect	Very severe	5
91	1824	Dec.	16	Hawkesbury	,,	10
94	1826	Nov.	4	Penrith	Severe	6
100	1829	Jan.	13	Sydney	,,	10
102	1829	Aug.	4	,,	Bullets	5
103	1829	Oct.	22	Parramatta and Sydney	Severe	5
103	1829	,,	21	Hunter	,,	6
105	1830	Feb.	2	,,	,,	7
107	1830	Oct.	26	Sydney	,,	10
109	1831	Feb.	21	,,	,,	5
122	1833	April	30	Bathurst	,,	5
128	1834	Nov.	1	Hunter	,,	4
128	1834	,,	20	Bathurst	,,	5
135	1837	Oct.	31	Maitland	Very severe	8
135	1837	,,	28	Sydney	Severe	7
138	1838	,,	12	Yass	,,	7
139	1838	Dec.	18	Parramatta and Hunter	,,	6
139	1839	Jan.	8	Maneroo	,,	7
142	1839	July	20	Yass	,,	7
142	1839	Aug.	22	Sydney	,,	7

* The dimensions given in this column refer to the size of the hail-stones.

TABLE I—*continued.*

Page.	Year.	Month.	Place.	Character.	Coef.
144	1839	Nov. 17	Richmond	Severe	10
144	1839	,, 14	Hawkesbury	,,	8
144	1839	Dec. 16	Marulan	,,	9
146	1840	Mar. 25	,, ...	,,	6
149	1841	Oct. 12	Paterson	,,	9
150	1847	July 2	,, ...	,,	7
150	1848	Jan. 30	Brisbane Water	,,	7
152	1852	April 5	Mangrove	,,	10
152	1858	Feb. 2	Brisbane Water	Very severe	8
152	1858	Nov. 5	,, ...	Light	4
153	1861	Feb. 16	,, ...	Very severe	8
153	1861	May 3	,, ...	Severe	7
154	1862	Jan. 25	,, ...	Light	4
154	1864	Sept. 15	Singleton	Severe	10
154	1864	Dec. 10	Lochinvar	Light	4
154	1864	Nov. 4	Singleton	Severe	10

TABLE II, showing Dates of Thunderstorms and Hailstorms at South Head during the years 1844 and 1848 to 1855.

Year.	Date.	Thunder.	Hail.
1844	Oct. 15 ...	Th.	
1848	Nov. 15 ...	Th.	
	Dec. 23 ...	Th.	
1849	Jan. 10 ...	Th.	
	,, 12 ...	Th.	
	Feb. 16 ...	Th.	
	,, 18 ...	Th.	
	,, 20 ...	Th.	
	,, 21 ...	Th.	
	Mar. 17 ...	Th.	
	April 1 ...	Th.	
	,, 16 ...	Th.	
	,, 22 ...	Th.	
	May 19 ...	Th.	
	Oct. 20 ...	Th.	
	Nov. 15 ...	Th.	
	,, 16 ...	Th.	
	,, 17 ...	Th.	
	Dec. 2 ...	Th.	
	,, 3 ...	Th.	
	,, 5 ...	Th.	
	,, 26 ...	Th.	
	,, 28 ...	Th.	
	,, 31 ...	Th.	

Year.	Date.	Thunder.	Hail.
1850	Jan 2 ...	Th.	
	,, 15 ...	Th.	
	Feb. 11 ...	Th.	
	,, 17 ...	Th.	
	,, 24 ...	Th.	
	Mar. 1 ...	Th.	
	,, 18 ...	Th.	
	,, 19 ...	Th.	
	April 14 ...	Th.	
	Sept. 1 ...	Th. ...	Hail.
	,, 5 ...	...	Hail.
	,, 15 ...	Th. ...	Hail.
	Oct. 11 ...	Th.	
	,, 14 ...	Th. ...	Hail.
	,, 15 ...	Th.	
	Nov. 7 ...	Th.	
	,, 9 ...	Th.	
	,, 11 ...	Th.	
	Dec. 8 ...	Th.	
	,, 9 ...	Th.	
	,, 17 ...	Th.	
	,, 22 ...	Th.	
1851	Jan. 3 ...	Th.	
	,, 15 ...	Th.	
	,, 19 ...	Th.	

TABLE II—*continued.*

Year.	Date.	Thunder.	Hail.
1851	Jan. 22	Th.	
	,, 27	Th.	
	Feb. 16	Th.	
	Mar. 3	Th.	Hail.
	,, 9	Th.	
	,, 10	Th.	
	,, 11	Th.	
	,, 23	Th.	
	,, 25	Th.	
	,, 27	Th.	
	April 14	Th.	
	Sept. 13	Th.	Hail.
	,, 22	Th.	
	Oct. 4	Th.	
	,, 11	Th.	
	,, 21	Th.	Hail.
	,, 24	Th.	
	Nov. 1	Th.	
	,, 2	Th.	
	,, 10	......	Hail.
	,, 17	Th.	
	,, 19	Th.	
	,, 20	Th.	
	Dec. 8	Th.	
	,, 21	Th.	
	,, 24	Th.	
	,, 26	Th.	
	,, 27	Th.	
	,, 30	Th.	
1852	Feb. 6	Th.	
	Mar. 28	Th.	
	April 5	Th.	
	June 15	......	Hail.
	July 3	Th.	
	,, 12	......	Hail.
	Sept. 21	Th.	
	,, 27	Th.	
	Oct. 7	Th.	
	,, 8	Th.	
	,, 22	Th.	
	Nov. 22	Th.	
	,, 23	Th.	
	,, 24	......	Hail.
	Dec. 8	Th.	
1853	Feb. 7	Th.	
	April 6	Th.	
	Sept. 3	Th.	Hail.
	Oct. 5	......	Hail.
	Nov. 2	Th.	
	,, 5	Th.	
	,, 14	Th.	
	,, 23	Th.	
	,, 24	Th.	
	,, 27	Th.	
	,, 28	Th.	
	Dec. 3	Th.	
	,, 4	Th.	
	,, 20	Th.	
1854	Jan. 2	Th.	
	,, 4	Th.	
	,, 10	Th.	
	,, 16	Th.	
	,, 18	Th.	
	Feb. 17	Th.	
	,, 25	Th.	
	Mar. 28	Th.	
	,, 29	Th.	
	,, 30	Th.	Hail.
	April 9	Th.	
	,, 12	Th.	
	Sept, 2	Th.	
	,, 5	Th.	
	Oct. 3	Th.	
	,, 18	......	Hail.
	Nov. 23	Th.	
	Dec. 23	Th.	
	,, 24	Th.	
	,, 25	Th.	
	,, 26	Th.	
1855	Jan. 5	Th.	
	,, 17	Th.	
	Aug. 23	Th.	
	Oct. 8	Th.	Hail.
	Nov. 5	Th.	
	,, 26	Th.	Hail.
	,, 28	Th.	Hail.

Many of these dates may be two or three days wrong, as the returns are weekly, and the date not always specified mo e fully than "three days' thunder," or "thunderstorms on two days."

TABLE II—*continued.*

THUNDERSTORMS, &c., Sydney.

Year and Date.	Aurora.	Thunder.	Remarks.	Year and Date.	Aurora.	Thunder.	Remarks.
1858.				1860.			
Oct. 19	......	Th.		Oct. 22	......	Th.	
Nov. 7	......	Th. ...	Hail also	Nov. 4	......	Th.	
Nov. 12	......	Th.		Nov. 6	......	Th.	
Nov. 17	......	Th.		Nov. 21	......	Th.	
Nov. 30	......	Th.		Dec. 2	......	Th. ...	Hail
Dec. 1	......	Th.		Dec. 8	......	Th.	
Dec. 4	......	Th.					
Dec. 5	......	Th.		1861.			
Dec. 9	......	Th.		Jan. 2	......	Th.	
Dec. 12	......	Th.		Jan. 21	......	Th.	
Dec. 19	......	Th.		Jan. 29	......	Tn.	
Dec. 27	......	Th.		Jan. 30	......	Th.	
	......	Th.		Jan. 31	......	Th.	
				Feb. 3	......	Th.	
1859.				Feb. 4	......	Th.	
Jan. 18	......	Th.		Feb. 6	......	Th.	
Jan. 29	......	Th.		Feb. 15	......	Th.	
Jan. 30	......	Th.		Feb. 16	......	Th.	
Feb. 9	......	Th.		Feb. 23	......	Th.	
Feb. 22	......	Many thunderstorms.		June 4	......	Hail	
Feb. 23				Aug. 11	......	Th.	
Mar. 2	......	Th.	Violent	Aug. 23	......	Th.	
Mar. 23	......	Th.		Sept. 12	......	Th.	
Mar. 25	......	Th.		Sept. 15	......	Th.	
Aug. 10	.....	Th.	Hail also	Oct. 22	......	Th.	
Aug. 30	Brilliant	......		Oct. 25	......	Th.	
	Aurora.			Oct. 31	......	Th.	
Sept. 1	......	Th.		Nov. 3	......	......	Hail
Sept. 12	......	Th.		Nov. 17	......	Th.	
Sept. 26	......	Th.		Dec. 11	......	Th.	
Oct. 18	......	Th.		Dec. 12	......	Th.	
Oct. 21	......	Th.		Dec. 20	......	Th.	
Nov. 1	......	Th.					
Dec. 10	......	Th.		1862.			
Dec. 24	......	Th.		Jan. 6	......	Th.	
Dec. 27	......	Th.		Jan. 11	......	Th.	
				Feb. 7	......	Th.	
1860.				April 16	......	Th.	
Jan. 8	......	Th.		April 28	......	Th.	
Feb. 10	......	Th.		June 22	......	Th.	
Mar. 28	Aurora.			Aug. 14	......	......	Hail
April 22	......	Th.		Sept. 5	......	Th.	
June 7	......	Th.		Oct. 27	......	Th.	
July 5	......	Th.		Oct. 28	......	Th.	
Aug. 12	Aurora.			Nov. 8	......	Th.	
Sept. 6	......	Th.		Nov. 11	......	Th.	
Sept. 8	......	Th.		Nov. 14	......	Th.	
Sept. 18	......	.. ...	Hail	Nov. 19	......	Th.	
Oct. 20	......	Th.		Nov. 20	......	Th.	

TABLE II—*continued.*

Year and Date.	Aurora.	Thunder.	Remarks.
1862.			
Dec. 8	......	Th.	
Dec. 14	......	Th.	
Dec. 20	......	Th.	
Dec. 21	......	Th.	
Dec. 25	......	Th.	
Dec. 26	......	Th.	
Dec. 31	......	Th.	
1863.			
Jan. 1	......	Th.	
Jan. 15	......	Th.	
Jan. 20	......	Th.	
Feb. 21	......	Th.	
Feb. 25	......	Th.	Hail
Feb. 26	......	Th.	
Feb. 27	......	Th.	
Feb. 28	......	Th.	
Mar. 3	......	Th.	Hail
Mar. 6	......	Th.	
Aug. 11	......	......	Hail
Aug. 12	......	......	Hail
Sept. 22	......	......	Hail
Oct. 1	......	Th.	
Oct. 26	......	Th.	
Dec. 9	......	Th.	
1864.	......		
Jan. 4	......	Th.	
Jan. 10	......	Th.	
Feb. 2	......	Th.	
Feb. 7	......	Th.	Violent
Mar. 3	......	Th.	
May 15	......	Th.	
May 22	......	Th.	
July 5	......	......	Hail
July 6	......	Th.	
Sept. 8	......	Th.	Hail, remarkable clouds
Sept. 11	......	Th.	
Oct. 2	......	Th.	
Oct. 27	......	Th.	
Nov. 4	......	Th.	Hail also
Nov. 6	......	Th.	
Nov. 21	......	Th.	
Dec. 2	......	Th.	
Dec. 9	......	Th.	
Dec. 10	......	Th.	
Dec. 14	......	Th.	
Dec. 20	......	Th.	

Year and Date.	Aurora.	Thunder.	Remarks.
1865.			
Jan. 5	......	Th.	
Jan. 8	......	Th.	
Jan. 9	.....	Th.	
Jan. 21	......	Th.	
Jan. 29	......	Th.	
Jan. 31	......	Th.	
Feb. 7	......	Th.	
Feb. 16	......	Th.	
Feb. 25	......	Th.	
Feb. 26	......	Th.	
Mar. 27	......	Th.	
Mar. 31	......	Th.	
April 17	......	Th.	
July 12	Aurora?		
July 19	......	Th.	
July 25	......	Th.	
Aug. 4	......	Th.	
Sep. 11	......	Th. ...	Hail, large
Sep. 17	......	Th.	
Oct. 11	......	Th.	
Nov. 2	......	Th.	
Nov. 6	......	Th.	
Nov. 19	......	Th.	
Dec. 1	......	Th.	
Dec. 10	......	Th.	
Dec. 16	......	Th.	
Dec. 21	......	Th.	
1866.			
Jan. 11	......	Th.	
Jan. 27	......	Th.	
Feb. 10	......	Th.	
Feb. 14		Th.	
Feb. 15		Th.	
Feb. 16		Th.	
Feb. 19	......	Th.	
Feb. 22	......	Th.	
Mar. 19	......	Th.	
April 20	......	Th.	
May 14	......	Th.	
May 28	......	Th.	
July 11	......	Th.	
Sep. 15	......	Th.	
Oct. 20	......	Th. ...	Hail, large
Oct. 22	......	Th.	
Oct. 26	......	Th. ...	Hail also
Nov. 7	......	Th.	
Nov. 10	......	Th.	
Nov. 11	......	Th. ...	Hail, inch long
Nov. 22	......	Th.	

TABLE II—*continued.*

Year and Date.	Aurora.	Thunder.	Remarks.
1866.			
Nov. 23	......	Th.	
Nov. 29	......	Th.	
Dec. 1	......	Th.	
Dec. 17.	......	Th. ...	Hail also
1867.			
Jan. 23	......	Th.	
Jan. 28	......	Th.	
Jan. 30	......	Th.	
Feb. 15	......	Th.	
Mar. 18	......	Th.	
Mar. 23	......	Th.	
Mar. 24	......	Th.	
Mar. 25	......	Th.	
Mar. 26	......	Th.	
Mar. 27	......	Th.	
Mar. 28	......	Th.	
Mar. 29	......	Th.	
Apl. 5	......	Th.	
Apl. 7	......	Th.	Powder Magazine struck
Apl. 12	......	Th.	
Apl. 13	......	Th.	
May. 12	......	Lightning at night.	
May 13	......		
May 18	......		
May 23	......		
May 27	......		
June 24	......		
July 27	......		
Sept. 5	......		
Sept. 6	......		
Sept. 11	......	Th.	
Sept. 21	......	Th.	Hail also
Oct. 2	......	Th.	
Oct. 9	......	Th.	
Oct. 22	......	Th.	
Oct. 31	......	Th.	
Nov. 4	......	Th.	
Nov. 28	......	Th.	
Nov. 30	......	Th.	
Dec. 1	......	Th.	
Dec. 7	......	Th.	
Dec. 11	......	Th.	
Dec. 27	......	Th.	
1868.			
Jan. 12	......	......	Hail
Jan. 16	......	Th.	
Jan. 17	......	Th.	
Jan. 18	......	Th.	
Jan. 27	......	Th.	
Jan. 29	......	Th.	
Feb. 10	......	Th.	
Feb. 13	......	Th.	
Mar 21	......	Th.	
Aug. 30	......	......	Hail
Sept. 18	......	Th.	
Sept. 21	......	Th.	
Oct. 12	......	Th.	
Dec. 4	......	Th.	
Dec. 12	......	Th.	
Dec. 24	......	Th.	
Dec. 25	......	Th.	
1869.			
Jan. 1	......	Th.	
Jan. 20	......	Th.	
Jan. 21	......	Th.	
Jan. 30	......	Th.	
Feb. 10	......	Th.	
Mar. 16	......	Th.	
April 30	......	Th.	
Sept. 18	......	Th. ...	Hail, heavy
Sept. 27	......	Th.	
Oct. 2	Aurora		
Oct. 11	......	......	Hail
Oct. 23	......	Th.	
Nov. 18	......	Th.	
Nov. 19	......	Th.	
Nov. 20	......	Th.	
Nov. 24	......	Th.	
Dec. 1	......	Th. ...	Hail
Dec. 2	......	Th.	
Dec. 7	......	Th.	
Dec. 8	......	Th. ...	Hail
Dec. 10	......	Th.	
Dec. 16	......	Th.	
Dec. 17	......	Th.	
Dec. 22	......	Th.	
Dec. 25	......	Th.	
Dec. 27	......	Th.	
1870.			
Jan. 8	......	Th.	
Jan. 19	......	Th.	
Feb. 1	Aurora		
Mar. 22	Aurora		
Mar. 25	......	Th.	
May 5	......	Th.	
May 11	......	Th.	
Aug. 14	......	Th.	
Aug. 26	......	Th.	

TABLE II—*continued.*

Year and Date.	Aurora.	Thunder.	Remarks.	Year and Date.	Aurora.	Thunder.	Remarks
1870.				1872.			
Sept. 24	Aurora			Feb. 9	......	Th.	
Sept. 25	Aurora			Feb. 25	......	Th.	
Oct. 25	Aurora			Mar. 9	......	Th.	
Oct. 26	Aurora			Mar. 14	......	Th.	
Nov. 6	......	Th. ...	Hail also	Mar. 15	......	Th.	
Nov. 7	......	Th.		May 2	......	Th.	
Nov. 9	Aurora	Th.		Aug. 7	......	Th. ...	Hail also
Nov. 12	......	Th.		Aug. 16	......	Th.	
Nov. 21	......	Th.		Aug. 30	......	Th.	
Nov. 22	Aurora			Oct. 4	......	Th.	
Nov. 23	......	Th. ...		Oct. 8	......	Th.	
Dec. 7	......	Th.		Oct. 15	Aurora	Th.	
Dec. 13	......	Th.		Oct. 16	......	Th.	
Dec. 16	Aurora	...		Oct. 17	Aurora	...	
Dec. 19	......	Th.		Oct. 18	Aurora	...	
Dec. 24	......	Th.		Nov. 6	......	Th.	
Dec. 30	......	Th.		Nov. 10	......	Th.	
Dec. 31	......	Th.		Nov. 19	......	Th.	
				Nov. 25	......	Th.	
1871.				Nov. 27	......	Th.	
Jan. 13	Aurora	Th.		Dec. 7	......	Th.	
Jan. 27	......	Th.		Dec. 9	......	Th.	
Feb. 3	......	Th.		Dec. 13	......	Th.	
Mar. 2	......	Th.		Dec. 15	......	Th.	
Mar. 23	Aurora	...		Dec. 28	......	Th.	
Mar. 28	Aurora	...		Dec. 29	......	Th.	
Apr. 5	Aurora	...					
Apr. 24	Aurora	...		1873.			
May 8	......	Th.		Feb. 9	......	Th.	
June 5	......	Th.		Feb. 10	......	Th.	
June 12	Aurora	...		Feb. 20	......	Th.	
Aug. 17	......	Th.		Feb. 21	......	Th.	
Sep. 24	......	Th.		Feb. 22	......	Th.	
Oct. 1	......	Th.		Feb. 23	......	Th.	
Oct. 5	......	Th.		Feb. 26	......	Th.	
Oct. 23	......	Th.		Mar. 10	......	Th.	
Oct. 24	......	Th.		Mar. 15	......	Th.	
Nov. 16	......	Th.		Mar. 28	......	Th.	
Nov. 21	......	Th.		Apl. 22	......	Th.	
Nov. 22	......	Th.		May 10	......	Th.	
Nov. 23	......	Th. ...	Hail also	June 5	......	Th.	
Dec. 10	......	Th.		July 5	......	Th.	
Dec. 11	......	Th.		July 25	......	...	Hail
Dec. 17	......	Th.		Aug. 16	......	Th.	
Dec. 31	......	Th.		Sept. 3	......	Th.	
				Sept. 9	......	Th.	
1872				Oct. 12	......	Th.	
Jan. 2	......	Th.		Oct. 22	......	Th.	
Jan. 22	......	Th.		Oct. 23	......	Th.	
Jan. 26	......	Th.		Oct. 31	......	Th.	
Feb. 2	......	Th.		Nov. 5	......	Th.	

TABLE II—*continued.*

Year and Date.	Aurora.	Thunder.	Remarks.	Year and Date.	Aurora.	Thunder.	Remarks.
1873.				1875.			
Nov. 9	......	Th.		Sept. 14	......		
Nov. 11	......	Th.		Sept. 18	......	Th.	
Nov. 15	......	Th.		Sept. 26	......	Th.	
Nov. 18	......	Th.		Oct. 10	......	Th.	Hail also
Nov. 21	......	Th.		Oct. 13	......	Th.	
Nov. 28	......	Th.		Oct. 31	......	Th.	
Dec. 17	......	Th.		Nov. 6	......	Th.	
				Nov. 16	......	Th.	
1874.				Nov. 29	......	Th.	
Jan. 5	......	Th.		Nov. 30	......	Th.	
Jan. 7	......	Th.		Dec. 8	......	......	Hail
Jan. 13	......	Th.		Dec. 24	......	Th.	
Jan. 22	......	Th.		Dec. 27	......	Th.	
Feb. 2	......	Th.		Dec. 31	......	Th.	
Feb. 5	......	Th.					
Feb. 6	......	Th.		1876.			
Feb. 8	......	Th.		Jan. 5	......	Th. ...	Hail also
Feb. 11	......	Th.		Jan. 15	......	Th.	
Feb. 15	......	Th.		Jan. 18	......	Th.	
Feb. 17	......	Th.		Feb. 10	......	Th.	
Feb. 18	......	Th.		Feb. 14	......	Th.	
Mar. 5	......	Th.		Feb. 26	......	Th.	
Mar. 12	......	Th.		Feb. 27	......	Th. ...	Hail also
May 11	......	Th.		April 7	......	Th.	
July 27	......	......	Hail	April 8	......	Th.	
Sept. 20	......	Th.		April 16	......	Th.	
Sept. 26	......	Th.		Aug. 12	......	Th.	
Oct. 4	......	Th.		Aug. 17	......	......	Hail
Oct. 20	......	Th.		Sept. 29	......	Th.	Hail also
Oct. 25	......	Th.		Oct. 7	......	Th.	
Oct. 29	......	Th.		Oct. 15	......	Th.	
Nov. 14	......	Th.		Oct. 16	......	Th. ...	Hail also
Nov. 27	......	Th.	Hail also	Oct. 29	......	Th. ...	Hail also
Dec. 10	......	Th.		Nov. 11	......	Th.	
Dec. 29	......	Th.		Nov. 16	......	Th.	
				Nov. 20	......	Th.	
1875.				Nov. 24	......	Th.	
Jan. 7	......	Th.		Dec. 16	......	Th.	
Jan. 10	......	Th.		Dec. 26	......	Th.	
Jan. 29	......	Th.					
Jan. 31	......	Th.		1877.			
Mar. 6	......	Th.		Jan. 2	......	Th.	
Mar. 14	......	Th.		Jan. 8	......	Th.	
Mar. 17	......	Th.		Jan. 29	......	Th.	
April 3	......	Th.		Feb. 1	......	Th.	
April 11	......	Th.		Feb. 22	......	Th.	
May 2	......	Th.		Feb. 23	......	Th.	
May 20	......	Th.		Mar. 15	......	Th.	
July 18	......	Th.		Mar. 16	......	Th. ...	Hail also
July 22	......	Th. ...	Hail	Mar. 30	......	Th.	
Aug. 25	......	......	Hail	May 1	......	Th.	

TABLE II—*continued.*

Year and Date.	Aurora.	Thunder.	Remarks.	Year and Date.	Aurora.	Thunder.	Remarks.
1877.				1878.			
May 23	......	Th.		Jan. 18	......	Th.	
July 15	......	Th. ...	Hail also	Feb. 5	......	Th.	
Aug. 19	......	Th.		Feb. 10	......	Th.	
Sept. 10	......	Th. ...	Hail also	Feb. 11	......	Th. ...	Hail also
Sept. 12	......	Th.		April 8	......	Th.	
Sept. 23	......	Th.		Aug. 17	......	......	Hail
Sept. 25	......	Th. ...	Hail also	Aug. 29	......	Th.	
Oct. 4	......	Th.		Oct. 7	......	Th.	
Oct. 9	......	Th.		Oct. 21	......	Th.	
Nov. 21	......	Th.		Dec. 8	......	Th.	
Nov. 26	......	Th.		Dec. 9	......	Th.	
Nov. 27	......	Th.		Dec. 11	......	Th.	
Dec. 1	......	Th.		Dec. 16	......	Th.	
Dec. 14	......	Th.		Dec. 21	......	Th.	
Dec. 18	......	Th.		Dec. 22	......	Th.	

TABLE III, showing recorded Hailstorms and Thunderstorms in each year, from 1795 to 1878.

Year.	Number of Hail-storms.	Number of Thunder-storms.	Thunder with Hail.	Year.	Number of Hail-storms.	Number of Thunder-storms.	Thunder with Hail.
A.D.		No record.	No record.	A.D.		No record.	No record.
1795	1			1818	1		
1796				1819	...		
1797	1			1820	...		
1798	1			1821	...		
1799	1			1822	...		
1800	...			1823	1		
1801	...			1824	3		
1802	...			1825	...		
1803	...			1826	...		
1804	1			1827	...		
1805	...			1828	...		
1806	2			1829	4		
1807	...			1830	1		
1808	...			1831	1		
1809	1			1832	...		
1810	1			1833	1		
1811	...			1834	2		
1812	3			1835	...		
1813	1			1836	...		
1814	2			1837	1		
1815	1			1838	2		
1816	...			1839	4		
1817	...			1840	1		

TABLE III—*continued.*

Year.	Number of Hail-storms.	Number of Thunder-storms.	Thunder with Hail.	Year.	Number of Hail-storms.	Number of Thunder-storms.	Thunder with Hail.
A.D.				A.D,			
1841	2	No record.	No record.	1860	2	14	1
1842	1			1861	2	22	...
1843	...			1862	2	21	...
1844	1			1863	5	13	2
1845	1			1864	2	20	1
1846	...			1865	3	26	1
1847	1			1866	4	25	4
1848	...	2		1867	1	29	1
1849	...	21		1868	2	15	...
1850	6	21	3	1869	4	24	3
1851	1	31	3	1870	...	19	1
1852	3	12	...	1871	1	20	1
1853	1	13	1	1872	...	27	1
1854	1	20	1	1873	1	28	...
1855	...	7	3	1874	1	25	1
1856	2	...	...	1875	3	25	1
1857	...	...	...	1876	1	22	5
1858	3	12	1	1877	0	25	4
1859	1	19	1	1878	1	14	1

[Diagram.]

Diagram shewing dates and relative intensity of Hailstorms.

Diagram shewing relative prevalence of Thunderstorms.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

Recent Changes in the Surface of Jupiter.

By H. C. Russell, B.A., F.R.A.S.

[*Read before the Royal Society of N.S.W., 1 December, 1880.*]

Some four years since I received a circular from the Royal Astronomical Society, requesting my co-operation in the work of systematically observing Jupiter, for the purpose of interpreting, if possible, the changing features which the planet presents from time to time to our gaze.

The Sydney $11\frac{1}{2}$-inch equatorial is well adapted for such purpose, owing to its fine defining powers and freedom from uncorrected colour; and in May, 1876, I therefore began a series of observations, making many drawings and notes. At that time the markings were sufficiently remarkable to enlist observers at once, and in the changes which have been going on ever since, sufficient alteration in form has taken place to keep up the interest and make the observer wish that Jupiter were always in the midnight sky, so that these changes might be followed in detail.

Before proceeding to the discussion of my own work, I shall perhaps be forgiven if I detain you a few moments by a very short account of the most important theories which have been put forward in explanation of Jupiter's belts.

In a paper published by Cassini, in Paris, in 1691, he says that the two equatorial belts of Jupiter were first seen in 1630, and he adds that they were remarkably permanent, for he watched them for forty years without seeing any change. Other observers, however, are of a different opinion, and assert that they are not always there. Hevelius says that in 1647 these belts were not visible, although he could see clouds upon the surface clearly, and Sir W. Herschel saw the planet once in 1793 without any sign of belts. In 1834 and 35, the northern belt was invisible, and (coming to my own experience) once in 1863 I saw his face covered with cloud-like forms from pole to pole, the usual equatorial belts being absent.

Cassini and others, judging of the condition of Jupiter from the periods of rotation derived from different markings, came to the conclusion that, since these times differed, the spots used in determining them must have a motion of their own, or that they were simply clouds.

Sir William Herschel, in 1793, wrote :—"I suppose that the bright belts of Jupiter included between the faint belts are zones wherein the atmosphere of the planet is most densely filled with clouds. The faint belts correspond to the regions in which the atmosphere is perfectly serene, and allows the solar rays to reach the solid portions of the planet, where according to my opinion the reflection is less powerful than from the clouds."

Mr. Proctor, who has made a careful study of the conditions under which Jupiter exists, thinks that since Jupiter, owing to his great distance from the sun, only receives $\frac{1}{25}$ part of the light and heat which reach the earth, it is impossible that his atmosphere should be loaded with clouds as we see it, resulting from sun heat alone, and that it is therefore extremely probable that the giant planet is now in the condition which geologists say evidently existed at one period of the earth's history, that is, that Jupiter is "still a glowing mass, fluid probably throughout, still bubbling and seething with the intensity of primeval fires, sending up continually enormous masses of clouds to be gathered into bands under the influence of the swift rotation of the giant planet." Not otherwise, Mr. Proctor thinks, can one understand whence his atmosphere is loaded with vapour masses.

The observed facts which I have to bring before you to-night have an important bearing upon these theories, in part tending to confirm them, and in part contradicting. It will be necessary, however, for us to bear in mind the extreme difficulty of observing the details upon the surface of Jupiter, owing to his enormous distance and the many difficulties which the terrestrial atmosphere puts in our way. It is only the most patient and trained observing, aided by powerful telescopes, that enables us to detect those minute markings on the planet which are all-important in the discussion before us.

There are markings, and even changes, which the possessor of a small telescope may see; but, to study Jupiter to advantage, requires the use of large instruments and very close scrutiny, if we are to arrive at any solution of the question whether there is anything permanent on the surface of the planet or not. The result of my own observation has convinced me that there is, and I think what follows will show that I have some grounds for thinking so.

First, with regard to the permanence of the belts. In 1876 I began to test this point by a careful measure of the positions of all the visible belts, using for the purpose the large telescope and a very fine micrometer. At that time the equator was occupied by four red-brown belts, which could be traced all round it; between them was a fainter red colour, sufficient to make the whole appear as one broad marking on the equator; this was by no means uniform; in places the belts were interrupted by white or coloured markings, and some of these were subject to frequent changes; in addition to these markings my measures included some fainter belts in the temperate zones and the polar caps.

This year everything to the casual observer seems changed from what it was in 1876, and I confess it was with no expectation of the result that on the 2nd November last I again applied the micrometer to the belts. The two outer ones of the four seemed to have disappeared, and the remaining two seem much altered in density, colour, and position, especially the northern one, which often seemed of a brilliant red.

I selected a time for the measures when the great red spot was visible, so that its latitude might be thereby fixed. I was not a little surprised, when I came to compare these measures with others taken in 1876, to find that the one set might be substituted for the other without much error; I then compared other measures that I had taken, with similar results, and looked to see if I could find older measures. So far I have only succeeded in finding some made by M. Arago in 1810-11 and 13. Unfortunately they only refer to the edges of what were then known as the *faint belts*, for at that time a white equatorial band was the brightest part of the planet. M. Arago makes no mention of colour or other markings, but the picture given shows markings in the faint belts and others nearer the poles; his measures extended over three years, and seem to have been very carefully made. They referred to the two extremes of each faint belt, which were no doubt the best marked features, and I find that they agree with my measures of the four equatorial belts, in fact they come almost exactly the same as the mean of my measures in 1876 and 1880, where they refer to what was then, and is still, the best defined feature of the planet; they agree within a tenth of a second of arc, and the greatest difference, which is in measures of a very ill-defined edge, there is not a difference of 2 seconds of arc. It thus appears, that at three dates taken at random in a period of seventy years, the four best marked belts of Jupiter were found in the same latitudes, and it is hence a fair inference that they are always there. During the four years over which my own work has extended, several fainter belts in the temperate zones and the polar caps have remained in the same positions.

Comparing the drawings made June 2, 1876, and November 2, 1880, photographed copies of which are attached, no one would at first sight think that the important features were unaltered in position, but a closer examination will show that the red spot is in the same latitude, and that the main markings of 1880 can be traced in 1876; but were it not for the measure which I have just mentioned, it would be difficult to decide which parts were clouds and which fixed features in the drawing of 1876; indeed this is one of the real difficulties that is constantly presented to the observer to distinguish one from the other, and so far as my experience goes, it can only be done by carefully recording the position of every feature, and in course of time, those which constantly recur in the same place will be recognised as fixed, and we shall learn to what extent the clouds change the appearance of the planet's markings. In the measures given we recognise the division of the planet into zones in a general way corresponding to those on the earth; we have the equatorial belt, and two in the temperate zones where the trades end; ours of course travel in latitude with the sun in his course $23\frac{1}{2}$ degrees on each side of the equator, but in Jupiter the sun's change of declination is only three degrees, so that the belts should seem fixed or nearly so.

Some of the changings in the markings of Jupiter take place with surprising rapidity, as I shall have occasion to tell you presently; and so enormous are the areas over which they are known to extend, that reasoning from what we know of terrestrial changes, much stress has been laid by some writers upon the impossibility of their occurrence under such atmospheric conditions as exist upon the earth, owing to the physical impossibility of translating the clouds, or whatever the markings be, over the enormous distances in the given time; but this argument, based as it is upon the possible velocity of the terrestrial winds, must be received with caution; because we know that clouds are not always caused by wind, but in some cases seem to form or disappear in a few minutes over terrestrial areas so great that it would be impossible for any wind to travel fast enough to form them. I have known clouds form in five minutes over the whole of a clear sky, and disappear at other times with similar rapidity. Now the least distance at which we can place the horizon limited by such clouds is 40 miles, so that the clouds must form over a spot 80 miles in diameter at least in five minutes; and for any wind to do this would mean a velocity of 960 miles in an hour, a speed which we know the wind cannot attain. When therefore similar changes are seen upon Jupiter, we are not bound to conclude that they are produced in a way that would be impossible if Jupiter had an atmosphere like that upon the earth. We must rather acknowledge that both planets are subject to influences from without, which are sufficient to cause great changes in the visible surface of clouds; whether such causes of change act upon both planets, or even all the planets simultaneously, is an interesting question upon which I shall have occasion to make some remarks presently.

Turning again to the principal belts upon Jupiter, I give here some of the measures I have taken, being those to which I have referred in the preceding remarks. I wish they had been begun some years since, but I did not foresee their importance.

Measure of the Equatorial Belts.

Measuring from the south pole of Jupiter to each belt in succession.

	1811.	1876.	1880.
	″	″	″
South pole to E	13·60	15·54	15·94
,, ,, F′	20·60	19·71	19·34
,, ,, G	23·67	22·57	24·55
,, ,, H	29·12	28·96	31·86

* The letters refer to the same belts in each year.

It will be seen that these measures F′ and G refer to the two equatorial belts which are situated one on each side of Jupiter's equator, in latitude 18° north and south; each is about 4,000 miles wide, and very regular in form. In the northern one the air is probably clear, and the light that we see it by is very little, as we should expect from the dark surface of a planet; in fact, it is rendered visible more by the light on each side of it than by any inherent in itself; how very faint it is may be illustrated by the fact that it takes a telescope of some considerable size to see that there is any colour at all—or, in other words, any light. When this is collected by a large object-glass it is decidedly red, a colour which we might expect it to be when we remember that the light has passed twice through Jupiter's atmosphere. Within the past two months I have had some splendid views of this belt with the large telescope and suitable magnifying power. It has often seemed to me so sharply defined as to stand out clear and distinct from all other markings, as if it were above them and made up of a number of bright red bars laid side by side, forming round the planet a magnificent girdle which has a lustre like silk.

The southern belt is not so striking; sometimes slightly red, it is oftener a warm brown colour, and although nearly as well defined as the northern one, it is by no means so striking.

Going northwards from the equatorial belts, we find in latitude 36° to 38° another well-defined but usually faint belt, of which I have more to say presently; and in the same south latitude another, which in 1876 was clear enough, but is now often invisible, probably because the south pole of Jupiter is turned away from the sun. On this belt is the now well-known red spot. Besides these there are other fainter belts, and the two polar caps, all of which it will be seen by the measures seem to be constant in their positions. Many observers have asserted that these belts, more especially the equatorial ones, are not visible up to the planet's edge; such is however, not my experience, for whenever the air is steady enough to use the large telescope I see them distinctly right up to the limb, somewhat fainter certainly, as they near it, but still completing the outline of the planet and showing no gap.

* See diagram.

Next to the great girdles which encircle Jupiter, "the red spot" is certainly the most remarkable feature that has ever been detected upon it; 30,000 miles long, by 8,500 miles wide, it covers a surface very much greater than that of the whole of the earth, and is easily seen with good telescopes, but in a powerful one it is a most striking object, and brighter coloured than anything else on the planet; but why that mass of flame-like light is red, and why a different red from any other marking, are questions not yet answered.

It is generally looked upon as a recent marking, and I have been at some trouble to trace its history, and shall I think be able to show you that it is much older than many suppose. The first published account of it is by Mr. F. C. Dennett, in the "English Mechanic" for 1879, page 277; he there asks if any one had seen a pink-coloured patch on the south temperate zone of Jupiter, which he had many times observed, and saw for the first time on July 27, 1878. From a letter in the "Observatory" for January 1879, it appears that Mr. Pritchett saw the same marking first on July 9th, 1878; since then there have been many letters on the subject, but I have not seen any earlier date mentioned than July 9th. On referring to my own drawings and notes I find that I first saw it separated from the belts on July 8th, 1878; it was then a faint and difficult object to see, but my drawing gives it a form and dimensions very much like what it has to-day. I was not long in recognising it as an old friend that I had frequently seen in 1876, at which time it was involved in the equatorial colour band, and somewhat different in shape but not in colour. I have many drawings of it as seen then, and have enlarged one to show you, with one made November 2, 1880. The drawings are all carefully made, estimating the size of each marking compared with the whole planet, so that they may be put on the paper as accurately as possible; and I find, on comparing them, that they are closely in accord, so much so that I have confidence in the dimensions of the spot when first seen as derived from them. I mention this because, when in 1876, I made the measures which have already been referred to, I did not measure the spot itself, but the belt which is almost in the same latitude as the north side of it, and which, knowing the size of the spot, serves to fix its latitude. From the south pole of Jupiter to this belt then measured 14″·94, so that the north side of the spot would be a little more, which measured on the drawing amounts to 0″·6, making its distance from the pole 15″·54. In November this year I measured the same space 15″·94, an agreement which may be taken as proof that its latitude has not changed. Again, comparing the drawing of June 2, 1876, with others, I found I had drawn it in the same position on October 11, 1880; and taking the most recent value of the period of rotation, it exactly measured this interval, showing that it has not changed in longitude. Finding the proof of its permanence so strong from my own observations, I looked amongst other drawings, and found in those published by the Earl of Rosse in the March 1874 number of R. A. S. Notices, four drawings, which show it in the same latitude and longitude as my own observations. The colour is there described as reddish and reddish yellow, but no particular remarks are made about it. Looking further back I found a drawing made by the keen-sighted Dawes, on 27th November, 1857, in which a similar form is depicted, but without colour, its latitude is the same, and the longitude also; but too much weight must not be given to this, for a small difference in the period of Jupiter's rotation (a rather uncertain quantity) would make all the difference in such a long period between agreement and disagreement.

These facts amount to very strong evidence, if not to proof, that the red spot is a fixed feature of Jupiter, or in other words solid ground and not clouds; that it seems to change a little in form is no proof to the contrary, where clouds have so much influence upon visible outline, and the changes in form are really not great. At present both ends are blunt-pointed; in 1876 the preceding end was round and the following pointed; and from Earl Rosse's drawings it appears that the preceding end was pointed and the following end rounded; and such changes are not important. I confess however that, before I collated my measures, the impression produced upon me by observing it was that the dimensions did change considerably. This does not however seem to be the case, for the measures show the contrary.

The colour I have selected by lamp-light to represent the colour of the spot is by day-light of a reddish yellow, and when compared with a scale of colour which gives six shades between red and yellow, it agrees with that one which is two shades on the red side of yellow. This tint may be said to be uniform and constant, though at times little variations in parts of it have been detected. I have however never seen anything which could be described as a marking: they were more variations of quantity than of quality. It is worth note that the shadow of a spot on this is black: if it were self-luminous this would not be the case.

Measures of the Red Spot.

In June, 1876, it was 13″·80 long and 4″·60 in width; on September 3, 1880, it was 4″·35 wide, the length was not then measured; on October 7, 1880, it was 15″·73 long and 4″·28 in width; and on October 28, 1880, it was measured again, 15″·00 long and 4″·26 in width.

While writing about the persistent position of this spot, I may mention that, on August 6, 1878, at 10h. 10m. p.m., I saw a small white spot of striking brilliance, much brighter in fact than anything else visible on Jupiter; it was on the northern side of the south equatorial belt, and a little in advance of the red spot. At the time there was a great development of colour between the belts, and this spot presented a clearly defined disc. It was seen again under similar circumstances on October 5, 1878, and thence not again until October 11, 1880, when it seemed to have started into being more brilliant than I had ever seen it before; it looked like some shining white substance laid *on* the dark belt, which it seemed to cut half in two. With a power of 300 it presented a well defined oval shape, the longer axis of which was inclined at about 30° to the dark belt, and its north end preceding. So unusual was it that at first I refused to believe it had an existence on Jupiter, thinking it must be in the telescope, but after moving one eye-piece after another until I had tried five, I was convinced that it formed part of the planet. I was most anxious to see it again, but could not see this part of Jupiter until October 18, and the spot was not visible. I looked on every available opportunity, and carefully examined this place eight times before I saw it again, which was on November 24. It then shone out with star-like brilliance; and although at first it appeared round, subsequently it looked oval. I have seen many of these spots, and this one several times before clearly defined, but I never saw one with a brilliance at all equal to this. From the repeated and careful observations which I made of this place between October 11 and November 24, I am convinced that the reason it is only sometimes visible is to be found in the clouds of Jupiter, for there always seems to be some clouds there when the spot is not visible. Each time this spot was seen it had the same relative position to the red spot.

There are several of these spots on the planet that I have been watching closely for some time past. They are all well-defined round spots, generally less than a second in diameter. It is not an uncommon thing to see their places occupied by white spots much larger, and probably of clouds; and once I noted a very striking change: it was on September 14, 1878, and the spot seemed to cut the south equatorial band almost in two; its situation was in the same longitude as the following part of the red spot. After I had finished my drawing and was watching it, a shower of rain obliged me to cover the telescope for an hour and a half; and then, when I looked again the white spot had contracted to one-fourth of its previous diameter, and the dark belt was re-formed. The now little spot did not present the hard disc of the others, and I have never seen it so; simply, as I believe, because I have not looked at the right time, for this place has the same cloud peculiarities as others where spots are found.

There are some of these cloud-like markings which I think further investigation will prove to be permanent features of the planet, and in some way connected with the white spots, for I have observed that in four instances certainly, and I think in every one, where a spot is visible, there is always to be found on the preceding side of it a cloud-like form, which extends into a diagonal, the end near the spot being the preceding end; in one or two instances the existence of a diagonal in a particular place has led me to look for and find the white spot belonging to it. This evident connection between the two markings, and their fixed positions on the surface suggests the idea that the white spots are snow-covered mountains, from which the clouds have for a time lifted; and the diagonal bands similar in colour to the north belt would be clear spaces taking their direction from the mountains. The proof is insufficient to convince one, but quite enough to make the suggestion, and to lead to the hope that we shall know more about it soon. These markings seem much more easily seen at some periods than at others, and as an illustration of their number I may mention, that at ten minutes past 8 p.m. on September 19, 1878, I saw no less than five well-defined diagonals extending from the south belt towards the north one, and one coming from the north towards the south: at this time the red spot was just passing off the planet, and next night I examined the part before the spot and found similar marks extending at least one-fifth of Jupiter's circumference, so that at that time almost the only markings between the belts were diagonals.

In connection with these also I will mention one of the most striking of the recent changes in Jupiter. On October 28, 7 p.m. 1880, when I looked at the planet I was astonished to see a large spot of decidedly blue colour, situated on the south equatorial belt, which it cut half in two; it looked like a mass of cloud, more dense in the centre than at the edges, and was of a generally rounded form, fully 6,000 miles in diameter. I had frequently, and only a few days before, examined this part of Jupiter, and was quite sure that what I saw was a sudden and recent development. I watched it with corresponding care that evening, but failed to see any motion in it or change of form. Two days later was the earliest date at which I could see it again; it was visible, but only as a ghost of its former self, and the blue was scarcely discernible; next day the blue was all gone, and only a brown mark remained. From the shape of this, viz., a tendency to form a diagonal, I suspected the existence of a white spot, and I watched carefully till I saw it, and had thus proof that the great cloud had formed over the top of a white spot. I may add that I have never before seen a marking upon Jupiter which was so blue in colour or so striking as this strange visitor was.

It is easy to see the two polar caps, but exceedingly difficult to detect anything there beyond the dark shade.

When the air is favourable the large telescope reveals a series of narrow bands upon which darker markings are sometimes seen; those in the north cap are fleeting, and the same may be said of a white spot seen there some time since. On the south cap there is a dark marking on the edge which has existed for some time; this is about the same longitude as the red spot, and from this point towards the preceding side, the edge of the cap ceases to be parallel to the equator, and extends towards it some distance. Where it attains its greatest distance from the pole, there is a large white patch on Jupiter, much whiter than anything else except the white equatorial spots. From many observations of the blue colour of these caps I am led to believe that it is an effect due to our atmosphere; I have, in fact, seen it disappear with improving definition and the light brown shade take it place.

In addition to the polar cap, there are in the northern hemisphere three faint (or usually faint) belts, and in the middle one of these I have seen more small black spots than anywhere else on the planet. Some of these have reappeared at intervals in the same place, and frequently with an enlargement of the belt where they are; at such times the belt for a short distance seems very irregular in outline, as if very much disturbed—in fact it presents similar features to those which mark a great disturbance in the next belt, such as I shall presently describe. In the southern hemisphere there is a belt corresponding to this, but different in appearance; it has for a long time, if not always, been marked by a dark spot half the size of and preceding the red spot. The nearest faint belt to the equator on the north side is a particularly interesting one, because of the great changes which take place in it. In 1876 it formed one of the four (then) nearly equal equatorial belts, and in size and colour it was inferior to none; in 1878 it had become as faint as it is now, and has so remained until within the past few weeks; it has often been quite invisible when the equatorial belts were very bright. On the 28th October, at 11 p.m., this year, I saw that a part of it was enlarged, and much darker in colour than usual, and upon examining closely I saw two black spots in the enlarged part, and noticed that just preceding this the belt was cut right in two by a band of white light similar to the surrounding surface. The following night I saw that there were three black spots, and that all this belt following them for a distance something like half the circumference of Jupiter was very much darker in colour and fully three times as wide as it had been, and this enlargement ended suddenly, the rest of the belt being in its normal state. With our ideas (for they would be different if we lived upon Jupiter) the change above described indicates the exertion of a tremendous force, whatever be the constitution of the belts, for the diameter of the belt had been increased from six or seven hundred miles to 2,000 miles, for a length of 120,000 miles, in the short space of a few days.

For the two following nights the air was not in a good state for observation, and I did not see anything about which I will now detain you. I may, however, mention that on November 1st a great enlargement, about 20,000 miles long, was seen in the belt north of this one.

On November 2nd I saw that one of the three black spots before mentioned had increased in size enormously, and had a black centre surrounded with a lighter shading, and looked very much like a sun-spot, and the belt was cut in two both before and after it. One could almost fancy he saw the giant cyclone sweeping the clouds round the dark central hole until they covered the belt on each side of it.

On November 10th this belt had become so much enlarged and deeper in colour that it was almost as conspicuous as the north equatorial belt, and the edge of it was most irregular, the whole belt looking as if it were made up of a line of cumulus clouds moving in the wildest confusion. On the following night a second of the dark spots was enlarged, and the whole belt seemed still more disturbed. On the 14th, 8h. 15m. p.m., at a spot then in the centre of Jupiter, the disturbed belt appeared cut down to its original dimensions, and one-half was the old belt and the other the new one, if I may so express it. I found that this point of contraction was not in the same longitude as the one before mentioned, but about 120 degrees after it. Since then the appearance of this belt has frequently changed, and when I saw it on the 25th it seemed to be made up of a series of loops or arches, and was more striking than ever.

I will not longer detain you with notices of any of the many other changes I have seen; but I think you must have noticed, in what has been said, that these changes seemed intensified in November; and the reflection is suggested to me that the earth, in the same period, has been changing its appearance to an outside observer. With the great storms and earthquakes which have visited the northern hemisphere, and in the long succession of cloudy weather and thunderstorms which we have experienced, a distant observer would see many and violent changes on the earth. I think I never before saw the record of so many storm curves as we have in the self-recorded curves during the past month; and, in the diagram of storms which accompanies the other paper I read to-night, you will see that the early part of November, when the earth passes through the great meteor stream, is a time at which many thunderstorms reach us. Have these meteors, or some other external cause, anything to do with the changes which have been going on in the two planets? When we know that a meteor dashing into the sun with a momentary flash stirred the magnetism of the earth, and recorded itself on the self-recording magnetometers at Greenwich, it would not be safe to say that there is no common cause for the changes we have been considering; and I am sure this suggestion would have come to you with far greater force if you could, with me, have watched, between the terrestrial clouds, the many changes going on in Jupiter. Much was missed, I know, for I saw many things after they were done, in a glimpse as it were; for instance, after a week of clouds here, I saw on November 14 that the whole aspect of Jupiter's northern hemisphere, from latitude 36° northwards, had changed from a bright surface marked by faint belts, to one mass of belts, in which the common ones were lost, and a host of strange markings put in their place. Answers to the questions—how, and when, and why all this took place, were covered up by the clouds that lasted here from November 7th to 14th.

The impression which a close study of Jupiter during the past four years has left upon my mind is that we see on the great planet very much the same phenomena as an observer placed upon Jupiter would see upon the earth; to him our planet would have a very different aspect from that by which we know it. On the polar sides of latitude 40° he would see an almost uninterrupted belt of clouds, shining white in the sunlight, probably almost as white as the snow caps; on the equatorial sides he would see the clearer regions of the trade winds, at times marked by persistent clouds or haze, which would hide every feature of the earth below, at best only visible by light that had passed twice through our atmosphere; and should he be fortunate enough to find the terrestrial air clear at the same time as his own, it would still be next to impossible to distinguish forest-covered earth from ocean; he would carefully note certain white points occasionally seen, and find they were constant in position; and if fortune favoured him, he would look when some terrestrial volcano shot up its ponderous cloud bank, black enough to obliterate everything beneath it, and perhaps, most conspicuous of all, would be the brilliant white cloud ring which generally surrounds the equator, somewhat broken and irregular in outline though it be. Watching these cloud features, he would see them travel north and south with the changing declination of the sun, and wonder whether the few bright points could be the only fixed things on the planet.

Just so, I think it is, that we see Jupiter. Our attention is arrested by the belts. We see on the polar sides of latitude 38° almost uninterrupted bright zones, where there is but little change; but from these latitudes towards the equator the case is different: at one time we find white zones covering everything from 38° to 18° on each side of the equator, as we see it at the present time; at another time all this is changed, and their place is occupied by ever-changing light-red-coloured rings as in 1876. On the equator at one time we see the brightest cloud zone on the planet, and at another a faint red one, which like that between the terrestrial trades is ever changing its features. On each side of this are situated the darkest rings to be found on the planet, and through these probably is our only chance of seeing the true surface, excepting those snow-covered mountain tops which parting clouds reveal.

[Diagrams.]

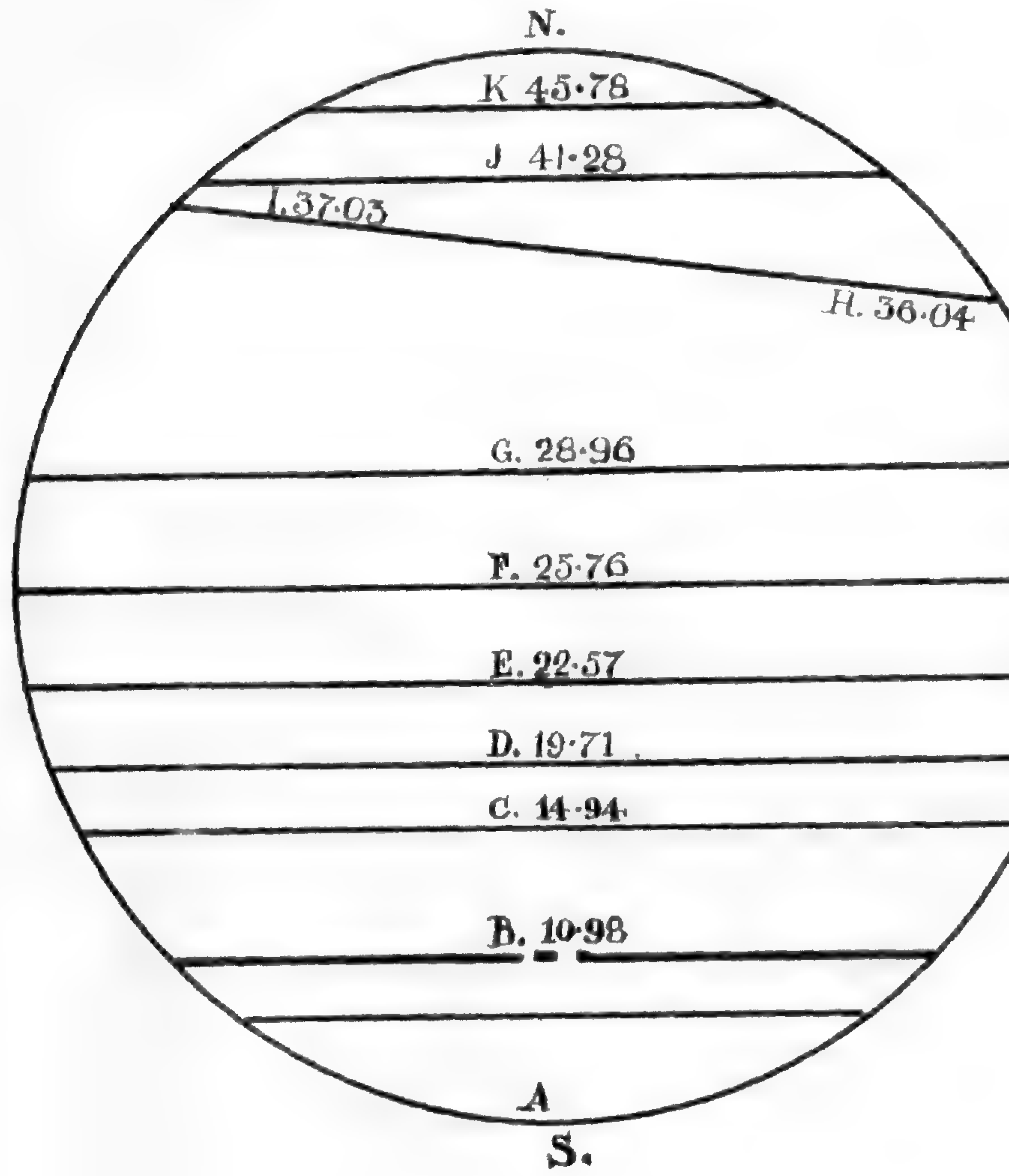
JUPITER AS SEEN WITH 11½-INCH REFRACTOR AT SYDNEY.

June 2, 1876,
10.40 p.m., S.M.T.

November 2, 1880,
9.37 p.m., S.M.T.

October 28, 1880,
7.10 p.m., S.M.T.

Measures of Jupiters Belts at Sydney
7.30 pm June 23rd 1876.



Measurements of Jupiters Belts at Sydney.
November 2nd 1880.

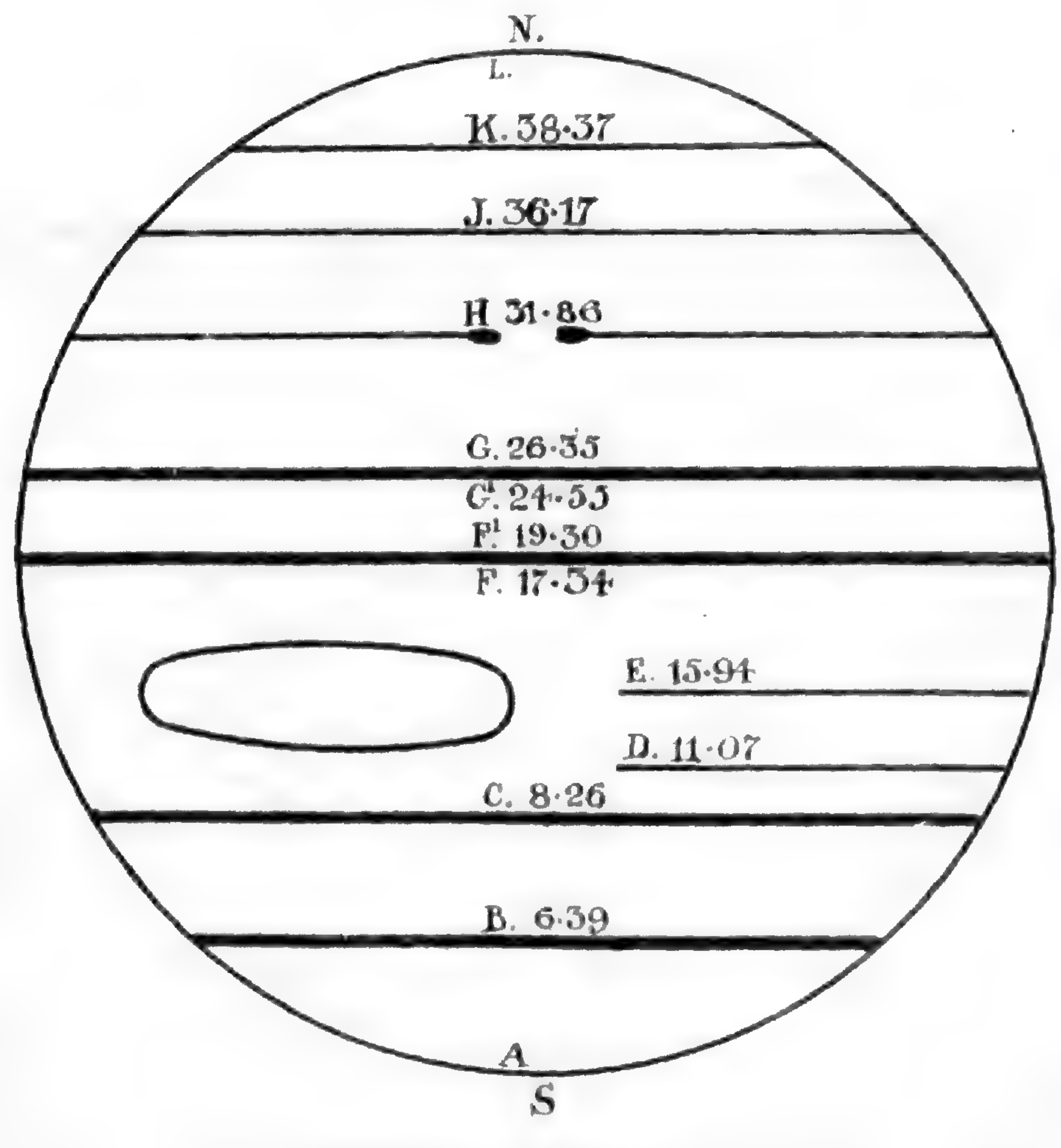


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE.
SYDNEY, NEW SOUTH WALES

5e 5–81

Remarks on the Colours of Jupiter's Belts, and some changes observed thereon during the opposition of 1880.

By Geo. D. Hirst.

[*Read before the Royal Society of N.S.W., 1 December, 1880.*]

I am not able, I am afraid, to add much of interest to the paper just read by Mr. Russell. My own observations of Jupiter this opposition have not been anything like as complete as I could wish. A long spell of cloudy weather when the planet was in its most favourable position made a great break just when regular and consecutive observations would have had most value; and since then, though we have been favoured at intervals with nights on which the air has been exceptionably steady, a large proportion of the clearest evenings have been unsuitable for good work, preventing the satisfactory employment of a large aperture, especially during the earlier hours of the night.

I have, however, the pleasure of laying before you a few drawings made by the aid of Mr. Colyer's $10\frac{1}{4}$-in. silvered glass reflector by Browning. They may be of some interest to compare with what has been done by the Sydney Observatory refractor. I have made every exertion to secure accuracy of detail, and especial attention has been given to the careful reproduction of the colours of the belts and polar regions. For this work the silvered glass reflector is particularly suitable, on account of its absolute achromatism.

The following is a brief review of some of the salient features of the planet noted during the last three months:—

North polar shading:—This maintains the fine sea-green tint noted by me first in 1876, but the colour is more pronounced. I can see it well with aperture reduced to 4 in.; it used to require at least 7 in., and a steady night. A new white belt has recently made its appearance here, extending apparently quite round the planet, but brighter in some places than others. The southern limit of the north pole shading has for some years been bordered by a narrow light-brown belt; this belt has this year darkened considerably in colour, on some occasions appearing almost black and very ragged; a large black spot has been noted on it of an ill-defined form; it seems subject to rapid change, as after an interval of two revolutions it has appeared so faint as barely to be visible in mid-transit, but I have seen it again on succeeding nights as conspicuous as before.

South of the north pole shading, and between it and the northern equatorial belt, runs a narrow purple streak; it completely circles the planet, and has been a permanent feature for several years. This year I noticed that it had split into two belts, but they are so narrow and close together that it requires the finest night to separate them. I think there is a genuine change here, for I had scrutinised this belt closely on the most favourable occasions previously without detecting the separation.

The northern equatorial belt appears generally, as it was last year, of a bright brick-red colour. I say generally, for on one or two occasions I have noted the entire disappearance of the red, which has been replaced by a dull-brown colour. Two of the drawings will demonstrate this.

Between the north and south equatorial belts lies the portion of the planet which appears at the present time to be undergoing a series of the most astounding changes, occurring too on an immense scale, and with such rapidity that a couple of revolutions occuping a little over twenty hours are quite sufficient to render the same portion of the disc quite unrecognisable; indeed I have seen small details change while attempting to draw them, and that in a manner not to be accounted for by their altered position due to the rotation of the planet. The portion of the equatorial belt immediately north of the great red spot is particularly noticeable for its rapid changes; I have noted appearances resembling cyclonic action here.

The south equatorial belt is generally of a bluish-grey colour, mixed occasionally with a tinge of crimson lake or sometimes rose-colour. These latter tints are not conspicuous, and can only be seen on a fine night. The rose or crimson generally runs along the southern border of the belt.

South of the equatorial band is the great red spot; this is now of a fairly symmetrical shape, both ends being slightly pointed; it looks larger to me than it did last year, and the colour is I think undoubtedly brighter; it appears to be now rather vermilion than red, anyhow its colour is certainly much brighter than that of the northern equatorial belt. Two faint and narrow belts following it have been seen on favourable occasions.

Between the great spot and the south equatorial belt a narrow band has lately come into view; I am certain it was not there prior to opposition; it is remarkable for its reddish brown colour, and appears to me to be an indication of the filling in of the space between the spot and the equatorial band.

The south pole shading still appears to me, as it has for some years past, of a warm grey colour, and no important changes have been noted there, except the advent of a dusky marking not well defined, and a white streak not noticed there last year.

I have spoken of the polar shadings, and as shadings they appear on ordinary nights, but I have several times suspected that what looked as an ill-defined shading might under especially favourable circumstances be resolved into a number of minute belts. On the 30th September occurred an opportunity seldom to be met with, for about 9h. to 9h. 30m. the conditions for observing were absolutely perfect with a power of 500, which the mirror bore with ease; the north and south polar shadings were seen to consist of hundreds upon hundreds of the minutest belts, but so fine were they and so close together that the slightest tremor of the atmosphere sufficed to merge them into each other. I tried the experiment several times of placing my warm hand against the outside of the tube, and the slight disturbance of the air inside caused by this instantly obliterated them. It was a beautiful sight, and a fine testimony to the excellence of Mr. With's mirror.

I have confined these few remarks chiefly to the colours of the various features of the planet; in other observations connected with it, abler hands than mine have doubtless turned this opposition to good account.

A Catalogue of Plants collected during Mr. Alexander Forrest's geographical exploration of North-west Australia in 1879.

By Baron Ferd. von Müeller, K.C.M.G., M.D., Ph.D., F.R.S.

[*Read before the Royal Society of N.S.W., 7 July, 1880.*]

The following enumeration of plants refers to collections, formed during Mr. Alexander Forrest's expedition of last year in the country between King's Sound and Port Darwin. It was intended to append the complete list of the expedition plants to his official report, but this could only be carried out in reference to the species gathered between Nickol-Bay and King's Sound, as the collections, obtained in the further progress of the journey, were by some oversight miscarried, and thus reached me too late to render the present list timely available for the exploration report. The specimens were partly collected by Mr. Forrest himself, partly by one of his companions, Mr. James C. Carey; and although hardly any new species were discovered, it seemed still of sufficient interest to give publicity to this index, as the localities for every kind of plant were accurately recorded, and thus new data concerning the natural spread of many of the rarer species became available.

The additions, successively made to the already long former lists of West Australian plants by the exertions of recent travellers, have gradually grown so extensive, that now nearly half of the whole vegetation of the Australian continent has been traced to within the boundaries of the vast West Australian territory. Further searches will doubtless add still much to the phytographic records also of the intratropic region, when colonisation in the north-west and in the interior will afford collectors of scientific material a permanent footing there.

To this list of names of plants and their localities I have added some data from my unpublished diaries of the expedition of 1855 and 1856, in which I accompanied Mr. Aug. Gregory, as I was one of the four, who in the early part of the latter year penetrated from the Victoria-River to Sturt's Creek as far as 20° 20′ south. The collections formed by me in that particular region, now after twenty-three years for the first time revisited by Mr. Forrest and his party, were mostly destroyed on the passage from Timor to Sydney, so that many of the localities now given from my journal remained ever since unrecorded.

This contribution to the phytography of North-west Australia may also tend to draw additional attention to the cultural resources of the vast region recently explored in so able a manner by Mr. A. Forrest. When we contemplate, that many millions of acres of open richly grassed and well watered pastoral country were discovered in addition to what was disclosed already by the expedition of 1855-1856,—when we consider, that the North-west of Australia is blessed by a salubrious clime, mitigated in its heat by the prevailing westerly and northerly sea-breezes; when we recognise, that the tropical rains keep the pastures verdant also during the hot season, and that in the cool season grasses and herbage remain also fresh; when we learn, that only a most sparse and unresisting aboriginal population occupies this large territory; when we remember, that these fine tracts of country, on which the light of geography has so recently been shed, are adjacent to many safe and spacious harbours; and when we reflect, how short a distance this new country is separated from India, and how easily the products of North-west Australia can be rendered also accessible through the Suez-Canal not only to the countries on the Mediterranean Sea but also to Britain,—then we may point to this newly opened part of the fifth continent as one of the most promising of any fields for immigration, for the safe and lucrative investment of monetary capital, and for the display of skill and assiduity of intelligent colonists.

Menispermeæ.

Tinospara smilacina, Benth. in Journ. Linn. Soc. v. suppl. p. 52. Ord River, Margaret River; Hooker's Creek, Termination Lake (F. v. M.).

Nymphaeaceæ.

Nymphaea stellata, Willd. sp. pl. II., 1153, Near Mt. Whittenoom (F. v. M.). Dr. Caspary has ascertained that the Egyptian *N. coerulea* of Savigny is specifically distinct. It may here incidentally be observed, that *Nelumbo nucifera* has been noticed near Mt. Elliot by Mr. Fitzalan.

Cappárideæ.

Capparis lasiantha, R. Br. in D.C. prodr. I., 247. Ord River. Found as far south as the Gascoyne River by Mr. Oliver Jones.

Roeperia cleomoides, F. v. M. in Hooker's Kew Miscell. IX., 15. Wickham River (F. v. M.). Dr. Eichler (Bluethen-Diagramme II., 208 and 211) has shown, that this genus cannot be united with Gynandropsis, as proposed by Bentham.

Cleome tetrandra, Banks in Cand. prodr. I., 240. Wickham River. Found as far south as the Comet River by Mr. P. O'Shanesy.

Cleome oxalidea, F. v. M. Fragm. I., 69. Wickham River. Noticed on the Gilbert River by Captain Armit.

Cruciferæ.

Lepidium pedicellosum, F. v. M. fragm. XI., 27. Ord River.

Droseraceæ.

Drosera Indica, L. sp. pl. 282. Margaret River.

Malvaceæ.

Hibiscus microchlaenus, F. v. M. Fragm. II., 116. Margaret River, Ord River; Stirling's Creek, Termination Lake, F. v. M. Noticed on the Triodia sandhills as far south as the vicinity of Fowler's Bay by Mr. Tietkens, who observes that the dromedaries delight to feed on this plant.

Hibiscus panduriformis, Burm. Fl. Ind. p., 151, t., 47, f., 2. Benn River (south of Connaught Range), near Mount Compton, near Depot Pool.

Hibiscus pentaphyllus, F. v. M. Fragm. II., 13. Margaret River, Humbert River, near Depot Pool, Wickham River.

Hibiscus ficulneus, L. sp. pl., 695. Rich Trap country on the upper Victoria River and Sturt's Creek. Petals towards the base beautifully red, but described by Roxburgh (as regards his H. strictus) as pure white throughout.

Gossypium australe, F. v. M. Fragm. I., 46. Margaret River, Ord River, Negri River (east of Connaught Ranges); Termination Lake (F. v. M.).

Sida corrugata, Lindl. in Mitch. three Exp. II., 13. Margaret River, Ord River,

Abutilon otocarpum, F. v. M. in Transact. Philos. Soc. Vict. 1855, p. 13. Hooker's Creek (F. v. M.).

Malvastrum spicatum, Asa Gray in Plant Fendler. 23. Ord River; Termination Lake (F. v. M.).

Adansonia Gregorii, F. v. M. in Hooker's Kew Miscell. IX., 14. Wickham River (F. v. M.).

Sterculiaceæ.

Waltheria Americana, L. sp. pl., 637. South of Connaught Ranges.

Melochia pyramidata, L. sp. pl., 674. South of Connaught Ranges.

Brachychiton ramiflorum, R. Br. in Horsf. Plant Javan. rarior. 234. South of Mt. Compton; Hooker's Creek (F. v. M.).

Bruchychiton diversifolium, R. Br. in Horsf. Pl. Jav. rar., 234. East of Oscar Ranges, south of Connaught Ranges, Humbert River; Sturt's Creek (F. v. M.).

Tiliaceæ.

Corchorus sidoides, F. v. M. Fragm. III., 9. East of Connaught Ranges.

URTICEAE.

Trema cannabina, Lour. Fl. Cochin. II., 562. East of Connaught Ranges, near Mt. Compton; Wickham River (F. v. M.).

Ficus coronulata, F. v. M. in Journ. Neerl. 1861, 242. East of Oscar Ranges, east of Connaught Ranges.

BIXACEÆ.

Cochlospermum heteronemum, F. v. M. in Hooker's Kew Garden Miscellany, IX., 15. Ord River, between Connaught and Rudolph Ranges; Stirling's Creek (F. v. M.); Glenelg River (Martin), Liverpool River (Gulliver). The name of this species was derived from the two forms of its filaments. Cochlospermum Gillivrayi occurs on the Endeavour River and at Cape Sidmouth (Dr. Curdie), C. Gregoryi on the Norman River (Gulliver).

MELIACEÆ.

Melia Azedarach, L. sp. pl., 384, var. australis. North of Oscar Ranges; Victoria River (F. v. M.).

SAPINDACEÆ.

Dodonaea platyptera, F. v. M. Fragm. I., 73. At Stirling's Creek and in its vicinity.

Dodonaea physocarpa, F. v. M. Fragm. I., 74. South of Rudolph Range.

Dodonaea polyzyga, F. v. M. Fragm. I., 74. East of Oscar Ranges, Negri River; Sturt's Creek (F. v. M.).

Distichostemon phyllopterus, F. v. M. in Hooker's Kew Miscell. IX., 306. Hooker's and Sturt's Creeks (F. v. M.).

Cardiospermum Halicacabum, L. sp. pl., 366. South of Connaught Ranges.

Atalaya hemiglauca, F. v. M. in Benth. Flor. Austr. I., 463. Ord River, between Connaught and Rudolph Ranges, near Depot Pool; Sturt's and Hooker's Creeks (F. v. M.). Dr. Radlkofer (Sitzungs Berichte der Kgl. Bair. Akad. der Wissenschaften, 1878, p. 326 and 327) distinguishes two more Australian species, *A. coriacea* from Lord Howe's Island, and *A. australis* from Cape York, both on very slight and probably not specific characteristics.

EUPHORBIACEÆ.

Adriana tomentosa, Cand. in Ann. Scien. Nat. 1 série VI, 223. East of Connaught Ranges, near Depot Pool.

Excaecaria Agallocha, L. sp. pl. ed. secunda, 1451, var. parvifolia. South of Rudolph Range.

Petalostigma quadriloculare, F. v. M. in Hooker's Kew Miscell. IX., 17. On Hooker's Creek and near the sources of Sturt's Creek.

Andrachne Decaisnei, Benth. Flora Austr. VI., 88. Near Depot Creek (F. v. M.). Probably perennial.

Euphorbia schizolepis, F. v. M. in Cand. Prodr. XV, part II., 20. Near Port Darwin.

Euphorbia eremophila, All. Cunningham in Mitchell's Tropical Austr., 348. Hooker's and Sturt's Creeks (F. v. M.).

FICOIDEÆ.

Mollugo Glinus, A. Rich. Flora Abyss. I., 48. East of Connaught Ranges; Sturt's Creek (F. v. M.).

Mollugo Spergula, L. sp. pl. edit. sec., 131. Near Termination Lake (F. v. M.).

NYCTAGINEÆ.

Boerhaavia diffusa, L. sp. pl., 3. Margaret River.

SALSOLACEÆ.

Salsola Kali, L. sp. pl., 212. Hooker's and Sturt's Creeks.

Kochia villosa, Lindl. in Mitch. Trop. Austr., 91. Ord River.

Rhagodia nutans, R. Br. prodr., 408. Near Ord River; Sturt's Creek (F. v. M.).

Dysphania Plantaginella, F. v. M. Fragm. I., 61. Between Connaught and Rudolph Ranges; also at Nickol Bay, Mrs. Crouch (spike 6 inches long); near Wittenoom Mountains (F. v. M.)

AMARANTACEÆ.

Gomphrena canescens, R. Br. Prodr., 416. Margaret River.

Gomphrena affinis, F. v. M. in Benth. Flora Austr. V., 254. Sturt's Creek (F. v. M.).

Amarantus interruptus, R. Br. Prodr., 414. Sturt's Creek, F. v. M. It may here incidentally be observed, that *A. enervis*, of which *A. tenuis* seems to be a variety, is either identical with *Chenopodium atriplicinum* or closely allied to it.

Ptilotus alopecuroides, F. v. M. Fragm. VI., 227. Upper Victoria River, Sturt's and Hooker's Creeks.

Ptilotus exaltatus, Nees in Lehm. pl. Preiss. I., 630. East of Oscar Ranges; Hooker's and Sturt's Creeks (F. v. M.).

Ptilotus spicatus, F. v. M. in Benth. Flora Austr. V., 243. East of Oscar Ranges; Sturt's Creek (F. v. M.). Flowers at first often dark red; quite an ornamental plant.

Ptilotus distans, Poiret Diction. suppl. IV., 620. Hooker's and Sturt's Creeks (F. v. M.).

Ptilotus corymbosus, R. Br. Prodr., 415. Stirling's Creek (F. v. M.).

Ptilotus psilotrichoides, F. v. M. fragm. X1., 94. (Psilotrichum capitatum fragm. I., 238). Near Negri's River.

Achyranthes aspera, L. sp. pl., 205. Ord River, Sturt's Creek (F. v. M.).

PORTULACEÆ.

Portulaca oleracea, L. sp. pl., 445. Frequent in the inland region; valuable to travellers as spinage or raw as an antiscorbutic herb on account of its acidity; variable in its forms and particularly in the size of its flowers. On the Wickham River and on Sturt's Creek the writer met a variety with beautifully red petals, as showy as those of *P. grandiflora.*

Portulaca napiformis, F. v. M. in Benth. Flora Austr. I., 169. Hooker's and Sturt's Creeks (F. v. M.). The petals never emarginate as those of *P. oleracea.*

POLYGONEÆ.

Polygonum plebejum, R. Br. Prodr., 420. Between Connaught and Rudolph Ranges.

Muehlenbeckia Cunninghami, F. v. M. Fragm. V., 91. Hooker's and Sturt's Creeks (F. v. M.).

LEGUMINOSÆ.

Jacksonia thesioides, A. Cunn. in Ann. Wien. Mus. II., 74. Near Rudolph Range.

Jacksonia odontoclada, F. v. M. in Benth. Flora Austr. II, 55. Near Rudolph Range.

Mirbelia oxyclada, F. v. M. Fragm. IV., 12. Near Termination Lake (F. v. M.). Petals yellow.

Bossiaea phylloclada, F. v. M. in Transact. Philos. Inst. Vict. III., 52. Near Mt. Compton.

Crotalaria Cunningham's, R. Br. Appendix to Sturt's Centr. Austr., 8. Sturt's Creek (F. v. M.).

Crotalaria linifolia, L. fil. suppl. pl., 328. Between Mueller Range and Ord River.

Crotalaria trifoliastrum, Willd. sp. pl. III., 983. Between Ord River and Mueller Range, east of Connaught Ranges, near Mt. Compton.

Crotalaria crispata, F. v. M. in Benth. Flora Austr. II., 179. Between Margaret River and Oscar Ranges; between Ord River and Mueller Range; near Termination Lake (F. v. M.).

Crotalaria retusa, L. sp. pl., 715. Ord River.

Crotalaria alata, Ham. in D. Don Prodr. Flor. Nepal., 241. Near Mt. Compton. Specimens, without flower or fruit, of this or a closely allied species, but easily recognisable by its broadly decurrent stipules; the specimens small-leaved. The species is new for Australia.

Lotus australis, Andr. Botan. Rep. tab., 624. Fitzroy River, east of Oscar Ranges, Ord River, Humbert River.

Psoralea cephalantha, F. v. M. Fragm. IV., 35. Benn River.

Psoralea plumosa, F. v. M. Fragm. IV., 22. Depôt Creek (F. v. M.).

Psoralea leucantha, F. v. M. in Transact. Vict. Institute III., 54. Margaret River, east of Connaught Ranges; Sturt's Creek, (F. v. M.).

Psoralea balsamica, F. v. M. in Transact. Vict. Institute III., 55. East of Oscar Ranges.

Psoralea Archeri, F. v. M. Fragm. IV., 21. East of Oscar Ranges, Benn River.

Psoralea patens, Lindl. in Mitch. three Exped. II., 9. Near Mt. Krauss, between the Connaught and Rudolph Ranges, near Depôt Pool; Sturt's Creek and Termination Lake (F. v. M.).

Indigofera linifolia, Retzius observ. IV., 29. Sturt's Creek.

Indigofera monophylla, Cand. prodr. II., 222. Ord River.

Indigofera trita, L. fil. suppl., 335. Negri River, Humbert River.

Indigofera viscosa, Lam. Diction. III., 247. Between Mt. Krauss and Mueller's Range.

Indigofera hirsuta, L. sp. pl., 751. Near Mt. Krauss; Sturt's Creek (F. v. M.).

Tephrosia flammea, F. v. M. in Benth. Flora Austr. II., 204 Near Termination Lake (F. v. M.).

Tephrosia coriacea, Benth. Flora Austr. II., 204; var. velutina South of Connaught Ranges.

Tephrosia uniovulata, F. v. M. Fragm. XI., 70. Margaret River, between Mueller's Range and Ord River.

Tephrosia rosea, F. v. M. in Benth. Flora Austr. II., 211. East of Oscar Ranges.

Tephrosia purpurea, Pers. Synopsis Plant II., 329. Ord River; Stirling's Creek (east of Connaught Ranges).

Swainsona oligophylla, F. v. M. in Benth. Flora Austr. II., 218. East of the Oscar Ranges. Nearer the equator than any congener.

Sesbania aculeata, Pers. syn. pl., 316. Between Connaught and Rudolph Ranges. thence towards Mt. Compton.

Sesbania simpliciuscula, F. v. M. in Benth. Fl. Austr. II., 213. Sturt's Creek (F. v. M.). Stipules dark-coloured. Upper petal with or without dots or red spots. Legumes long, erect. Seeds prismatic-oblong, brownish, shining, about 2 lines long. Roots beset with small bulbilles.

Sesbania grandiflora, Pers. Synops. pl. II., 316. Wickham's River.

Erythrina vespertilio, Benth. in Mitch., Trop. Austr., 218; status normalis; Humbert River. Varietas biloba, Ord River.

Rhynchosia minima, Cand. Prodr. II., 380. Between Mueller Range and Ord River.

Canavalia obtusifolia, Cand. Prodr. II., 404. Margaret River.

Bauhinia Leichhardtii, F. v. M. in Transact. Vict. Inst. III., 50. Margaret River, Ord River, near Mt. Compton and Depot Pool; Hooker's and Sturt's Creeks and Termination Lake (F. v. M.).

Cassia glutinosa, Cand. Prodr. II., 945. Margaret River, Ord River.

Cassia venusta, F. v. M. Fragm. I., 165. East of Oscar Ranges, Humbert River, Hooker's and Sturt's Creek (F. v. M.).

Cassia magnifolia, F. v. M. Fragm. I., 166. Between Mueller Range and Ord River.

Cassia desolata, F. v. M. in Linnæa, 1852, p., 389. Margaret River.

Cassia mimosoides, L. sp. pl., 379. Between Rudolph Range and Mt. Compton. Traced by me southward to the vicinity of Termination Lake.

Acacia Sentis, F. v. M. in Journ. Linn. Soc. III., 128. Near the Rudolph Range, Sturt's Creek (F. v. M.).

Acacia retivenia, F. v. M. Fragm. III., 128. Margaret River.

Acacia Wickhami, Benth. in Hook. Lond. Journ. Bot. I., 379. Margaret River.

Acacia stipulosa, F. v. M. in Journ. Linn. Soc. III., 119. East of the Oscar Ranges, Humbert River.

Acacia pallida, F. v. M. in Journ. Linn. Soc. III., 147. Margaret River. Noticed on the Ennesleigh River by Captain Armit. Seeds greyish-brown, not shining, roundish or somewhat quadrangular, compressed, 3-4 lines long ; funicle pale brown, replicate near the hilum, but not expanded into a strophiole.

Acacia Farnesiana, Willd. sp. pl. IV., 1083. Hooker's and Sturt's Creeks (F. v. M.). Found at Mt. Hale by Mr. Carr.

MYRTACEÆ.

Barringtonia acutangula, Gaertn. de fructib. et sem. II., 97, t. 101. Humbert River, junction of Wickham and Victoria River.

Eugenia eucalyptoides, F. v. M. fragm. IV., 55. East of Rudolph Range.

Calycothrix microphylla, A. Cunn. in Bot. Mag., 3323. East of Oscar Ranges, between Connaught and Rudolph Ranges.

Melaleuca minutifolia, F. v. M. in Transact. Phil. Inst. Vict. III., 45. Between Connaught and Rudolph Ranges.

Melaleuca Leucadendron, L. mant. plant, 105. Between Rudolph Range and Mt. Compton.

Melaleuca genistifolia, Sm. in Trans. Linn. Soc. III., 277. Ord River, Depot Pool.

Eucalyptus aspera, F. v. M., in Journ. Linn. Soc. III., 95. East of Connaught Ranges.

Eucalyptus pruinosa, Schauer in Walp. Rep. II., 926. Benn River.

Eucalyptus terminalis, F. v. M. in Journ. Linn. Soc. III., 89. Sturt's Creek and Stirling's Creek (F. v. M.).

Eucalyptus rostrata, Schlecht. Linnaea XX., 655. Hooker's and Sturt's Creeks (F. v. M.).

LYTHRACEÆ.

Rotala diandra, F. v. M. (*Ameletia diandra*, F. v. M. Fragm. III., 108). Margaret River; sources of Sturt's and Hooker's Creeks (F. v. M.).

Dr. Koehne, after an extensive study of the whole order of Lythraceae, has shown (Sitzungs-Berichte des botan. Vereins der Provinz Brandenburg, 1877, p. 47-49), that the genus Rotala could well be re-established, as already contended by Hiern (in Oliver's Flora of Tropical Africa II., 466 and 476), the differences consisting in the dehiscence of the fruit, in which respect Rotala holds about the same position to Ammannia as Bergia to Elatine. To the genus Nesaea, in the limitation assigned by Koehne, we must now also refer *Lythrum Arnhemicum*, which I separated as a sub-genus under the name of Calopeplis (Fragm. Phytogr. Austr. III., 109), its affinity to Nesaea having been pointed out by myself already in 1862.

Ammannia Indica, Lam. illustr., 1555. Between Connaught Ranges and Humbert River.

Ammannia multiflora, Roxb. flora Ind. I., 426. Margaret River.

ONAGREÆ.

Jussiaea suffruticosa, L. sp. pl., 388. Ord River, sources of Hooker's and Sturt's Creeks (F. v. M.).

Ludwigia parviflora, Roxb. flora Ind. I., 419. Sturt's Creek (F. v. M.).

COMBRETACEÆ.

Gyrocarpus Jacquini, Roxb. Plant Corom. I., 2; t., 1. Negri River, Margaret River, Sturt's Creek (F. v. M.).

Terminalia platyphylla, F. v. M. Fragm. II., 150. Near Hooker's and Sturt's Creeks (F. v. M.).

HALORAGEÆ.

Haloragis leptotheca, F. v. M. Fragm. III., 32. Fitzgerald Range, sources of Hooker's and Sturt's Creeks (F. v. M.).

I have restored the specific name of this plant, because Decaisne's drawing in Duperry Voyage, Botanique t., 70, represents rather the roundish fruit of *H. tetragyna* than the elongated fruit of *H. leptotheca*, the degree of roughness being variable. Brogniart appears not to have published the text of *H. acanthocarpa*, so that we are left in uncertainty whether it came from an intratropical or extratropical place; but some of the other plants figured in the Atlas next to *H. acanthocarpa* are species obtained in New South Wales. With *H. tencrioides* all may be forms of one species.

Haloragis ceratophylla, Endl. Atakt., 16; t., 15. Sturt's Creek (F. v. M.).

STACKHOUSIACEÆ.

Stackhousia viminea, Smith in Rees Cyclop., 1819. Fitzgerald Range.

PROTEACEÆ.

Banksia dentata, L. fil. suppl. pl., 127. East of the Oscar Ranges.

Grevillea striata, R. Br. in Transact. Linn. Soc. X., 177. Ord River, near Connaught Ranges, junction of Wickham and Victoria Rivers, Hooker's and Sturt's Creeks (F. v. M.).

Grevillea Chrysodendron, R. Br. in Trans. Linn. Soc. X., 176. Near Mt. Compton.

Grevillea mimosoides, R. Br. in Trans. Linn. Soc. X., 177. Ord River.

Grevillea Wickhami, Meissn. in Cand. Prodr. XIV., 380. Margaret River; a variety with the outside of the calyx and the style hairy.

Grevillea leucadendron, A. Cunn. in R. Br. Prot. nov., 25. Sturt's Creek (F. v. M.).

Grevillea refracta, R. Br. in Transact. Linn. Soc. X., 176. Hooker's Creek (F. v. M.).

Hakea arborescens, R. Br. in Transact. Linn. Soc. X., 187. Sources of Hooker's and Sturt's Creeks.

Hakea lorea, R. Br. Proteaceæ novæ, 25. Sturt's Creek (F. v. M.).

SANTALACEÆ.

Santalum lanceolatum, R. Br. Prodr., 356. North of Nicholson Plains; Hooker's and Sturt's Creeks (F. v. M.).

Exocarpus latifolia, R. Br. Prodr., 356. Sources of Hooker's and Sturt's Creeks.

RUBIACEÆ.

Gardenia resinosa, F. v. M. Fragm. I., 54. Sources of Hooker's and Sturt's Creeks (F. v. M.).

Oldenlandia mitrasacmoides (*Hedyotis mitrasacmoides*, F. v. M. Fragm. IV., 37). Sturt's Creek, near Mt. Mueller. The genera Hedyotis and Oldenlandia require to be united, and then the latter takes precedence, being established by Plumier already in 1703, and adopted by Linné in 1740, whereas Hedyotis became only founded by Linné in 1747. Oliver and Hiern initiated already this re-arrangement of the species in the transactions of the Linnean Society, 1873, and in the flora of tropical Africa III., 53–65. Of Australian congeners hitherto thirteen have been described.

COMPOSITÆ.

Erigeron sessilifolius, F. v. M. Fragm. XI, 102. Depot Pool.

Epaltes australis, Lessing in Linnaea V., 148. Termination Lake (F. v. M.).

Calotis breviseta, Benth. in Hueg. enum., 60. Sturt's Creek, near Termination Lake (F. v. M.).

Pterigeron odorus, Benth. Flora Austr. III., 532. Ord River.

Moonia trichodesmoides, Benth. flora Austr. III., 540. East of Oscar Ranges.

Glossogyne tenuifolia, Cass. in dict. sc. nat. LI., 475. Between Mueller's Range and Ord River, Sturt's Creek (F. v. M.).

Pterocaulon verbascifolius, Benth. in B. and H. gen. plant., 294. Humbert River.

Pterocaulon sphacelatus, Benth. in B. and H. gen. plant., 294. Eastern branch of Fitzroy River, north of Nicholson Plains.

Flaveria Australasica, Hooker in Mitch. Trop. Austr., 118. East of Connaught Ranges.

Helichrysum apiculatum, Cand. Prodr. VI., 195. Wickham River.

Gnaphalium Indicum, L. sp. pl., 852. A variety with globular mostly terminal flower-clusters; Depot Pool.

Gnaphalium luteo-album, L. sp. pl., 851. Between Connaught and Rudolph Ranges.

LOBELIACEÆ.

Lobelia quadrangularis, R. Br. Prodr., 563. Between Connaught Ranges and Humbert River.

APOCYNEÆ.

Wrightia saligna, F. v. M. in Benth. Flora Austr. IV., 317. Sources of Hooker's and Sturt's Creeks (F. v. M.).

Carissa Brownii, F. v. M. Fragm. IV., 45, var. lanceolata. Ord River, between Connaught Ranges and Humbert River; Hooker's and Sturt's Creeks (F. v. M.).

ASCLEPIADEÆ.

Sarcostemma australe, R. Br. Prodr., 463. Sturt's Creek (F. v. M.).

Cynanchum floribundum, R. Br. Prodr., 463. Between Mueller's Range and Ord River, Depot Creek (F. v. M.).

Microstemma glabriflorum, F. v. M. Fragm. I., 58. Southern sources of the Victoria River, from whence I also recorded *Secamone ovata* in my diary.

ACANTHACEÆ.

Dicliptera glabra, Decaisne herb. Timor., 55. Ord River.

Hypoestes floribunda, R. Br. Prodr., 474. Ord River, Humbert River.

Nelsonia campestris, R. Br. Prodr., 481. Depot Pool.

Justicia procumbens, L. Flora Zeilanica, 19. Sturt's Creek (F. v. M.).

CONVOLVULACEÆ.

Evolvulus linifolius, L. sp. pl. ed. sec., 391. Ord River.

Ipomœa hederacea, Jacq. collect. I., 124. East of Oscar Ranges; flowers in this case solitary.

Ipomœa erecta, R. Br. Prodr., 487. Stirling's Creek, near Fitzgerald's Range.

Ipomœa reptans, Poiret Encycl. Méthod., suppl. III., 460. Sturt's Creek in many places, extending to near Termination Lake, also on Hooker's Creek (F. v. M.). As regards the dehiscence of its fruit this species holds the same relation to other congeners as Limnanthemum to Villarsia.

Ipomœa alata, R. Br. Prodr., 484. Sturt's Creek (F. v. M.).

Ipomœa heterophylla, R. Br. Prodr., 487. Sturt's Creek (F. v. M.).

Ipomœa dissecta, Willd. Phytogr., 5 t., 2. Near Termination Lake (F. v. M.).

Ipomœa gracilis, R. Br. Prodr., 484. Sturt's Creek, near Termination Lake (F. v. M.).

Ipomœa denticulata, Choisy in Cand. Prodr. IX., 379. Sources of the Victoria River (F. v. M.).

Convolvulus parviflorus, Vahl. Symbol. III., 29. Sturt's Creek (F. v. M.).

Breweria media, R. Br. Prodr., 488. Noticed by me as far south as Termination Lake (F. v. M.).

Breweria linearis, R. Br. Prodromus, 488. Sturt's Creek (F. v. M.).

Breweria pannosa, R. Br. Prodr., 488. Seen by the writer as far south as Termination Lake.

SOLANACEÆ.

Physalis minima, L. sp. pl., 183. Depôt Pool.

Solanum echinatum, R. Br. Prodr., 417. Near Termination Lake (F. v. M.).

GOODENOVIACEÆ.

Goodenia scaevolina, F. v. M. Fragm. I., 118. Hooker's and Sturt's Creek, near Termination Lake (F. v. M.)

Goodenia lamprosperma, F. v. M. Fragm. I., 116. Margaret River.

Goodenia heterochila, F. v. M. Fragm. III., 142. East of Oscar Ranges, between the Ord River and Mueller Range. Corolla gibbous at the base.

Calogyne pilosa, R. Br. Prodr., 579. Depôt Creek (F. v. M.)

Leschenaultia agrostophylla, F. v. M. Fragm. VI., 8., t. XLVII. Near Fitzgerald Range.

ASPERIFFOLIÆ.

Cressa Cretica, L., sp. pl., 223. Termination Lake (F. v. M.).

Heliotropium ovalifolium, Forsk. Flora Ægyptiaco-arab., 38. Near Depot Pool.

Ehretia saligna, R. Br. Prodr., 496. East of Connaught Ranges, on Sturt's Creek far south, not rare (F. v. M.)

Trichodesma Zeilanicum, R. Br. Prodr., 496. East of Oscar Ranges, Margaret River; in many places near Sturt's Creek (F. v. M.). Oldest generic name *Pollichia*, of Medicus (1783.)

LABIATÆ.

Ocimum sanctum, L. mant. plant, 85. Ord River.

Moschosma polystachya, Benth. in Wall. pl., Asiat. rar. II., 13. Near Connaught Ranges; near Mt. Wittenoom (F. v. M.).

Anisomeles salvifolia, R. Br. Prodr., 503. East of the Oscar Ranges.

Mentha Australis, R. Br. Prodr., 505.

It is this species, which I recorded from Sturt's Creek and near Hooker's Creek in my itineration journal. The specimens were lost, with a large portion of my other collections from far inland, on the transit by ship to Sydney; but I hardly entertain any doubt about the exactness of the identification; at all events we have no other records of the occurrence of Mints in North-west Australia.

Teucrium integrifolium, F. v. M. in Benth. Flora Austr. V., 133. Near Mt. Wittenoon (F. v. M.).

LENTIBULARIEÆ.

Utricularia chrysantha, R. Br. Prodr., 432. Near Fitzgerald Range; found also by Mr. Thos. Gulliver on the Gilbert and on the Norman River.

VERBENACEÆ.

Premna acuminata, R. Br. prodr., 512. Between Connaught Ranges and Humbert River.

MYOPORINÆ.

Eremophila maculata, F. v. M., in Papers Royal Soc., Tasm. III., 297. Margaret River; a yellow-flowered variety on Sturt's Creek (F. v. M.).

Eremophila Latrobei, F. v. M., report on Babbage's pl. 17, var. filifolia. Ord River.

Myoporum tenuifolium, G. Forster, Prodr., 44. Depôt Creek (F. v. M.).

ORCHIDEÆ.

Cymbidium canaliculatum, R. Br. Prodr., 331. Benn River (Connaught Ranges).

PANDANEÆ.

Pandanus aquaticus, F. v. M., Fragm. V., 40. Stirling's Creek (F. v. M.). Fruitlets quite free, 5–7-angled, club-shaped, attenuated at the base, outside orange-coloured except the greenish summit; the thin pulp of somewhat acrid taste; receptacle roundish-pyramidal, triangular, 5–6 inches long. This species occurs in many places of Arnhem's land, as observed already by Dr. Leichhardt. Its stem of lesser height and more slender than that of the following species.

Pandanus odoratissimus, L. fil. suppl., 424. Near Connaught Ranges and Mt. Compton; near Stirling's Creek (F. v. M.).

FLAGELLARIEÆ.

Flagellaria Indica, L. sp. pl., 333. East of the Oscar Ranges.

COMMELYNEÆ.

Commelyna agrostophylla, F. v. M., Fragm. VIII., 59. Port Darwin; sources of Sturt's Creek, F. v. M. United by Bentham with *C. lanceolata,* restored as a species by the present monographer of the order, C. B. Clarke, Esq., who writes to me: "I find the species quite distinct on many grounds, and further believe that the Commelynas, which have all the ovary-cells uniovulate, never vary so as to exhibit any 2-ovulate cells. I have never found a single instance of variation on this point." It may here incidentally be remarked, that the Rev. Dr. Woolls has recently found in the vicinity of Port Jackson a yellow-flowered Commelyna, which may prove (after further observation of the fruit) reducible as a variety to *C. cyanea.*

Aneilema anthericoides, R. Br. prodr., 270. Hooker's Creek and upper part of Sturt's Creek (F. v. M.)

Cyanotis axillaris, Schult. Syst. Veget. VII., 1150. Hooker's Creek (F. v. M.); found on the Palmer River by Mr. Wycliffe.

CYPERACEÆ.

Cyperus vaginatus, R. Br. Prodr., 213. Margaret River; Sturt's, Hooker's and Depot Creeks (F. v. M.).

Cyperus difformis, L. amoen. acad. IV., 302. Sturt's Creek (F. v. M.).

Cyperus trinervis, R. Br. Prodr., 213. Wickham's River (F. v. M.).

Cyperus pulchellus, R. Br. Prodr., 213. Wickham's River (F. v. M.); found also at Port Darwin by Mr. Holtze, and at the Palmer River by Mr. Wycliffe. Occasionally fully one foot high.

Lipocarpha microcephala, R. Br., append. to Tuck. Congo, 40. Whickham's River, Hooker's Creek and Sturt's Creek (F. v. M.).

Scleria pygmaea, R. Br., Prodr., 240. Upper Victoria River, near Depot Creek (F. v. M.).

GRAMINEÆ.

Panicum gracile, R. Br. Prodr., 190. Sturt's Creek (F. v. M.).

Panicum spinescens, R. Br. Prodr., 193. Upper Victoria River and Sturt's Creek (F. v. M.); occurs also on the Darling, Lachlan and Murray Rivers.

Perotis rara, R. Br. Prodr., 172. Upper Victoria River, Sturt's Creek, Termination Lake (F. v. M.).

Erianthus articulatus, F. v. M. Fragm. VIII., 118. Near the Fitzgerald Ranges.

Erianthus fulvus, Kunth enumer. I., 479. Upper Victoria River, Hooker's and Sturt's Creeks (F. v. M.).

Erianthus irritans, Kunth enumer., I., 479. Southern sources of the Victoria River.

Andropogon triticeus, R. Br. Prodr., 201. Upper Victoria River, on the sandstone tableland. A stately grass, but formidable on account of the piercing awns of enormous length.

Arundinella Nepalensis, Trin. spec. gram. t., 268. Near the Fitzgerald Ranges.

Amphipogon strictus, R. Br. Prodr., 175. Hooker's Creek (F. v. M.).

Pappophorum commune, F. v. M. report on plants of Gregory's Exped. in search of Leichh, p. 10. Sturt's Creek.

Triraphis mollis, R. Br. Prodr., 185. Near Termination Lake, where I also noticed a Neurachne, and also a Sporobolus allied to *S. Virginicus*.

Triodia pungens, R. Br. Prodr., 182. On the sandstone tableland towards the sources of the Victoria River, also on Hooker's and Sturt's Creek, (F. v. M.).

Chloris acicularis, Lindl. in Mitch. Trop. Austr., 33. Sturt's Creek (F. v. M.).

Elusine cruciata, Lam. Encycl. Méthod. t., 48, fig. 2. Termination Lake (F. v. M.).

Ectrosia leporina, R. Br., Prodr., 186. Near Fitzgerald Range; Sturt's Creek, where a second species also occurs (F. v. M.).

Poa ramigera, F. v. M., in Transact. Vict. Inst., 1855, p. 45. Sturt's Creek (F. v. M.).

Filices.

Blechnum orientale, L., sp. pl., 1077.
East of Oscar Ranges.

Cheilanthes tenuifolia, Swartz Synop. fil., 129. Hooker's Creek and upper part of Sturt's Creek (F. v. M.).

Ophioglossum vulgatum L., sp. pl., 1062. Upper Victoria River Mr. Flood.

Positions shown on the Map.

King's Sound.
Fitzroy River.
Fraser River.
Collier Bay.
King Leopold's Ranges.
Mount Humbert.
Mount Anderson.
Hochstetter's Plains.
Mount Tuckfield.
Mount Abbott.
St. George's Ranges.
Oscar Range.
Mount Campbell.
Mount Krauss.
Müeller's Ranges.
Margaret River.
Nicholson's Plains.
Ord River.
Connaught Range.
Rudolph Range.
Humbert River.
Victoria River.
Depôt Pool.
Wickham River.
Mount Compton.
Cambridge Gulf.
Admiralty Gulf.

[Map.]

(4o 23—80)

ROUTE OF ALEX. FORREST'S EXPEDITION IN 1879.

Ringbarking and its Effects.

By W. E. Abbott, Esq., J.P., Glengarry.

[*Read before the Royal Society of N.S.W., 7 July, 1880.*]

It is now about twenty years since ringbarking, or destroying the native forests by cutting a ring of bark off all round each tree, began to be practised in the watershed of the Hunter River, and about ten years since the practice became general. It was begun, I believe, by Mr. Thomas Hungerford, of Bucrami, and immediately taken up by the Messrs. White, from whom the new process for improving the grazing capacity of the runs spread rapidly in every direction, so that at the present time I am inclined to think that at least three-fourths of all the purchased land on the Hunter has been ringbarked, beside a very considerable area of Crown lands.

There are a good many opinions about the seasons at which ringbarking should be done, and also as to the best method for ensuring the destruction of the trees; but as I wish in this paper to deal with it only in reference to its effects, I shall not discuss them. The very rapid spread of ringbarking, in spite of the opposition of all the lovers of fine scenery and of many scientific men, amongst whom the late Vice-President of this Society (the Rev. W. B. Clarke) was the most prominent, proves that there must be a clear gain to the graziers in getting rid of the timber; and up to the present time no ill effects have been found to follow from it, though the prophets of evil have been numerous and their prophecies supported by arguments and opinions drawn from all parts of the world.

The two principal objections urged against the new method of improving the land were: First, that the creeks and rivers would dry up owing to the increased evaporation; and, second, that the rainfall would be reduced owing to the removal of the very large condensing surface offered by the trees to moisture-laden winds passing over the country.

Now, I will ask, how have these predictions been fulfilled? and, in reply, will give my own experience, and as far as possible a summary of the effects that have followed from ringbarking in the watershed of the Hunter River.

In 1869, after having seen the very great increase in the grazing capacity of Messrs. White's runs which followed from ringbarking, I began on my own run at Glengarry, which is situated on the Page River, about 12 miles south-east from Murrurundi, and about 16 miles from the summit of Liverpool Range.

The greater part of the land ringbarked is about 1,300 feet above sea-level by aneroid barometer measurement, though some of the ridges rise to a height of 2,000 feet, and one or two of the highest peaks to nearly 3,000. The most of the run and all that which has been ringbarked is of volcanic formation, consisting of black soil flats and basaltic ridges with white box timber.

In 1869 and 1870 I ringbarked the greater part of the watershed of two small creeks and the whole of the watershed of a third; each of these creeks being about 2 miles long, and draining well-defined valleys shut in by high ridges of basalt. I shall refer to them in this paper as creeks No. 1, 2, and 3. I have made inquiries about them as far back as 1850, and find that from that date to 1860 they were dry water-courses only holding water for a few days after rain, and in a few places in the winter months, always drying up completely in summer and never running as permanent streams at any time.

From my own observations from 1860 to 1870, I know that their character had not changed up to the latter date, so that here we have three water-courses draining three small valleys and maintaining the same character for a period of twenty years.

No. 1 creek drains about 1,200 acres, of which (as near as I can estimate without having the watershed surveyed) 910 acres are ringbarked and the remainder covered with growing timber, the growing timber being on the head of the creek. The ringbarking was done in the beginning of 1870, and as soon as the timber was dead the creek assumed the character of a permanent stream. This of course was a surprise to me, but as I had not kept any rainfall records up to that time, nor paid much attention to them, I attributed the change to the two or three wet years that followed 1870, and expected that the creek would soon return to its old state.

So little faith had I in the change, that I went to a considerable expense in dividing the land into paddocks to provide a watering-place to the river in each paddock, and these watering-places I have never had occasion to use since.

No. 2 creek contains about 850 acres, and is ringbarked in the same way as No. 1, that is about 300 acres of growing timber have been left on the head of the creek. The valley drained by No. 2 is narrower and about the same length as No. 1, in fact running parallel to and divided from it by a steep range.

My experience with No. 2 is precisely the same as that with No. 1. No. 3 is of the same geological character as Nos. 1 and 2, but the area drained by it does not adjoin the drainage areas of either of the former. It contain sabout 800 acres, all ringbarked, and seems to be less affected by drought than either of the former.

This I attribute to the fact that No. 3 has a rock bottom through the whole of its course, while Nos. 1 and 2 have some gravel beds under which the water may flow.

The geological formation of all three creeks is volcanic, there being no stratified rocks as far as I can see in any part of them. All three began to run in 1871, and have continued ever since to run as permanent streams, and in the last drought ending here in the beginning of 1878, though the volume of water was less than it usually is, the creeks never ceased running, even up to the third year of drought.

The three creeks that have been ringbarked flow from west to east, and there is a creek flowing from east to west on the opposite side of the ridge to No. 1, with about the same area of drainage, and almost of exactly similar character, except that the timber remains in its natural state. This creek is merely a dry water-course, and has not changed in any particular during the last twenty years, although there is nothing to distinguish it from No. 1, except that it flows to the west, and the fall of the land on the western side of the ridge is about 250 feet more than on the eastern.

On the 17th of May last I measured the water flowing out of each of the three creeks first described, by damming them and causing all the water to flow through a spout into a vessel of known capacity, and found that the flow of permanent water was as given under. I chose the date named because, for the previous four months, there had been a very small rainfall (about four inches), and I wished, by measuring after a considerable period of dry weather, to make sure that I was not over-estimating the permanent annual outflow.

The average rainfall here since 1875 is just 25 inches, and taking the rainfall for the previous five years at Murrurundi, which is the nearest station where a rain-gauge has been kept, the average fall is still within a few points of 25 inches for the ten years. No rain-gauges were kept in this part of the country before 1870.

The water begins to flow in the creeks a short distance below the green timber, so that in comparing the outflow with the area drained I have only taken into the calculation the area of drainage that is ringbarked.

Measurements.

No. 1 creek contains :—

300 acres green timber.

910 acres ringbarked.

Rainfall at 25 for twelve months ...	516,140,625 gallons.
Permanent outflow at $26\frac{1}{2}$ gallons per minute for a year...	13,924,800 gallons.
Or about $\frac{1}{37}$ of annual rainfall, or taking at rate of rainfall for previous four months, $\frac{1}{21}$.	

No. 2 creek contains :—

300 acres green timber,
550 acres ringbarked.

Rainfall for year at 25 inches	311,953,125 gallons
Permanent outflow at 11 gallons per minute for one year	5,781,600 gallons
Or about $\frac{1}{54}$ of annual rainfall, or taking at rate of rainfall for previous four months, $\frac{1}{30}$.	

No. 3 creek contains :—

800 acres ringbarked.

Rainfall for year at 25 inches	453,750,000 gallons
Permanent outflow at 20 gallons per minute for one year	10,512,000 gallons
Or about $\frac{1}{43}$ of annual rainfall, or taking at rate of previous four months, $\frac{1}{24}$.	

These calculations do not take into consideration the flood-water, but only the permanent flow, and the quantity of flood-water passing away during a heavy fall of rain must be very considerable, as the fall of the ground from the heads of the creeks to the river, a distance of 2 miles, is about 500 feet. I regret that I am unable to obtain the total outflow for a year, but I do not see how it could be done, as the rise and fall is so rapid that it would be necessary to attend to it day and night during the whole time rain was falling.

My experience in reference to the three creeks described has been repeated in every instance where I have had timber ringbarked, and, as far as I can learn, in every part of the Hunter River watershed the result has been the same as in my case. No exception has come under my notice, though of course the result is more apparent in some cases than in others.

There can I think be no doubt that, on the Hunter River watershed at least, the most noticeable effects of ringbarking have been the increased flow of water in the creeks when the timber was dead and the increase in the number of springs, though of course the first effect mentioned follows from the second.

This has been an unexpected advantage to graziers, as the only object in view at first was to increase the production of grass.

This increase in the flow of water may be produced in two ways :—

First, the roots of the trees decaying may act as a sort of subsoil drainage, leading the water down into the subsoil and afterwards allowing it to drain off slowly into the water-courses. If this is the only cause, one of the very greatest advantages of ringbarking will be but temporary.

The other explanation—and the one which seems to me most probable—is, that when the timber is dead the large proportion of the rainfall which was formerly taken up by the roots of the growing trees and evaporated from their leaves is allowed to find its way to the creeks and rivers. The fact that the Eucalyptus is perhaps the most vigorous growing tree known, and that it has been used successfully to dry up swampy land in other parts of the world, would seem to support this explanation.

Though I have never paid any attention to the science of botany, and am not competent to give a very decided opinion, it seems highly probable that the fact of all or nearly all the Eucalyptus species having both surfaces of the leaves similar, and so presenting a double evaporating surface to the atmosphere, would, with their very energetic growth, account for the country on which they grow being dryer than other countries where the conditions of rainfall and latitude are the same, and this leads me to a possible explanation of the anomaly presented by most of our Australian rivers. If we compare such a river as the Thames in England with the Hunter in New South Wales, we shall find that, though the area of drainage is not very unequal, the Hunter having the larger area and the heavier rainfall, the outflow of the Thames is out of all proportion larger than that of the Hunter. I have not seen any record of the annual outflow of the Thames, and none has been kept of that of the Hunter, but I take the fact that the Thames is navigable for a great part of its course, even to a height of 250 feet above sea-level, and the Hunter scarcely at all, as proof that the former must have very much the larger quantity of water. There must be a reason for this, and though an underground outlet might account for some rivers having less than the usual outflow in proportion to rainfall, it cannot apply to all.

The large amount of evaporation in our climate will of course have a great effect, but I cannot help thinking, after seeing the results of ringbarking, that the nature of our forests has a very considerable and perhaps the largest share in producing the remarkable dryness and absence of springs which seems to be characteristic of Australia. If this scarcity of water in proportion to our rainfall is, as I suppose, peculiar to Australia, then in looking for the cause wemust find one that is also peculiar to Australia.

Our geological formations are not different from those of other parts of the world, nor is there any reason as far as I know for supposing that the evaporation here is greater than in other countries situated in the same latitude either north or south of the equator.

Our forest growth is certainly exceptional, whether the two things are connected in the way of cause and effect or not. I do not know that we have sufficient data to determine the question either way at present, but if the work which Mr. Russell has begun in keeping a record of the outflow of some of our rivers is carried on, before the present generation has passed away there will be something on which to base an opinion.

A few years ago it would have been deemed the very acme of absurdity for any man to destroy the timber on his land for the purpose of producing permanent water, and now it is done every day as a matter of course.

That the destruction of the forests will reduce the rainfall is, I think, unlikely.

The theory that the amount of rainfall in any country depends on the area of its forests seems to be very generally received, and may have arisen from the fact that where there is a large and regular rainfall there is pretty sure to be a heavy forest growth, but a little thought will show that the forest is the result of the rainfall, not the rainfall of the forest.

Indeed it is hard to understand how any forest could come into existence if the amount of rainfall were influenced mainly by the forest growth, as the forest would have to precede the rainfall and yet could not grow without it.

In conclusion, I wish to call attention to a report by Mr. Draper, Director of the New York Observatory, America, which was published in the *Scientific American* supplement for January 3rd, 1880, and which bears on the subject of this paper. The question whether deforestation reduces rainfall, or alters climate in any way, is the one which Mr. Draper proposes to himself, and the answer after supplying necessary data is that it does not.

Mr. Draper shows that neither the rainfall nor the temperature of the Atlantic States of America has altered in any appreciable degree within the last century, and these, I think, are the States in which, within the last century, a larger amount of deforestation has been done than in any other part of the world.

Not being satisfied with the length of time over which the rainfall records extended in his own country, Mr. Draper took those of Paris in France, extending over a period of 190 years, and found on examining them that during that time there had been a slight increase in the rainfall, not steadily but in oscillations extending over long periods. The report from which I quote says nothing about the clearing of forests in France in the last two centuries, but I suppose from the increase of population and other causes there must be very much less forest land there now than there was two hundred years ago.

Notes on the Fossil Flora of Eastern Australia and Tasmania.

By Ottokar Feistmantel, M.D., Palæontologist, Geological Survey, Calcutta.

[Read before the Royal Society of N.S.W., 4 August, 1880.]

In 1876 the late very lamented Rev. W. B. Clarke, of Sydney. N. S. Wales, forwarded to me a collection of Australian fossil plants for comparison with the Gondwána plants of India, and for eventual description. Short notes which I communicated in letters to the late Rev. W. B. Clarke on this collection of plants were embodied in the fourth edition of his "Remarks on the Sedimentary Formations of N. S. Wales, 1878"; and a paper on the same subject, illustrated by eighteen plates, was published by myself in the German Palæontographica (edited by Dunker and Zittel) in 1878.

In 1878 I received another smaller but nevertheless very interesting collection of plants by the late Rev. W. B. Clarke, and subsequently also several specimens by Mr. C. S. Wilkinson, Government Geologist. As amongst these plants there were either new forms or better specimens of already figured ones, and as in the meantime also other papers dealing with Australian Palæontology[1] were published, I decided upon publishing a second paper on the Australian Flora, which afforded also an opportunity of correcting several important misprints in the previous publication; it is also published in the German Palæontographica, 1879, and illustrated by twelve plates, and in a few weeks I shall have the honour of forwarding these papers on the Australian Flora, together with others on the Indian Flora, to Mr. C. S. Wilkinson. In the meantime I think the following notes may be useful as a general review of the whole work.

The flora under consideration belongs to the palæozoic and mesozoic formations, while the few tertiary plants, which were also sent, will be described later—perhaps together with some more plants with which I may be favoured for description.

Fossil plants from the mentioned strata are known at present from Queensland, New South Wales, Victoria, and Tasmania; from all these districts, except the Colony of Victoria, plants

[1] Mr. Clarke's above-mentioned fourth edition of his Remarks, &c., and Mr. R. Etheridge's Catalogue of Australian Fossils, 1878.

were represented in the above collections; others were already described before by other authors, and it will, I think, be the best to discuss at first the distribution of the plants according to the mentioned provinces (beginning from north), from which also the classification of the strata will best be seen, and then to give some notes on the flora in systematic order.

Although these notes will at the same time also correct several of the misprints which unavoidably occurred in my above work, I yet think it necessary to here draw attention to one especially since it must appear misleading.

In the second list given at my first paper on the Australian Flora (1878), on pages 124, 125, the last column, containing the sequence of the Australian formations, is totally misprinted, as the Wianamatta and Hawkesbury beds should stand opposite to the Panchet and Damuda group of India, while the Newcastle beds and all the other beds below them should have been represented as below the horizon of the Talchir beds. In my second paper I tried to correct this list, but after further information received from Mr. C. S. Wilkinson, the correlation will have to be altered slightly yet.

I.—QUEENSLAND.

Literature—Daintree: "Geology of Queensland" (Qu. Journ. Geol. Soc. London, 1873). The plants are described by Mr. W. Carruthers. We find them again in Mr. R. Etheridge's above-mentioned catalogue.

Daintree describes the following plant-bearing formations:—

1. *Mesozoic coal-beds* (Carbonaceous), in the southern part of the Colony, especially at Maryborough, Brisbane, Tivoli mines near Ipswich, Talgai Diggings on the Condamine River. Mr. W. Carruthers has described the following—*Sphenopteris elongata*, Carr.; *Pecopteris* (Thinnfeldia) *odontopteroides*, Morr. (Feistm.); *Cyclopteris cuneata*, Carr.; *Tæniopteris Daintreei* (which appears to differ from Prof. M'Coy's species), and *Cardiocarpum Australe*, Carr. Amongst the Australian plants which I had before me there were the following—the true *Tæniopteris Daintreei*, M'Coy; *Sagenopteris rhoifolia*, Presl., and an *Otozamites* (comp. Mandeslohi Kurr). These species are from the Talgai Diggings, and the two latter are new for Australia.

These beds are, as we shall see further on, equivalent with some beds in New South Wales, Victoria, and Tasmania.

2. *Palæozoic coal-beds*, with plants and palæozoic animals. These are found more in the northern portion of the Colony. Of

plants the following genera are mentioned—*Glossopteris, Schizopteris, and Pecopteris.* (See Carruthers in Daintree, l.c.)

These beds are presumably equivalent with the lower coal-beds in New South Wales. There were no specimens from here at my disposal.

3. *Devonian,* on Mt. Wyatt, Broken River, Canoona River. Mr. W. Carruthers described from these beds a lepidodendroid plant as *Lepidodendron nothum,* Ung. I have not seen any specimens from Queensland, but there were several amongst the New South Wales plants which agree very well with Mr. Carruthers' figures.

II.—NEW SOUTH WALES.

Of the numerous papers and works dealing with the geology and palæontology of this province, I mention the following—

Strzelecki: Physical description of N. S. Wales and Van Diemen's Land, 1845, with plates. (Fossil Flora described by Prof. Morris.)

M'Coy: On the Fossil Botany and Zoology of the Rocks associated with the Coal in Australia. In Ann. and Mag. Nat. Hist., 1847, vol. xx. 1st ser., with plates.

Dana: United States Exploring Expedition, Geology, 1849. With plates.

Wilkinson, C. S.: Mines and Mineral Statistics, &c., 1875, p. 127, *et seq.*

Clarke, W. B., especially: Remarks on the Sedimentary Formations of N. S. Wales. 4th edition, 1878. Besides this several papers in Qu. Journ. Geol. Society, London.

Feistmantel, Ottokar: Palæozoische und mesozoische Flora des Ostlichen Australien. Palæontographica, 1878–79.

Also Mr. Etheridge's Catalogue is to be quoted again.

The stratigraphical relations are best described by Mr. Clarke in his Remarks, &c.; the flora we find in Strzelecki's (Morris), M'Coy's, and Dana's papers; I myself described also several new forms; while Mr. Clarke has especially drawn attention to the vertical distribution of certain genera of fossil plants.

The marine fossils were fully treated on by Prof. De Koninck, in his work—Recherches sur les Fossiles palæozoiques de la Nouvelle-Galles du Sud. Bruxelles, 1876–1877.

I proceed in descending order—

1. *Mesozoic beds.*—Mr. Wilkinson describes in Mines and Mineral Statistics, 1875, p. 127, certain beds on the Clarence River as "Mesozoic." Amongst the plants sent by Mr. Clarke there

were also two specimens from this locality, in which I recognized *Tæniopteris Daintreei*, M'Coy, and *Alethopteris Australis*, M'Coy; from this circumstance I compared these beds with the mesozoic beds in Queensland and with others in Victoria (see further on).

2. *Wianamatta and Hawkesbury beds.*—These are certain beds above the upper coal measures (Newcastle beds) in New South Wales. In the text of his above-mentioned work (p. 68), the Rev. W. B. Clarke discusses these beds, in the chapter headed "Mesozoic or Secondary Formations." In the tabular list (p. 155) he includes them under the heading "Supra-carboniferous"; in both cases they are therefore represented as younger than the Newcastle beds, which is in so far of importance as, according to information received from Mr. Wilkinson (in letters dated 30/9/78 and 25/11/79), certain physical characters tend to correlate the Hawkesbury, which from a palæontological point of view are not widely separated from the Wianamatta beds, with the Bacchus-Marsh sandstones in Victoria (see further on), with which again I have correlated from palæontological evidence the Talchir-Karharbári beds in India, in the former of which similar physical relations have been observed. I shall mention this again when speaking of the Bacchus Marsh sandstones. The fossils from these beds hitherto known are—

a. Wianamatta beds—

Fishes[1]: *Palæoniscus gracilis*, Eg.; *Cleithrolepis granulatus*, Eg.

Plants: *Pecopteris* (Thinnfeldia) *odontopteroides*, Morr. (Fstm.); *Odontopteris microphylla*, M'Coy; *Pecopteris tenuifolia*, M'Coy; *Macrotæniopteris Wianamattæ*, Feistm. (1878).

b. Hawkesbury beds—

Fishes: *Cleithrolepis granulatus*, Eg. (l.c.); *Myriolepis Clarkei*, Eg., (ib.) *Thinnfeldia* (Pecopteris) *odontopteroides*, Fstm.[2]; *Sphenopteris* sp., and *Odontopteris* sp. (Both mentioned by Professor McCoy.)

These fossils clearly show that both these rock groups are in closest relation to each other.

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[1] Egerton (Sir Ph.): On some Ichthyolites from N. S. Wales. Qu. Journ. Geol. Soc., 1864.

[2] Recently (1879) described and illustrated by myself from specimens kindly presented by Mr. Wilkinson, and collected at Mount Victoria, N.S. Wales, in the Hawkesbury beds.

3. *Upper Palæozoic.* Under this heading Mr. Clarke comprised several groups :—

a. *Upper Coal Measures* or *Glossopteris beds,* also "Newcastle beds." These beds were by Professor M'Coy considered as oolitic; R. Etheridge in his catalogue also quotes the fossils from the same in the chapter "Mesozoic." I myself included them in the group of beds above the marine fauna, without assigning to them any certain age, but considering them as older than the Bacchus Marsh sandstones, and by all means as older than the Indian coal-beds (Damuda series). The Rev. W. B. Clarke considered them palæozoic, and so does Mr. C. S. Wilkinson, to which there appears now no objection at all (see still further on the Bacchus-Marsh sandstones), although it can still be questioned if they have to be considered as really carboniferous.

The best known localities where fossils from these beds were collected are Blackman's Swamp, Bowenfels, Guntawang, Mudgee, Illawarra, Mulubimba, Newcastle, Wollongong.

The fossils hitherto known are—

Fishes : *Urosthenes Australis,* Dana (a heterocercal fish).

Plants : *Phyllotheca Australis,* M'Coy (and two other species which I think do not differ from this one); *Vertebraria Australis,* M'Coy ; *Sphenopteris lobifolia,* Morr.; *alata,* Bgt.; *alata* var. *exilis,* Morr.; *hastata,* M'Coy; *germana,* M'Coy; *plumosa,* M'Coy; *flexuosa,* M'Coy.

Glossopteris Browniana, Bgt.; *linearis,* M'Coy; *ampla,* Dana; *reticulum,* Dana; *cordata,* Dana; *tæniopteroides,* Feistm.; *Wilkinsoni,* Feistm.; *parallela,* Feistm.

Gangamopteris angustifolia, M'Coy; *Gang. Clarkeana,* Feistm.; *Caulopteris(?) Adamsi,* Feistm.

Zeugophyllites elongatus, Morr.; *Nöggerathiopsis spathulata,* Dana, sp. (Fstm.); *Nögg. media,* Dana, sp. (Fstm.) *Brachyphyllum Australe,* Fstm.; scales of conifers.

b. *Upper marine beds ;* beds with marine animals.

c. *Lower coal measures ;* beds with coal seams and flora, below and in association with marine palæozoic animals. These beds are in so far of interest as in them the three genera *Phyllotheca, Glossopteris,* and *Nöggerathiopsis,* appear to take their origin.

According to communications received from the late Mr. Clarke, it appears that two divisions in these may be distinguished separated by the lower marine beds.

a. *A higher group (Glossopteris-bearing portion),* at Anvil Creek, Greta, Harper's Hill, and Raymond Terrace, &c., with the following fossils:—*Phyllotheca,* sp., *Glossopteris*

Browniana, Bgt., *Gl. Browniana*, var. *præcursor*, Fstm. *Gl. primæva*, Fstm., *Gl. Clarkei*, Fstm., *Gl. elegans*, Fstm., *Nöggerathiopsis prisca*, Fstm.

Amongst the specimens sent by the late Mr. Clarke there were also fragments of a plant which I took to be *Annularia*, and which I named *Ann. Australis*, Fstm.

b. A lower group with lower carboniferous plants, at the localities—Arowa, Port Stephens, and Smith's Creek (near Stroud), with the following fossils[1]:—*Calamites radiatus*, Bgt., *Sphenophyllum*, sp., *Rhacopteris inæquilatera*, Göpp., sp., *Rh. intermedia*, Feistm., *Rh. comp. Römeri*, Feistm., *Rh. septentrionalis*, Feistm., *Archæpteris Wilkinsoni*, Feistm., *Cyclostigma australe*, Feistm., *Lepidodendron Veltheimanum*, Stbg., *Lepid. Volkmannianum*, Stbg.

This flora is certainly very interesting, and indicates strongly the age of Mountain Limestone (Culm), if not Heer's "Ursastufe." One circumstance must be mentioned specially, which I was not well acquainted with when I wrote my first paper on the Australian flora. Professor M'Coy described, from Arowa, a *Glossopteris linearis*, together with an *Otopteris ovalis*, classing consequently this locality also with the other localities of *Glossopteris beds* (or Newcastle beds). The late Rev. W. B. Clarke, however, sent two small specimens of Professor M'Coy's *Otopteris ovata* from Arowa, which clearly show that this species is the same as *Rhacopteris inæquilatera*, from Smith's Creek (Stroud), and that the locality, Arowa, has indeed to be classed with this group of beds; and if Professor M'Coy's observation of the association of *Glossopteris linearis*, M'Coy, with *Rhacopteris inæquilatera*, Göpp., sp., is a correct one, then this *Glossopteris* is the oldest representative of the whole genus.

c. Marine Beds; lower beds with a marine palæozoic fauna; the base of the upper palæozoic.

4. Middle Palæozoic, (Devonian). Beds at Goonoo Goonoo on the Peel River, Back Creek Diggings, on the Barrington River, with the following fossils:—

Lepidodendron nothum, Ung., and *Cyclostigma*, sp. This *Lepidodendron* is identical with the same form described by Mr. W. Carruthers, from Queensland, and on account of which these beds in Queensland were classed as Devonian. The same can therefore also be said of these beds in New South Wales.

5. Lower Palæozoic (Silurian.) In Profesor De Koninck's above-mentioned work, a plant, *Spirophyton (?) caudaphasiani*, is quoted from Silurian beds, at Duntroon.

[1] Mostly new forms, and all figured for the first time by me from Australia.

III.—VICTORIA.

The classification of the plant-bearing beds and the description of plants may be found in the following works:—

M'Coy: Prodromus of the Palæontology of Victoria. Decades I-V, 1874–1877.

Brough Smyth: Reports of Progress, Geolog. Survey of Victoria, 1876, &c.

Selwyn: Notes on the Geology of Victoria, 1860 (Qu. T.G.S.)

The following rocks are distinguished:—

1. *Upper Mesozoic* (Bellarine beds). Near Bellarine, at Cape Paterson, on the Wanon River (Coleraine), &c. The fossils are, *Phyllotheca Australis*, Bgt., *Alethopteris Australis*, Morr., sp., *Tæniopteris Daintreei*, M'Coy, *Zamites* (Podozamites) *Barklyi*, M'Coy., *Zam. ellipticus*, M'Coy, *Zam. longifolius*, M'Coy.

These beds are to be correlated with the already mentioned mesozoic beds in Queensland, and are most likely of Jurassic age; they are then also equivalent with the mentioned mesozoic beds in New South Wales (Clarence River), and with the mesozoic beds in Tasmania, to be described further on.

2. *Lower Mesozoic;* the Bacchus Marsh sandstones or *Gangamopteris* beds. Beds of Bacchus Marsh, W.N.W. of Melbourne, containing plant remains only, representing only one genus with three species; *Gangamopteris obliqua* M'Coy, *Gangam. angustifolia*, M'Coy, *Gangamopteris spathulata*, M'Coy.

These beds are of peculiar interest for correlation of the Indian and Australian coal-beds. Certain physical relations appear to correlate these beds with the Hawkesbury beds (as mentioned before), both containing ice-borne boulders; the same relations, as well as the abundance of the genus *Gangamopteris*, would tend to correlate the Indian Talchir division with these Bacchus Marsh sandstones, consequently also with the Hawkesbury beds. The Indian coal-beds overlie the Talchirs, while the Newcastle beds underlie the Hawkesbury. This shows the difference between the two respective coal formations, which expressed in a formula would appear thus:—

Damuda series. (Indian coal-beds.)		
Talchir division. Talchir group and Karharbàri coal-beds.)	*Bacchus Marsh Sandstones.* (Victoria.)	*Hawkesbury beds.* (N. S. Wales.)
		Newcastle beds. (Upper coal measures in N. S. Wales.)

3. *Carboniferous.* Avon River sandstones; beds on the Avon River in Gippsland, with *Lepidodendron Australe* M'Coy, which species I believe to be different from *Lepidod. nothum*, Ung.

4. *Devonian.* Iguana Creek beds, at the Iguana Creek, E. Victoria, with *Sphenopteris Iguanensis*, M'Coy; *Aneimites Iguanensis*, M'Coy; *Archæopteris Howitti*, M'Coy; and *Cordaites Australis*, M'Coy.

IV.—TASMANIA.

The position of the plant-bearing beds in Tasmania (Spring Hill and Jerusalem basin) is not yet quite clearly made out. Count Strzelecki, who collected the first plants in Tasmania, described it as if the plants came from a bed which at one place appeared to dip under beds with *Pachydomus globosus.* Professor McCoy on the other hand says[1] that Mr. Selwyn, F.R.S., formerly Director of the Geological Survey in Victoria, found the beds in their natural position, *i.e.* the *Pachydomus* beds below the Carbonaceous beds, and M'Coy considers them of course as Mesozoic. This view seems confirmed by a recent observation. M. Crépin has, in 1875, described and figured a few specimens of *Pecopteris odontopteroides*, from Tasmania, in the *Bulletin de l'Acad. Royale de Belgique*, 1875; he represented them according to the information available at that time as coming from the Carboniferous. But on the other hand he observed the important fact, that on the same specimens there was with the *Pecopteris odontopteroides*, Morr., associated another plant, *i.e. Sphenopteris elongata*, Carr., just as it was described by Mr. W. Carruthers from the Carbonaceous beds (Mesozoic-Jurassic) in Queensland; so that there is little doubt that these beds of the Jerusalem basin, Tasmania, are the representatives of the mesozoic beds in Queensland, consequently also of those in N. S. Wales (Clarence River), and Bellarine beds (Victoria).

The fossils from these beds in Tasmania hitherto known are:—*Pecopteris* (Thinnfeldia) *odontopteroides*, Morris; *Sphenopteris elongata*, Carr.; *Alethopteris Australis*, Morr.; *Sagenopteris Tasmanica*, Feistm.; *Zeugophyllites elongatus*, Bgt. They are from the Spring Hill, Jerusalem basin.

[1] Transactions Roy. Soc., Victoria, 1860, vol. v, p. 104.

The relations mentioned in the foregoing pages can be illustrated by the following tabular list (I also take into it the Indian Gondwána system).

Queensland.	New South Wales.	Victoria.	Tasmania.	India.
Upper Mesozoic coal strata (Carbonaceous).	Mesozoic beds on the Clarence River.	Upper Mesozoic beds. (Bellarine beds).	Strata on the Spring Hill, Jerusalem basin.	Upper Gondwánas.
	Wianamatta and Hawkesbury beds.	.... Lower Mesozoic beds. The Bacchus-Marsh sandstones.	....	Damuda Series. Talchir division. (Talchir group and Karharbar's coal-beds.)
	Upper coal measures, Newcastle beds.			
Lower (palæozoic) coal beds (Northern coalfields).	Upper Marine beds. Lower coal measures on the Stony Creek, Rix's Creek, at Greta, &c. Lower Marine beds.			
	Strata at Port Stephens, on the Smith's Creek, &c. Marine beds.	Carboniferous on the Avon River, Gippsland.		
Devonian beds with *Lepidodendron nothum*, Ung.	Devonian beds with *Lepidodendron nothum*, Ung.	Devonian beds on the Iguana Creek.		

I shall now add a few remarks on the fossils from the plant and coal-bearing beds in Australia (exclusively of the marine fossils), enumerating them in systematical order.

A. Animals.

Fishes.

Palæoniscus antipodeus, Egerton. Wianamatta beds.

Cleithrolepis granulatus, Eg.; the tail of this species not sufficiently distinct. Wianamatta and Hawkesbury beds.

Myriolepis Clarkei, Eg. Hawkesbury beds. (The tail of this species is not known.)

Urosthenes Australis, Dan.; a heterocercal fish from the Newcastle beds.

B. Plants.[1]

1. Equisetaceæ.

Phyllotheca Australis, Bgt. (pls. vi, fig. 3; vii, 1, 2; xv, 1, 2). This species has in Australia a distribution from the lower coal measures (below the first marine fauna) into the upper mesozoic beds of Queensland and Victoria. In Europe and Siberia this genus occurs in Jurassic beds only; in India we know it from the upper portion of the Damuda series.

Vertebraria Australis, M'Coy. (pl. vi, 1, 2). Systematic position not settled with certainty, but most probably *equisetaceous*; here known from the upper coal measures (Newcastle beds). In India it occurs in the Lower Gondwánas (Talchir and Damuda division).

Calamites radiatus, Bgt. (pl. vi *a*, fig. 1; vii *a*, figs. 3, 4). From beds at Smith's Creek, Stroud.

Annularia Australis, Feistm. (pl. vii *a*, figs. 5, 6); the first and hitherto only species described from Australia. From lower coal measures at Greta, N. S. Wales.

Sphenophyllum, Sp. (pl. ii, fig. 1). Fragmentary. Lower coal measures, Port Stephens, N. S. Wales.

2. Filices.

Sphenopteris.—Of this genus six species are described (by M'Coy and Dana) from the Newcastle beds.

Sphenopteris Iguanensis, M'Coy.—From the Iguana Creek, Victoria.

Sphenopteris elongata, Carr.—At first described by Mr. Carruthers from the upper Mesozoic coal-beds in Queensland, and later by Mr. Crépin from apparently equivalent beds in Tasmania, Jerusalem basin.

[1] To those species which have been figured in my papers the numbers of the respective plates and figures will be added; and to distinguish the plates of the second memoir on the Australian flora from the first, I shall add to the Roman plate numbers of the second memoir the letter *a*.

Aneimites Iguanensis, M'Coy.—Devonian. Iguana Creek, Victoria.

Archæopteris Howitti, M'Coy.—Devonian. Locality the same.

Archæopteris Wilkinsoni, Feistm. (pl. vi *a*, figs. 3, 4; vii *a*, 1). Lower coal measures, Smith's Creek (Stroud), N. S. Wales.

Archæopteris, Sp. (pl. iv *a*, fig. 4).—From the same locality.

Rhacopteris inæquilatera, Göpp. (pl. ii, fig. 3; iii, iv, 1, 2; i *a*, 1, 2; ii *a*, iii *a*, iv *a*, 2, 3, 6; v *a*, 4, 5; vi *a*, 2).—This species is numerous. To judge from specimens from Arowa (see pl. v *a*, figs. 4, 5), Prof. M'Coy's *Otopteris ovata* belongs to this species. Localities—Port Stephens, Smith's Creek, Stroud, and Arowa, all N. S. Wales.

Rhacopteris intermedia, Feistm. (pl. ii, f. 2).—Port Stephens; lower coal measures.

Rhacopt. comp. *Römeri*, Fstm. (pl. ii *a*, f. 2).—Smith's Creek, Stroud; lower coal measures.

Rhacopt. septentrionalis, Fstm. (pl. iv *a*, f. 5).—Smith's Creek, Stroud; lower coal measures.

Thinnfeldia odontopteroides, Fstm. (Morr. sp.) (pls. xiv, fig. 5; xv, 3—7; xvi, 1; ix *a*, x *a*, and xi *a*).—Prof. Morris described in Strzelecki's above-mentioned work, a fossil plant from the Jerusalem basin, as *Pecopteris odontopteroides*, Morr., without being however able to justify this determination. Prof. M'Coy placed later the same species with *Gleichenites*. Mr. W. Carruthers quotes it from Queensland again as *Pecopteris odontopteroides*, and gave two figures. M. Crépin, who described several specimens from Tasmania, classed it with *Odontopteris*, and compared it with *Odontopt. alpina*, Gein., considering the beds from which it came as Carboniferous. But its association, as mentioned before, on the same specimens with *Sphenopteris elongata*, Carr., leaves no doubt about the correlation of these Tasmanian beds. I could compare specimens from Queensland and Tasmania, and also from the Wianamatta and Hawkesbury beds in New South Wales. The comparison has shown that in the specimens from all the localities there occurs a dichotomy of the frond pretty regularly as in the genus *Thinnfeldia*, that the venation was in general the same, and that also the shape of the leaflets of all of them could be traced to a common form. All the characters distinguish this plant completely from the genus *Pecopteris*, and it appeared to me that it should best be classed with *Thinnfeldia*, under which name I have described it in my above-mentioned memoirs; for the support of this view I quote its great resemblance to *Thinnfeldia crassinervis*, Gein., from the Rhætic beds of the Argentine Republic.[1]

[1] Palæontographica: Cassel, 1876.

As regards the vertical distribution I must distinctly point out that, as far as known at present, this plant has not been met with below the Hawkesbury beds; it therefore does *not occur* in the Newcastle beds. The quotation of it in my first memoir on the Australian Flora as being also known from the Newcastle beds, was caused by a mistake with regard to the locality Clark's Hill, which I thought to be in the Newcastle beds while it is in the Wianamatta beds.

In the mentioned memoir I also quoted it as coming doubtfully from the lower coal measures, which referred to the occurrence of this species in Tasmania; this was before I had sufficient information about the position of these Tasmanian beds.

We know therefore this plant from the following horizons and localities:—

a. Upper Mesozoic beds. Ipswich (figures in my first memoir pl. xv, figs. 3, 5, 6), and Tivoli Mines, Queensland (Mr. W. Carruther's figures, l.c.); Jerusalem basin, Tasmania (figures in my first memoir, pl. xv, figs. 4, 7; Morris' original figures, 1845, and the figures in M. Crépin's paper, 1875).

b. Wianamatta beds. Clark's Hill, near Cobbity, New South Wales (figure in my first memoir, pl. xvi, fig. 1, and the specimens discussed by Prof. M'Coy).

c. Hawkesbury beds. Mt. Victoria, in N. S. Wales, kindly sent for description by Mr. C. S. Wilkinson (figured in in my second memoir, pl. x *a*–xii *a*).

Odontopteris microphylla, M'Coy, Wianamatta beds, Clark's Hill. In my first memoir also wrongly quoted from the Newcastle beds.

Cyclopteris cuneata, Carr. Upper mesozoic beds, Tivoli Mines, Queensland.

Alethopteris Australis, Morr. sp. (plate xiv, figs. 1, 1*a*). Upper mesozoic beds of Victoria, New S. Wales (Clarence River), and Tasmania; *is not known from the Newcastle beds.* In my first memoir doubtfully quoted from lower coal measures; this referred again to the doubtful beds in Tasmania, which however, are mesozoic.

Pecopteris ? tenuifolia, M'Coy. Wianamatta beds, Clark's Hill, near Cobbity, a doubtful species.

Gleichenia dubia, Feistm. (pl. xv, fig. 8.) Wianamatta beds. Appears to be really a *Gleichenia*, but doubtful as to the species.

Tæniopteris Daintreei, M'Coy (pl. xii *a*, fig. 5, 5*a*). Prof. M'Coy described this species at first from the upper mesozoic beds in Victoria. Later, Mr. W. Carruthers quoted it from Queensland, but the latter seems to differ from the former in some characters, and the identity of these both was doubted. I have however figured a specimen from the Talgai Diggings, Queensland, which is indeed identical with M'Coy's original form. I also could recognize the same species in several specimens from the mesozoic beds on the Clarence River, N. S. Wales.

Macrotæniopteris Wianamattæ, Feist. (pl. xiii, fig. 2). Wianamatta beds. Better specimens would be very desirable for further comparison.

Genus Glossopteris, Bgt. This genus (a single leaf, with a distinct midrib and netted secondary venation) is in Australia very numerous. This genus was one of the chief reasons of the scientific controversy between Prof. M'Coy and the late Rev. W. B. Clarke; the former author taking the *Glossopteris* beds in Australia to be mesozoic, while the Rev. W. B. Clarke asserted the occurrence of *Glossopteris* below palæozoic marine beds, and consequently considered the *Glossopteris* beds (including the Newcastle beds) as palæozoic. So much is certain, that *Glossopteris* in Australia does occur in certain beds below marine beds with a palæozoic fauna, and the Newcastle beds most probably belong yet to the palæozoic epoch, but in any case I should think them younger than those beds below the marine fauna. In India it is chiefly known from the Lower Gondwána system (and here in the Damuda series), but a few specimens were also found in the Jabalpúr group of the Upper Gondwána system.

Glossopteris Browniana, Bgt. (pls. viii, figs. 3, 4; x, figs. 1, 3–5. 7: xi, fig. 1; viii *a*, fig. 1.) Upper coal measures (Newcastle beds), at various localities. Lower coal measures at Greta, N. S. Wales.

Glossopteris elegans, Feistm. (pl. viii *a*, fig. 2, 2*a*.) Lower coal measures at Greta.

Glossopteris primæva, Feistm. (pl. v, fig. 3.) Lower coal measures at Greta.

Glossopteris Clarkei, Feistm. (pl. v, fig. 4.) Lower coal measures, Rix's Creek, N. S. Wales.

Glossopteris Browniana, var. *præcursor*, Feistm. (pl. v, figs. 5–7.) Lower coal measures, Stony Creek, N. S. Wales.

Glossopteris linearis, M'Coy (pls. viii, figs. 1, 2; xi, figs. 3, 4; xii, fig. 4). Numerous in the Newcastle beds, but quoted also by Prof. M'Coy, from Arowa, in association with *Rhacopteris inæquilatera*, Gopp., sp. (*Otopteris ovata*, M'Coy), which would bring it down into lower carboniferous beds.

Glossopteris ampla, Dan. (pl. xi, fig. 2; xii, fig. 7), *Gl. reticulum*, Dan., *Gl. elongata*, Dan., and *Gl. cordata*, Dan. Upper coal measures (Newcastle beds), N. S. Wales.

Glossopteris Wilkinsoni, Feistm. (pl. xiii, fig. 1). A very peculiar form from the coal measures at Bowenfels.

Glossopteris tæniopteroides, Feistm. (pl. ix, fig. 1), and *Gl. parallela* Feistm. (pl. ix, fig. 2). Newcastle beds, N. S. Wales.

L

Genus Gangamopteris, M'Coy. Can shortly be described as a *Glossopteris* without a distinct midrib.

Gangamopteris Clarkeana, Feistm. (pl. xv, fig. 9). Upper coal measures (Newcastle beds), N. S. Wales; rare.

Gangamopteris angustifolia, M'Coy. Upper coal measures, N. S. Wales, and the Bacchus-Marsh sandstones, Victoria; in the latter numerous. In the Indian Talchir group and Karharbári beds.

Gangamopteris obliqua, M'Coy, and *Gang. spathulata*, M'Coy. Bacchus Marsh sandstones, Victoria. Both have close representatives in the Indian Talchir division.

Sagenopteris rhoifolia, Presl. (pl. xii *a*, figs. 1–4, 7). New for Australia. Upper mesozoic beds, Queensland, Talgai Diggings on the Condamine River.

Sagenopteris(?) Tasmanica, Feistm. (pl. xv, fig. 10.) Jerusalem basin, Tasmania.

3. *Lycopodiaceæ.*

Lepidodendron nothum, Ung. (Carruthers emend.); (pls. i, figs. 1–5; i *a*, figs. 1, 2.) Queensland (described by Mr. W. Carruthers); New S. Wales (described and figured by myself); Devonian beds.

Lepidodendron dichotomum, Stbg. (pl. vi *a*, fig. 5); *Lepid. Veltheimianum*, Stbg. (pl. vii *a*, fig. 2, and probably pl. v *a*, figs. 2, 3), and *Lepid. Volkmannianum*, Stby. (pl. v *a*, fig. 1), all figured for the first time by myself. Lower carboniferous beds at Smith's Creek, Stroud. To *Lepid. Veltheimianum*, Stbg., is, I think, to be placed the *Lepidod. rimosum*, Corda, mentioned by Mr. W. B. Clarke.[1]

Lepid. Australe, M'Coy. Carboniferous, Avon River, Victoria. I think it different from *Lepid. nothum*, Carr.

Cyclostigma Australe, Feistm. (pls. iv, fig. 3; v, fig. 1; iv *a*, fig. 1.) Lower carboniferous, Smith's Creek (Stroud). This genus appeared to me to indicate Prof. Heer's "Ursastufe."

Cyclostigma, sp. (pl. i, fig. 6). Another form, occurring together with *Lepidodendron nothum*, Ung., in Devonian beds in Queensland and N. S. Wales. The one specimen figured by me is not sufficient to decide whether it is identical with the former species or not.

4. *Cycadeaceæ.*

Zamites (Podozamites) *Barkleyi*, M'Coy, *Zam.* (Pod.) *ellipticus*, M'Coy, and *Zam. longifolius*, M'Coy. From the upper mesozoic beds, Bellarine beds, Victoria.

[1] A drawing of it, from a photograph, was given by me, in my first memoir, 1878, pl. v, fig. 2.

Otozamites comp. *Mandeslohi*, Kurr. (pl. xii *a*, fig. 6). This is the first *Otozamites* identified from Australia. From upper mesozoic beds, Queensland, Talgai Diggings, appears very close to *Otoz. Mandeslohi*, a Liassic species, to which I refer it for the present.

Zeugophyllites elongatus, Morr. (copy, pl. xiii, fig. 6). Described at first from the Jerusalem basin, Tasmania; later, from the Newcastle beds. It was, by some authors, compared with *Schizoneura*, also with *Nöggerathia*, but from both it is equally distinguished.

Genus Nöggerathiopsis, Feistm. (pl. xvi, figs. 2–4, as *Nöggerathia*, and pl. viii *a*, fig. 3, as *Nöggerathiopsis*, Feistm). Certain leaves were described by Prof. Dana as belonging to the genus *Nöggerathia*; they came from the Newcastle beds, and this genus was then quoted repeatedly from Australia. Also from the Indian coal-beds similar leaves were known and quoted as *Nöggerathia*. Similar leaves were besides these known from certain coal deposits in the Altai Mountains (Kusnezk basin), and also classed with *Nöggerathia*.

I classed the Indian leaves in the beginning also with *Nöggerathia*, but later when writing my memoir on the Talchir-Karharbári flora, for which purpose I had to examine these leaves closer, I found them to differ from the genus *Nöggerathia* proper; I called them consequently *Nöggerathiopsis*, and placed with this new genus the Australian leaves also, which in my first memoir (1878) are still quoted as *Nöggerathia*, while in the second I classed them already with the new genus *Nöggerathiopsis*, Feistm.

Further comparison has shown that these Indian and Australian leaves (*Nöggerathiopsis*) are also in close relation to those leaves from the Kusnezk basin in the Altai; these were also recently recognized by Prof. Schmalhausen not to be *Nöggerathia*, and were placed with a new genus called *Rhiptozamites*, Schmal., in the class *Cycadeaceæ*. These two genera are certainly very closely related. The flora of the Kusnezk basin (Altai) was recently recognized to be a Jurassic flora, and *Rhiptozamites* is the Jurassic representative of *Nöggerathiopsis*, which begins in palæozoic rocks in Australia, and is also numerous in the Indian lower Gondwánas. I have already mentioned that *Nöggerathiopsis* is not to be confounded with *Zeugophyllites* nor with *Schizoneura*. The species are :—

Nöggerathiopsis media, Dana, and *Nögg. spathulata*, Dana. From the Newcastle beds, New S. Wales. To one of these may belong the leaves figured by me in the first Memoir, pl. xvi, figs. 2–4.

Nöggerathiopsis prisca, Feistm. (pl. viii *a*, fig. 3). Lower coal measures at Greta, N. S. Wales.

Cordaites Australis, M'Coy. Devonian beds at the Iguana Creek, Victoria.

5. Coniferæ.

Brachyphyllum Australe, Feistm. (pl. xvii); several specimens of a conifer, belonging apparently to the genus *Brachyphyllum* were found in the Newcastle beds at Bowenfels, N. S. Wales.

The interesting character of this Australian flora is that certain forms, which otherwise in Europe and Asia are principally met with in mesozoic beds, occur in Australia already in beds which are below marine beds with a palæozoic fauna. These are:—

Phyllotheca, Bgt., begins in the lower coal measures of Australia (N. S. Wales), is very numerous in the upper coal measures (Newcastle beds), and is also found in the upper mesozoic beds at Cape Paterson, Victoria. The genus also occurs in the upper portion of the Indian coal-beds (Kámthi-Raniganj group); numerous species are known from the Jurassic beds of Siberia (Altai Mountains, E. Siberia and Amur countries), amongst which one species very close to *Phyll. Australis.* In Europe it is known from the Italian Oolite. It is also quoted from the Karoo beds in Africa.

Glossopteris, Bgt. Known from lower carboniferous beds (Arowa) in N. S. Wales; lower coal measures, N. S. Wales and Queensland; very numerous in the upper coal measures (Newcastle beds), N. S. Wales; numerous in the lower portion of the Indian Gondwána system, but also found in the upper portion. Also in the Russian Jura (Prof. Trautschold). Also common in the Karoo beds.

Nöggerathiopsis, Feistm. Begins in the lower coal measures in N. S. Wales; becomes more numerous in the upper coal measures (Newcastle beds), New S. Wales. It is numerous in the Talchir and Damuda divisions of the lower Gondwána system in India, and it has a very close representative in *Rhiptozamites*, Schmalh., from the Siberian Jura (Mts. Altai and on the Tunguska River, Yenissei).

About the correlation of the Australian and Indian floras, the necessary remarks were already made on a preceding page.

In conclusion, I beg leave to express my greatest indebtedness to the late Rev. W. B. Clarke, for having kindly placed the fossils and much valuable information at my disposal, and to Mr. C. S. Wilkinson, Government Geologist, N. S. Wales, for having communicated to me the nice specimens of *Thinnfeldia odontopteroides* from Mt. Victoria (Hawkesbury beds), and other information in his letters to me. I only hope that also in future I may be favoured with his confidence.

On the Acids of the Native Currant *(Leptomeria acida)*.

By EDWARD H. RENNIE, M.A. (Sydney), B. Sc. (London), Demonstrator of Chemistry in the Medical School, St. Mary's Hospital, London. Communicated by Prof. Liversidge.

[*Read before the Royal Society of N.S.W., 2 June, 1880.*]

THE intensely acid taste of the Native Currant *(Leptomeria acida)* must be familiar to most Australians. Since, however, so far as I have been able to ascertain, no account of any chemical examination of the acid in question has been published, it occurred to me that it might be worth while to investigate the matter. For this purpose a preparation of the currants was made by my brother, Mr. G. E. Rennie, and forwarded to me at London. The following was his method of procedure :—The currants were boiled with water for some time, and the skin, &c., strained off; to the solution excess of sodic carbonate was added, and the whole evaporated to dryness on the water bath.

A qualitative examination of the residue thus obtained was first made in order to ascertain what acid or acids were present. The substance was dissolved in water, acidified with acetic acid, and lead acetate added in excess. The precipitate was filtered off, well washed, suspended in water, and decomposed by sulphuretted hydrogen. This was found to be the most satisfactory method of getting rid of colouring matter, &c., which very much interfered, and in fact almost prevented, filtration. The acid liquid was then concentrated, divided into several portions, and examined as follows :—

a. To one portion lime water in excess was added *in the cold.* A slight gelatinous precipitate separated immediately. This precipitate, when washed and heated in a test tube with a drop or two of dilute ammonia and a crystal of silver nitrate, gave the brilliant mirror characteristic of tartaric acid.

b. To a second portion, highly concentrated by evaporation, acetate of potassium and acetic acid were added. On agitation for some time a white crystalline precipitate separated.

These reactions indicate the presence of a small quantity of tartaric acid.

c. To a third portion was added a *cold* solution of chloride of calcium, mixed with a large excess of ammonia (the chloride of calcium had been previously boiled with the ammonia and the precipitate of carbonate filtered off), the whole allowed to stand for some time, filtered, and then evaporated to a very small bulk. A mere trace of precipitate separated, indicating probably a small quantity of citric acid.

d. To the solution from *(c)*, after filtration, a large bulk of strong alcohol was added, when a very bulky precipitate was immediately formed, indicating probably malic acid. In order to confirm this supposition a considerable quantity of the calcium salt was prepared as above, filtered off, well washed, redissolved in water, and precipitated with acetate of lead, and the latter prepitate thoroughly washed. This was then divided into two portions.

Portion 1 was suspended in water, decomposed by sulphuretted hydrogen, and the acid liquid evaporated to dryness on the water bath. The residue, when slowly heated in a test tube, gave the crystalline sublimate characteristic of malic acid.

Portion 2 was dried at 100° ; and here it may be stated that the wet mass when taken from the filter-paper and placed in the water oven, became partly liquid, and the solid portion melted under the liquid to a resinous mass, a reaction said to be exhibited by lead malate. There being some doubt as to the amount of water retained by this compound, the mass dried at 100° was further heated at 200° till constant in weight, so that, if lead malate it were, it might be converted into fumarate. A weighed portion was then converted into lead sulphate with the following result:—

Weight taken.	Found.	Calculated *for* $PbC_4H_2O_4$.
·829 gramme.	·787 $PbSO_4$	
	= ·5376 Pb	
	= 64·84 %	64·49 %

This seems to prove conclusively that the greater part of the acidity of these currants is due to malic acid.

In order to estimate approximately its quantity, 5 grammes of the substance were dissolved in water, acidified with acetic acid, precipitated by lead acetate, and then, *without filtration*, sulphuretted hydrogen passed through the liquid. It was found that in this way most of the colouring matter, &c., was carried down with the lead sulphide. The latter was filtered off, the citric and tartaric acids separated as described above *(c)*, and to the solution a large bulk of alcohol added. The calcic malate was then filtered off, washed with alcohol, dried, and ignited to convert it into carbonate. The residue was treated with a dilute solution of ammonic carbonate in order to dissolve out any remaining sodium chloride, again filtered, ignited, and then treated two or three times with ammonic carbonate in the ordinary way till no further increase of weight was produced. In this way 5 grammes of substance yielded 1·153 $CaCo_3$ = 1·983 calcic malate = 1·544 malic acid = 31 per cent. nearly. As the original substance gave off nearly 12 per cent. of water at 100°, and was found to contain on titration about 13 per cent. of Na_2Co_3 (added in excess), the above numbers must be increased considerably; so that we find the quantity of malic acid in the solid residue produced by just neutralising the juice with carbonate of soda and evaporating to dryness, to be over 40 per cent. This is, of course, a very rough estimation, and probably below the truth, inasmuch as it is impossible to precipitate the whole of the calcic malate by the above method; still it serves to show that the juice of the Native Currant is capable of yielding a very large percentage of malic acid.

The filtrate after the precipitation of the calcic malate was not very carefully examined, but appeared to contain little else but unprecipitated calcic malate and some organic colouring matter; and it is evident that since the sodic malate, water, excess of sodic carbonate, sodic tartrate, ash, &c., will make a total of somewhere near 70 per cent. of the whole, the residue, after subtracting the extractive matter, such as gum, colouring matter, &c., must be very small, and therefore it was not thought worth while to attempt any further examination.

The ash formed on ignition contained a mere trace of carbonate of lime, showing that very little of the acids could have been present as calcium salts. Very considerable quantities of potassium carbonate were however found.

The Alkaloid from Piturie.

By Professor Liversidge, Assoc. R. S. Mines, F.I.C.

[*Read before the Royal Society of N.S.W., 3 November, 1880.*]

I am indebted to the kindness of Mr. de Renzie Wilson, of Bangate Station and the Retreat, Barcoo River, for the supply of piturie, upon which this investigation was conducted, also to other friends who placed some smaller quantities at my disposal. Mr. Wilson had considerable difficulty in procuring a sufficient supply for my purpose; he states that the blacks prize it very highly; so much do they value it that it can only be obtained from them in very small quantities at a time, hence it involves the expenditure of much time and trouble to collect together a few pounds weight of the substance. The blacks in his district on the Barcoo obtain it from the Diamantina blacks who trade yearly with the Mulligan or Kykockodilla tribe, in whose country the piturie grows. One parcel which Mr. Wilson sent to me was some months in transit, as it had to be carried down on camels to Port Augusta; the sea journey from Port Augusta to Sydney was of course a question of only a few days.

The first parcel of piturie was in the form of broken twigs, and fragments of leaves of a pale brown colour, emitting a smell somewhat similar to tobacco; the fine dust causes sneezing. This is its usual state, but the second parcel forwarded by the camels was much less broken up and was of a darker colour, the difference being probably due to the less careful drying which it had undergone, for, as Mr. Wilson explained in his letter, the camels started earlier than was expected, and in consequence the piturie had to be packed up before it was thoroughly dried.

Unfortunately none of the samples contained either flowers or seeds, but I have but little doubt that the piturie supplied to me was obtained from the plant *Anthocercis Hopwoodii*, since known as *Duboisia Hopwoodii*;[1] (F. v. M.), and now named *D. pituri* by Dr. Bancroft;[2] one of the Solanaceæ.

Dr. Bancroft gives the following description of the piturie plant:[2] "The pituri grows about 50 miles east and west of the 138° meridian, the boundary between Queensland and South Australian territory, and from 22° to 25° south latitude. It is a

[1] Frag. Phytograph. x. 20, Baron von Mueller.
[2] Pituri and Tobacco, by Dr. Bancroft, Jour. Queensland Phil. Soc., 1879.

shrub or small tree about 8ft. high, with a stem at the thickest part at times as much as 6 inches in diameter. Wood light, close-grained, lemon-coloured, with a smell of vanille when newly cut. Suckers spring up around the tree, from long, rough roots spreading near the surface. Leaves 3 to $3\frac{1}{2}$ inches long, pointed at both ends, $\frac{1}{4}$ inch wide, mid-rib distinct, margin slightly recurved; flower, a funnel-shaped tube, from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch long, with five bluntish divisions, spreading to about $\frac{1}{4}$ inch across. Three reddish lines run from each division down the throat of the flower, as in the genus *Myoporum*, which latter may be known by having four or five stamens of equal length. The pistil of the pituri extends to the length of the two longer stamens. Stamens four, two long and two short; anthers, yellow, kidney-shaped, filament attached to the concave side, the anther bursting along the convex margin; best seen by examining a flower that is just at the point of opening. Fruit, a green berry resting in the minute calyx. As it ripens it changes to black, and contains dark-brown kidney-shaped seeds, covered with minute pits, recognisable by the aid of a pocket lens. Ripe berries soon fall off, and should be looked for under the tree, as those gathered from the branches are not mature enough to germinate."

Mr. Wilson informs me that the blacks mix the piturie with the ashes of the leaves of a particular plant and usually roll the mixture up with a green leaf into the form of a quid before chewing; the addition of the wood ashes is doubtless made for the same reason that lime is mixed with betel by the Malays and others, namely, for the purpose of slowly liberating the alkaloid during the process of mastication. The quid or bolus is, on ceremonial occasions, said to be passed from native to native, each one masticating it for a time, and then passing it on, it finding a resting place behind the original proprietor's ear until again required.

The effects of the piturie seem from all accounts to be very much the same as those set up by tobacco-smoking; it does not appear to have the exciting effect upon the blacks with which it was at one time credited. As is the case with other luxuries, it is reserved by the older men for their own use exclusively, neither women nor young men being allowed to use it. The reasons for using it appear to be much the same as those which induce white people to smoke and in certain cases chew tobacco.

I have made no attempts to experiment upon the physiological effects of the alkaloid, since this part of the subject has been very fully treated by Dr. Bancroft and other observers. The examination was made mainly with the view to ascertain its chemical composition, and, if possible, constitution. The supply of alkaloid was insufficient to admit of both questions being treated.

In a letter dated 5th September, 1879, the Baron von Mueller, K.C.M.G., has been kind enough to place at my disposal the following account of the alkaloid obtained by him from pituric, which is the substance of a paper of his read before the Apothecaries' Society of Vienna :—

"For the preparation of piturine and pituric acid the branchlets and leaves of *Duboisia Hopwoodii*, F. v. M., were subjected to exhaustion by boiling water, the infusion evaporated to honey thickness, then mixed with three volumes of alcohol, the resulting solution evaporated to the consistence of an extract, the latter dissolved in water and precipitated by basic acetate of lead. The precipitate separated by filtration, contained a peculiar acid substance, while the filtrate, after sufficient concentration and after mixing with an excess of caustic soda solution and ether, yielded to the latter the alkaloid which was purified by agitating its etherous solution with diluted sulphuric acid, thereby forming the sulphate of piturine. The aqueous solution of the latter was then again decomposed by caustic soda, the pure alkaloid removed by ether, and the solution evaporated at a gentle heat. It formed a brownish liquid of oil like thickness, heavier than water, of acrid and burning taste and tobacco odour, much affecting the organs of sight and respiration. It is volatile and forms fogs with diluted hydrochloric acid, is of strong alkaline reaction, and combines thoroughly with acids.

"Its hydrochloride forms precipitates with the chlorides of platinum and gold, with picric and tannic acids, phosphomolybdate of soda, bi-iodide of potassium, the iodide of potassio-mercury and potassio-bismuth, also with phospho-wolframate of soda,[1] but this precipitate is easily dissolved in an excess of this reagent. Piturine mixes with every proportion of water, alcohol, and ether. Concentrated hydrochloric and nitric acids do not affect a colouration with it; concentrated sulphuric acid forms reddish brown clouds and dissolves to a brownish green liquid. The yield was about 1 per cent. of alkaloid from the dried plant.

"Piturine is in some respects allied to nicotine, but more closely akin to the duboisine of *Duboisia myoporoides* (R. Br.), the latter being of lighter colour, of bitter not acrid taste, of fainter odour, less irritating to the eyes and respiratory passages; its hydrochloride in solution is not precipitated by chloride of platinum, but is so by phospho-wolframate of soda, and the precipitate is not redissolved by a superabundance of that reagent."

A. Ladenburg, *Comptes Rendus*, 1880, vol. 90, p. 874–876, however states that the alkaloid of *Duboisia myoporoides* is identical with hyoscyamine and that it crystallizes in small needles, fusing at 108°5 C., and is isomeric with atropine, from which it is distinguished by forming a brilliantly lustrous compound with gold chloride, fusing at 159° C. Also when treated with baryta it is converted into *tropine* and *tropic* acid, both of which are also obtained from atropine.

[1] Metatungstate of soda.

The great discrepancy between A. Ladenburg's account and the Baron von Mueller's can I think be only accounted for by the supposition that Ladenburg must have been supplied with a different material. Baron von Mueller and Rummel (Jour. Chem. Soc. January, 1879), state very plainly that the *Duboisia myoporoides* yields a *volatile oily* alkaloid, and this is again confirmed by the extract from the Baron's letter, already quoted.

In the same paper Baron von Mueller also describes pituric or duboisic acid obtained from the precipitate given by the piturie on the addition of basic acetate of lead.

In the Pharmaceutical Society's Journal for April 5th, 1879, there is an account of an examination of some piturie made by Mons. Petit, of Paris, in which he comes to the conclusion that the alkaloid is identical with nicotine; but M. Petit does not seem to have had sufficient material to permit a combustion to be made of the alkaloid; he had to rely mainly upon its reactions with certain chemicals, and apparently was only able to make one determination each of the platinum and chlorine in the platinum salt; the amounts of which apparently roughly corresponded with those required for the chloro-platinate of nicotine, viz., 34·4 per cent. platinum and 37 per cent. chlorine, the percentages obtained being platinum 34· per cent. and chlorine 36 per cent. These results however cannot be regarded as final, since, as will be shown later on, the platinum salt cannot be depended upon, as it is not of uniform composition.

Preparation of the Alkaloid.

The piturie was extracted with boiling water slightly acidified with sulphuric acid, the liquid concentrated by evaporation and distilled with an excess of caustic soda, the alkaline distillate neutralized by hydrochloric acid, evaporated over a water bath until reduced to a small bulk; as the residue was of a yellowish colour it was once more distilled with caustic soda, the distillate neutralized with hydrochloric acid and again concentrated; it was now nearly colourless, caustic soda was again added, and the liquid shaken up with ether.

The ether was next removed by distillation at as low a temperature as possible in a current of hydrogen, the heat meanwhile being raised gradually until it reached 140°C., a bath of sulphuric acid being used for this purpose. It was allowed to remain at this temperature for about six hours; the bath was then removed, and the distillation continued at a still higher temperature over a naked flame, the current of hydrogen being still maintained, until all the alkaloid, with the exception of a very small quantity, which had become charred, had passed over in a clear and colourless condition. During the distillation the thermometer indicated a temperature between 243° and 244°C.

I. 60 grammes of the substance gave ·622 grm. of the alkaloid, or 1·037 %. In this case the alkaloid was not allowed to boil, but was maintained at a temperature of 140° C. in a current of hydrogen for several hours, to remove water and traces of ammonia.

II. In a second experiment 500 grammes of the piturie gave 12·34 grammes of alkaloid, or 2·47 %, when distilled in a current of hydrogen.

The piturie did not contain any non-volatile alkaloid.

The alkaloid when freshly prepared is clear and colourless, but with access of air rapidly becomes yellow, and finally brown, especially when exposed to the sunlight. In a sealed tube one specimen has remained unchanged during the past eight months.

It is soluble in all proportions in water, alcohol, and ether, yielding colourless solutions. On paper it produces a greasy stain, which disappears after a time.

No determinations by weighing have yet been made of its specific gravity, but it is just a little heavier than water, a drop of it sinking slowly to the bottom of a vessel of distilled water.

When freshly prepared its smell is very like that of nicotine; afterwards, when darkened in colour and thickened in consistency, the odour is more like that of pyridine.

It is volatile at ordinary temperatures, its vapour forming a dense fog with hydrochloric acid. Its vapour irritates the mucous membranes very much, and when working with it induced violent headaches.

The taste is acrid and pungent, and very persistent.

It neutralizes acids completely; but the neutral solutions of acetate, sulphate, and hydrochloride all become acid on evaporation from the loss of alkaloid.

Oxalic acid is the only acid which yields a crystalline salt, but this is more or less mixed with free acid, from the loss of alkaloid by volatilization, an acid salt mixed with free oxalic acid being left.

The acetate, sulphate, and hydrochloride, when kept over strong sulphuric acid, dry up into hard, brittle, transparent, varnish-like substances, without the slightest trace of crystallization, even after standing for months. All these compounds are very hygroscopic, especially the sulphate, and are very readily soluble in alcohol.

Reactions of the Alkaloid.

Neither concentrated hydrochloric acid nor nitric acid changes the colour of the alkaloid in the cold, but when warmed, hydrochloric acid imparts a slightly reddish colour, and nitric acid turns it yellow. Concentrated sulphuric acid turns it brown after some time, immediately when warmed.

Platinic chloride does not precipitate an aqueous solution of the alkaloid (1:100 aq:) so long as the alkaloid is in excess, but when the solution has become neutralised, the addition of another drop of platinic chloride throws down a slight yellowish flocculent precipitate, which dissolves on heating, but does not reappear on cooling; if a larger quantity of the platinic chloride be added, the precipitate still dissolves on the application of heat, but on cooling reappears in a crystalline condition.

In a solution of 1 part of the hydrochloride of the alkaloid to 50 of water, a precipitate similar to the above is thrown down, and if heated, a part redissolves, the undissolved portion turns to an orange yellow colour and becomes crystalline—the dissolved salt also crystallizes only on cooling. Under the microscope the crystals appear to have the form of the octahedron, or combinations of that with other forms belonging to the cubical system. More dilute solutions of the hydro-chloride are not precipitated by platinic chloride.

All the following tests were made with an aqueous solution of 1 part of the alkaloid to 100 water.

Mercuric chloride, in the aqueous solution of the alkaloid throws down a white cheesy precipitate, insoluble in an excess of the precipitant, easily soluble in hydrochloric acid; on heating to boiling the precipitate softens, but does not actually melt; it is difficultly soluble in boiling water; on cooling it is redeposited in an amorphous state.

A few drops of *mercuric chloride* give a white precipitate in a solution of the hydrochloride, which disappears on shaking, but when the mercuric chloride is in excess, a white crystalline precipitate is thrown down, which is rather easily soluble in hot water; on cooling, crystals in the form of rhombic prisms and plates are deposited, soluble in hydrochloric acid.

Copper sulphate in an aqueous solution of the alkaloid gives a light green precipitate, insoluble in an excess of the alkaloid. In a solution of the hydrochloride the copper sulphate does not produce any change.

A few drops of *gold chloride* added to the aqueous solution give a reddish white precipitate, which disappears on shaking; a larger quantity of the re-agent gives a flocculent reddish-white precipitate, which is persistent, soluble in hydro-chloric acid with difficulty.

In the solution of the hydrochloride a few drops of gold chloride give a reddish-white precipitate, which redissolves on agitation; a larger quantity of the re-agent gives a reddish precipitate, which is permanent but easily soluble in hydrochloric acid, much more so than the precipitate from the alkaloid.

Tannic acid gives a greyish-white precipitate in the aqueous solution—easily soluble in hydrochloric acid. In the neutral solution of the hydrochloride there is a greyish-white turbidity only, which disappears on the addition of hydrochloric acid.

The double iodide of mercury and potassium ($HgI_2,2KI$) gives a heavy white crystalline precipitate in the aqueous solution. Under the microscope this is seen to be made up of small plates arranged in stellate groups. With hydrochloric acid the precipitate becomes yellow and pasty, but does not dissolve in the cold, readily soluble on heating; on cooling the solution becomes turbid.

In the solution of the hydrochloride $HgI_2,2KI$ gives a heavy amorphous yellowish white precipitate; on the addition of a little hydrochloric acid it becomes pasty; on heating, a part dissolves; with a larger quantity of hydrochloric acid, the whole dissolves on heating; on cooling, it is redeposited as a yellow amorphous powder.

On the addition of a small quantity of an alcoholic solution of iodine a yellowish turbidity only is imparted to the solution, which is persistent for some hours; but a greater quantity produces a brown precipitate.

On treating the alkaloid with concentrated sulphuric acid and a trace of potassium bichromate in powder, the fluid takes the colour of the bichromate; after a time it changes to a dirty brown and then to green. When warm the change of colour takes place immediately.

With manganese peroxide (MnO_2) instead of the bichromate, no change takes place in the cold; when warm a faint violet colour is produced.

The alkaloid behaves very like nicotine with picric, phosphomolybdic and metatungstic acids; the addition of picric acid throws down a yellow precipitate soluble in hydrochloric acid.

Phosphomolybdic acid forms a yellowish white amorphous precipitate, insoluble in cold dilute hydrochloric acid, easily and completely dissolved on warming.

The precipitate with nicotine is a dirty yellowish white amorphous, insoluble in cold dilute hydrochloric acid, soluble when warmed, but apparently not so readily as is the precipitate from the piturie alkaloid, some white flakes being left undissolved.

Metatungstate of sodium forms with both piturine and nicotine a white amorphous precipitate, soluble only in much dilute hydrochloric acid when warmed.

Iodine.—When iodine dissolved in ether is added to an etherial solution of the alkaloid the fluid becomes brownish red and turbid; after a short time yellowish red needles are deposited, the mother liquor being yellow; these crystals are easily soluble in alcohol, yielding a brownish red solution; when the alcoholic solution is evaporated at the ordinary temperature, indistinct needles and oily drops are left behind.

When this alcoholic solution is treated with caustic soda in the cold, a smell similar to that of iodoform is emitted, not that of the alkaloid; from the nicotine compound nicotine is liberated, according to Wertheim (Watt's Dict. of Chemistry, iv, p. 47).

The iodine compound of piturine melts at about 110° C., that of nicotine at 100° C. (Watt's Dictionary of Chemistry, vol. iv, p. 47).

Differences.

From coneine it is distinguished by its aqueous solution not becoming turbid on heating nor by the addition of chlorine water. It differs from aniline by not being coloured by chloride of lime; it differs from picoline in specific gravity (picoline being only ·9613 at 0° C.); from pyridine by its re-action with copper sulphate, the precipitate $Cu(OH)_2$ produced by pyridine with copper sulphate re-dissolves in an excess of the precipitant; and it appears to be distinguished from nicotine by its reactions with platinic chloride, gold chloride, iodine and mercuric chloride also by Palm's test. According to Palm (Russische Zeitchrift für Pharmacie I. 4 and Husemann's Pflanzenstoffe) nicotine when gently warmed with a little hydrochloric acid of 1·12 sp. gr. turns violet and on the addition of a little strong nitric acid the colour changes to a deep orange—the only sample of nicotine to be obtained in Sydney yielded the latter part of the above test very well; the orange being very stable, the violet colour was not so well marked. The piturine does not change colour at all, but when more heat is applied it becomes yellow.

The Composition of the Alkaloid.

To determine the composition of the alkaloid, the carbon and hydrogen were estimated in the usual way by combustion with lead chromate; the nitrogen by the soda-lime process; the ammonium chloride left after the evaporation of the excess of hydrochloric acid was titrated with decinormal solution of silver nitrate.

The alkaloid for the determination of the carbon, hydrogen, and nitrogen was taken from two different specimens prepared from two different supplies of the piturie, but in both cases the boiling points were the same, viz., 243° to 244° C.

To prevent oxidation, the alkaloid was enclosed in the combustion bulbs immediately after its preparation.

The results obtained were as follows:—

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Carbon............	76·63	76·64	......	......	lost.	76·53	......	76·46
Hydrogen	8·49	8·46	......	......	8·52	8·51	......	8·41
Nitrogen	......	......	14·80	15·00	......	......	15·01	......

The average of these eight analyses is—

Carbon	76·56
Hydrogen	8·48
Nitrogen	14·94

And the relative proportions when calculated in the usual way are—

Carbon	5·98
Hydrogen	7·96
Nitrogen	1·00

or very nearly 6 : 8 : 1.

The formula would therefore be C_6H_8N, which requires—

			Theory.	Found.
C_6	=72	=	76·59 per cent.	76·56 per cent.
H_8	= 8	=	8·51 ,,	8·48 ,,
N	=14	=	14·90 ,,	14·94 ,,
	94		100·00	99·98

To confirm this formula a platinum double salt was prepared in the usual manner. The crystals so obtained were orange red octahedra fairly soluble in warm water, but very easily soluble when even a trace of the free alkaloid is present; partly soluble in alcohol, but insoluble in ether.

To ensure as far as possible uniformity of composition, the platinum salts were always prepared from the same portion of alkaloid with the same solution of platinic chloride, and as much as possible under the same circumstances; notwithstanding this the percentages of platinum and of chlorine obtained were never the same, for the salts prepared at different times, neither did they fit in or correspond with the above-mentioned formula. The amount of chlorine was too small for the usual proportion of 1 Pt. to 6 Cl. met with in the normal double salts of platinum; in some cases it was even less than 1 : 5.

The amount of platinum was determined in twenty-three cases upon salts prepared at ten different times, but from the same substance and with the same platinic chloride; the amount of Pt. varied from 34·15 per cent. to 38·40 per cent.; seven analyses yielded between 35·35 and 35·55 per cent. Pt. Nine determinations of chlorine were made, and they varied from 31·32 to 36·86 per cent. Cl.

The platinum salt is therefore clearly not of uniform composition or else very unstable; it undergoes decomposition with loss of chlorine during evaporation, even when conducted under the desiccator without the aid of heat.

The mercuric-chloride double salt, prepared by adding an excess of saturated solution of mercuric-chloride to a solution of the hydrochloride of the alkaloid, crystallized well in rhombic plates and prisms; the double salt was crystallized from boiling water, dried at 100° C., and the amount of mercury and chlorine determined in it.

Two analyses gave—

	I.	II.		Mean.
Mercury.........	63·26 per cent.	63·09	=	63·175
Chlorine	24·60 ,,	24·64	=	24·620

The mean results calculated in the usual manner come to 1·00 Hg: 2·1955 Cl, or 5 Hg: 10·9775 Cl, or very nearly 5 Hg: 11 Cl., which would fit to the formula

$$(C_6H_8N)_2HCl + 5\ HgC_2$$

which requires 63·31 per cent. Hg and 24·72 per cent. Cl, while the corresponding compound of nicotine

$$C_{10}H_{14}N_2,HCl + 5\ HgCl_2$$

would require 64·37 per cent. Hg and 25·15 per cent. Cl.

Besides, nicotine is said to form under the same circumstances a double salt containing 4 $HgCl_2$ instead of 5 molecules of $HgCl_2$. (*Vide* Watt's Dictionary of Chemistry, iv., p. 47.)

The above two analyses appear to make it probable that the true formula of the alkaloid is $(C_6H_8N)_2$ or $C_{12}H_{16}N_2$, *i.e.* double that yielded by its ultimate analysis, but much importance cannot of course be attached to such a compound as $(C_6H_8N)_2HCl + 5HgCl_2$, in which the amount of alkaloid present is so very small.

Alkalimetric Power.

0·2986 gramme of the alkaloid required 18·5 c.c. $\frac{1}{10}$ normal sulphuric acid, a corresponding amount to that required by nicotine, to form $(C_{10}H_{14}N_2)_2\ H_2SO_4$; the molecular weight of nicotine being 162, 0·0162 × 18·5 = 0·2997 instead of 0·2986.

I hope at some future period to continue the subject of this paper; meanwhile my best thanks and acknowledgments are due to my assistant, Dr. Helms, now Assistant Demonstrator in the University Laboratory, for his very valuable help in carrying out the details of this investigation.

NOTE.—The name of this substance has been spelt in many different ways, such as, "pitchiry," "picherie," "pedgery," "bedgery," and "pitury"; the most usual spelling at present is "pituri." To show that the final "i" in pituri is not to be pronounced as "i" in *pine* I have spelt the word "piturie."

On Salt-bush and Native Fodder Plants of New South Wales.

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[*Read before the Royal Society of N.S.W., 3 November, 1880.*]

In all civilized countries much attention has been directed to the composition and value of the various fodder plants grown in them, ever since Leibig first directed attention to the valuable aid which agriculture might obtain from the study of such subjects by chemical methods. That this should be so is not surprising, seeing the important rôle which the cultivation of these plants plays in European agriculture, forming indeed the foundation on which modern farming is based, feeding the animals which not only supply meat and much of our clothing, but also furnish the greater part of the manure required to bring the vegetable food of man to perfection. It is, however, somewhat surprising that in this country no attention whatever has, as far as I can learn, been directed to the native plants, and the more so when perhaps three-fourths of the wealth of the community is, or has been, derived from its flocks and herds. For many reasons foreign to the purpose of this paper, it has been too much the interest of every one to let the sheep and cattle of to-day eat the best there is, even if they destroy it off the face of the earth, without regard to what those of to-morrow will do. It seems reasonable to suppose that in our peculiar climate, subject to periods of continued drought, and having in many cases soils peculiarly saline, that the plants which have withstood these influences for ages past would be more reliable than others developed under different conditions of soil and climate. That many introduced plants do flourish here and grow with a vigour never seen in their native habitats is undoubted, but, as Dr. Schomberg remarks in his pamphlet on introduced weeds in South Australia, it remains to be seen whether that increased growth may not be the means of their own destruction.

It has therefore been thought of sufficient interest to induce me to make a beginning, by examining a few of those plants which form the staple pasture of the famed Riverina district, and I now lay the results before you, accompanying them with a table showing the average composition of other fodders of good quality for comparison. All the European plants which are used for feeding vary greatly in composition at different periods of their growth, and I have selected analyses of hay or straw made of the plant at the period of flowering, when they are at their best. The analyses have all been recalculated from the authorities given, so as to reduce them to the same method of statement adopted for my own work. The analyses of the meadow hay, red clover and lucerne, were all stated as containing 15 per cent. of water, which is the average in well-made hay; and the ashes were all, with the exception of the oats, given in 100 parts of ash only, and that containing carbonic acid, and the chlorine was given in the free state. As the plants which are to be brought under your notice are not used in the form of hay, and as the specimens examined had in their long journey become in some cases partially dried, and in others (the more succulent ones) were in a state of incipient fermentation, which rendered it necessary to dry them as rapidly as possible, no water determinations were made, and the analyses are given on the dried plants.

Immediately on their arrival they were divided into woody portions, and tender parts, including small twigs and every part it was considered probable that the sheep would eat; the separate parts were weighed, and a sufficient quantity of the edible matter was dried on a water bath, and afterwards ground in a coffee-mill for the proximate organic analysis. The remainder of the plant was partially air-dried and then charred in a clay crucible at a dull red heat; from the excessive quantity of alkaline salts present it was found impossible to remove much more of the carbon without running serious risk of losing part of the salts by volatilization, and the analyses were therefore made on the charred material, which generally contained about 50 per cent. of carbon. In determining the quantity of ash the carbon was removed as far as possible by incineration, the remainder being afterwards determined and deducted. As the char evolved sulphuretted hydrogen on treatment with acid, it was moistened with concentrated nitric acid for the estimation of sulphuric and phosphoric oxides. In calculating the analyses, the carbon dioxide, sand, and alumina found have been deducted, following in respect to the first the Continental method. It is not, properly speaking, an inorganic constituent, the salts not being in combination with it in the plant; and although its rejection is regarded by some English chemists as removing a distinctive feature of the ash, that is simply a question of what one regards as such feature. In some of the ashes—that from plants which could be well dusted—there was no sand nor alumina, and in the others the amount of these constituents rose and fell together, showing that both were derived from adherent impurity; but as no such connection could be observed with regard to the soluble silica, this has been retained. A large portion of each ash was examined for manganese and the rarer constituents of plant ashes, which could in no case be detected. The greatest variation in the original ash analyses amounted to 0·24 over and 0·31 under 100, and I have therefore, for simplicity of calculation, ventured to calculate the analyses into 100 parts exactly. The ash analyses are stated in two columns, the first showing the composition in 100 parts, the second on the dried plant.

No. 1. *Atriplex sp.* Dwarf salt-bush.

Oil	2·94
Carbohydrates	40·96
Aluminoids	14·68
Woody fibre	15·60
Ash—CO_2	25·82
	100·00

Nitrogen	2·35
Woody parts of plant	37 per cent.
Edible ,, ,,	63 per cent.

Ash analysis.	On ash.	On plant.
Potash	21·18	5·47
Soda	49·34	12·74
Chloride of sodium	2·31	·60
Lime	12·74	3·29
Magnesia	4·83	1·25
Ferric oxide	·73	·19
Sulphuric oxide	4·43	1·14
Phosphoric ,,	2·80	·72
Silica soluble	1·64	·42
	100·00	25·82

No. 2. *Atriplex campanulata.* Small salt-bush.

Oil	2·24
Carbohydrates	43·47
Aluminoids	12·25
Woody fibre	18·12
Ash—CO_2	23·92
	100·00

Nitrogen	1·96
Woody parts of plant	8 per cent.
Edible ,, ,,	92 per cent.

Ash analysis.	On ash.	On plant.
Potash	13·61	3·25
Soda	26·22	6·27
Chloride of sodium	35·36	8·46
Lime	8·47	2·03
Magnesia	5·82	1·39
Ferric oxide	1·83	·44
Sulphuric oxide	2·62	·63
Phosphoric ,,	3·80	·91
Silica soluble	2·27	·54
	100·00	23·92

No. 3. *Atriplex sp.* Salt-bush weed.

Oil	2·08
Carbohydrates...	43·19
Albuminoids	13·37
Woody fibre	14·88
Ash—CO_2	26·48
	100·00

Nitrogen	2·14
Woody parts of plant	4 per cent.
Edible " "	96 per cent.

Ash analysis.	On ash.	On plant.
Potash	20·21	5·25
Soda	40·82	10·81
Chloride of sodium	7·95	2·10
Lime	14·56	3·96
Magnesia	5·13	1·36
Ferric oxide	·92	·24
Sulphuric oxide	2·57	·68
Phosphoric "	4·41	1·17
Silica soluble	3·43	·91
	100·00	26·48

No. 4. *Atriplex sp.*

Oil	2·28
Carbohydrates...	43·64
Albuminoids	12·68
Woody fibre	14·44
Ash—CO_2	26·96
	100·00

Nitrogen	2·19
Woody parts of plant...	46 per cent.
Edible " "	54 per cent.

Ash analysis.	On ash.	On plant.
Potash	29·38	7·92
Soda	23·56	6·35
Chloride of sodium	12·46	3·36
Lime	15·47	4·17
Magnesia	6·96	1·88
Ferric oxide	1·21	·33
Sulphuric oxide	1·01	·27
Phosphoric "	3·44	·93
Silica soluble	6·51	1·75
	100·00	26·96

No. 5. *Atriplex sp.*

Oil	1·56
Carbohydrates	38·70
Albuminoids	16·18
Woody fibre	14·48
Ash CO_2	29·08
	100·00
Nitrogen	2·59
Woody parts of plant	48 per cent.
Edible ,, ,,	52 per cent.

Ash analysis.	On ash.	On plant.
Potash	26·54	7·72
Soda	32·29	9·39
Chloride of sodium	6·21	1·80
Lime	14·56	4·24
Magnesia	6·60	1·92
Ferric oxide	1·65	·48
Sulphuric oxide	3·57	1·04
Phosphoric ,,	4·21	1·22
Silica soluble	4·37	1·27
	100·00	29·08

No. 6. *Kochia pyramidata.* Blue-bush.

Oil	2·14
Carbohydrates	32·63
Albuminoids	19·94
Woody fibre	8·04
Ash CO_2	37·25
	100·00
Nitrogen	3·19
Woody parts of plant	37 per cent.
Edible ,, ,,	63 per cent.

Ash analysis.	On ash.	On plant.
Potash	12·39	4·62
Soda	34·43	12·83
Chloride of sodium	26·67	9·93
Lime	8·75	3·26
Magnesia	7·32	2·72
Ferric oxide	1·28	·48
Sulphuric oxide	1·11	·41
Phosphoric ,,	3·98	1·48
Silica soluble	4·07	1·52
	100·00	37·25

No. 7. *Atriplex numularia.* Old man salt-bush.

Oil	2·18
Carbohydrates	42·85
Albuminoids	16·45
Woody fibre	7·24
Ash CO_2	31·28
	100·00

Nitrogen	2·63
Woody parts of plant	10 per cent.
Edible ,, ,,	90 per cent.

Ash analysis.	On ash.	On plant.
Potash	15·69	4·91
Soda	29·57	9·25
Chloride of sodium	30·28	9·47
Lime	8·65	2·71
Magnesia	6·77	2·12
Ferric oxide	·64	·20
Sulphuric oxide	3·17	·99
Phosphoric ,,	4·11	1·28
Silica soluble	1·12	·35
	100·00	31·28

No. 8. *Chenolea bicornis.* Cotton-bush.

Oil	2·88
Carbohydrates	56·03
Albuminoids	9·18
Woody fibre	24·91
Ash CO_2	7·00
	100·00

Nitrogen	1·47
Woody parts of plant	6 per cent.
Edible ,, ,,	94 per cent.

Ash analysis.	On ash.	On plant.
Potash	24·73	1·731
Soda	20·17	1·412
Chloride of sodium	8·24	·577
Lime	24·33	1·703
Magnesia	8·27	·579
Ferric oxide	1·28	·090
Sulphuric oxide	3·95	·276
Phosphoric ,,	5·44	·381
Silica soluble	3·59	·251
	100·00	7·000

No. 4 contained or gave up to ether more chlorophyll than any of the others; the quantity of this was generally small, judging from the colour of the solution.

By an unfortunate mistake the whole of the original specimen of No. 6 (the blue-bush) was incinerated. In writing for another specimen, it was suggested that only the more tender parts of the plant need be sent, which suggestion was almost too literally carried out; and as there had been rain between the two gatherings, the plant had entered on its vigorous spring growth, so that the specimen consisted almost entirely of young, succulent shoots. This accounts for the high percentage of ash and albuminoids, which are generally higher in immature plants, and the ash would probably be richer in alkaline salts than the ash analysis made on the original specimen shows. Being then in a different stage of development, this analysis does not very well bear comparison with those of the other plants.

The different character of the ash of the cotton-bush from the others was at once shown on charring, as the mass in the crucible slowly burnt away after its removal from the fire, and without further application of heat, and the residue after this spontaneous combustion did not contain above 20 per cent. of carbon. It was also noticed that on burning a small portion for the ash determination, it differed somewhat from the other seven, as they all burned with a luminous and more or less smoky flame, which was particularly the case with No. 7, diffusing at the same time a peculiar, somewhat fishy odour, whilst it exhibited no such peculiarity either as to flame or odour.

TABULAR STATEMENT of the Composition of European Fodder Plants at the time of flowering.

	1 Meadow Hay.		2 Red Clover.		3 Lucerne.		4 Oaten Hay.	
Fat	3·29		3·64		2·94		4·34	
Carbohydrates	48·25		43·79		40·95		49·18	
Albuminoids	10·82		16·70		17·06		10·86	
Woody fibre	30·35		29·17		31·41		30·24	
Ash	7·29		6·70		7·64		5·38	
	100·00		100·00		100·00		100·00	
	On ash.	On plant.	On ash.	On plant.	On ash.	On plant.	On ash.	On plant.
Potash	26·20	1·915	32·25	2·161	13·66	1·044	35·24	1·907
Chlo. potassium	2·54	·184	3·06	·205	2·05	·156	7·59	·408
Chloride sodium	11·04	·805	3·84	·257	2·60	·199	2·75	·148
Lime	13·88	1·002	38·19	2·225	62·83	4·800	11·55	·621
Magnesia	4·97	·362	12·04	·806	4·90	·374	3·69	·199
Ferric oxide	·46	·033	·74	·050	1·03	·078	·61	·033
Phosphoric oxide	6·25	·455	9·77	·654	8·15	·623	10·28	·553
Sulphuric oxide	5·33	·388	2·95	·191	3·90	·298	2·67	·144
Silica	28·21	2·056	2·65	·178	·81	·062	25·34	1·363

No. 1. Mean of fifty analyses, representing hay of good quality. Way. Watt's Dict. 2nd Sup., p. 530.
No. 2. Mean of eleven analyses of hay of good quality. Way. Loc. cit.
No. 3. Mean of a small number of analyses. Way. Loc. cit.
No. 4. Oats at period of flowering, entire plants. Arndt. Jarsb. Agri. Chem., 1858–9, p. 24.

To arrive at the value of a fodder plant, there are many properties which have to be taken into consideration, besides the actual nutritive value as ascertained by analysis, in determining their suitability for grazing, such as the rapidity of growth of the plant, ability to withstand drought and constant cropping, and acceptability in respect to flavour to the cattle. On such points it is beyond my power to speak, but it appears to me a subject of sufficient importance and interest to induce some of those who have the opportunity to make accurate notes on the plants in this direction, and publish the results.

The order in which the salt-bushes proper are considered to stand from a grazier's point of view, are 1st, *A. numalaria*, or old man salt-bush; 2nd, the dwarf salt-bush, the others not being so much considered. The cotton-bush is considered to be of great value, both from the fact that the sheep get very fat on it, notwithstanding its unpromising appearance, which reminds one of a half-dried European broom-bush, but also from its ability to withstand long protracted drought. The blue-bush (*Kochia*) is not held in much esteem by the sheep, who do not eat it unless pushed by hunger, and their owners naturally place it low down in the list. This must be entirely a question of flavour, as so far as can be judged from the proximate analysis of the immature plant examined, it must have nearly the same nutritive value as the salt-bushes.

An examination of these analyses, and a comparison with the examples of well known European fodders given, shows that the whole of these plants stand in a good position with regard to nutritive value.

Like the greater number of the plants of the natural order *Chenopodiacæ* they contain an extraordinary amount of ash, and its preponderance at once strikes one on looking at the analyses, so that they seem well entitled to their popular name of salt-bushes, although there are only three which contain a very large proportion of common salt. I can only find one analysis of a plant of the same genus, viz., *A. verrucifera* from the Kergis Steppes, which contains 12·5 per cent of ash,[1] whilst in the specimens examined it ranges from 24 per cent. to 31·28 per cent.; but in species in other genera, of the same order as *Salsola*, the ash sometimes rises as high as from 30 to 42 per cent., as determined by the same author,[2] and many of these plants were formerly, and in some cases are even now for local use, of much importance as a source of soda.

In the following columns are given the ratios in which the total ash, the common salt, and the potash stand in relation to the total

[1] Göbel, Watt's Dict., 1–474.
[2] Watt's Dict. V. p. 176.

digestible matter taken as 100, including in that term the oil, carbohydrates, and albuminoids. There is also given the average of the salt-bushes properly so called, omitting the blue-bush, as the analysis was made on a specimen at a different and imperfect stage of growth, and the cotton-bush, as it is a plant of an entirely different character.

The great difference between the salt-bushes and European fodders is thus shown conspicuously, and the former are placed entirely by themselves, whilst the cotton-bush, as far as the points considered are concerned, ranges itself with the latter.

Ratios of digestible matter of Ash, Potash, and Salt.

	Digestible.	Ash.	Potash.	Salt.
1. Dwarf salt-bush	100	44	7·417	1·024
2. Small salt-bush	100	41	5.607	14·590
3. Salt-bush weed	100	45	8·952	3·581
4. ———	100	47	13·516	5·734
5. ———	100	53	13·751	3·207
7. Old man salt-bush	100	51	7·986	15·403
Average	100	47	9·538	7·689
8. Cotton-bush	100	10	2·541	·847
Meadow hay	100	12	3·207	1·604
Red clover	100	10	3·524	·720
Lucerne	100	12	1·969	·581
Oaten hay	100	8	3·277	·863

These plants being chiefly used for the pasturage of sheep, we may glance at what effects might be expected to take place on the animals, for there seems little doubt that changes in them must occur from a diet so very different to that on which they have been bred from immemorial time in Europe. Youatt, after speaking of the effect of climate on sheep and their wool, says :—"Pasture has a far greater influence on the fineness of the fleece. The staple of the wool, like every part of the sheep, must increase in length or in bulk when the animal has a superabundance of nutriment ; and on the other hand, the secretion from which the wool is formed must decrease like every other when sufficient nourishment is not afforded."[1]

Sheep, in common with other herbivoræ, appear to require a large quantity of soluble chlorides, which, by evolving free hydrochloric acid in the stomach, or rather in the gastric juice, enables them to digest very considerable quantities of cellulose. According to Bidder and Schmidt,[2] 1,000 parts of the gastric juice of

[1] Youatt on the Sheep, p. 70.
[2] Watt's Dict. II. 822.

the sheep contain 986·148 parts of water, whilst out of the remaining 13·852 parts 6·0 consist of soluble chlorides and 1·557 of hydrochloric acid. It is seen that the salt-bushes supply these chlorides in large proportion, and we might therefore expect the digestion to be active and to effect the assimilation of the nutritive matter with certainty.

It is in the wool, however, that we should expect the greatest effect to take place from such a diet. Youatt says (page 60) "The abundance and healthiness of the wool is proportional to the amount of yolk." The yolk of wool consists partly of fatty matter combined to a greater or less extent with lime and earthy matter in the form of an insoluble soap, but its greater part consists of a peculiar compound containing potash called "suint." This substance forms about one-third of the weight of raw merino wool and about 14 per cent. in ordinary wool, and is readily soluble in cold water. It is used to a considerable extent as a source of potash in France[1] where 1,000 tons per annum of potashes are obtained from it. Hoffman says[2] that 1,000 lbs. of wool yield from 70 to 80 lbs. of pure carbonate of potash, and 5 lbs. to 6 lbs. of sulphate and chloride of potassium, the weight of dry suint being from 140 lbs. to 180 lbs., and this would give, as an average yield from the suint, 17 per cent. of actual potash, and 1·5 per cent. of chloride and sulphate. From the percentage of suint given this evidently refers to ordinary wool, and, as merino wool contains twice as much, the actual quantity of potash will be double, and 1,000 lbs. of greasy merino wool would carry off about 60 lbs. of potash. From the ready solubility of this substance in cold water, it appears probable that much of it may be washed out of the wool by rain and dew during its growth, and that the quantity remaining in the shorn fleece may represent only a small portion of that which has been elaborated by the sheep. This would constitute a considerable drain on the potash obtained by the animal from its food, and it appears evident that the plants we are considering, from their richness in that alkali, would enable the sheep, and especially merinoes, to withstand that drain and produce that abundance of yolk on which it appears the fineness of the wool so much depends. That this is so is shown by the high esteem in which Riverina wool is held, and I hope by an examination of the wool itself to come to a definite conclusion on the matter.

The cotton-bush does not differ much in the matter of the ratios just considered from ordinary European fodders, and it evidently owes its value to the high percentage of carbohydrates which it contains, in which it stands above all competitors, and from which it obtains its fattening properties.

[1] Roscoe & Schorlemmer's Chemistry, vol. II. pt. I., p. 94.
[2] Report on Chemical Products in International Exhibition, 1862, p. 42.

In the following columns are given—1st, the percentage of digestible matter (organic); 2nd, the ratio of albuminoids to oil and carbohydrates, or of flesh-forming material to fat-forming, the former being taken as 100.

	1.	2.	3.
1. Dwarf salt-bush	58·58	100	287
2. Small salt-bush	57·96	100	565
3. Salt-bush weed	58·64	100	338
4. ———	58·60	100	362
5. ———	56·14	100	249
6. Blue-bush	54·71	100	174
7. Old man salt-bush	61·48	100	211
8. Cotton-bush	68·09	100	641
Meadow hay	62·36	100	478
Red clover	64·13	100	284
Lucerne	60·95	100	256
Oaten hay	64·38	100	482

It will be observed that in every case the total amount of digestible matter in the salt-bushes falls below that in the European fodders, with the exception of the old man and the cotton-bush; but this in all cases is due to the greatly increased quantity of ash, as in none of them is the quantity of indigestible organic matter so great. The ratios of carbohydrates to albuminoids vary greatly in the different plants, in some cases fully as low as in the leguminosæ, in some rising as high and higher than in the grasses. The exceptionally low ratio in the case of the blue-bush is undoubtedly due to the very immature condition of the specimen examined. I do not feel warranted in drawing any conclusion from these ratios, taken from such a small number of samples, but place them before you in the hope that some one else, by examining the plants from the different standpoints already indicated, may enable us to arive at the proper composition of a fodder plant to produce the best result in wool or mutton, or both.

In conclusion, my thanks are due to Mr. Mair, of Groongal, Narandera, and to Mr. Wilson, of the Mercantile Bank, for procuring me the plant specimens; and to Mr. Moore for naming them for me.

Water from a Hot Spring, New Britain.

By A. LIVERSIDGE, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 1 September, 1880.*]

THE sample of water forming the subject of this note was collected from a hot spring in one of the islands of the New Britain group, by the Rev. George Brown, Wesleyan missionary, to whom my thanks are due for the trouble taken in safely bringing it to Sydney.

The water was of a yellow tinge, and smelt of sulphuretted hydrogen; at first it was neutral to test-papers, but afterwards became very faintly acid, probably from the oxidation in part of the sulphuretted hydrogen.

No attempt was made to determine the amount of sulphuretted hydrogen and other gases, inasmuch as the quantity of water was but small, and moreover on account of the time which had elapsed since its collection (some few months), it was thought that the amounts of gases present at the time of examination would afford but little information as to the actual quantities contained by the water when freshly collected.

The residue left on evaporation to dryness at 100° C. amounted to 36,312 parts per 1,000,000, or 2,541·84 grains per gallon, which is about the same as average sea-water.

Composition of the Residue, dried at 100° C.

	% in residue.	Parts per million of water.	or Grains per gallon.
Silica	·200	72·6	5·08
Alumina and iron sesquioxide	·440	159·7	11·18
Calcium sulphate	1·394	506·2	35·43
,, chloride	2·240	813·4	56·93
Magnesium chloride	4·710	1,710·3	119·72
Sodium chloride	87·320	31,707·6	2,219·53
Potassium ,,	traces	......	......
Combined water	3·696	1,342·2	93·97
	100·000	36,312·0	2,541·84

Water from a Hot Spring, Fiji Islands.

By A. Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 1 September, 1880.*]

When at Kandavu, Fiji Islands, in 1876, I heard of the boiling springs at Savu Savu, but to my great regret my stay of three or four days only at Kandavu was too short to allow me to visit them, and I am indebted to the kindness of Dr. T. D. Bromlow, R.N., for the sample of water forming the subject of this note.

The water was contained in clear glass bottles, well corked and sealed. I mention this because the sample had evidently been collected with great care. On more than one occasion I have received samples of mineral waters which proved to be worthless for chemical investigation, simply because insufficient care had been exercised in the collection and bottling; this was often a source of regret to me, since much trouble must have been taken to procure the samples, and still more to get them safely to Sydney; when distant from towns it is, of course, not always possible to obtain glass-stoppered bottles, but when procurable there is nothing so convenient and suitable as the large half-gallon bottles known as Winchester quarts.

The water was clear and colourless, after the deposition of the small amount of matter which it had in suspension, free from smell, but with a strongly marked saline taste; to test-papers it was neutral, or but very faintly alkaline. On evaporation to dryness the filtered water left a very white extremely deliquescent residue, which on ignition fused but did not blacken, thus showing the absence of any appreciable amount of organic matter.

The specific gravity of the water was found to be 1·0064 at 60° F.

The total quantity of solid matter in solution, weighed after drying the residue at 110° C., was found to be 8,320 parts per million, or 582·40 grains per gallon; but, after driving off the combined water at a dull red heat, the residue was reduced to 7,813 parts per million, or 546·91 grains per gallon—*i.e.* it lost 6·09 per cent.

The rarer elements were carefully sought for in this residue by means of the spectroscope, but none were found. The total quantity of water at my disposal was but small—some four pints; perhaps a larger quantity would have enabled one to detect their presence. Neither iodine nor bromine could be found although carefully sought for.

Composition.

	% in residue.	Parts per million of water.	or Grains per gallon.
Silica, insoluble	1·681	133·3	9·20
,, soluble	·074	5·8	·40
Alumina and traces of iron sesquioxide	·534	41·7	2·92
Aluminium chloride	1·646	128·6	9·00
Phosphoric acid (P_2O_5)	traces	......	......
Calcium chloride	46·754	3,652·9	255·70
,, sulphate	4·770	372·7	26·09
Magnesium chloride	·154	12·0	·84
Sodium ,,	42·171	3,294·8	230·64
Potassium ,,	1·756	137·2	9·60
Carbonic acid	traces	......	......
Loss	·460	34·0	2·52
	100·000	7,813·0	546·91

From the above it will be seen that the salts in solution consist of chlorides for the most part, and that the chlorides of calcium and sodium largely preponderate over the others; the amount of calcium chloride is unusually large.

No mention was made by Dr. Bromlow of the temperature of the water.

The action of Sea-water upon Cast-iron.

By A. LIVERSIDGE, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 1 September, 1880.*]

THE specimen forming the subject of this note was obtained from the screw of the dredge "Hunter" employed in Newcastle Harbour, N.S.W.

Mr. Moriarty, the Engineer-in-Chief for Harbours and Rivers, tells me that the dredge had not been wrecked as I had previously been informed, in fact she is still at work; but that the screw became so rotten as to necessitate its removal. He accounts for the rapid decay, and very sufficiently, by the iron having been in actual contact with the copper sheathing of the vessel. In the same letter Mr. Moriarty mentions that an old iron cannon was taken up from the foul waters at the head of Darling Harbour, where it had lain for some twenty years, but the corrosion had only eaten its way in to about $\frac{1}{16}$ of an inch.

Even on the most cursory examination the specimen is seen to differ entirely from the original cast-iron, except in form, which seems to be unchanged; the material however is so altered in composition that it may be safely described as a pseudomorph, since it is almost entirely made up of oxide of iron and particles of graphite. It is quite sectile, being readily cut with a knife; the powder under the microscope presents a mixture of brilliant scales of graphite, mixed with brown-coloured oxide of iron and a few widely scattered minute particles of metallic iron; these on removal by means of a magnet answer to all the tests for metallic iron, and flatten out with a bright metallic lustre when ground in an agate mortar.

In colour the external part of the specimen is of a dull grey, within it is of a rusty brown colour, with darker bands which follow more or less closely the outer contour lines.

Different portions of the mass apparently vary somewhat in composition; the portion taken for examination was purposely chosen from the innermost part, as it appeared to be firmer and less friable than the very outside of the specimen; but even this only contained ·04 per cent. of metallic iron; the boss of the screw was, I understand, only superficially acted upon; the part examined by me came from one of the blades. On analysis it was found to have the following composition:—

Carbon	68·73
Iron protoxide	23·23
Iron sesquioxide	1·79
Iron, metallic...	·04
Manganese	·62
Phosphorus	absent
Sulphur	traces
Silicon	5·59
	100·00

The specific gravity at 62° F. taken upon a piece weighing 58·405 grammes was found to be but 1·63.

The carbon was not estimated directly, partly on account of the difficulty of satisfactorily determining its amount by the combustion process, and partly because, after everything else had been determined, it was thought that the amount of carbon could be estimated with sufficient accuracy by taking the difference.

The silicon was estimated in the form of silica by fusion with the mixed carbonates of potash and soda, the carbon being burnt off by the addition of potassium chlorate; the residue was extracted with boiling water, the silica rendered insoluble and determined in the usual way.

The metallic iron was extracted by means of a magnet, treated with fuming nitric acid, to get rid of attached impurities, washed, dissolved in hydrochloric acid, and estimated volumetrically.

It is interesting to note that the phosphorus has been eliminated completely by the action which has gone on, and that the amount of sulphur is quite small; for both were probably present in the original cast-iron.

Several instances of the effects produced by sea-water acting upon cast-iron are quoted by Gmelin in his "Handbook of Chemistry," vol. v, p. 218. These are also referred to in Watts' "Dictionary of Chemistry," vol. iii, p. 331, but no additional cases appear to be cited in the latter work, although published in 1871, *i.e.* twenty years later. The instances quoted are the following:—

Certain cannon-balls out of a number which had lain for forty-two years under sea-water were found to be converted into a substance like plumbago, some to the distance of half an inch, others to the very centre. (*Sill. Amer. Jour.*, 4. p. 178.)

Some cannon-balls lying in the sea on the coast of Norway since 1692, had retained their form and bulk, but had lost ⅔rds of their weight, yielded to the knife, did not act upon the magnet, and were free from metallic iron (Deslongchamp J., *Chem. Med.*, 13, p. 89).

Cannon-balls raised at Carlscrona from a sunken vessel, lost fifty years previously, were found to be changed through $\frac{1}{3}$rd of their thickness into a porous graphitic mass, which became strongly heated when exposed to the air for a quarter of an hour, in fact so hot as to drive the water off in steam. (*Berzelius Lehrb.*)

Dr. Percy, F.R.S., lately Professor of Metallurgy at the Royal School of Mines, in his volume on the metallurgy of iron and steel, quotes some instances collected by Henry Wilkinson in his work "On the extraordinary effect produced on Cast-iron by the action of Sea-water," 1841. Amongst them he gives the following :—"Many of the vessels of the Spanish Armada were sunk off the shore of Mull in Scotland, and in 1740 some of the guns of a vessel named the 'Florida' were raised. These were both brass and cast-iron guns, and on scraping the latter which were deeply corroded, they became so hot that they could not be touched. However, they lost this property after two or three hours exposure to the air, and there was no difference in the appearance of the substance before and after the combustion." "In a naval engagement with the French off Portsmouth in 1545, the 'Mary Rose' of the English Fleet was so overweighted with ordnance that she sank with all her crew of nearly 600 men. On the 16th June, 1836, a 24-pounder brass gun, 11 feet in length, belonging to this vessel, was raised with the aid of diving apparatus. This gun had a cast-iron shot in it, which on exposure to the air, is stated, became nearly red hot and fell to pieces." "At the same time," Mr. Wilkinson writes, "four brass and three iron guns were raised from the wreck of the 'Mary Rose.' The iron guns were of the ancient description, formed of iron bands hooped together with iron rings, and they were all loaded, but the guns being made of wrought or malleable iron did not exhibit the same phenomena as the balls, which were made of cast-iron. Those balls, which by their diameter ought to have weighed 30 lbs., were reduced to 19 lbs. 3 ozs. The 8-inch or 70-lbs. ones were only 45 lbs., and although to external appearance, the same as regular shot, they fell to pieces *red hot* on exposure to the air.*

No complete analyses seemed to have been made of the graphite-like residues ; hence no comparison could be made between the composition of this specimen from the "Hunter" and that of others.

Dr. Percy refers to some experiments made by Professor Daniell.†

A cube of grey cast-iron was acted upon by dilute hydrochloric acid. When the acid was saturated the cube was taken out and found to consist of a soft spongy substance, but apparently

* Percy's "Iron and Steel," p. 147.

† Percy's "Iron and Steel," p. 146, quoting from the Journal of Science and Art, vol. ii, p. 278.

undiminished in bulk. A specimen of white cast-iron having a radiated fracture was similarly treated; the dark grey spongy residuum could be easily cut with a knife and resembled plumbago. Some of it when placed to dry on blotting-paper spontaneously heated and smoked in the course of a minute. In another case when a considerable quantity of it had been heaped together it ignited and scorched the paper.

But the most valuable contributions to our knowledge upon this subject were made by Mr. Robert Mallet, F.R.S., in his Reports to the British Association for the years 1838, 1840, and 1843. These reports were made at the request of the British Association, and they contain the results of a most careful and elaborate series of experiments made to ascertain the action of sea and river water, both clear and foul, and at various temperatures, upon many hundred specimens of cast and wrought iron and steel, as well as to test the advantages of various protective paints and varnishes; they also contain the results of experiments made to ascertain the protection afforded by zinc, &c., to iron structures in contact with water.

Mr. Mallet mentions a case* in which bars of cast-iron 3 inches broad and 1 inch thick, which formed protectors to the copper of a vessel, to the amount of about $\frac{1}{100}$ of its surface, were in a voyage of not quite five months to Jamaica and back, converted into plumbago to the depth of half an inch; this statement is of special interest in connection with the specimen from the "Hunter."

Mallet states that Priestley was one of the first of those who observed this conversion of cast-iron into a plumbago-like mass of mixed oxide of iron and carbonaceous matter, and that such residues frequently but not invariably became hot or spontaneously inflammable on exposure to the air. Mallet states that under certain circumstances even the purest malleable iron is converted into this plumbago-like substance, and quotes instances. The same writer mentions that some cannon-balls which were found in the sea near the site of the battle of La Hogue had, after an immersion of 145 years, been converted into plumbago to the depth of an inch in some cases and right through in others; and assuming their diameter to have been about $6\frac{1}{4}$ inches, the usual size of 32-lb. shot, he points out that the iron had been destroyed to a depth of $3\frac{1}{8}$ inches during the above number of years,—a much more rapid rate of action than he obtained from his special experiments.

The foregoing will probably suffice as instances of the action of sea-water, brought about more or less by accident. Mr. Mallet's experiments are far too numerous to quote here—I can merely give a bare summary of his results.

* Brit. Association Report, vol. viii, 1838, p. 262.

Mallet found that the approximate depth of corrosion in clear sea-water at the end of one century would be as follows :—*

Welsh cast-iron.	Hot and cold blast	·306 inch.
Irish ,,	Cold	·306 ,,
Mixed cast-irons ;	Scotch and Welsh, Irish and Welsh, &c.	·337 ,,
Scotch cast-iron.	Chiefly hot blast	·379 ,,
Staffordshire, Shropshire, and Gloucestershire cast-iron.	Hot and cold blasts ...	·385 ,,
Grey cast-iron, mixed.	Skin removed by planing	·419 ,,
Derbyshire and Yorkshire cast-iron.	Hot and cold	·431 ,,
Wrought-iron.	Standard bar, No. 2 Dowlais ...	·543 ,,

In another table † he gives the approximate depth of corrosion for the following wrought-irons and steels at the end of one century in clear sea-water, foul sea-water, in clear fresh-water, and when freely exposed to the weather in Dublin :—

	Clear sea-water.	Foul sea-water.	Clear fresh-water.	Exposed to the weather in Dublin.
Red short bar, Staffordshire..	·276 inch.	·644 inch.	·032 inch.	·335 inch.
Common bar, Shropshire......	·927 ,,	·434 ,,	·081 ,,	·540 ,,
Best bar, Staffordshire.........	·316 ,,	·423 ,,	·039 ,,	·361 ,,
Best Welsh bar, Dowlais......	·278 ,,	·638 ,,	·035 ,,	·353 ,,
Low Moor boiler plate.........	·215 ,,	·404 ,,	·035 ,,	·332 ,,
Common boiler plate	·272 ,,	·554 ,,	·038 ,,	·412 ,,
Swedish bar, Danemora	·277 ,,	·726 ,,	·030 ,,	·470 ,,
Fagoted scrap bar	·064 ,,	·379 ,,	·024 ,,	·219 ,,
Blister steel bar, soft	·298 ,,	·425 ,,	·015 ,,	·301 ,,
Sheer steel bar, soft	·313 ,,	·676 ,,	·025 ,,	·389 ,,
Cast steel, tilted bar, soft ...	·441 ,,	·559 ,,	·026 ,,	·279 ,,
Do. do. hard...	·239 ,,	·430 ,,	·043 ,,	·156 ,,

As in the former table the results were obtained from specimens which had been immersed for 732 days.

Mallet found that the corrosion of cast-iron, which has had its skin removed by planing, is precisely the same in moist air as in clear sea-water, also, that the rate of corrosion of cast-iron in sea-water is a decreasing one, when the coat of plumbago and rust first formed is removed prior to a second immersion. When the coating is untouched the corrosion goes on at a nearly uniform rate. The coating of plumbago and rust is negative to the metal, hence, when left on it assists in the corrosion of the metal ; in fresh water this is not so strongly marked, since the coating is harder and less porous, thus to a greater or less extent it mechanically defends from corrosion.

* British Association Reports, 1840, vol. x, p. 299.
† Brit. Association Reports, vol. xiii, 1843, p. 53.

The rapid action of sea-water upon cast-iron and the commoner varieties of wrought-iron is probably due mainly to the local galvanic action set up between the diffused scales of graphite, films of slag, or other foreign matter.

Where cast-iron is exposed to the combined action of fresh water and of sea-water, as at the mouths of rivers, the action is said to be much more rapid, for the heavy sea-water remains below while the lighter fresh water floats above, thus producing a voltaic pile having two liquids and one solid, also in places where the sea-water is foul and more or less contaminated with sulphuretted hydrogen.

The action of acid waters in copper and other mines, and of solutions of the salts of copper upon iron is well known, and it is taken advantage of by the miner in the humid or precipitation processes for the extraction of copper. It is quite a common thing for workers in certain mines to find neglected articles of cast-iron which have been exposed to the action of "acid" waters converted into masses of graphite-like matter.

The action of sea-water upon iron, and especially upon cast-iron structures, must be one of very great interest and importance to engineers; it is certainly one well worthy of further investigation, especially in connection with the construction of cast-iron cylinders for the support of piers and wharfs in harbours and estuaries. The copper sheathing of ships and the metal of cast-iron wharf would form a galvanic couple if connected in any way either by actual contact, by wet hawsers, fenders, or by other means affording a passage for the electric current.

Mallet refers to the well known rapidity with which recently made castings become coated with rust when exposed to a shower of rain, and he states that it takes place much more rapidly in the case of castings made in "dry sand" or "loam" than in those made in damp or "green sand" moulds. He says, "in 'loam' or dry sand moulds, moisture not being present, but little hydrogen is generated by the fluid metal to burn off the 'facing' of charcoal which remains '*parsemé*' on the surface of the casting, producing innumerable voltaic couples in contact with water; while in the case of the 'green sand' castings, most of the charcoal facing is removed in a gaseous form from the casting before it leaves the sand." But I am inclined to think that this difference is probably due in part, if not wholly, to the formation of a film of magnetic oxide of iron by the steam from the moisture: the protective action of such a film has long been known, although it was not made use of on a large scale until Mr. Barff, the Professor of Chemistry at the Royal Academy, brought out his process.

On the Composition of some Wood enclosed in Basalt.

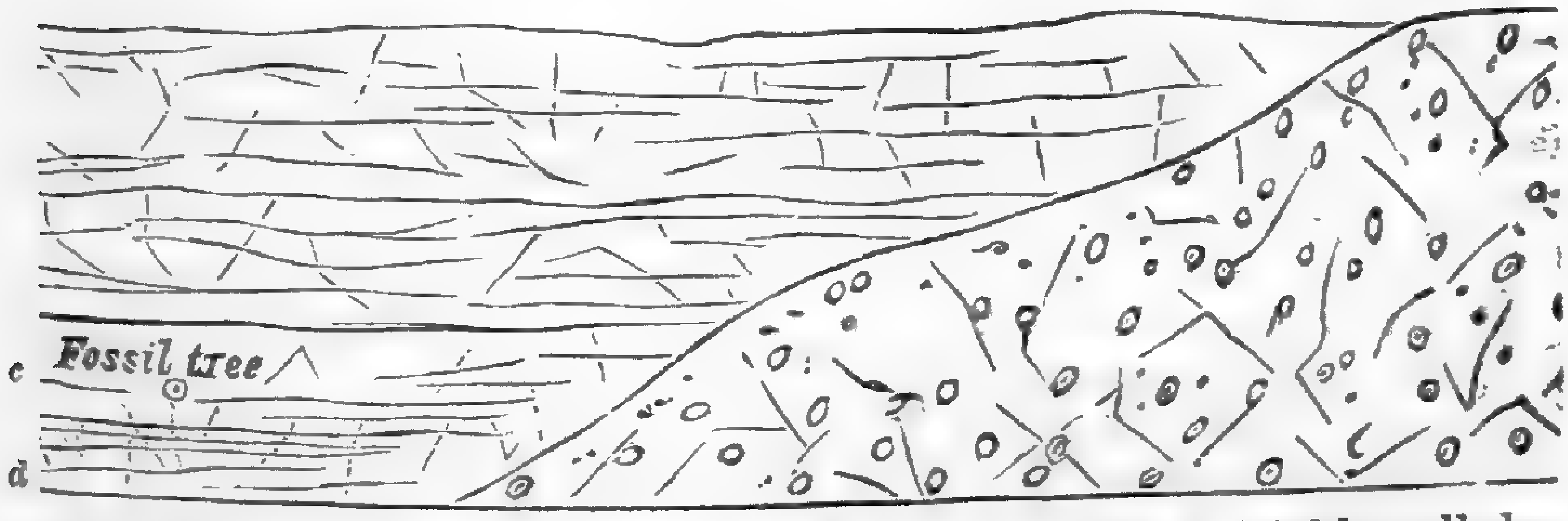
By A. LIVERSIDGE, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 1 December, 1880.*]

THE specimen forming the subject of this note was found by Mr. C. S. Wilkinson, F.G.S., at Inverell, where the Macintyre River has cut through the basalt and formed a river cliff; by the formation of this section the included fragments of wood and trunks of trees are exposed to view.

In the "Mines and Mineral Statistics" published by the Mining Department in 1875, Mr. Wilkinson gives the following description of the manner in which the fossilized wood occurs, and on the same page (p. 76) he gives a diagram showing the position occupied by the particular tree trunk from which this specimen was taken:—

"An interesting cliff section of basalt may be seen on Mr. Colin Ross's property on the bank of the river at Inverell. The following is a sketch of it:—



"*a, b,* amygdaloidal basalt, much decomposed; *c,* friable cellular basalt, enclosing fragments of wood and pieces of earth; *d,* dense columnar basalt; *e,* volcanic breccia, composed of fragments of basalt of various sizes embedded in an indurated volcanic mud, much stained with peroxide of iron, which imparts to the rock varying shades of deep red and yellow. This breccia is older than the *a b c d,* and evidently formed the side of a hill on which plants were growing at the time of the basalt eruption; for at the junction of the basalt and breccia lies a thin bed of red clay, the former surface soil, in which I discovered numerous stems of plants. Some of these stems are in an upright position, and even penetrate a few inches into the basalt rock above, and several I found with the woody matter but little altered. These facts are very singular, as proving the viscid state of the overflowing basaltic lava, to have thus surrounded the small plants without destroying them, and how rapidly it must have cooled. Another interesting relic of the newer pliocene period that this section reveals is the trunk of a tree, about 2 feet in diameter, imbedded in the layer of basalt marked *c* in the above sketch.

"The wood, though much changed, yet retains its fibrous structure most completely. It somewhat resembles the stringy-bark, and may possibly be a species of eucalyptus; but this is difficult to decide without the aid of the microscope.

"Surrounding the tree is a soft substance 2 inches thick, which was probably the bark."

As pointed out by Mr. Wilkinson, the woody structure has not been destroyed and it is still visible to the unassisted eye, but with the aid of a microscope the structure of the cellular tissue is much more clearly seen; patches of white carbonate of lime and of yellow oxide of iron are also observed to have been deposited within its substance.

The specimen seems to have been considerably crushed and broken; in general appearance it looks as if a number of angular fragments of charcoal had been pressed together. This brecciated structure was probably set up after the trunk was enveloped by the fluid lava, and was doubtless caused by the contraction of the rock round the wood, as it solidified and cooled.

When heated in a closed tube much water is given off; when ignited on platinum foil it does not inflame or glow like a carbonaceous substance, but quickly burns to a pale brownish-grey ash; the carbon, which has apparently been converted into graphite, is present in very small quantity, and barely sufficient to impart a black colour to the substance.

It effervesces with acids, is fragile, and sufficiently soft to be scratched with the thumb-nail.

Analysis.

Water lost at 100° C. ...	12·54
Combined water ...	·46
Silica ...	35·57
,, soluble ...	·31
Carbon ...	5·14
Iron sesquioxide ...	1·76
,, protoxide ...	3·67
Manganese ...	traces
Alumina ...	15·79
Lime $=(16{\cdot}42. CaCO_3)$ ...	9·20
Magnesia $=(7{\cdot}24. MgCO_3)$ ...	3·45
Potash ...	·22
Soda ...	·27
Sulphur ...	traces
Sulphuric acid ...	,,
Carbonic acid ...	11·29
Loss ...	·33
	100·00

The lime and magnesia evidently exist as carbonates; a small quantity of the protoxide of iron may also exist in combination with carbonic acid, as there is ·28% of carbonic acid left after converting all the lime and magnesia into carbonates. The alumina and iron probably exist in the form of silicate, as the amount of silica is nearly sufficient to form a silicate of the formula R_2O_3, $3SiO_2$, or if the water also be taken into account, $Al_2O_33SiO_2 + 4H_2O$.

As it contains traces of sulphur and of sulphuric acid, small quantities of iron pyrites are probably present.

The combined water was determined by heating the powdered substance in a combustion tube and collecting the water in a weighed chloride of calcium tube, and the carbon by combustion with lead chromate in a current of oxygen, the silica by fusion with the mixed alkaline carbonates, and the alkalies by Dr. J. Lawrence Smith's process with calcium carbonate and ammonium chloride.

Masses of silicified wood are very common in nearly all basaltic areas over all parts of the world, and they are very noticeable in many parts of this Colony; this particular specimen is different from the above, inasmuch as, instead of being composed almost exclusively of silica or of hydrated silica, as is the case with ordinary silicified wood, it has been mineralized by a mixture of various substances.

On account of the mineralized wood having such a complex constitution, it may be thought that it may have been merely replaced mechanically—*i.e.*, it might be supposed that the wood has been burnt or rotted away and the mould left by it filled in with earth and charcoal, but such is not the case. There is no doubt that the mineral matter has been deposited from solution; the woody tissue, which was doubtless much charred, has been almost completely replaced particle by particle, by the deposition of mineral matters from infiltered water holding them in solution. This process must have been a very slow one, the cavities of the cells were probably filled first, the cell walls were next gradually removed, except those portions represented by the small remaining quantity of graphite-like carbon, and replaced by mineral matter as the decay went on, but so slowly and quietly that no violence was done to the microscopic structure of the woody tissue.

On the Composition of some Coral Limestones, &c., from the South Sea Islands.

By A. Liversidge, Associate R. S. Mines, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 6 October, 1880.*]

1. Reef Coral, New Hebrides.

A white crystalline limestone, the fractured surfaces of which present all the appearance of aragonite; for the most part it is made up of radiating prismatic crystals, the remainder being coarsely crystalline like marble. No trace of organic structure could be detected. The external surfaces are, however, coated with a thin film of purple-coloured organic matter, which burns when heated on platinum foil. Before the blowpipe the limestone whitens and falls to pieces like aragonite.

I am indebted to the kindness of the late Commodore Goodenough, R.N., for this and the succeeding specimen. This distinguished naval officer always took a very lively interest in the geology and mineralogy of the countries which he visited, and seldom failed to collect and bring back with him any specimens which were procurable.

Locality: Island of Vati, or Sandwich Island, New Hebrides Group; from shore at the level of high-water-mark.

Analysis.

Hygroscopic moisture	·26
Alumina and traces of iron sesquioxide ...	·23
Lime	54·62
Magnesia	·08
Silica	·51
„ soluble	·21
Potash	traces
Sodium chloride	1·02
Phosphoric acid	traces
Carbonic acid	42·32
Loss	·75
	100·00

A second portion from the interior only contained traces of sodium chloride.

2. Red Reef Coral, New Hebrides.

Of a reddish brown colour, intermixed with white, due mostly to small fragments of coral and shell disseminated through the mass; these make the rock look very much like a bone breccia from a cave deposit. Different portions vary in composition. Contains traces of organic matter.

Analyses.

	I.	II.
Hygroscopic moisture	·50	——
Silica	1·17	——
„ soluble	·17	——
Alumina and	2·81	1·69
Iron sesquioxide		·62
Lime	48·75	——
Magnesia	3·36	2·33
Potash	·15	——
Soda	·40	——
Chlorine	traces	·12
Phosphoric acid	traces	traces
Carbonic acid	43·22	41·25
	100·53	

The determinations in the second column were made upon another specimen.

The red colour of this specimen is probably due to the presence of decomposition products, such as clay, &c., derived from the disintegration of lava or other similar rocks; this seems to be borne out also by the presence of alkalies other than as chlorides, as well as by the presence of the silica, alumina, iron, and magnesia.

3. Coral Limestone, Duke of York Island.

This specimen and the following was collected by Dr. Messer, R.N., of H.M.S. "Pearl," from a raised reef on the Duke of York Island, one of the Union Group, at a height of 110 feet above the sea level.

Analysis.

Hygroscopic moisture	·019
Organic matter	·500
Silica	·789
Alumina and traces of iron sesquioxide	1·973
Manganese	traces
Lime	52·094
Magnesia	·861
Potash	·983
Soda	·848
Chlorine	traces
Carbonic acid	41·679
Loss	·254
	100·000

4. Tuff Rock?

This specimen was also collected in 1876 by Dr. Messer, on the island of Vati, one of the New Hebrides, from what he describes as a raised terrace of coral rock, which crops out above Havannah Harbour, at a height of 525 feet above sea-level, the highest point of the island being about 1,500 feet.

The rock is greyish white in colour and readily friable; but, as will be at once apparent from the analysis, it is not a limestone, although it may have been found to contain corals.

On addition of acid it effervesces but feebly, showing the presence of only a small amount of carbonic acid.

Analysis.

Hygroscopic moisture, @ 100° C. ...	3·68	21·82 % Soluble in acid.
Combined water, by ignition ...	7·58	
Carbonic acid	1·04	
Silica	·70	
Alumina	6·60	
Iron sesquioxide	·56	
Lime	1·66	
Magnesia	trace.	
Potash and soda	traces.	
Silica	56·56	78·18 Insoluble in acid.
Alumina	14·80	
Lime	trace.	
Magnesia	6·76	
Loss	·06	
	100·00	

The combined water was determined by ignition of the rock to complete fusion; allowance was made for the carbonic acid which was also driven off at the same time.

5. Tuff Rock, New Hebrides.

Brought by the late Commodore Goodenough, R.N., from the shore, below high-water-mark, of Port Sandwich, Mallicollo, New Hebrides. A greyish-coloured rock, breaking with a large conchoidal fracture, with smooth earthy-looking surfaces devoid of lustre; of very fine grain. Soft, and readily scratched with a knife. Emits a dull sound when struck. Specific gravity, 2·186.

It was labelled "coral sand rock," but, as will be seen from the analysis, it is mainly a silicate of alumina.

Analysis.

Hygroscopic moisture	4·41
Combined water, by difference	1·71
Carbonic acid...	·30
Silica	62·57
Alumina and traces of iron sesquioxide ...	28·82
Lime	·74
Magnesia	traces.
Potash	·60
Soda	·85
	100·00

On the Inorganic Constituents of the Coals of New South Wales.

By W. A. DIXON, F.I.C., F.C.S., Lecturer on Chemistry, Technical College, School of Arts, Sydney.

[*Read before the Royal Society of N.S.W., 6 October 1880.*]

IN the early part of this year I made, for the Department of Mines, proximate analyses of the coals of the Colony shown at the late Exhibition, the samples being taken from the whole thickness of the seams from the sections exhibited, rejecting however the bands which are thrown aside in actual working. Having the residue of these samples and some others, it appeared that information of some interest might be obtained from an examination of the ash, and it was hoped that some light might be thrown on the insoluble ash constituents of the plants from which the coal has been formed.

For the analyses the coals were charred and burned at a dull red heat until the ash was obtained as free as possible from carbon. This, in the case of coals whose ash contains little iron, is an exceedingly tedious process, so that in some of them it was found necessary to determine the residual carbon, and deduct it from the analysis. The ash was then treated by digestion with hydrochloric acid for about three-quarters of an hour at a temperature near the boiling point of the acid, which contained about 22 per cent. of actual H Cl. The residue was fused with mixed alkaline carbonates, and the insoluble constituents determined in the usual manner.

The coals of the Colony naturally divide themselves into three classes, namely, those of the Northern, Southern, and Western fields, and the character of the ash follows, as a rule, the same divisions, except that the ash of the coal found at Redhead, eight miles south of Newcastle, differs from that of the others in its neighbourhood in containing much less iron and alumina, and an increased quantity of silica. With the coals of the Northern district may be taken a sample from the Clarence River district, the ash of which was obtained from a small hand specimen only.

The whole of the ashes showed traces of alkalies, carbonic acid and chlorine, besides those constituents given, but the quantity was in all cases very minute. The following are ash analyses from the Northern fields :—

Newcastle Coal Company's Colliery

Specific gravity of coal, 1·283; percentage of ash in coal, 4·76; colour of ash, reddish.

Analysis—

Alumina	27·21	Soluble in acid 43·30
Ferric oxide	11·11	
Lime	1·46	
Magnesia	1·56	
Sulphuric oxide	·72	
Phosphoric „	1·24	
Alumina	6·51	Insoluble in acid 56·34
Ferric oxide	3·02	
Lime	·61	
Magnesia	·63	
Silica	45·57	
Undetermined and loss ...	·36	
	100·00	

Australian Agricultural Company's Colliery.

Specific gravity of coal, 1·286; percentage of ash, 4·44; colour of ash, reddish.

Analysis—

Alumina	22·84	Soluble in acid 42·25
Ferric oxide	15·20	
Lime	1·98	
Magnesia	traces.	
Sulphuric oxide	·97	
Phosphoric „	2·26	
Alumina	3·45	Insoluble in acid 56·55
Ferric oxide	traces.	
Silica	53·10	
Undetermined and loss ...	·20	
	100·00	

Co-operative Coal Company's Colliery, Plattsburgh, near Newcastle.

Specific gravity of coal, 1·310 ; percentage of ash, 4·20 ; colour of ash, reddish.

Analysis—

Alumina	23·34	Soluble in acid 40·43
Ferric oxide...	9·33	
Lime	3·71	
Magnesia	1·99	
Sulphuric oxide	·72	
Phosphoric ,, ...	1·34	
Alumina	5·90	Insoluble in acid 58·88
Ferric oxide...	3·17	
Magnesia	·49	
Silica	49·32	
Undetermined and loss ...	·69	
	100·00	

Newcastle Wallsend Colliery.

Specific gravity of coal, 1·347 ; percentage of ash, 4·28 ; colour of ash, reddish.

Analysis—

Alumina	22·25	Soluble in acid 39·78
Ferric oxide...	11·20	
Lime	3·05	
Magnesia	1·31	
Sulphuric oxide	·83	
Phosphoric ,, ...	1·14	
Alumina	6·48	Insoluble in acid 60·73
Ferric oxide...	3·31	
Lime	·32	
Magnesia	·41	
Silica	50·21	
	100·51	

NEW LAMBTON COLLIERY, near Newcastle.

Specific gravity of coal, 1·291; percentage of ash, 6·72; colour of ash, red.

Analysis—

Alumina	15·00	Soluble in acid 38·98
Ferric oxide...	17·72	
Lime	2·26	
Magnesia	2·72	
Phosphoric oxide	1·28	
Alumina	5·56	Insoluble in acid 61·10
Ferric oxide...	2·16	
Lime	·69	
Magnesia	·37	
Silica	52·32	
	100·08	

FERNDALE COLLIERY, Newcastle.

Specific gravity of coal, 1·296; percentage of ash, 3·84; colour of ash, buff.

Analysis—

Alumina	23·24	Soluble in acid 38·96
Ferric oxide...	9·21	
Lime	2·41	
Magnesia	2·11	
Sulphuric oxide	·74	
Phosphoric „	1·25	
Alumina	6·42	Insoluble in acid 61·15
Ferric oxide...	3·44	
Lime	·24	
Magnesia	·23	
Silica	50·82	
	100·11	

Waratah Colliery.

Specific gravity of coal, 1·293; percentage of ash, 4·64; colour of ash,

Analysis—

Alumina	22·31	Soluble in acid 36·81
Ferric oxide...	8·11	
Lime	2·41	
Magnesia	·98	
Sulphuric oxide	·71	
Phosphoric ,, ...	2·29	
Alumina	4·59	Insoluble in acid 63·07
Ferric oxide...	2·31	
Silica	56·17	
Undetermined and loss ...	·12	
	100·00	

Redhead, near Newcastle.

Specific gravity of coal, 1·325; percentage of ash, 6·84; colour of ash, grey.

Analysis—

Alumina	13·59	Soluble in acid 23·17
Ferric oxide...	4·74	
Lime	1·96	
Magnesia	·71	
Sulphuric oxide	·45	
Phosphoric ,, ...	1·72	
Alumina	5·03	Insoluble in acid 76·65
Ferric oxide...	1·97	
Silica	69·65	
Undetermined and loss ...	·18	
	100·00	

This sample contained no chlorine.

Ash of Coal from the Clarence River.

Percentage of ash in coal, 8·75; colour, grey.

Analysis—

Alumina	22·78	Soluble in acid 29·70.
Ferric oxide...	4·01	
Lime	1·26	
Magnesia	·48	
Sulphuric oxide	·21	
Phosphoric „	·96	
Alumina	5·13	Insoluble in acid 70·25
Silica	65·12	
Undetermined and loss ...	·05	
	100·00	

For comparison with these results samples of the roof and floor of the Australian Agricultural Company's seam were obtained from Mr. Gregson, who kindly sent me three samples of each. Of the roofs two specimens were much alike, and consisted of a shaly sandstone containing a small quantity of coaly matter, whilst the third contained so much of this as to be an impure coal containing 49 per cent. of ash, and was not analyzed further; of the floors two specimens were analyzed corresponding to the roof specimens; the remaining specimen was very similar in appearance to that marked Old No. 1 way. The samples were treated in exactly the same manner as the coals; the organic matter being burnt off at a dull red heat, and in doing so both specimens of the roof burnt with a faintly luminous flickering flame, one of the floor specimens with considerable flame, and the other with none.

Roof Galley Way.

Percentage of organic matter and water, 9·97.

Analysis of residue—

Alumina	6·68	Soluble in acid 11·81
Ferric oxide...	2·77	
Lime	·42	
Magnesia	1·32	
Sulphuric oxide	·21	
Phosphoric „	·41	
Chlorine	traces.	
Alumina	12·31	Insoluble in acid 87·87
Silica	75·56	
Undetermined and loss ...	·32	
	100·00	

Roof Old No. 1 Way.

Percentage of water and organic matter, 7·70.

Analysis of residue—

Alumina	11·89	
Ferric oxide...		
Lime	1·61	
Magnesia	·93	
Phosphoric oxide	·37	
Insoluble	84·73	
Undetermined	·47	
	100·00	

As this was evidently very similar to the last, the analysis was not carried into greater detail.

Floor Galley Way.

Percentage of organic matter and water, 30·95.

Analysis of residue—

Alumina	8·26	Soluble in acid 11·54
Ferric oxide...	2·21	
Lime	·42	
Phosphoric oxide	·65	
Alumina	13·58	Insoluble in acid 88·60
Silica	75·12	
	100·24	

Floor Old No. 1 Way.

Percentage of organic matter and water, 4·30.

Analysis of residue—

Alumina	4·88	Soluble in acid 8·72
Ferric oxide...	2·84	
Lime	·53	
Magnesia	·31	
Phosphoric oxide	·16	
Alumina	12·43	Insoluble in acid 91·16
Silica	78·73	
Undetermined and loss ...	·12	
	100·00	

On glancing at these last four analyses one is struck with the fact that the phosphoric oxide seems to increase with the quantity of organic matter, and that the quantity of alumina in the soluble portion does not bear the same relation to that in the insoluble as it does in the coal ashes. The analyses were not made in expectation of finding any such difference, but it is believed that the times of digestion with acid were in all cases nearly the same. It would perhaps be better to divide the alumina into easily soluble and difficultly soluble than simple soluble and insoluble, as more soluble alumina might be obtained by more protracted digestion, but in the case of the specimens of floors the insoluble alumina required prolonged fusion to obtain it in solution at all. The ratio between the insoluble and soluble alumina in the various analyses of the northern coals is as follows:—

A. A. Company ...	1 : 6·5	Wallsend	1 : 3·4
Waratah	1 : 4·8	New Lambton ...	1 : 2·7
Clarence River ...	1 : 4·4	Redhead	1 : 2·7
Newcastle Co. ...	1 : 4·2	Roof Galley Way	1 : 0·5
Co-operative ...	1 : 3·9	Floor	1 : 0·6
Ferndale	1 : 3·6	,, Old No. 1 Way	1 : 0·4

These ratios exhibit a surprising difference, and appear to indicate that the ash constituents of the coal are not derived simply from admixture of the material of the floor or roof in an unchanged state. Unfortunately the whole of the samples had either been used in the analyses or thrown away before this difference was observed, so that a more particular examination of this point could not be made.

It has been suggested by Dana[1] that the alumina present in coal may have been in some measure derived from the ashes of lycopodiaceous plants as lepidodendron, which suggestion he based on the observations of Dr. A. Aderholdt and Prof. Church on the ashes of various lycopodiums. Alumina found in the ashes of plants is generally ascribed to adherent impurity, but in 1852 Dr. Aderholdt[2] found that the ashes of *Lycopodium chamæcyparissus* and *L. clavatum* consisted largely of alumina; thus, in that from the first plant free from spores he found 51·85 per cent., and with spores 57·37 per cent.; in that of the second 26·65 per cent. These results have been confirmed by Church,[3] who, after taking every precaution to remove adherent alumina from the plants, found in *L. alpinum* 33·5 per cent., in *L. clavatum* 15·24 per cent., and in *L. selago* 7·29 per cent., and also by Salm-Horstmar[4] and

[1] Manual of Geology, J. D. Dana, 2nd Ed., 366 (1874).
[2] Ann. d. Chem. u. Pharm., lxxxii, 111 (1852).
[3] Chem. News, xxx, 137 (1874).
[4] J. Pr. Chem., xl, 302.

Solms-Laubach.[1] The different ratio of soluble to insoluble alumina in the coal ashes to that in the roofs and floor appears to coincide with this view, as if this earth had been assimilated by the plants we may readily believe that it would remain more easily soluble than that which had not been subjected to such treatment.

Sir Robert Kane[2] in some analyses of the ashes of peat gives—

Alumina	5·41	3·79	1·68
Sand and silicates insoluble in acids	2·17	2·10	7·68

and in the first two of these, even if the whole insoluble matter was alumina, which is unlikely, the ratio of soluble to insoluble would be high. Some of the results obtained from peat ashes by Messrs. Kane and Sullivan[3] point in the same direction.

In none of the published analyses of coal ashes that I have seen are the portions soluble and insoluble in acid analysed separately. The analyses have evidently been made either by direct fusion with alkaline carbonates (or by treatment with hydrofluoric acid), or by treatment with hydrochloric acid without further examination of the insoluble residue. Neither of these methods could show the difference here noticed, and possibly it would not be so noticeable if the treatment with acid was persisted in until nothing further would dissolve, as alumina in some forms dissolves with extreme slowness although solution may ultimately be complete. In the extensive series of analyses of British argillaceous iron ores from the coal measures by Messrs. Dick and Spiller given by Dr. Percy,[4] most of which have been made by the double method, it is observable that in not a single instance does the soluble alumina reach more than about one-fourth of the insoluble, and very often it is only one-tenth. In this respect the alumina in these ores is in much the same condition to that observed in the floors and roofs, or it is somewhat more insoluble. In connection with this matter Prof. W. Thomson, in a paper on the nature of the sea bottom in the deeper parts of the Atlantic and Southern Oceans[5], considers that the red clay there found is an organic deposit, being a residue of the globigerina ooze from which the carbonate of calcium has been removed by solution, and suggests that all or many clays may be of similar origin. Church, on the other hand, regards this red clay as an oxidation product of glauconite,[6] which in its turn is considered by Ehrenberg to consist of

[1] Ann. Ch. Pharm., c., 297.
[2] The Industrial Resources of Ireland, p. 37.
[3] Report on the Nature and Process of the Destructive Distillation of Peat, made to the Commissioner for Woods, 1851.
[4] Percy's Metallurgy, Iron and Steel, 210 to 220 (1864).
[5] Proc. Roy. Soc., xxiii, 32 (1874).
[6] Chem. News, xxxi, 199.

the stony nuclei and silicified shells of polythalamiæ,[1] and if this is correct the organic origin of the clay would only be antedated. All published analyses of clays being made, like those of the coal ashes, for other purposes take no notice of the solubility of the various constituents, but it seems probable that an examination in this direction might throw some light on the subject, and I hope shortly to take the matter up.

The presence of phosphoric oxide in coal ashes is not noticed in many published analyses, but as this substance might easily be overlooked and determined along with, and as alumina or iron, according to the method of analysis employed, its not being in the list of constituents does not necessarily imply its absence, unless it is noted as having been looked for. Le Chatelier and Leon Durand-Claye[2] have given analyses of French coal ashes, showing from 0·2 to 1·5 per cent., and E. Riley[3] has found in Welsh coals from 0·21 per cent. to 3 per cent. of phosphoric oxide in the ash. This substance is evidently a plant residue, and is present in notable quantity in the strongly caking northern coals, which contain a much larger quantity than could be introduced by simple intermixture of the material of either the floor or roof, whilst it seems unlikely that it could be removed from either source by solution and be deposited in the coal. It may be observed, indeed, that the quantity present in the roofs and floors of the A. A. Company's seam is roughly proportional to the quantity of organic matter present, and that in the floor from the galley way the quantity of this oxide and organic matter nearly corresponds to the proportion in the coal itself, and this specimen having the largest amount of oxide, the experimental error is reduced. In the ash analysis of peat by Sir Robert Kane (loc. cit.), he found the phosphoric oxide to vary from 0·24 to 2·57 per cent., and Dr. Ronalds[4] found in three samples 2·19-3·56 and 2·82, which shows that the phosphorus compounds offer very considerable resistance to removal by solution under circumstances which are probably analagous to those under which the coal seams were originally deposited.

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[1] Jahresb. f. Chem. 1854, p. 885.
[2] Bulletin de la Soc. d'Encourag. l'Industrie Nationale, 1873.
[3] Percy's Metallurgy Fuel, p. 352.
[4] Knapps' Technology, by Ronalds and Richardson, vol. i, p. 21.

COALS OF THE SOUTHERN DISTRICT.

OSBORNE WALLSEND COLLIERY.

Specific gravity of coal, 1·404 ; percentage of ash, 10·20 ; colour of ash, grey.

Analysis—

Alumina	30·31	Soluble in acid 40·51
Ferric oxide...	8·68	
Lime	1·18	
Magnesia	traces.	
Sulphuric oxide	·34	
Phosphoric „	traces.	
Alumina	5·24	Insoluble in acid 60·00.
Ferric oxide...	traces.	
Silica	54·76	
	100·51	

ILLAWARRA COAL COMPANY, Mount Pleasant Colliery.

Specific gravity of coal, 1,354 ; percentage of ash, 8·76 ; colour of ash, grey.

Analysis—

Alumina	34·07	Soluble in acid 41·75
Ferric oxide...	6·03	
Lime...	·82	
Magnesia	traces.	
Sulphuric oxide	·51	
Phosphoric „	·32	
Alumina	6·50	Insoluble in acid 57·69
Ferric oxide...	traces.	
Silica	51·19	
Undetermined and loss ...	·56	
	100·00	

BULLI COLLIERY.

Specific gravity of coal, 1·369 ; percentage of ash, 11·28 ; colour of ash, grey.

Analysis—

Alumina	26·84	Soluble in acid 35·77
Ferric oxide...	7·95	
Lime	·67	
Magnesia	traces.	
Sulphuric oxide	·31	
Phosphoric „	traces.	
Alumina	7·60	Insoluble in acid 64·53
Silica	56·93	
	100·30	

Coal Cliff.

Specific gravity of coal, 1·378; percentage of ash, 10·80; colour of ash, greyish white.

Analysis—

Alumina	31·56	Soluble in acid 38·84
Ferric oxide...	5·33	
Lime	·75	
Magnesia	·60	
Sulphuric oxide	·31	
Phosphoric „	·29	
Alumina	3·61	Insoluble in acid 61·02
Ferric oxide...	traces.	
Silica	57·41	
Undetermined and loss ...	·14	
	100·00	

Berrima.

Specific gravity of coal, 1·408; percentage of ash, 9·40; colour of ash, greyish white.

Analysis—

Alumina	18·61	Soluble in acid 24·00
Ferric oxide...	4·68	
Lime	·58	
Sulphuric oxide	·13	
Phosphoric „	traces.	
Alumina	·82	Insoluble in acid 75·87
Silica	75·05	
Undetermined and loss ...	·13	
	100·00	

Katoomba.

With these may be taken the Katoomba coal, as the character of the ash is similar, and differs from the other Western coals.

Specific gravity of coal, 1·400; percentage of ash, 10·04; colour of ash, greyish white.

Analysis—

Alumina	35·26	Soluble in acid 37·10
Ferric oxide...	·98	
Lime	traces.	
Magnesia	·30	
Phosphoric oxide	·56	
Alumina	3·23	Insoluble in acid 62·81
Silica	59·58	
Undetermined and loss ...	·09	
	100·00	

These ashes distinguish themselves from those of the north in containing much less phosphoric oxide; the average of the former giving 1·5 per cent., of the latter 0·22 per cent. The ratio of the soluble to the insoluble alumina is greater and the range is also greater, especially owing to including the inland coals with those of the coast, which by themselves are tolerably uniform.

The ratios of insoluble to soluble alumina are:—

Berrima	1	:	21·4
Katoomba	1	:	10·9
Coalcliff	1	:	8·7
Osborne Wallsend	1	:	5·7
Illawarra	1	:	5·2
Blliu	1	:	3·5

There are no analyses of roofs or floors to compare with these, but both, at all events in the case of the last three coals, are described as sandstone, and a rock containing so large a quantity of alumina as these ashes would scarcely be so described. As the total alumina varies in them from 35 per cent. to 40 per cent. they are richer in that earth than almost any fire-clay. It therefore appears as if the high percentage of alumina, the most of which is readily soluble, is again due to an original assimilation by the coal-producing plants.

COALS OF WESTERN DISTRICT.

Vale of Clwydd Colliery.

Specific gravity of coal, 1·328; percentage of ash, 9·72; colour of ash, grey.

Analysis—

Alumina	22·91	Soluble in acid 26·03
Ferric oxide...	1·55	
Lime	·81	
Magnesia	traces.	
Sulphuric oxide	·17	
Phosphoric „	·59	
Alumina	14·55	Insoluble in acid 73·85
Ferric oxide...	traces.	
Magnesia	1·05	
Silica	58·25	
Undetermined and loss ...	·12	
	100·00	

Eskbank.

Specific gravity of coal, 1·329; percentage of ash, 9·88; colour of ash, grey.

Analysis—

Alumina	21·13	Soluble in acid 24·61	
Ferric oxide...	1·39		
Lime	·78		
Magnesia	·61		
Sulphuric oxide	·16		
Phosphoric "	·55		
Alumina	14·21	Insoluble in acid 75·23	
Magnesia	trace.		
Silica	61·02		
Undetermined and loss ...	·15		
	100·00		

Lithgow Valley

Specific gravity of coal, 1·340; percentage of ash, 9·68; colour of ash, greyish white.

Analysis—

Alumina	20·24	Soluble in acid 23·72	
Ferric oxide...	1·42		
Lime	·74		
Magnesia	·57		
Sulphuric oxide	·11		
Phosphoric "	·64		
Alumina	16·02	Insoluble in acid 76·23	
Silica	60·21		
Undetermined and loss ...	·05		
	100·00		

The ashes of these coals show a notable increase in the percentage of silica, as compared with those of the other fields, and they differ also in presenting a much lower ratio of soluble to insoluble alumina. The ratios, taking the insoluble as 1, as before, are—

Vale of Clwydd	1	:	1·5
Eskbank	1	:	1·4
Lithgow	1	:	1·2

The phosphoric oxide is intermediate in quantity between the Hunter River and Southern districts, but, if we regard the additional quantity of insoluble ash as introduced from extraneous sources, it would more nearly approach the former.

There still remains to be referred to, the torbanite or kerosene mineral, of which New South Wales possesses deposits of incomparable excellence, at Joadja Creek, near Berrima, Hartley, and elsewhere. These minerals yield between 70 and 80 per cent. of volatile hydrocarbons, and are successfully used both for the production of gas, of which the yield is from eighteen to twenty thousand cubic feet, having an illuminating power of about forty candles, and for the production of illuminating oils and paraffine. The seam at Joadja Creek is covered by a thin stratum (9 or 10 inches) of bituminous caking coal, whilst underneath there is a similar layer of coal of inferior quality, the true floor and roof being sandstone rock. The following are analyses of the ash of each division of the seam.

Top Coal.

Percentage of ash, 6·71. The ash was slightly pink-coloured and very voluminous, indeed it occupies about once and a half or twice the space of any of the other ashes examined, and nearly the bulk of the original coal.

Analysis—

Alkalies and chlorine ...	4·05	Soluble in water.
Alumina	11·23	Soluble in acid 24·43
Ferric oxide	11·55	
Lime	·20	
Magnesia	·63	
Phosphoric oxide	·92	
Alumina	22·15	Insoluble in acid 71·01
Ferric oxide	traces.	
Silica	48·86	
Undetermined and loss ...	·41	
	100·00	

Torbanite.

Percentage of ash, 10·27; specific gravity, 1,098; colour of ash, greyish white.

Analysis—

Alumina	14·74	Soluble in acid 16·90
Ferric oxide...	·76	
Lime	·30	
Magnesia	·45	
Phosphoric acid	·65	
Alumina	5·40	Insoluble in acid 82·51
Ferric oxide...	traces.	
Silica	77·12	
Undetermined and loss ...	·58	
	100·00	

Bottom Coal.

Percentage of ash, 22·88 ; ash very dense, grey coloured.

Analysis—

Alkalies	0·85	Soluble in water.
Alumina	20·04	Soluble in acid 22·95
Ferric oxide...	1·84	
Lime	·28	
Magnesia	·36	
Phosphoric oxide	·44	
Alumina	7·79	Insoluble in acid 76·42
Ferric oxide...	traces.	
Silica	68·63	
	100·23	

The ratios of the insoluble to soluble alumina in these ashes are :—

Top coal	1	:	0·5
Torbanite	1	:	2·7
Bottom coal	1	:	2·5

The ash of the upper coal presents in this respect a great difference from all the others examined, whilst the other two are very similar. On digesting another portion of the ash of each of these coals with hydrochloric acid for four hours, the top coal gave 6·30 per cent. more of soluble alumina, whilst the bottom coal gave almost exactly the same result as before. The ratio with this increased solubility would, however, only be 1 : 1, which still shows a marked difference from all the other coals.

The similarity in composition of the ashes of the torbanite to those of the various coals, including the presence of a notable quantity of phosphoric oxide, does not appear to agree with Mr. Skey's conclusion that this mineral is formed by the absorption of bitumen by clay.[1] He found that clay absorbed bituminous matter from petroleum (the quantity is not stated), and became black, and as no such absorption took place with finely divided silica, concludes that the reaction is due to the alumina. In this sample of torbanite the ash only amounts to 10 per cent., of which 7 per cent. is silica, and we can scarcely think that the 2 per cent. of alumina would suffice for the condensation of so many times its own weight of bitumen. It seems probable, rather, that this mineral has been formed like coal from plants either of a different kind or under peculiar conditions. That the conditions of deposition have something to do with it is borne out by the observation of Mr. Fell, who has had much to do with the working of the

[1] Chem. News, xxxi, 16.

mineral in this country, and who informs me that as the "cover" increases the mineral becomes denser and passes into a slaty coal, which does not yield either the same quantity or quality of liquid hydrocarbons on distillation.

It is curious to note what a large percentage of ferric oxide is required to communicate a decided colour to the ashes, and it appears impossible to judge by appearance of the quantity actually present. Thus, some of the Newcastle coals with 9 per cent. or a little over are decidedly red, whilst the upper Joadja Creek coal containing 11 per cent. had only a faint pink colour. Dr. Fr. Muck[1] observes that if coal ashes contain much lime that there may be a large quantity of ferric oxide present without communicating its colour, and ascribes this to its being in the form of calcium ferric silicate. In the ashes of our coals there is very little lime, and yet the iron does not communicate nearly the same colour that it does in other instances, as, for example, in brick-dust, which is of a very decided red if it contains 10 per cent. of ferric oxide.

[1] Determination of ash in coal, and incineration in general. Zeitschrift f. Anal. Chem. xix, p.131. Chem. News, xlii, p. 41.

Upon the Composition of some New South Wales Coals.

By A. LIVERSIDGE, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 8 December, 1880.*]

THE following paper contains the results of an examination into the chemical composition of some samples of certain New South Wales coals, "kerosene shale," and of one or two carbonaceous minerals which, although they cannot properly be classed with the coals, yet can conveniently be included in such a paper as this.

I may mention that most of the samples of the coals were collected by the officers of the Mining Department and were reported upon by me to that Department in 1875.[1] The proportions of moisture, volatile matter, fixed carbon, ash, coke, and sulphur only were then determined, as information upon these points is quite sufficient for all ordinary purposes. Shortly afterwards, as I had the remains of the specimens, I thought it would be desirable to determine the ultimate composition, and to ascertain the chemical composition of the ashes of these coals.

I particularly wished to see how the New South Wales coals compared with those of Europe, and especially with English coals, and to do so ultimate analyses had to be made, *i.e.*, the amount of carbon, hydrogen, nitrogen, etc., had to be determined; this of course necessitated the expenditure of considerable time and trouble, but it enabled me to ascertain how the calorific intensity of the fuels, calculated from the percentage amounts of carbon and hydrogen, correspond with their evaporative powers as determined experimentally by means of Thompson's calorimeter.

The ashes were analysed mainly because it was thought that a knowledge of their chemical composition would be of service to the metallurgist as well as of some general scientific interest; it is of course of great importance to many metallurgists to know the composition of the ashes of the coal which he uses, since some of the constituents may have a bad effect upon the products of his furnaces, and in some cases even render the metal useless for certain purposes.

Methods of Analysis.—I may perhaps mention the methods of analysis followed, since it is sometimes of interest to any one going

[1] Annual Report of the Mining Department, 1875, p. 127.

over similar ground to know what processes were employed; and when it is wished to compare results it is often a great advantage to be able to use the same methods The proximate analyses were made according to the well known process described in Crooke's "Select Methods in Chemical Analysis," p. 368, in each case upon about 2 grammes of the freshly powdered coal.

The sulphur was estimated by heating about 2 grammes of the coals with chlorate of potash and strong nitric acid, and then adding strong hydrochloric acid; the solution being largely diluted, filtered, and precipitated in the ordinary way.

The specific gravity was determined upon the coal in the form of a coarse powder; the powder was allowed to soak in the specific gravity bottle, placed in a warm place, until air-bubbles ceased to be evolved, when cool the second weighing was proceeded with.

All the determinations were made in duplicate.

The carbon and hydrogen were determined by combustion with lead chromate in a current of oxygen; it was found that when cupric oxide and a current of oxygen were employed that the carbon was liable to be understated. The nitrogen was determined in the ordinary way by the soda-lime process.

Calculated calorific intensity and evaporative power.—The theoretical evaporative power was determined experimentally by means of Thompson's calorimeter, for a description of which see Dr. Percy's Metallurgy, vol. i., p. 541. The results given are the means of several experiments. The calorific intensity was calculated according to the formula given by the same author, p. 537.

On examining the two sets of results, *i.e.*, the calculated calorific intensity and the calculated evaporative power as determined by the calorimeter, it will be at once apparent that they do not in all cases place the coals in the same order—there is no doubt that other things besides the absolute quantities of carbon, hydrogen, oxygen and ash, influence the production of heat and help to determine the value of a coal—we as yet really know very little as to how the combustible elements are combined in coals, or whether there are differences in the mode of such combination in different coals—it is most probable that there are—but we do know that there are considerable variations in the mechanical structure of coals, which must necessarily influence the rate of combustion and the amount of heat generated.

It is a well-known fact that many commanders of steam vessels belonging to the Royal Navy, the great Mail Companies, and to the Intercolonial lines prefer southern to northern coal, although the former contains more ash, the disadvantage of the greater proportion of ash is considered to be counterbalanced by the fact that the southern coal burns uniformly and does not form a clinker; but when it is desired to get up steam rapidly, then the rich northern coal is preferred.

In the report[1] to the Mining Department upon the theoretical evaporative power of certain coals, I pointed out that "these results represent the theoretical, calorific, or evaporative power of the samples, *i.e.*, the weight of water which would be converted into steam by the complete combustion of one pound of each of the various coals respectively."

"It must, however, be clearly understood that the actual heat-producing or evaporative power of a coal obtained in practice, depends very greatly upon the size, construction, and form of both furnace and boiler, as well as upon the method of firing or burning, and upon many other equally obvious circumstances; it will, therefore, be apparent that the results can only be *rigidly* compared when the conditions under which the fuels are burnt are alike, as was the case in the experimental trials."

Analysis of the Ash.—The ash was prepared for analysis by incinerating the powdered coal in a muffle furnace at a dull red heat; in order to obtain the ash as expeditiously as possible from a fairly large quantity of coal, a tray 10 x 6 x 1 inch deep, made out of stout platinum foil, was used for the incineration.

The ash was rendered soluble by direct fusion with the mixed alkaline carbonates, and proceeded with in the usual manner for silica, alumina, iron, lime, &c.; the alkalies were determined in separate portions by Dr. J. Lawrence Smith's process, *i.e.*, by fusion with calcium carbonate and ammonium chloride.

The phosphoric and sulphuric acids were also determined in separate portions of the ash; as the proportion of phosphoric acid, where present, was shown by the qualitative tests to be small, the molybdic acid process was employed, about two grammes weight of ash being taken in duplicate in each case.

NORTHERN DISTRICT.

Waratah Colliery.

A good firm, bright coal, with well-marked lines of lamination, bright layers preponderate. Fracture fairly even, breaking into cuboidal masses. Layers of fibrous "mineral charcoal" or "mother-of-coal" in between the bright layers; these are also to be observed in nearly all the other coals.

Specific gravity, 1·303.

Proximate Analysis.

Moisture	2·21	
Volatile hydrocarbons	36·70	
Fixed carbon	55·82	Coke, 59·97 per cent.
Ash	4·15	
Sulphur	1·12	
	100·00	

[1] Report of the Mining Department, Sydney, 1877, p. 207.

Coke.—Good, firm, bright and silvery lustre, well swollen up, with small cauliflower-like excrescenses.

Ash.—Loose and flocculent, reddish colour.

Ultimate Analysis.

Carbon	81·06	Dried at 100° C.
Hydrogen	5·81	
Oxygen	6·52	
Sulphur...	1·14	
Nitrogen	1·23	
Ash	4·24	
	100·00	

The calorific intensity calculated from the above is 8,271 units. According to experiments with the calorimeter 1 lb. of this coal would convert 14·3 lbs. of water into steam.

Analysis of Ash.

Silica	47·30
Alumina	35·58
Iron sesquioxide	9·67
Manganese	absent
Lime	4·95
Magnesia	·30
Potash	1·92
Soda	·05
Phosphoric acid	trace
Sulphuric acid	1·20
	100·97

Nodular Coal.—A smooth, rounded, nodule of anthracitic coal from the Waratah mine; about 2 inches in diameter, harder than the ordinary coal, in which I understand it was found embedded—the rounded form is apparently not due to attrition or the action of running water; but appears to be of a concretionary nature.

On being struck with a hammer the mass flew to pieces, as if it had been in a state of strain or tension; the fragments were small and showed conchoidal fracture surfaces. I believe that these nodules are sometimes met with of much larger size.

Specific gravity, 1·294.

Proximate Analysis.

Loss at 100° C.	3·32
Volatile hydrocarbons	32·41
Fixed carbon	62·35
Ash	1·72
Sulphur	·19
	99·99

Ultimate Analysis.

Carbon	83·828	Dried at 100° C.
Hydrogen	5·437	
Oxygen	8·236	
Sulphur	·190	
Nitrogen	·530	
Ash	1·779	
	100·000	

It will be noticed that the amount of ash is much less than in the ordinary coal from this mine.

CARDIFF MINE, LAKE MACQUARIE.

A bright, firm, and compact looking anthracitic coal; when struck emits a clear ringing sound, very unlike the dull sound given out by soft and friable varieties of coal.

Across the joints and planes of stratification it breaks with a somewhat splintery and conchoidal fracture.

Tough, and does not yield readily to pressure.

Does not soil the fingers; no mother-of-coal or mineral charcoal observed. When ignited, decrepitates somewhat, and burns with but a small amount of flame.

A few scattered grains of pyrites were observed in the sample, but the total amount of sulphur present, as shown by the following statement of percentage composition, is below the average:—

*Proximate Analysis.**

Hygroscopic moisture	1·853
Volatile matter	43·354
Sulphur	·348
Fixed carbon	49·486
Ash	4·944
	99·985

Coke.—54·430 per cent., bright in lustre, and fairly well swollen up.

Ash.—Grey, loose; contains traces of copper.

Ultimate Analysis.

	Inclusive of moisture.	Exclusive of moisture.
Carbon	80·727	82·251
Hydrogen	4·303	4·384
Oxygen	6·816	6·945
Nitrogen	1·009	1·028
Sulphur	·348	0·354
Ash	4·944	5·038
Hygroscopic moisture ...	1·853	....
	100·000	100·000

Specific gravity, 1·286.

* Report to the Department of Mines, A. Liversidge, 1876, p. 184.

The calorific intensity calculated from the above results is 7,857 units.

Analysis of Ash.

Silica	38·360
Copper	trace
Alumina	35·575
Iron sesquioxide	9·278
Manganese protoxide	2·606
Lime	8·050
Magnesia	1·080
Potash	·593
Soda	2·259
Phosphoric acid	·240
Sulphuric ,, ...	2·255
	100·296

The presence of copper is rather an unusual occurrence in coal ashes; the copper probably existed as copper pyrites. An examination for gold was made upon this ash, but without success; the ash from some 30 or 40 lbs. weight of coal was tested.

Anvil Creek.

Structure laminated, but compact; not so much mother-of-coal present as in that from the Waratah Mine. Breaks into cuboidal masses. Does not readily soil the fingers.

Specific gravity, 1·323.

Proximate Analysis.

Moisture	1·74	
Volatile hydro-carbons ...	41·10	
Fixed carbon	47·90	} Coke 55·70 per cent.
Ash	7·80	}
Sulphur	1·46	
	100·00	

Coke.—Good, firm, bright silvery lustre, not much swollen up.

Ash.—White.

Dried at 100° C.

Ultimate Analysis.

Carbon	77·15
Hydrogen	5·91
Oxygen	6·07
Sulphur	1.48
Nitrogen	1·46
Ash	7·93
	100·00

Calculated calorific intensity, 8,009.

By experiment with the calorimeter 1 lb. of this coal would convert 12·65 lbs. of water into steam.

Analysis of Ash.

Silica	48·70	50·16
Alumina	38·84	40·50
Iron sesquioxide	2·71	2·00
Manganese	traces	traces
Lime	5·20	4·10
Magnesia	·70	·32
Potash	2·13	2·02
Soda	·43	·12
Phosphoric acid	trace	trace
Sulphuric acid (SO_3) ...	·85	·56
Loss	·44	·22
	100·00	100·00

The second analysis was made upon a specimen from a different part of the seam.

RUSSELL'S MINE.

Made up of alternate bright and dull laminæ, which merge one into the other irregularly, giving the coal a streaky appearance quite distinct from the laminated appearance of a coal made up ot well defined bright and dull layers. The bright layers have a very brilliant pitchy lustre. Fracture somewhat conchoidal. Does not soil the fingers.

Specific gravity, 1·274.

Proximate Analysis.

Moisture	1·85	
Volatile hydro-carbons...	44·09	
Fixed carbon	49·95	Coke, 52·65 per cent.
Ash	2·70	
Sulphur	1·41	
	100·00	

Coke.—Good, firm, bright silvery lustre, with cauliflower-like excrescenses.

Ash.—Loose, colour red, but paler than the Waratah coal ash.

Dried at 100° C.

Ultimate Analysis.

Carbon	77·37
Hydrogen	6·48
Oxygen	10·46
Sulphur	1·43
Nitrogen	1·51
Ash	2·75
	100·00

Calculated calorific intensity, 8,034.

By experiment with the calorimeter, 1 lb. of this coal would convert 13·21 lbs. of water into water.

Analysis of Ash.

Silica	44·30
Alumina	38·65
Iron sesquioxide	7·85
Manganese	absent
Lime	5·05
Magnesia	·49
Potash	1·37
Soda	·01
Phosphoric acid	absent
Sulphuric acid	1·84
Loss	·44
	100·00

GRETA.

In appearance very similar to the Waratah coal, but with less mother-of-coal. Does not soil the fingers; streaky appearance. Fracture conchoidal across the layers.

Specific gravity, 1·287.

Proximate Analysis.

Moisture	2·25	
Volatile hydro-carbons... ...	39·21	
Fixed Carbon	54·41	Coke 57·13 per cent.
Ash	2·72	
Sulphur	1·41	
	100·00	

Coke.—Good, firm, not quite so bright as the former, but rougher in in the grain and more swollen up.

Ash.—Loose, buff-coloured.

Dried at 100° C.

Ultimate Analysis.

Carbon	78·41
Hydrogen	6·60
Oxygen	9·34
Sulphur	1·44
Nitrogen	1·43
Ash	2·78
	100·00

Calculated calorific intensity, 8,208.

According to experiments with the calorimeter 1 lb. of this coal would convert 13·21 lbs. of water into steam.

Analysis of Ash.

Silicia	48·14
Alumina	39·99
Iron sesquioxide	4·40
Manganese	absent
Lime	5·95
Magnesia	traces
Potash	·82
Soda	·19
Phosphoric acid	trace
Sulphuric acid	·77
	100·26

Wallsend.

A bright coal; laminated structure well marked; breaks into irregular cuboidal fragments. Does not soil the fingers readily. Contains a little fibrous mineral charcoal, or mother of coal.

Specific gravity, 1·333.

Proximate Analysis.

Moisture	2·75	
Volatile hydro-carbons	34·17	
Fixed carbon	57·22	Coke 61·86 per cent.
Ash	4·64	
Sulphur	1·22	
	100·00	

Coke.—Much the same as from the Greta coal, but with large cauliflower-like excrescences.

Ash.—Of a pinkish shade, being white mixed with reddish particles.

Dried at 100° C.

Ultimate Analysis.

Carbon	79·96
Hydrogen	6·26
Oxygen	7·08
Sulphur	1·25
Nitrogen	·68
Ash	4·77
	100·00

Calculated calorific intensity, 8,323.

According to experiments with the calorimeter 1 lb. of this coal would convert 13·21 lbs. of water into steam.

Analysis of Ash.

Silica...	39·30
Alumina	25·24
Iron sesquioxide	26·02
Manganese	1·03
Lime	4·35
Magnesia	·30
Potash	traces
Soda...	,,
Phosphoric acid	·12
Sulphuric acid	4·51
	100·87

AGRICULTURAL COMPANY'S MINE, NEWCASTLE.

Very similar to the Waratah coal, but a shade less bright. Breaks into irregular cuboidal fragments. Does not soil the fingers. Contains films of mineral charcoal

Specific gravity, 1·297.

Proximate Analysis.

Moisture	2·20	
Volatile hydrocarbons	33·60	
Fixed carbon	57·52	} Coke 62·87 per cent.
Ash	5·35	}
Sulphur	1·33	
	100·00	

Coke.—A good firm coke; very large cauliflower-like excrescenses.

Ash.—Heavy, white.

Dried at 100° C.

Ultimate Analysis.

Carbon	78·76
Hydrogen	6·34
Oxygen	7·28
Sulphur	1·36
Nitrogen	·79
Ash...	5·47
	100·00

Calculated calorific intensity, 8,235.

By experiments with the calorimeter 1 lb. of this coal would convert 12·92 lbs. of water into steam.

Analysis of Ash.

Silica	50·05
Alumina	34·90
Iron sesquioxide	13·81
Manganese...	traces
Lime	·56
Magnesia	·00
Potash	·19
Soda...	·02
Phosphoric acid	absent
Sulphuric acid	1·06
	100·59

WESTERN DISTRICT.

Bowenfells.

Dull lustre, rather strongly laminated; laminæ of bright coal very thin. Does not soil the fingers. Fracture is in parts large conchoidal.

Specific gravity, 1·399.

Proximate Analysis.

Moisture...	2·36
Volatile hydro-carbons	28·35
Fixed carbon	56·54
Ash	11·40
Sulphur	1·35
	100·00

Coke.—Does not cake; only a loose and incoherent black powder left.

Ash.—Heavy, white.

Dried at 100° C.

Ultimate Analysis.

Carbon	70·72
Hydrogen	5·65
Oxygen	9·65
Sulphur	1·38
Nitrogen	·93
Ash	11·67
	100·00

Calculated calorific intensity 7,245.

According to experiments with the calorimeter 1 lb. of this coal would convert 12·65 lbs. of water into steam.

Analysis of Ash.

Silica	69·15
Alumina	29·69
Iron sesquioxide	·63
Manganese	traces
Lime...	·25
Magnesia	trace
Potash	·36
Soda...	·32
Phosphoric acid (P_2O_5)	·09
Sulphuric acid (SO_3)	·22
	100·71

Eskbank.

A good compact coal; soils the fingers; lustre dull; laminæ not well defined,

Specific gravity 1·335.

Proximate Analysis.

Moisture	2·00	
Volatile hydro-carbons	33·55	
Fixed carbon	49·97	Coke, 62·88 per cent.
Ash	12·91	
Sulphur	1·57	
	100·00	

Coke.—Fair, but rather tender.
Ash.—Brilliant white colour.
Dried at 100° C.

Ultimate Analysis.

Carbon	72·30
Hydrogen	5·43
Oxygen	6·65
Sulphur	1·60
Nitrogen	·85
Ash	13·17
	100·00

Calculated calorific intensity, 7,426.

By experiment with the calorimeter 1 lb. of this coal would convert 12·65 lbs. of water into steam.

Analysis of Ash.

Silica	62·15
Alumina	29·43
Iron sesquioxide	1·20
Manganese	traces
Lime	1·35
Magnesia	1·73
Potash	2·10
Soda	·19
Phosphoric acid	·05
Sulphuric ,, ...	1·12
Loss	·68
	100·00

Vale of Clwydd.

A compact coal; rather bright on the whole, the bright layers being fairly numerous; fracture irregular; a fresh surface does not soil the fingers.

Specific gravity, 1·323.

Proximate Analysis.

Moisture	2·10	
Volatile hydro-carbons ...	33·35	
Fixed carbon	53·38	Coke, 63·18 per cent.
Ash	9·80	
Sulphur...	1·37	
	100·00	

Coke.—Hard, compact, and fairly lustrous.

Ash.—Of a very feeble grey tint.

Dried at 100° C.

Ultimate Analysis.

Carbon	69·86
Hydrogen	5·82
Oxygen	11·89
Sulphur	1·40
Nitrogen	1·02
Ash	10·01
	100·00

Calculated calorific intensity, 7,138.

According to experiments with the calorimeter, 1 lb of this coal would convert 12·10 lbs. of water into steam.

Analysis of Ash.

Silica	59·55
Alumina	37·35
Iron sesquioxide	2·00
Manganese	traces
Lime	·53
Magnesia	traces
Potash	,,
Soda	,,
Phosphoric acid	,,
Sulphuric ,, (SO_3)	·39
Loss	·18
	100·00

Lithgow Valley.

Has much the appearance of the Vale of Clwydd coal. Does not soil the fingers.

Specific gravity, 1·329.

Proximate Analysis.

Moisture	1·95	
Volatile hydro-carbons ...	34·18	
Fixed carbon	52·34	Coke, 62·46 per cent.
Ash	10·12	
Sulphur	1·41	
	100·00	

Coke.—Hard, compact, and fairly lustrous—about the same as the last.

Ash.—White in colour.

Dried at 100° C.

Ultimate Analysis

Carbon	69·41
Hydrogen	6·10
Oxygen	11·70
Sulphur	1·44
Nitrogen	1·03
Ash	10·32
	100·00

Calculated calorific intensity, 7,206.

According to experiments with the calorimeter, 1 lb of this coal would convert 12·10 lbs. of water into steam.

Analysis of Ash.

Silica	59·10
Alumina	38·95
Iron sesquioxide	·40
Manganese	traces
Lime	·85
Magnesia	·30
Potash	traces
Soda	,,
Phosphoric acid (P_2O_5)	·20
Sulphuric acid (SO_3)	·43
	100·23

SOUTHERN DISTRICT.

Mount Kembla.

A coal of medium brightness, with laminated structure, breaking with a granular surface in places; splits readily along the planes of lamination. The bright layers are tender, and break into small pieces with conchoidal surfaces.

Specific gravity 1·363.

Proximate Analysis.

Moisture	1·50
Volatile hydrocarbons	19·74
Fixed carbon	67·18
Ash	10·72
Sulphur	·86
	100·00

Coke.—Coal does not cake, therefore no true coke formed—a dull black fritted mass only is left.

Ash.—Brilliant white colour.

Dried at 100° C.

Ultimate Analysis.

Carbon	80·67
Hydrogen...	5·30
Oxygen	1·58
Sulphur	·87
Nitrogen	·70
Ash	10·88
	100·00

Calculated calorific intensity, 8,276.

According to experiments with the calorimeter, 1 lb. of this coal would convert 13·21 lbs. of water into steam.

Analysis of Ash.

Silica	52·57
Alumina	43·55
Iron sesquioxide	·95
Manganese	traces
Lime	1·35
Magnesia	·60
Potash	·15
Soda	·27
Phosphoric acid (P_2O_5)	·17
Sulphuric acid (SO_3)	·79
	100·40

Mount Keira Coal

Possesses much the same characters as the last, only soils the fingers rather more readily.

Specific gravity, 1·379.

Proximate Analysis.

Moisture	1·15	
Volatile hydro-carbons ...	23·51	
Fixed carbon	64·65	Coke, 74·35 per cent.
Ash	9·70	
Sulphur	·99	
	100·00	

Coke.—Hard, fairly lustrous, and much swollen up, with cauliflower-like excrescences.

Q

Ash.—Loose, brilliant white colour.

Dried at 100° C.

Ultimate Analysis.

Carbon	78·82
Hydrogen	5·17
Oxygen	3·87
Sulphur	1·00
Nitrogen	1·33
Ash	9·81
	100·00

Calculated calorific intensity, 7,983.

According to experiments with the calorimeter, 1 lb. of this coal would convert 12·92 lbs. of water into steam.

Analysis of Ash.

Silica	53·00
Alumina	46·88
Iron sesquioxide	traces
Manganese	absent
Lime	traces
Magnesia	,,
Potash, Soda	·10
Phosphoric acid	absent
Sulphuric ,, ...	,,
Loss	·02
	100·00

This ash practically answers to the formula Al_2O_3, 2 SiO_2.

BERRIMA.

A good firm coal, but more tender than the others. The bright ayers present in fair proportion.

Specific gravity, 1·364.

Proximate Analysis.

Moisture	1·70	
Volatile hydro-carbons ...	32·78	
Fixed carbon	53·84	Coke, 64·24 per cen
Ash	10·40	
Sulphur	1·28	
	100·00	

Coke.—Bright and lustrous ; very much swollen up.

Ash.—White.

Dried at 100° C.

Ultimate Analysis.

Carbon	69·92
Hydrogen	4·55
Oxygen	13·09
Sulphur	1·30
Nitrogen	·56
Ash	10·58
	100·00

Calculated calorific intensity, 6,653.

According to experiments with the calorimeter, 1 lb. of this coal would convert 11·82 lbs. of water into steam.

Analysis of Ash.

Silica	67·45
Alumina	31·00
Iron sesquioxide	·40
Manganese protoxide	·16
Lime	·15
Potash	·24
Soda	·18
Phosphoric acid	trace
Sulphuric ,, (SO_3)	·06
Loss	·36
	100·00

Nattai.

A hard, compact, lustrous anthracitic coal, slightly stained in parts with iron oxide, which looks as if it had been derived from the decomposition of iron pyrites; but, contrary to what was expected, hardly a trace of sulphur was found to be present. Any pyrites which the coal may have originally contained must have practically undergone complete decomposition and removal.

Anthracitic coals generally occur in places where the coal measures have been more or less disturbed or changed, *i.e.*, in places where there is considerable contortion of the strata, and also where there are intrusive metamorphic or igneous rocks. Probably this particular specimen came from a portion of a seam which had been affected by one of the intrusions occurring in the district.

Proximate Analysis.

Loss at 100° C.	3·287	
Volatile hydro-carbons	4·337	
Fixed carbon	87·959	Coke, 92·375
Ash	4·416	
Sulphur	trace	
	99·999	

Ultimate Analysis.

Carbon	91·246
Hydrogen	3·605
Oxygen and nitrogen	0·583
Sulphur	trace
Ash	4·566
	100·000

Calculated calorific intensity, 8,590.

The ash of this coal was not analysed.

Bulli.

The following analysis was made by Mr. Richard Smith, of the Metallurgical Laboratory in the Royal School of Mines, London; it has been recalculated to correspond with the others.

Specific gravity, 1·471.

Proximate Analysis.

Water	1·03
Volatile hydro-carbons, &c.	23·65
Fixed carbon	61·61
Ash	13·17
Sulphur	·54
	100·00

The theoretical calorific or evaporative power, that is, the weight of water converted into steam by 1 lb. of the coal, as determined by experiment with the calorimeter is 12·21 lbs. A second experiment gave a like result.

Ultimate Analysis.

Carbon	75·57
Hydrogen	4·70
Oxygen and nitrogen	4·99
Sulphur	0·54
Ash	13·17
Water	1·03
	100·00

The colour of the ash is reddish white.

When the portion of the powdered coal is heated in a closed vessel, the gases evolved burn with a yellow luminous, somewhat smoky flame, and a slightly lustrous coherent coke is left, which differs little in bulk from the original coal.

I have inserted the following analysis here for convenience, since it is too short a matter to publish separately.

Allora, Queensland.

A specimen of coal from near to Allora, a small township on the Dalrymple Creek, about 14 miles from Warwick.

Specific gravity, 1·284.

Proximate Analysis.

Loss at 100° C.	5·75
Volatile hydro-carbons	44·98
Fixed carbon	40·59
Ash	8·02
Sulphur	·66
	100·00

The coal is bright, with almost a jet-like lustre; in parts very firm and compact; free from earthy layers; does not soil the fingers; breaks with a well marked conchoidal fracture.

The following tables Nos. 1, 2, and 3 are reproduced from my report to the Government, and the remarks upon them are practically the same as those which appeared in that report, but with such alterations as are rendered necessary by the additional information yielded by the examination of further specimens.

TABLE I.

Northern District Coals.

Proximate Constituents.

Name of Colliery.	Moisture.	Volatile hydro-carbons.	Fixed carbon.	Ash.	Sulphur.	Sp. gr.	Coke.
Russell's	1·85	44·09	49·95	2·70	1·41	1·274	52·65
Greta	2·25	39·21	54·41	2·72	1·41	1·287	57·13
Waratah	2·21	36·70	55·82	4·15	1·12	1·303	59·97
Wallsend	2·75	34·17	57·22	4·64	1·22	1·333	61·86
Cardiff Mine	1·85	43·35	49·49	4·94	·34	1·286	54·43
A. A. Coy's Mine, Newcastle.	2·20	33·60	57·52	5·35	1·33	1·297	62·87
Anvil Creek	1·74	41·10	47·90	7·80	1·46	1·323	55·70

The coals in the above table are arranged in order, according to the amount of ash present, the first of the series containing the smallest, and the last the largest weight of ash. With the exception of the specimens from Anvil Creek and the Cardiff Mine it is rather interesting to note that the proportion of fixed carbon increases with the increase in the amount of ash—the proportions of volatile hydro-carbons naturally undergo a corresponding diminution.

Speaking generally, the coals which yield a large percentage of volatile hydro-carbons may be said to be the best adapted for the manufacture of gas.

It will also be at once apparent that the specific gravity in most cases affords a very good indication of the quality of the coal. As a general rule, ordinary coals which possess a high specific gravity contain a large proportion of ash.

TABLE II.

Western District Coals.

Proximate Constituents.

Name of Colliery.	Loss at 100° C.	Volatile hydro-carbons.	Fixed Carbon.	Ash.	Sulphur	Sp. gr.	Coke.
Wallerawang	1·95	27·25	61·86	8·94	....	1·398	70·10
Do.	1·51	33·24	55·74	9·50	....	1·333	65·24
Vale of Clwydd	2·10	33·35	53·38	9·80	1·37	1.323	63·18
Lithgow Valley	1·95	34·18	52·34	10·12	1·41	1·329	62·46
Bowenfells	2·36	28·35	56·54	11·40	1·35	1·399	None
Eskbank	2·00	33·55	49·97	12·91	1·57	1·335	62·88

It is noticeable that the quantity of ash yielded by these western coals is much greater than is yielded by the northern ones, also that the specific gravity is higher as a rule.

The ash in all the specimens examined is white and dense, whereas many of the northern coals yield ashes of a buff or red tint, which are often quite loose and flocculent.

It is a common opinion that the relative amounts of sulphur present in different coals can be approximately estimated by the redness of the ash—on the supposition that the whole of the sulphur exists in the coal in the form of iron pyrites—but such is not the case; on referring to the analyses on the Northern District coals, it will be seen that some of the coals which left pure white coloured ashes contained the largest amount of sulphur, and that others which left red ashes contained the smallest quantity of sulphur.

Sulphur may be present in coals in various forms—either in combination with iron as pyrites, which is the most common form of all—as sulphuric acid in combination with the inorganic constituents of the coal, such as alumina, lime, magnesia, or potash; or it may even exist in the form of organic compounds.

TABLE III.

SOUTHERN DISTRICT COALS.

Proximate Constituents.

Name of Colliery.	Loss at 100° C.	Volatile hydro-carbon.	Fixed Carbon.	Ash.	Sulphur	Sp. gr.	Coke.
Nattai	3·28	4·34	87·96	4·41	trace	..	92·37
Mount Keira	1·15	23·51	64·65	9·70	·90	1·379	74·35
Berrima	1·70	32·78	53·84	10·40	1·28	1·364	64·24
Mount Kembla	1·50	19·74	67·18	10·72	·86	1·363	none
Bulli (*R. Smith*)	1·03	23·65	61·61	13·17	·54	1·471	74·78

In order that an opinion may be formed with regard to the coals of New South Wales, it will perhaps not be amiss to compare them with some of those produced in various parts of Great Britain.

In the first place, the proportion of ash in a coal is a matter of the greatest importance; the value of coal as a fuel depends to a great extent upon the smallness of the quantity of non-combustible matter which it contains; if the amount be very large the coal will be perfectly worthless; but for some purposes, as Dr. Percy states, —"A certain amount of inorganic matter in coal is sometimes beneficial in preventing its too rapid combustion in the furnace. On this account a kind of coal called 'brasils,' which occurs in the middle of the Tenyard coal in South Staffordshire, is preferred for reverberatory furnaces by some smelters in Birmingham."[1] Neither must the quality or chemical composition of the ash be neglected, for if the ashes be easily fusible, as they usually are when a large quantity of iron is present, they tend to "clinker up" the grate and thus cause great waste of heat, and the expenditure of much extra time and labour in stoking.

We have seen that the Northern District coals yield on the average the smallest amount of ash, which is from 2·70 per cent. to 7·80, with an average percentage of 4·61; the Western District coals range from 8·94 to 12·91 and average 10·44 per cent.; and the Southern District coals, omitting the sample from Nattai, which seems to be somewhat exceptional in character, yield from 9·70 to 13·17 per cent., and average 10·99 per cent. ash—thus:—

Percentage of Ash.

	Minimum.	Mean.	Maximum.
Northern Coal-fields of seven samples	2·70	4·61	7·80
Western Coal-fields of six samples	8·94	10.44	12·91
Southern Coal-fields of five samples	9·70	10·99	13·17

[1] Percy's Metallurgy, vol. i., p. 280.

Now English Newcastle (Northumberland) coking coal contains from 0·79 to 2·49 per cent. ash (see Percy's Metallurgy, vol. i., p. 99), and averages 1·68. The Nottinghamshire contains 3·9 per cent., and coal from Blaina, South Wales, averages 2·63 per cent. English non-coking coals run rather higher; thus South Staffordshire coal varies from 1·55 to 6·44, and South Wales from 1·20 to 7·18; Scotch coals from 1·43 to 6·75; so that as far as the proportion of ash is concerned, some of our Northern coal is quite equal to the Welsh and Scotch coals, and but little inferior to the English Newcastle coal.

A matter to which it is necessary to pay careful attention is the proportion of sulphur present in a coal. The presence of a large amount of this element not only renders the use of the coal unpleasant for domestic purposes, but makes it useless for most manufacturing and metallurgical operations.

The quantity of sulphur existing in the New South Wales coals is by no means excessive, and they will in this respect compare not unfavourably with those of other countries.

Percentage of Sulphur.

	Minimum.	Mean.	Maximum.
Northern Coal-fields	·34	1·18	1·46
Western " "	1·35	1·42	1·57
Southern " "	·54	·91	1·23
Newcastle coal (England)[1] ..	·55	·97	1·51

Playfair and De la Beche found during their investigation for the English Government, that the mean percentage of sulphur was as follows :—

Welsh coal	1·42 per cent. sulphur
Derbyshire	1·01 " " "
Lancashire	1·42 " " "
Newcastle	0·94 " " "
Scotland	1·45 " " "

Most of the secondary and tertiary coals, on the other hand, contain a larger proportion of sulphur, usually two or three and sometimes as much as even 5·0 or 6·0 per cent.

Composition of the Ashes.—In the table showing the percentage composition of the ashes it will be noticeable there are great differences in the amounts of silica, alumina, and of iron sesquioxide. Some of the ashes, however, in the different groups seem to agree fairly well together, and although the samples came from different districts, yet it may be that they are from an extension of the

([1] *Vide* Percy's "Metallurgy," vol. I.)

same seam. The composition of the ashes as well as of the coals may help us to correlate the coal seams of the different districts one with the other, *i.e.*, assist in determining their positions in a geological section of the whole of the coal measures as developed in different parts of the Colony. Judging from the composition of the ashes, one would be inclined to say, that not only do certain of the coals in each district come from the same seam, but that the western coals from Vale of Clwydd and Lithgow Valley belong to the same horizon as the southern coal from Berrima; but much importance cannot be attached to this matter, certainly it would never do to allow the analysis of one specimen only from a given seam, to have much influence, for although a sample of coal may appear to be free from foreign substances and to look perfectly uniform to the eye—in fact appear to be homogenous throughout—yet on analysis it is nearly always found that the different parts of one and the same piece yield different proportions of ash, carbon, hydrogen, &c. Hence, if different portions of the same lump vary we may naturally expect that samples taken from different parts of the seam should also vary. But in spite of minor variations in different specimens of coal from any given seam we find that on the average the coal will have a fairly uniform composition; to obtain uniform and truly representative samples portions should be taken of the whole thickness of the seam from different parts of the working face. It would be well to take some tons weight of the coal, which should be broken up into pieces of moderate size and well mixed. From this heap portions should then be removed, in radial lines cutting down to the centre, and thrown into a smaller heap of a few hundred-weights; after this smaller heap has been well mixed portions should be again removed radially and a third time well mixed; this last could then doubtless be regarded as a true sample and not a mere specimen, as a single lump of coal must necessarily be. Too much care cannot possibly be taken over the collection and preparation of samples.

TABLE IV.

I. Northern District Coals.

Locality.	Specific Gravity.	Composition per cent. exclusive of water only.						Water, per cent.	Coke, per cent.	Calorific intensity (calculated).	Water converted into steam by 1 lb coal with calorimeter.
		Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.				
Wallsend	1·333	79·96	6·26	7·08	0·68	1·25	4·77	2· 75	61·86	8323	13·21
Waratah	1·303	81·06	5·81	6·52	1·23	1·14	4·24	2· 21	59·97	8271	14·30
A. A. Co., Newcastle	1·297	78·76	6·34	7·28	0·79	1·36	5·47	2· 20	62·87	8235	12·92
Greta	1·287	78·41	6·60	9·34	1·43	1·44	2·78	2· 25	57·13	8208	13·21
Russell's Mine	1·274	77·37	6·48	10·46	1·51	1·43	2·75	1· 85	52·65	8034	13·21
Anvil Creek	1·323	77·15	5·91	6·07	1·46	1·48	7·93	1· 74	55·70	8009	12·65
Cardiff Mine	1·286	82·25	4·38	6·95	1·03	0·35	5·04	1·853	54·43	7857	—

II. Western District Coals.

Locality.	Specific Gravity.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Water, per cent.	Coke, per cent.	Calorific intensity (calculated).	Water converted into steam by 1 lb coal with calorimeter.
Eskbank	1·335	72·30	5·43	6·65	0·85	1·60	13·17	2·00	62·88	7426	12·65
Bowenfells	1·399	70·72	5·65	9·65	0·93	1·38	11·67	2·36	...	7245	12·65
Lithgow Valley	1·329	69·41	6·10	11·70	1·03	1·44	10·32	1·95	62·46	7206	12·10
Vale of Clwydd	1·323	69·86	5·82	11·89	1·02	1·40	10·01	2·10	63·18	7138	12·10

III. Southern District Coals.

Locality.	Specific Gravity.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Water, per cent.	Coke, per cent.	Calorific intensity (calculated).	Water converted into steam by 1 lb coal with calorimeter.
Nattai	...	91·246	3·605	0·583	...	Trace	4·566	3·287	92·375	8590	Undet.
Mount Kembla	1·363	80· 67	5· 30	1·58	0·70	0·87	10· 88	1· 50	...	8276	13·21
Mount Keira	1·379	78· 82	5· 17	3·87	1·33	1·00	9· 81	1· 15	74·35	7983	12·92
Berrima	1·364	69· 92	4· 55	13·09	0·56	1·30	10· 58	1· 70	64·24	6653	11·82
Bulli (*R. Smith*)	1·471	76· 35	4· 75	5·04	...	0·55	13· 31	1· 03	74·78	...	12·21

TABLE V.

Composition of Ash.

Locality.	Per Centage of Ash.	Silica.	Alumina.	Iron Sesqui-oxide.	Man-ganese (MnO.)	Lime.	Mag-nesia.	Potash.	Soda.	Phos-phoric Acid.	Sul-phuric Acid.
I.—*Northern District Coals.*											
Russell's Mine	2·70	44·30	38·65	7·85	......	5·05	0·49	1·37	0·01	......	1·84
Greta	2·72	48·14	39·99	4·40	......	5·95	trace	0·82	0·19	trace	0·77
Waratah	4·15	47·30	35·58	9·67	......	4·95	0·30	1·92	0·05	,,	1·20
Wallsend	4·64	39·30	25·24	26·02	1·03	4·35	0·30	trace	trace	·12	4·51
Cardiff Mine	4·94	38·36	35·57	9·27	2·60	8·05	1·08	0·59	2·25	0·24	2·25
A. A. Company's Mine	5·35	50·05	34·90	13·81	trace	0·56	......	0·19	0·02	......	1·06
Anvil Creek	7·80	48·70	38·84	2·71	,,	5·20	0·70	2·13	0·43	trace	0·85
Anvil Creek, 2nd specimen	......	50·16	40·50	2·00	,,	4·10	0·32	2·02	0·12	,,	0·56
II.—*Western District Coals.*											
Vale of Clwydd	9·80	59·55	37·35	2·00	trace	0·53	trace	absent	trace	trace	0·39
Lithgow Valley	10·12	59·10	38·95	0·40	,,	0·85	0·30	trace	,,	·20	0·43
Bowenfells	11·40	69·15	29·65	0·63	,,	0·25	trace	0·36	0·32	·09	0·22
Eskbank	12·91	62·15	29·43	1·20	,,	1·35	1·73	2·10	0·19	·05	1·12
Weatherboard	......	83·80	14·43	·40	,,	·35	·95	·32	·12	absent	·46
III.—*Southern District Coals.*											
Mount Keira	9·70	53·00	46·88	trace	absent	trace	trace	......	0·10	absent	absent
Mount Kembla	10·72	52·57	43·55	0·95	trace	1·35	0·60	0·15	0·27	·17	0·79
Berrima	10·40	67·45	31·00	0·40	0·16	0·15	......	0·24	0·18	trace	0·06
IV.—"*Kerosene Shale.*"											
Greta Mine	15·870	29·643	64·397	3·050	absent	1·438	·250	·748	·355	·744	......

Kerosene Shale.

The name "kerosene shale" is not at all appropriate. The mineral does not possess the properties of a shale, *i.e.*, it has not the characteristic lamellar or platy structure of a shale. Hand specimens are almost always devoid of all traces of stratification, but occasionally indications can be seen where the mineral is in the form of sufficiently large blocks, or when it is *in situ*, but even then the planes of stratification are mainly rendered visible by the presence of layers or films of earthy matter. Near the top and bottom of the deposits the stratification layers are, however, usually better marked—*i.e.*, where the shale merges into the roof and floor.

The so called "kerosene shale" does not differ very widely from cannel coal and torbanite. Like cannel coal, it usually appears to occur with ordinary coal in the form of lenticular deposits. Like cannel coal also, when of good quality it burns readily without melting, and emits a luminous smoky flame. When heated in a tube it neither decrepitates nor fuses, but a mixture of gaseous and liquid hydro-carbons distils over.

In colour it varies from a brown-black, at times with a greenish shade, to full black. The lustre varies from resinous to dull. The fracture is usually broad conchoidal, but the concavities are sometimes very deep in proportion to their breadth, and at times long flexible concave-convex strips can be detached. When struck it emits a dull wooden sound. The powder is light brown to grey; the streak shining. It usually weathers to a light grey colour, and the surfaces of the joints also are often coated with a white film.

It is easily cut into shavings. Thin sections under the microscope present a reticulated appearance. The network is black and opaque, enclosing brown and amber-coloured translucent particles.

Prof. Silliman has proposed the name of *Wollongongite* for the mineral; but this has not come into general use, neither is it an appropriate name, since the specimen sent to him was not from Wollongong, but from Hartley. All the Wollongong oil shales which I have seen are of quite a different character; they are true black carbonaceous shales with well marked lamination, and often contain fossil ferns, especially the fronds of the glossopteris. No chemical examination has yet been made of any of them.

Unless it be decided to give the mineral a new name, I would suggest that it would be better to call it cannel coal or torbanite rather than kerosene shale, since the oil which it yields is probably not kerosene, and the substance itself is not a shale, and moreover it is not very widely separated, either in physical properties or in chemical composition, from either torbanite or the cannel coals.

1. From Joadja Creek.

Black, with a brownish shade; breaks with a large and well-marked conchoidal fracture.

Specific gravity 1·103.

Proximate Analysis.

Loss at 100° C.	1·160
Volatile hydro-carbons	73·364
Fixed carbon	15·765
Ash	9·175
Sulphur	·536
	100·000

The ash is of a grey colour, with a slight reddish tinge.

2. A second specimen had a sp. gr. of 1·054.

Proximate Analysis.

Loss at 100° C.	·440
Volatile hydro-carbons	83·861
Fixed carbon	8·035
Ash	7·075
Sulphur	·589
	100·000

In this case the ash was practically white.

3. A third specimen from the same locality gave the following results :—

Specific gravity, 1·229.

Proximate Analysis.

Loss at 100° C.	·040
Volatile hydro-carbons	82·123
Fixed carbon	7·160
Ash	10·340
Sulphur	·337
	100·000

4. A specimen from Murrurundi, of a dark grey, almost black colour, but spotted with small specks of a white clay-like substance, gave the following results :—

Proximate Analysis.

Loss at 100° C.	1·165
Volatile hydro-carbons	71·882
Fixed carbon	6·467
Ash	19·936
Sulphur	·549
	99·999

Dried at 100° C.

Ultimate Analysis.

Carbon	66·788
Hydrogen	9·712
Oxygen and nitrogen	2·774
Sulphur	·555
Ash	20·171
	100·000

5. From the Greta Mine. This also contains small specks of white clay.

Specific gravity, 1·13.

Proximate Analysis.

Loss at 100° C.	1·475
Volatile hydro-carbons	53·798
Fixed carbon	27·946
Ash (grey)	15·870
Sulphur	·911
	100·000

Dried at 100° C.

Ultimate Analysis.

Carbon	65·610
Hydrogen	7·507
Oxygen and nitrogen	9·851
Sulphur	·924
Ash	16·108
	100·000

Analysis of Ash.

Silica	29·643
Alumina	64·397
Iron sesquioxide	3·050
Manganese	absent
Lime	1·438
Magnesia	·250
Potash	·748
Soda	·355
Phosphoric acid	·744
	100·625

6. Another sample from the Greta Mine gave the following results :—

Proximate Analysis.

Loss at 100° C.	·48
Volatile hydro-carbons	61·18
Fixed carbon	25·13
Ash	13·21
	100·00

7. From the central part of a section taken from the Hartley seam, where it is most free from mineral matter. Exhibited at the Agricultural Society's Show, 1873.

*Proximate Analysis**

Moisture and volatile hydro-carbons ...	82·24
Fixed carbon	4·97
Ash	12·79
	100·00

Specific gravity, 1·052.

Ultimate Analysis.

Dried at 100° C.

Carbon	69·484
Hydrogen...	11·370
Oxygen, nitrogen, and sulphur ...	6·356
Ash	12·790
	100·000

The following analyses of Torbanite, Cannel Coal, and Albertite were expressly made to see how they compare in composition with the New South Wales kerosene shale :—

TORBANITE.

Torbane Hill, Edinburgh.

8. Black brown colour, light brown streak, flat conchoidal fracture. Scattered over with minute glistening particles.

Specific gravity, .

Proximate Analysis.

Loss at 100° C	·720
Volatile hydro-carbons, &c.	69·695
Fixed carbon	9·045
Ash (white)	20·540
	100·000

Does not form a coke—a black powder only is left.

* See "Minerals of New South Wales" p. 37, by A. Liversidge.

CANNEL COAL.

Wigan, England.

9. Black, well marked conchoidal fracture, shining streak and black powder.

Specific gravity, 1·259.

Proximate Analysis.

Loss at 100°C.	1·464	
Volatile hydro-carbons, &c.	45 900	
Fixed carbon	45·519	52·636 coke
Ash	7·117	
	100·000	

A bright lustrous coke is left, somewhat cauliflower-like in form.

ALBERTITE.

New Brunswick.

10. Intensely black, highly lustrous with well marked conchoidal fracture.

Specific gravity, 1·105.

Proximate Analysis.

Volatile hydro-carbons, &c.	57·490
Fixed carbon	42·086
Ash	·424
	100·000

The ash is of a very pale brown colour.

The coke is highly lustrous, much swollen, hollow, like a bladder with smooth outward surface.

TABLE No. VI.

"KEROSENE SHALES" COMPARED WITH OTHER HYDRO-CARBONS.

No.	Locality.	Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur	Specific Gravity
2	Joadja Creek (No. 2)	0·44	83·861	8 035	7·075	0·589	1·054
3	Joadja Creek (No. 3)	0·04	82·123	7·160	10·340	0·337	1·229
7	Hartley Vale	....	82·24	4·97	12·79	....	1·052
1	Joadja Creek (No. 1)	1·16	73·364	15·765	9·175	0·536	1·103
—	Cannel Coal, Mold Flints (*Dr. Percy*)	....	72·08	21 91	6·01	....	...
4	Murrurundi	1·165	71·882	6·467	19·936	0·549	....
—	Torbanite, Torbane Hill (*H. How*)	....	71·17	7·65	21·18	....	1·170
—	Cannel Coal, Scotland (*Dr. Percy*)	....	69·77	10·45	19·78	....	....
8	Torbanite, Torbane Hill....	0·720	69·695	9 045	20·540	....	....
6	Greta Mine	·48	61·18	25 13	13·21	....	....
10	Albertite, from New Brunswick	....	57·490	42 086	0·424	....	1·10
5	Greta Mine	1·475	53·798	27·946	15·870	0·911	1·130
9	Cannel Coal, Wigan........	1·464	45·900	45 519	7·117	....	1·259

11. Hydro-carbon—Waratah Mine.

Amongst the specimens in the University collection is a piece of grey-coloured shale containing a curious more or less rectangular pipe-like perforation filled with a carbonaceous mineral.

There is no history to this specimen, but it is labelled "over the Waratah seam," hence it doubtless came from the colliery of that name.

The mineral is jet black, highly lustrous, very brittle, breaking into long more or less regular four-sided prismatic pieces. These prisms run at right angles to two of the walls of the pipe. The cross fracture is conchoidal—the powder or streak is black.

The powdered mineral is insoluble in alcohol, bisulphide of carbon, benzol, ether, ammonia, caustic soda, and sodium hyposulphite, but it is partly soluble in boiling nitric acid, yielding a brown solution.

Readily inflammable, does not fuse, burns with a smoky luminous flame and disagreeable smell.

On platinum foil swells up but slightly.

Specific gravity, 1·30. Hardness about 2.

Proximate Analysis.

Loss at 100° C.	3·600	
Volatile hydro-carbons &c.	29·174	
Fixed carbon	63·772	Coke,
Ash	1·064	64·836 %
Sulphur	2·380	
	99·990	

The ash is of a rich brown colour, light and spongy. No true coke is found; the residue is fritted together and slightly swollen up.

Ultimate Analysis.

Moisture at 100° C.	3·600
Carbon	70·246
Hydrogen	5·080
Oxygen	17·630
Sulphur	2·380
Ash	1·064
	100·000

It does not quite agree with any described mineral, but on the whole it seems to resemble albertite more closely than any other. The composition does not yield a satisfactory formula. It is perhaps unnecessary to make a new mineral species of this substance.

12. Bog Butter.

A soft white, somewhat unctuous substance, like fat, only less greasy ; inclined to crumble to pieces when pressed. Probably a form of *adipocere*.

Found between Twofold Bay and Brogo.

Dried at 100° C.

Ultimate Analysis.

Carbon	80·648
Hydrogen	5·618
Nitrogen	5·461
Oxygen	1·553
Ash	6·720
	100·000

The above results do not afford a satisfactory formula.

On some New South Wales Minerals.

By A. Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 3 November, 1880.*]

Alunogen.

In the form of fibrous masses, made up of long, acicular crystals, white, silky lustre, like satin spar. Found as an efflorescence in a sandstone cave near Wallerawang; it is very commonly met with elsewhere in the caves and under overhanging ledges of the sandstone rocks of the Colony.

Analysis.

Water	47·585
Matter insoluble in water	1·079
Alumina	15·198
Sulphuric acid	34·635
Soda...	·931
Potash	·337
Loss	·235
	100·000

The formula for the above is practically $Al_2O_33SO_3 + 18H_2O$. Another specimen from the same place was found to contain a notable quantity of magnesium sulphate.

Analysis.

Water by difference	47·388
Silica	1·908
Alumina	13·113
Sulphuric acid	33·067
Lime	·798
Magnesia	3·726
	100·000

Andradite—Common Garnet.

Found associated with magnetite at Wallerawang; of a brown colour, rather dull. Crystallized in rhombic dodekahedra. Compare the composition of this crystallized garnet with the massive.—(See magnetite from Wallerawang.)

Analysis.

Hygroscopic moisture	·322
Carbonic acid	1·982
Silica	34·164
Alumina	3·251
Iron sesquioxide	29·435
,, protoxide	·931
Manganese protoxide	·553
Lime	28·303
Magnesia	absent
Potash	·341
Soda	·186
Loss	·532
	100·000

Atacamite.

Crystallized in radiated groups of small acicular crystals. Dark olive-green colour, vitreous lustre, apple-green streak, translucent. New South Wales; but exact locality unknown.

Analysis.

Water lost at 105°	·536
,, combined direct	13·955
Copper oxide	64·709
Copper chloride	13·218
Silica and insoluble matter	7·599
	100·017

Bismuthite.

Hydrated carbonate of bismuth, in the form of dull grey or white earthy-looking rolled fragments—usually about the size of a pea, but sometimes larger pieces are found. Breaks with a dull earthy fracture. Found with the stream tin over most parts of the New England tin district. From Pond's Creek.

Hardness = 3 to 4.

Analysis.

Silica	4·695
Bismuth trioxide (Bi_2O_3)...	76·061
Alumina and traces of iron sesquioxide...	1·983
Carbonic acid	5·426
Water, by difference	11·835
	100·000

The above does not agree with the usual formula given for this mineral. The specimen is more or less impure, as is shown by the presence of the silica, alumina, &c.

Cacholong.

A specimen of opaque porcelain white cacholong passing into white opal. Adheres strongly to the tongue. Hardness 5–6. From the Tumut River.

Sp. gr. = 1·884.

Analysis.

Water lost at 105° C.	2·553
,, combined	5·185
Silica	88·811
Alumina and traces of iron sesquioxide...	1·206
Lime	1·134
Magnesia	·485
Loss	·626
	100·000

The loss is probably mainly due to the difficulty of driving off the whole of the combined water.

Chloropal.

Found in veins in the basalt at Two-mile Flat, near Mudgee. Of a pistachio-green colour—earthy, somewhat fibrous in parts, looks like a decomposition product. Friable ; fracture and splintery to earthy. H. 2–3. Sp. gr. 1·94. Yields green powder. Emits an argillaceous odour when breathed upon. Before the blowpipe blackens, does not fuse, becomes magnetic. With hydrochloric acid is decomposed, silica being left. Does not gelatinize.

Analysis.

Water lost at 105° C.	12·313
,, combined	5·224
Silica	49·657
Iron sesquioxide	29·108
Manganese	traces
Lime	2·606
Magnesia	·508
Soda	·599
Potash	·170
	100·185

Copper.

Diffused grains of metallic copper occur in a dark grey porphyrytic phonolite near Kiama.

Chrysocolla.

A massive specimen, of a bluish-green colour—much darker outside than within. Breaks with a somewhat splintery and conchoidal fracture. Brought from Wheeo as a specimen of jasper.

Hardness = 4. Sp. gr. 2·37 to 2·43.

Analysis.

Water lost at 120° C.	11·92
" " red heat	9·40
Copper oxide (CuO)	35·28
Iron oxide	trace
Silica	43·11
Loss	·29
	100·00

Which does not answer to the usual formula. It is probable that some of the silica exists in the free state.

Grossularite.

Lime alumina garnet.

From near Mudgee; of a rich dark brown colour; translucent. Imperfectly crystallized in groups of large rhombic dodekahedra.

Analysis.

Silica	40·517
Alumina	19·906
Iron sesquioxide	·285
Iron protoxide	3·165
Manganese protoxide	3·700
Lime	32·245
Magnesia	traces
Carbonic acid	·254
	100·072

Halloysite.

Black; brittle; conchoidal fracture; black streak on paper. Somewhat greasy feel; does not adhere to the tongue. Soft, readily scratched by nail, leaving shiny streak.

Collected by Mr. C. S. Wilkinson, F.G.S., from near Berrima.

Analysis.

Water lost at 105° C.	3·047
" combined	12·840
Silica	45·289
Alumina	38·547
Lime	trace
Loss	·277
	100·000

Hæmatite.

Very common in the Hawkesbury sandstone, in irregular deposits, crevices, joints, as concretionary masses and nodules; gives a red streak. Is often more or less mixed with sand and other impurities.

The following analysis was made upon a specimen collected in the neighbourhood of Sydney.
Sp. gr. 4·49.

Analysis.

Water lost at 105° C.	·646
Silica	4·210
Alumina	·713
Iron sesquioxide	90·555
,, protoxide	3·632
Manganese	trace
Lime	—
Magnesia	—
Phosphoric acid	absent
Loss	·244
	100·000

The above results show the specimen to be an extremely good iron ore.

Hæmatite, Brown.

A massive form, dark brown to pitchy black colour; brown streak. Somewhat vesicular in places.

From the neighbourhood of Jamberoo.

Sp. gr. 3·52.

Analysis.

Water lost at 105° C.	1·335
,, combined	11·872
Iron sesquioxide	77·155
Alumina	1·232
Manganese	·428
Lime	·257
Magnesia	trace
Silica	8·507
	100·786

Hæmatite, Brown.

In the massive form. Found with the titaniferous iron ore, Uralla.

Sp. gr. 3·611.

Analysis.

Water lost at 100° C	1·787
,, combined, by difference ...	10·652
Silica	3·782
Alumina	·159
Iron protoxide	3·526
,, sesquioxide	77·132
Manganese protoxide	·940
Lime	2·022
Magnesia	traces
	100·000

HORNBLENDIC MINERAL.

A light grey, sub-translucent mineral, which breaks in places something like a very fine-grained quartzite or jade, with somewhat conchoidal surface ; in other places there is a fibrous structure due to the presence of bright acicular crystals. The weathered portions are stained brown with oxide of iron, and show the cavities left by fossils. It seems to have been highly charged with the shells of spirifera.

Collected by Mr. C. S. Wilkinson, F.G.S., on the Mudgee Road.

Partly soluble in acid.

Extremely tough. Hardness 6–7. Sp. gr. 3·003.

Analysis.

Loss on ignition	·60
Silica	50·44
Alumina	6·19
Iron sesquioxide	1·25
Lime	28·70
Magnesia	11·14
Soda	1·16
Loss	·52
	100·00

The sedimentary rock in which the fossils were originally embedded must have been highly metamorphosed to account for the present character of the matrix. The formula is practically $2\ (\frac{2}{3}\ CaO \frac{1}{3}\ MgO)\ 3\ SiO_2$.

LEAD.

An irregular piece, about $1\frac{1}{2}$ inch long by 1 inch wide, and about $\frac{1}{8}$ to $\frac{3}{16}$ of an inch thick, with rough surface, as if it had filled a jagged crevice, coated on the outside with clay-like earthy matter, mixed with much oxide of lead of a brilliant red colour. The edges were slightly rounded as if waterworn. Did not look at all as if it had been reduced artificially or had been derived from bullets or sources of that kind.

The majority of the specimens of native lead which have been brought to me from time to time have usually been derived from bullets, which have found their way into the river gravel, &c., and have been found by the miners when washing for gold.

Weight = 32 grammes. Found near Gundagai.

LIMESTONE.

Slightly crystalline, of a grey colour, with a few thin streaks of a lighter colour. Small patches of a pale green mineral can be detected in parts, something like glauconite in appearance.

Contains a considerable amount of impurity, and leaves a noticeable residue when decomposed with hydrochloric acid.

From a two-inch band exposed in the Minumurra Creek, Jamberoo.

Sp. gr. 2·679.

Analysis.

Water lost at 105° C.	·73
,, combined	2·00
Silica and substances insoluble in acid...	13·08
Soluble silica	·52
Iron sesquioxide	5·02
,, protoxide	3·52
Alumina	·46
Lime	38·27
Strontia	traces
Carbonic acid	35·70
Loss	·70
	100·00

Limonite.

A variety of hæmatite known as *clay band iron ore*, from Wallerawang, taken from the uppermost band.[1]

This specimen was taken from the outcrop of the seam, and has probably been subjected to bush fires, since the proportion of water is far less than is required; and moreover the mineral contains a trace of magnetic iron, and yields a dark chocolate powder instead of the usual yellow-coloured one.

Clay Band No. 1.—Wallerawang.

Analysis.

Water lost at 100°	1·31	
,, combined	4·17	
Insoluble silica	3·63	
Soluble ,, ...	·51	
Alumina	2·13	
Manganese protoxide	1·60	
Iron ,, ...	·52	} =60·13 %
,, sesquioxide	85·32	} metallic iron
Lime	·35	
Magnesia	·29	
Sulphur	·04	
Phosphoric acid...	traces	
	99·87	

[1] For analyses of other specimens see Iron and Coal Deposits at Wallerawang, by A. Liversidge. Jour. Roy. Soc. N.S.W., 1874.

Clay Band No. 2.—Wallerawang

Analysis.

Water lost at 100° C.	1·35	
,, combined	10·29	
Silica	3·66	
,, soluble	·07	
Alumina	1·38	
Iron protoxide	·67	=55·80 %
,, sesquioxide	78·96	metallic iron
Manganese protoxide	2·43	
Lime	·65	
Magnesia	·14	
Phosphoric acid...	traces	
Sulphur	traces	
	99·60	

Clay Band No. 3.—Wallerawang.

Analysis.

Water lost at 100° C.	·97	
,, combined	10·07	
Silica	8·34	
,, soluble	·27	
Alumina	1·20	
Iron protoxide	·46	=54·46 %
,, sesquioxide	77·29	metallic iron
Manganese protoxide	·76	
Lime	·19	
Magnesia	·28	
Phosphorus	traces	
Sulphur	traces	
	99·83	

Clay Band, Jamberoo.

Clay band iron ore from Jamberoo; of a dark reddish brown colour; looks very much like a clay or shale, which in fact it really is. Has a somewhat laminated structure; breaks with a flat conchoidal fracture, with dull earthy surfaces.

Sp. gr. 2·73.

Analysis.

Water lost at 105° C.	1·452
,, combined	11·000
Silica and insoluble matter	57·258
Alumina	15·070
Iron sesquioxide	13·019
,, protoxide	1·255
Manganese	·257
Lime	·158
Magnesia	traces
Phosphoric acid	traces
Sulphur	absent
Loss	·531
	100·000

Limonite Concretions.

In the form of small concretionary nodules, some of which are as spherical as marbles, in other cases they are more or less elongated; or two or three of the globular forms may be joined together. Some possess a curiously wrinkled or corrugated surface, but most are quite smooth but not polished, the material being rather soft. On breaking them open they are seen to have traces of a concentric structure; the outer portions occasionally present indications of a radiate fibrous structure also. The hydrated oxide of iron seems to have been originally diffused through an impure carbonate of lime and magnesia; then to have segregated together into these concretionary forms, for occasionally the nodules are met with enclosed in such a matrix.[1]

Hardness, 3–4; Sp. gr., 3·52. The streak or powder is yellow.

Analysis.

Water lost at 105°	3·173
,, combined	7·304
Silica	5·819
Alumina	·634
Iron sesquioxide	81·877
Manganese protoxide	·561
Lime	·503
Magnesia	traces
Loss	·129
	100·000

Magnetite.

From a vein at Wallerawang, where the magnetite is associated with a vein stuff or matrix mainly composed of a ferruginous garnet.[2] The following analysis was made upon an intimate mixture of the two minerals as they occur in the vein.

Analysis.

Water lost at 100° C.	·30	
,, combined	1·63	
Silica	16·28	
,, soluble	2·51	
Alumina	1·35	
Iron protoxide	3·67	= 41·87% metallic iron
,, sesquioxide	55·74	
Manganese protoxide	2·99	
Lime	14·28	
Magnesia	·62	
Sulphur	traces	
Phosphoric acid	traces	
Carbonic acid	·54	
Loss	·09	
	100·00	

[1] *See* Jour. Roy. Soc. N.S.W., 1873, p. 96.

[2] *See* also Iron and Coal Deposits, Wallerawang. Jour. Roy. Soc., N.S.W., 1874.

The finely divided ore was then separated by means of a magnet, the magnetic and non-magnetic parts then examined separately.

The portion removed by the magnet amounted to 56%, but as will be seen by the following analyses it was found impossible by this means to obtain the magnetite quite free from the vein stuff.

Analysis.

	Magnetic.	Non-magnetic.
Water lost at 100°C. ...	·26	·21
,, combined	1·69	1·14
Silica	8·61	28·66
Silica soluble	·65	3·88
Alumina	1·97	1·13
Iron protoxide	6·91	·56
,, sesquioxide	70·47	35·91
Manganese protoxide ...	2·39	1·62
Zinc-nickel, traces of ...	·13	....
Lime	6·96	24·44
Magnesia	·20	1·00
Phosphoric acid	traces	....
Sulphur	traces	....
Carbonic acid	absent	1·66
	100·24	100·21

The non-magnetic part thus answers to the general formula for the iron-lime-garnet, $3\ CaO, 2\ SiO_2 + Fe_2O_3, SiO_2$.

HAUSMANNITE. ?

A hard compact mineral, with a very minute crystalline structure; strikes fire with steel; fracture conchoidal; of a dark iron-grey colour. Found in the Wellington district.

Sp. gr. 6·466 ; hardness, 6·5.

Soluble in hot strong hydrochloric acid, with evolution of chlorine, a residue of white silica being left.

Analysis.

Silica	11·778
Alumina	4·061
Iron sesquioxide	3·153
Manganese protoxide	31·516
,, binoxide	50·125
Lime	traces
Magnesia	traces
	100·633

This mineral is one of unusual hardness and specific gravity for one consisting essentially of the oxides of manganese. The silica is probably present merely as an impurity in combination with the iron and alumina.

Menaccanite.

A variety of titaniferous iron ore. From near Uralla; found in the river deposits, by miners working for gold; in the form of black pebbles, with a sub-metallic lustre.

Sp. gr. 4·44.

Analysis.

Silica	9·491
Alumina	14·799
Titanic acid	44·506
Metallic iron	23·019
Oxygen	8·185
Lime	traces
Magnesia	traces
	100·000

The iron exists in the form of both protoxide and sesquioxide, the former being present in the larger quantity. As it is difficult to determine accurately the amount of protoxide in a difficultly soluble mineral such as this, the total iron has been stated as metallic iron, and the oxygen estimated by difference.

The alumina and silica doubtless exist in combination as silicate.

Pyroxene.

Of a green colour, more or less decomposed, only traces of the previous crystallization left. Soft and fragile. From Oberon; collected by Mr. C. S. Wilkinson, F.G.S.

Analysis.

Water lost at 100°C.	·210
Silica	35·319
Alumina	5·922
Iron sesquioxide	28·557
,, protoxide	1·809
Manganese protoxide	4·056
Lime	22·751
Magnesia	absent
Potash	·378
Soda	·221
Loss and undetermined	·777
	100·000

Sp. gr. 3·48

Scheelite.

Massive, with a portion of a crystal showing on one side, of an amber colour, translucent, resinous lustre, brittle, splintery fracture. Hardness, 4–5; sp. gr. 6·097. Associated with a dark green chloritic vein stuff. From the Victoria Reef Gold Mine, Adelong.

The following analysis was made for me by Dr. Helms :—

Analysis.

Loss at a red heat	·25
Tungstic acid	79·53
Lime	19·14
Alumina	·58
Magnesia	·07
	99·57

The above results correspond to the formula $CaWO_4$.

SIDERITE.

Carbonate of iron. In this specimen the siderite is diffused through a compact grey-coloured clay stone. From the neighbourhood of Jamberoo.

The following analysis was made of the whole, as it was found impossible to separate the particles of siderite, so as to ascertain its value as an ore of iron.

Sp. gr. 2·79.

Analysis.

Water lost at 105°C.	·932
,, combined	11·922
Silica and insoluble matter	42·292
Alumina	22·837
Iron protoxide	12·870
Manganese protoxide	1·048
Magnesia	traces
Potash soda	,,
Phosphoric acid	,,
Carbonic acid	7·816
Titanic acid	·716
	100·433

TIN-STONE OR CASSITERITE.

A specimen of dark-coloured, almost black stream tin-stone, from the Jupiter Mine, Vegetable Creek, New England.

Analysis.

Stannic oxide (SnO_2)	89·92
Titanic acid (TiO_2)...	·69
Alumina	6·75
Silica	·80
Iron sesquioxide	2·30
	100·46

Sp. gr. 6·629.

WOLFRAM.

Of the usual bronzy-black colour, sub-metallic lustre; opaque; lamellar structure, only traces of crystal faces. Found in quartz veins with tin-stone, Inverell.

Analysis.

Tungstic acid	77·640
Iron protoxide	18·760
Manganese...	4·121
	100·521

A pink schistose mineral was found embedded in the slates and other rocks at the S.E. corner of Rocky Ridge, by the late Dr. Thomson, Professor of Geology in the University of Sydney, and Mr. Norman Taylor.[1]

The mineral is somewhat friable, earthy and meagre to the touch; emits an argillaceous odour when breathed upon; adheres to the tongue; is decomposed by hydrochloric acid with separation of granular silica; yields a very pleasing bright pink-coloured powder; before the blow-pipe does not fuse, but darkens slightly; heated in a tube it evolves moisture, darkens, but re-acquires its original colour on cooling. As the mineral is evidently only a non-crystallized decomposition product it is unnecessary to give it a name.

Analysis.

Water lost at 105° C.	1·335
Silica	61·951
Alumina	24·120
Iron protoxide	1·222
,, sesquioxide...	3·400
Lime	7·850
Magnesia	trace
Loss	·122
	100·000

[1] The Mudgee Diamond Fields, by Thomson and Taylor. Jour. Roy. Soc., N.S.W., 1869.

Notes upon some Minerals from New Caledonia.

By A. LIVERSIDGE, Associate R. S. Mines, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 1 September, 1880.*]

THE following notes and analyses have been made upon some minerals which were kindly placed at my disposal by Mr. Pryor, F.G.S., Manager of the Balade Copper Mine, Ouegoa, New Caledonia, Mr. Rossiter of Noumea, Mr. Douglas Dixon, late of Sydney, and other friends. My thanks are especially due to Mr. Pryor, who has evidently been at very great pains to collect good and typical specimens for me, as well as to send trustworthy information as to localities, mode of occurrence, and other similar matters.

I should mention that this paper is intended to be merely a description of the particular specimens received, and as far as I have yet been able to work upon them; it is not meant to be a general account of the minerals of New Caledonia.

GOLD.

Disseminated in fine grains and particles through a mica-schist much stained with red oxide of iron; in parts of the rock pseudomorphous cubical cavities are abundant, apparently left by the removal of crystals of iron pyrites; the red colour of much of the schist is probably due to the decomposition of the pyrites, sesquioxide of iron has been formed, and the gold, which was doubtless held by the pyrites, set free.

The bright red coloured schist is sometimes mistaken by miners for red oxide of copper, and for gossan.

Gold is also met with in a talcose schist with quartz.

Locality: Fern Hill Mine, Manghine, Diàhot River; also in auriferous pyrites at Niengneue.

COPPER.

Native Copper.—As irregular strings and thin plates, filling the joints in rotten and much fissured quartz veins; most of the fissures are about half an inch apart, and more or less at right angles to each other; the metallic copper is accompanied by a certain amount of the red oxide of copper or cuprite. Balade Mine.

Copper Gossan.—Of the usual character, consisting of friable earthy red oxide of iron, containing a trace of copper mixed with more or less quartz.

Balade and Sentinelle Mines.

Cuprite.—The red oxide of copper, crystallized in the form of minute octahedra lining small cavities in a light brown coloured siliceous veinstuff.

Bouenoumala. Balade and Sentinelle Mines.

Tile Ore.—This, the earthy variety of red oxide of copper, occurs at the Balade and Sentinelle Mines. The specimens received from Mr. Pryor are mixed with streaks of the green carbonate of copper.

Tenorite.—The black oxide of copper occurs at the Balade mine in the form of a loose black powder intimately associated with copper pyrites.

Sulphate of Copper.—From the Balade Mine, where it is met with on the outcrop of the lode in the form of beautiful pale blue crystals—some distinct; but in other specimens the crystals are very small and arranged in mammillated aggregations.

Malachite.—The green hydrated carbonate of copper; most of the specimens from the Balade mine merely show it as a coating, or sparingly diffused through the mica-schist; some are more massive, but friable and more or less earthy, but none sufficiently compact to present the usual characteristics of the typical malachite. It is also found at Goundolai, Diàhot River, associated with cuprite and other ores of copper. Also Sentinelle Mine.

Chessylite.—The blue hydrated carbonate of copper; occurs with other copper ores at the Sentinelle mine, Diàhot River, situated about 2 miles from the Port of Pam, and 17 from the Balade mine. Some of the chessylite is in the form of nodular crystallized masses, with a radiated internal structure, associated with a white kaolin-like clay, presenting very much the same appearance as the chessylite from the Cobar mine, and apparently occurring under somewhat similar circumstances.

Redruthite.—Copper glance or the grey subsulphide of copper; massive, of very good quality, associated with cuprite. Balade mine.

Bornite.—The variegated or purple sulphide of copper and iron also occurs at the Balade mine: of a bronze colour, massive and of good quality.

Chalcopyrites.—This, the common form of copper pyrites, appears to be very abundant at the Balade mine and of good quality. It occurs both massive and in the form of small strings and layers running through a mica-schist, in much the same way as we often find layers of quartz under similar circumstances; this mica-schist is often very much contorted, and in such a way as to present a very pretty wavy silky lustre.

The chalcopyrites is also occasionally met with lining fissures. One or two of the specimens kindly sent to me by Mr. Pryor are fairly well crystallized, the form being in one case the sphenoid with curved faces; in the other specimens, also from the Balade mine, the crystals are smaller but better developed, consisting of groups of tetragonal pyramids combined with faces of the secondary prism and the basal pinacoid.

Most of the specimens of chalcopyrites received from the Balade mine would be described by miners as peacock copper, on account of the iridiscent tarnish tints which they present.

Associated with the copper pyrites are the minerals quartz, both opaque white and translucent, calcite, dolomite (ferruginous), passing into siderite, the carbonate of iron, chlorite, magnetite, pyrrhotine, iron pyrites, and others; one of the most interesting is perhaps the white fine-grained crystalline marble, closely resembling statuary marble in appearance; it is very unusual for marble to appear under such circumstances; calcite is however very commonly met with in mineral veins. Some of the fragments of marble are quite small, and are almost completely surrounded by the copper pyrites with sharply defined boundaries, just as if lumps of marble had fallen into the vein and had been subsequently surrounded by ore.

Mr. Pryor states that the calcite, siderite, chlorite, and dolomite are only found when the beds of quartz which lie between laminæ of the strata are in actual contact with the copper deposits; they then not unfrequently form the upper or under boundaries of the ore deposits. At the point of contact he has observed also that the opaque white quartz generally gives way to the transparent variety.

In speaking of the deposits of copper ore at the Balade mine, Mr. Pryor says:—"The deposits consist of compact yellow copper ore almost free from any kind of gangue whatever. Quartz even is only found in quantity upon the coming in or going out of ore, forming as it were contact beds between it and the schist. It is also noteworthy that no cavities or hollows are found in these "pipes" of mineral, and this circumstance accounts for there being no crystals of any kind, except a few very small ones of calcite and chalcopyrite which line the faces of some of the joints. These joints extend uninterruptedly across the strata and ore at the same angle, which varies from 40° N. in the smaller to vertical in the larger ones, and the two faults, while their strike is approximately the same, and may all therefore be referred to the same system of fracture. Another series of joints—merely divisions in the rock—occur however, and these dip S. but are not represented in the deposits.

To give you an idea of the geological formation of the district, I have collected 34 specimens illustrative of the various metamorphic rocks which are met with in ascending the mountain in a N. or transverse direction for a distance of about 2½ miles, *i.e.* from its base near where the deposits of copper crop out at surface.

This chain of hills attains its greatest altitude at this point, where it is 2,500 feet above sea-level, and extends about 30 miles E. and 10 W. with a general strike E. 27° S. There are being worked at present five distinct pipes of ore, S. 41½° W. with remarkable regularity at an angle varying from 20° to 45°. On some future occasion I hope to furnish you with a description of these singular formations and observations thereon, as well as the necessary reduced sections and diagrams, without which it would be difficult to explain them. Garnets with glaucophane, and crystals of amphibole, occur abundantly in these rocks, but I have found none larger than those sent you. The crystals of titaniferous iron and magnetite are not so plentiful apparently, at least on the surface, from whence I procured nearly all the specimens of rocks. About ¾ of a mile to the east of this mine, there appear to be either intrusive masses or dykes of serpentine (judging from what can be seen at surface) associated with which are small pieces of chrysolite and asbestos, while the enclosing country is talcose schist."

Lead.

Galena.—The sulphide of lead; from Coumac, in masses with a finely granular structure, reputed to be highly argentiferous; the specimen given to me by Mr. Rossiter contained but a small quantity of silver.

Zinc.

Zinc blende.—The sulphide of zinc: specimens from Coumac and the Baie Lebris, said to be argentiferous, are black in colour, massive, with granular structure, and in parts much stained with oxide of iron.

Antimony.

Antimonite.—The sulphide of antimony; a fine specimen of the massive variety from Nakety, on the East Coast, with coarsely-bladed structure like much of the Borneo ore, was contained in Mr. Rossiter's collection.

The specimen is coated in part with yellow oxide of antimony, to the thickness of about half an inch.

Titanium.

Rutile.—The dioxide of titanium TiO_2.

Crystallized in incompletely developed prisms, much striated, of a dark hair brown colour; in most cases the prisms are much flattened and partly embedded, and not sufficiently well-formed to admit of measurements being made with the goniometer.

In another specimen long, slender, translucent reddish-brown crystals of rutile penetrate through and through a mass of rock crystal. Some of the crystals are bent and broken.

Ouegoa, Diàhot River.

Nickel.

M. Jules Garnier seems to have been the first to discover the existence of a nickel-bearing mineral in New Caledonia: he first met with it as far back as 1864 and made his discovery public in 1867[1], but he did not, apparently, make any investigation into the chemical composition of the mineral in question: afterwards M. Garnier placed some of the mineral in the hands of M. Jannettaz, mineralogist to the Natural History Museum of Paris.

In a letter to the "Moniteur de la Nouvelle Calédonie" of January 6th, 1875, upon the minerals of New Caledonia, translated and quoted by the late Rev. W. B. Clarke[2], M. Garnier claims the priority of discovery as follows:—

"I have recorded this in my journal, 24th September, 1864:—Continuing to ascend the river of Dumbéa; the rocks which I meet with are little variable, they are amphibolitic and often hold chromate of iron; the rock is also accompanied by a green matter which sticks to the surface—nickel. Moreover it was one of the first steps in the country to announce nickel. I sent specimens of it to the Rev. W. B. Clarke, as he has had the goodness to state in his letter. I did not then give the descriptions, waiting for the definite work which I could only make in a place where I could be aided by the light of clever experiments, and also with instruments for investigation that I lacked in the Colony. It was Mons. Jannettaz, mineralogist at the Museum, who was so good as to analyse this green substance, which was thought might also be chrome in a certain condition, the oxidising salt, if we might judge by the abundance of chromate of iron in all the rocks. The analysis of Mons. Jannettaz gave me satisfaction. It was really that of nickel, and I was then able to say, in my 'Geology of New Caledonia,' p. 85 (1867):—'It would be highly interesting to study more completely the deposits of nickel, &c.

In 1869 I again wrote:—"The serpentines and in a general way of the rest, all the rocks which accompany them are often covered with a coating of beautiful green, which is nothing but silicate of nickel, alumina, and magnesia. * * * The nickel in this condition is so abundant that we ought to hope to find one day a workable deposit of it." (Bulletin de l'Industrie Minérale, p. 301, tome XV.)

From the above it does not appear that M. Jannettaz made a complete analysis of the mineral: he merely ascertained its composition qualitatively.

Since my previous analysis of the nickel-bearing minerals from New Caledonia[3] I have had opportunities to examine a very

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[1] Geol. Nouv. Cal., p. 85, J. Garnier, 1867.
[2] Jour. Roy. Soc., N.S.W., vol. IX, p. 47.
[3] A new nickel-bearing Mineral from New Caledonia. A. Liversidge. *Quart. Jour. Chem. Soc., London, July*, 1874. Nickel Minerals from New Caledonia, by A. Liversidge, Jour. Roy. Soc., N.S.W., 1874.

large number of specimens from different deposits in New Caledonia and especially of the one named *Noumeaite*; the variety known as *Garnierite* does not appear to be at all abundant, nor does it appear to be of much importance to the mineralogist.

Both varieties lose a portion of their combined waters when heated to 100°C.; the amount is variable in different specimens.

Noumeaite.—No crystallized specimens appear yet to have been met with; the mineral appears to be completely amorphous, not even a crystalline structure being recognizable, unless the fibrous appearance of some be regarded as such; it occurs in massive pieces, in botryoidal and stalactitic forms, as incrustations with smooth mammillated surfaces, in brecciated masses, as the cementing material of serpentine breccias, also as concretions, and in the massive form with a *petaloidal* structure, *i.e.* the mineral splits up into pieces with smooth polished concave-convex surfaces which fit into one another somewhat like the petals of an unopened flower-bud; this kind of structure is very often seen in mineral veins of all kinds and in their walls also where there is a *slickenside* or *miroir*. Occasionally it is found invested with a drusy coat of small sparkling quartz crystals.

In hardness and toughness it varies very much, sometimes being quite soft and brittle, crumbling between the fingers, and in other cases both hard enough and tough enough to be cut into ornaments. These harder varieties take a very fair polish, and rival malachite in beauty and effect. At the Paris Exhibition of 1878, Messrs. Christofle had some beautiful polished samples, including some columns veneered with noumeaite.

In colour it is met with of various shades of green, from the very palest tinge, through apple green to a full rich malachite green; the very pale varieties apparently seem to be nothing more than a hydrated silicate of magnesia more or less charged with silicate of nickel. Some of the pale varieties, although not hard, are from their great toughness extremely difficult to powder.

One specimen of noumeaite from Mont d'Or passes on one side into a layer of pale green jade like mineral breaking with a splintering fracture and possessing a hardness of rather more than 6, and otherwise resembling jade. This layer had apparently been in contact with the walls of the vein and had somewhat the appearance of a *slickenside*. I have not yet had time to examine the specimen further.

Some specimens have been found to contain minute traces of copper.

The following analyses, numbered from 1 to 7, were made from sets of specimens which I had carefully freed from the matrix; these sets were prepared so as to ascertain how far specimens resembling one another in colour and appearance, and from the same mine, differed from one another in chemical composition. Dr. Leibius, of the Mint, Sydney, was kind enough to undertake the analysis of one set of these specimens.

No. 1. Light green coloured specimens, showing petaloidal structure; from the Bel Air Mine, Ouaïlou, East Coast.

Analyses.

	a.	*b.*	*c.*	*d.*
Water lost at 100° C	10·01	10·95	12·38	14·47
Combined water at red heat ...	9·62	8·82	7·31 (by diff.)	6·77
Silica	48·90	48·25	49·36	44·96
Soluble		..	·17	·56
Alumina, Iron sesquioxide ...	trace	·55	traces	·56
Nickel protoxide ...	14·85	14·60	13·75	14·62
Magnesia	16·22	16·40	17·03	17·43
	99·60 Leibius	99·57	100·00	99·37

In *b c* and *d* the first portion of the water was driven off at 105°C. instead of at 100°C.

No. 2. A pale variety, very tough, from the same large block.

Water lost at 100° C. ...	12·71	11·28
Combined water	9·26	10·37 (by difference)
Silica	48·85	50·15
Alumina	trace	·57
Iron sesquioxide	trace	trace
Nickel protoxide	11·50	10·20
Magnesia	16·81	17·43
	99·13 Leibius	100·00

No. 3. A dark translucent green, brittle, botryoidal or mammillated form from Boa Kaine mine, Kanala.

Water lost at 100° C.	7·24
Combined, loss at red heat	12·92
Silica...	35·50
Alumina	·85
Iron sesquioxide	trace
Nickel protoxide	29·65
Magnesia	13·44
	99·60 Leibius

Another specimen of this, but of a lighter colour, had the following composition:—

Water lost at 100° C.	8·65
Combined water	8·95
Silica	36·79
Silica soluble	·70
Alumina, Iron sesquioxide	11
Nickel oxide (NiO)	29 72
Magnesia	14·97
	99·89

No. 4. Of a rich green colour, intermixed with lighter portions, brecciated and showing a striated and fluted surface next to the walls of the vein, somewhat like a slickenside in appearance; the specimen of white hydrated silicate of magnesia. (See No. 7) formed the boundary wall or casing of the vein. Bel Air mine.

Analysis.

Water lost at 100° C.	11·15
Combined water lost at red heat... ...	8·50
Silica...	46·20
Alumina } Iron sesquioxide }	absent
Nickel protoxide	20·88
Magnesia	12·93
	99·66 Leibius

No. 5. Translucent dark green coloured, brittle specimens, with mammillated surfaces, from Nakety.

Analysis.

	I.	II.
Water lost at 100° C. ...	6·70	6·44
Combined water lost at red heat	12·39	11·53 (by difference)
Silica	39·75	38·35
Alumina	traces	·40
Iron sesquioxide	traces	·15
Nickel protoxide... ...	29·10	32·52
Magnesia	12·84	10·61
	100·78 Leibius	100·00

No. 6. A translucent pale green variety from Ouaïlou.

Analysis.

Water lost at 100° C.	11·05
Water lost at red heat	9·70
Silica	48·00
Alumina	absent
Iron sesquioxide	...
Nickel protoxide	15·39
Magnesia	16·92
	101·06 Leibius

No. 7.—The casing from the walls of a vein of dark green noumeaite at the Bel Air mine, Kanala, consisted of a dazzling white very tough hydrated silicate of magnesia which in parts was quite free from nickel, and in others merely tinged with the palest green. The surface towards the vein was much grooved, striated, and polished, and had apparently formed part of a slickenside.

This mineral very closely resembles meerschaum in composition, in appearance, and in many of its properties. It is, however, much tougher than ordinary meerschaum, being as difficult to break apart as rock cork ; it, moreover, presents in parts a more or less well-developed petaloidal structure. The specific gravity is 2·55, meerschaum being only about 1·3 to 1·6. There are occasional black dendritic markings within it.

One specimen possessing a very pale green tinge gave the following results :—

Analysis.

Water lost at 100 C.	14·30
,, combined	8·87
Silica	51·81
,, soluble	·13
Alumina	1·36
Iron sesquioxide	
Nickel oxide (NiO)	2·32
Magnesia	21·35
	100·14

Two other specimens devoid of any green tinge gave the following results :—

Analysis.

	I.		II.	
Water lost at 100° C.	11·77		13·30	at 105° C]
Combined water, at red heat...	9·70		8·58	by diff.
Silica	53·80		53·80	
Alumina...	absent		·75	
Iron sesquioxide	absent		trace	
Nickel protoxide	·24		·58	
Magnesia	24·82		22·99	
	100·33	Leibius	100·00	

The above composition furnishes the formula :—2 MgO, 3 SiO_2, 5H_2O, or 2 MgO,3SiO_2,H_2O, if the water driven off at 100° C. be disregarded.

The brownish or plum-coloured serpentine with which the noumeaite is often associated usually contains alumina, iron, &c. ; hence (in cases where analyses show the presence of any considerable quantity of these) it may be, I think, assumed that the mineral has not been completely separated from its gangue, but that both have been take together.

The following analyses of some of the dark green brecciated Kanala ores, from which the gangue had not been wholly removed, will serve to show this :—

Water lost at 105° C. ...	8·765	8·016	8·65
Combined, by difference ...	9·034	6·550	8·95
Silica	47·041	38·108	36·79
,, soluble	...	...	·70
Alumina	1·376	2·584	5·36
Iron sesquioxide	·157	1·137	
Nickel oxide	14·544	31·853	24·72
Lime	absent	trace	
Magnesia	19·083	11·752	14·97
	100·000	100·000	100·14

Another ore gave :—

Analysis.

Water lost at 100° C.	9·46
,, combined, by difference	7·77
Silica	43·12
,, soluble	·93
Alumina and iron sesquioxide	1·31
Nickel oxide	19·89
Magnesia	17·52
	100·00

The foregoing analyses confirm the statement made in 1874 that the mineral is of uncertain composition; it ranges from practically pure hydrated silicate of magnesia to what is also practically only hydrated silicate of nickel. Some specimens which are now being examined quantitatively contain but a very small quantity of magnesia.

Garnierite.—Since the receipt of the first specimen in 1874, I have obtained only one or two additional examples of this variety of the hydrated silicate of nickel and magnesia. It is at once distinguished from the more important mineral noumeaite by its adherence to the tongue, and by its falling to pieces when immersed in water, and (like halloysite) even when allowed to remain adherent to the tongue for a moment or so. It might be roughly described, apart from its composition, as being a green-coloured halloysite. Apart from these characters, there appears to be but little difference between the two varieties.

Kupfernickel, the arsenide of nickel, is reported from Kanala; but the statement requires confirmation. A specimen so labelled proved to be poor chalcopyrites encrusted with a thin film of impure green carbonate of copper. I expect this mineral will be found in New Caledonia, but up to the present I have not seen any authentic specimens.

COBALT.

Up to the present the only cobalt-bearing mineral from New Caledonia which I have had an opportunity to examine has all been of one kind, viz., the variety known as earthy cobalt ore, asbolite or "wad," *i.e.*, an impure oxide of manganese containing cobalt oxide. It apparently occurs in the form of irregular deposits, and as more or less spherical concretionary nodular masses, with mammillated surfaces, embedded in an unctuous red clay. This clay is probably derived from the decomposition of the serpentine and other rocks of the district.

These nodules are black or bluish-black in colour, but usually superficially coated either with the red-coloured clay or with red oxide of iron. I understand that they are quite soft when first dug up; they readily stain the fingers, and yield to the knife at once, cutting like graphite, but with a blue-black shining metallic streak instead of a grey-black one.

Some of the nodules present a very vesicular structure, like certain kinds of lava. Even the apparently quite compact nodules often enclose patches of the clay, especially towards the centre.

Many of them present a very striking resemblance to the manganese nodules dredged up from the depths of the sea by the "Challenger." I do not feel quite justified in throwing out any suggestions as to whether they were formed under similar conditions, since I have no personal knowledge of the conditions under which they are found; but as far as an opinion can be formed from the specimens which I have had an opportunity to examine, I am inclined to think that they were not, but that the concretionary process has been set up subsequently—that is, the cobalt seems to have been originally disseminated throughout the clay, but has since segregated together and assumed the nodular form.

Asbolite also occurs as dendritic markings in the kaolin from a locality on the river Leia.

Some nodules of the ore from Unia were examined, with the following results:—

Analyses.

	Specimen No. 1.	No. 2.	No. 3.
Water lost at 100° C.	8·68	10·19	10·54
,, combined	8·87	9·74	9·83
Silica	15·34	15·15	17·20
Alumina	8·86	8·70	7·65
Iron sesquioxide	10·41	10·26	5·51
Chromium ,,	·52	·51	·87
Nickel oxide	traces	traces	traces
Cobalt ,,	15·67	15·43	13·59
Manganese peroxide (MnO_2)	11·52	9·57	12·05
Lime	traces	traces	traces
Magnesia	20·80	20·46	22·63
	100·67	100·01	99·87

The following contains but little magnesia—Coumac.

Analysis.

Water lost at 100° C.	2·86
Water combined by difference	16·57
Silica	1·06
Alumina	11·37
Iron sesquioxide	23·52
Chromium sesquioxide	traces
Manganese peroxide (MnO_2)	32·41
Cobalt oxide (Co O)	10·42
Lime	absent
Magnesia	1·79
	100·00

The following analysis of a specimen from Baie des Pirogues shows the presence of nickel in rather larger proportion than usual.

Water lost at 100° C.	6·072
Combined water, by difference	13·759
Silica with traces of chrome iron ...	4·476
Alumina	21·529
Iron sesquioxide	18·396
Chromium sesquioxide	traces
Manganese peroxide (MnO_2)	27·588
Cobalt oxide	4·927
Nickel oxide	2·256
Lime	trace
Magnesia	·418
Potash	·123
Soda...	·216
Phosphoric acid (P_2O_5)	·240
	100·000

From the foregoing analyses it will be seen that the earthy cobalt ore from New Caledonia differs considerably from those met with in other places; baryta is entirely absent, although often present in this mineral from other localities. (See analyses given by Dana, *Descriptive Mineralogy*, p. 182), but magnesia seems to have taken its place in the asbolite from some of the New Caledonian mines.

Specimen from Unia of poor quality.

Water lost at 100° C.	2·720
Combined water, by difference	22·901
Insoluble silica	1·699
Soluble	·230
Tin...	trace
Iron sesquioxide	10·308
Alumina	37·421
Chromium sesquioxide	traces
Manganese peroxide (MnO_2)	16·598
Cobalt oxide (CoO)	3·387
Nickel oxide (NiO)	2·645
Lime	absent
Magnesia	1·311
Potash	·176
Soda	·328
Sulphuric oxide (SO_3)	·276
	100·000

IRON.

Magnetite.—In the form of small very perfect octohedra diffused through massive granular chlorite.

Balade mine, Ouegoa.

Red Hæmatite.—In a red-coloured micaceous schist, highly charged with oxide of iron, and in consequence often mistaken for the gossan of a copper-vein; the iron oxide has apparently been formed at the expense of iron pyrites, since much of the schist is dotted all over with small rectangular cavities, pseudomorphous after iron pyrites.

Balade mine.

Brown Hæmatite.—A specimen from Baie du Sud evidently of very good quality, curiously permeated by reticulating cavities.

Also met with in a talcose schist in the form of pseudomorphs after cubes of iron pyrites; Mr. Pryor mentions breaking open one of these and finding a nucleus inside, about one-third of the size of the entire pseudomorph, made up of minute crystals of pale green-coloured sulphur, &c.

Pyrrhotine.—The magnetic variety of iron pyrites (Fe_7S_8) collected by Mr. Pryor at the Balade mine.

Massive, of a brown-yellow colour with metallic lustre, associated with copper pyrites and transparent quartz, which is diffused through the mass, just as is seen in some of the pyrrhotine from Bodenmais in Bavaria.

One of the specimens presented a somewhat cylindrical concretionary form, surrounded by a kind of crust of mica-schist, composed of white mica and quartz with a few flakes of black mica.

Through the joints of some of the specimens layers of brown hæmatite were present, underneath which the pyrrhotine had a crystalline surface, but no distinct crystals could be found. It was thought that perhaps this mineral might contain nickel like the pyrrhotine from Kelfva in Sweden, and in the Gap mine in Pennsylvania, but none could be found in the specimen examined.

Marcasite.—In the form of nodules, smooth externally and converted into hydrated brown oxide of iron to the depth of about half an inch, but the interior still in part consisting of radiating crystals of marcasite. These nodules closely resemble those from the English chalk, evidently set free from a soft matrix, which was probably limestone.

Locality, Mount Tiebaghi.

Iron Pyrites.—The bisulphide of iron, $Fe\,S_2$.

In the form of fairly well developed cubes, both isolated and twinned, embedded in a slaty matrix from the Balade mine.

CHROMIUM.

Chromite.—The deposit of chromite or chromate of iron, commonly known as chrome iron ore, appear to be very extensively developed in New Caledonia, as well as of extremely rich quality.

The ore is met with in the form of alluvial deposits, as well as *in situ* in the serpentine and other rocks. I am informed that some of these alluvial deposits are now being worked on a large scale.

The majority of the specimens are massive, with a crystalline, granular, or lamellar structure; also in the form of more or less distinct lustrous black octahedra, closely packed together; often the ore is however stained with oxide of iron, and mixed with more or less steatitic matter. Some of the specimens yield as much as 66 per cent. of chromium sesquioxide.

One specimen made up of rather large imperfectly-developed iron-gray crystals—some nearly half an inch in diameter—was found to have the following composition:—

Analysis.

Silica and insoluble matter[1]	3·54
Alumina	4·51
Chromium sesquioxide	66·54
Iron protoxide	10·85
Magnesia	15·03
	100·47

The amount of chromium sesquioxide is unusually large; this is due to much of the iron protoxide being replaced by magnesia, the difference being due to the lower equivalent of the latter.

The above numbers approximate to the usual formula, $RO, R_2 O_3$.

Localities: Petit Mont d'Or, Coumac, Tiebaghi, Ouaghi, Ouaïlou, Baie du Sud.

Non-metalliferous Minerals.

Coal.—A specimen of the so-called anthracite, from Paita, near Noumea, came into my possession some time ago; it is in the form of a nodular mass, hard, earthy, of poor quality, and quite unfit either for ordinary domestic use or metallurgical operations.

Torbanite or "Kerosene Shale."—A specimen of torbanite or kerosene shale labelled "New Caledonia," exists in the Sydney University collection. I cannot however trace its history, and do not know from what part of New Caledonia it is supposed to have been brought. It has very much the same appearance and physical qualities as the New South Wales mineral which goes by the name of kerosene shale, although it is not a shale and does not yield kerosene, but a mineral oil of another kind.

Analysis.

Moisture / Volatile hydro-carbons	65·17
Fixed carbon	8·71
Ash	26·12
	100·00

The specific gravity is 1·238.

[1] Free from chromium.

Quartz.—In the form of fragments of colourless and transparent rock crystal, also as vein quartz, both white and tinged with various colours from the admixture of impurities, also in the form of white pebbles cemented together with brown oxide of iron, and mixed with some more or less decomposed mica, similar in appearance to the conglomerate from the New England diamond drift; collected by Mr. Pryor.

Chalcedony.—In flat pieces as if set free from fissures, often white outside like chalk flints; in colour various shades of brown and grey, also quite white as in carnelian. Collected by Mr. Rossiter, from Bouenoumala, Coumac.

Chert.—Of various shades of grey through brown to black, and much fissured, from Pointe Nea (?), near Noumea, apparently weathered out of a limestone rock; breaks with the usual square splintering fracture of chert, and is thus distinguished from flint and other forms of quartz, which break with a conchoidal fracture.

Opal.—One of the hydrated forms of silica. Of various shades of pale translucent brown, through grey to opaque white; some of the white varieties have a flesh-coloured tinge, and dendritic markings are common in all the specimens from Olande.

Calcite.—Calcium carbonate crystallizing in the rhombohedral system. There are several specimens of this mineral, some collected by Mr. Rossiter, from near Port la Guerre, which were mostly massive cleavage fragments. Mr. Pryor's collection from the Balade mine contained a few specimens crystallized in rhombohedra, and associated with small quartz crystals, taken from the joints of the mica-schist near to the deposits of copper ore. Also others apparently from the lode, intimately associated with copper pyrites.

Aragonite.—The variety of carbonate of lime crystallizing in the rhombic system; occurs of a reddish colour, presenting a coarsely crystalline structure on the fractured surface. The Balade mine.

Another variety is of a pure white colour, breaking with a fine crystalline fracture, and presenting much the appearance of alabaster, apparently derived from veins only a few inches across; where stained with iron oxide resembles somewhat the celebrated Algerian onyx marble. It apparently forms the vein stuff of certain portions of the copper veins.

Limestone.—Of a grey or dove colour, suitable for building or ornamental purposes; from the Baie de l'Oyselinat, Noumea, and from near Coumac. Collected by Mr. Rossiter. Mr. Pryor sent some specimens from an outcrop on the Diàhot River, near to the Balade mine. M. Ratte speaks of the great extent of this limestone, in his Catalogue of Minerals from New Caledonia, sent to the Paris Exhibition of 1878.

Dolomite.—Occurs in the veins with the copper ore intermingled with quartz. Balade mine.

Ankerite.—A variety of this mineral of a pale brown colour was found by Mr. Pryor, at the Balade mine, associated with quartz and copper pyrites; breaks readily into more or less lamellar pieces; contains manganese, as well as iron, lime, and magnesia.

Magnesite.—In the massive form, white, very dense, hard, and breaking with a conchoidal fracture; somewhat platy structure. A qualitative analysis shows it to be very pure.

A concretionary variety was contained in Mr. Rossiter's collection, labelled "Barytes from Bouenoumala," but on testing for barium none could be detected; the specimen had the same peculiarly reticulated surface and mammillated form as the magnesite found on the New South Wales diamond fields.

Garnet.—In some cases these are very well crystallized in the form of the rhombic dodekahedron, varying in size from $\frac{1}{20}$ to $\frac{5}{8}$ inch in diameter, most of them being $\frac{1}{4}$ inch.

Some are brick red and more or less opaque, whilst others are of a rich more or less transparent red, similar to the varieties used for jewellery.

The matrix is of two kinds; the one is a hard and very heavy schistose rock, composed of quartz, glaucophane, and some epidote; the other matrix is the rather uncommon variety of hornblende known as glaucophane. The faces of the larger rhombic dodekahedral crystals occurring in the glaucophane matrix are, as it were, built up of plates, so that the edges of the garnets would present, if cut through, a step-like section.

Usually each face of the garnet crystal is covered or in contact with a plate of mica; these mica crystals often extend beyond the face of the garnet in one or more directions. When the garnet is detached, a mould of it is left, beautifully lined with mica.

In some cases the garnets have crystallized in thin red films between the plates of mica; in other places the solid garnet crystals penetrate right through the layers of mica.

An analysis of the garnets was made with the following results: Sp. gr. 4·011.

Analyses.

	I.	II.	Mean.
Silica	38·10	38·21	38·15
Alumina	22·09	22·27	22·18
Iron protoxide	21·17	21·35	21·26
Manganese ditto	5·50	5·58	5·54
Lime	7·88	7·68	7·78
Magnesia	4·64	4·84	4·74
Loss on ignition	0·33	0·29	0·31
	99·71	100·22	99·96

which gives the following formula :—

$$3\,(FeO, MnO, CaO, MgO), 2SiO_2 + Al_2O_3, SiO_2.$$

Mica.—From the Balade mine, in the form of white silvery plates, some of which are about half an inch in diameter; but no well-developed crystals were present; by transmitted light the thicker plates present a dull greenish shade. Disseminated through some of the masses of mica are small red translucent crystals of garnet, and between the plates of mica films of garnet have occasionally crystallized out.

Plates of this silvery white mica are also found sparsely scattered through the glaucophane, especially in the glaucophane bearing the garnets; in other cases again, the mica is in excess, the glaucophane playing a subordinate part.

On analysis this mica was found to have the following composition:— Sp. gr. 2·938.

Analysis.

The following analysis was prepared on a very small quantity of the material, as it was only possible to collect a very limited amount of this silvery white mica; hence much importance cannot be attached to it:—

Water, combined	4·31
Silica	50·60
Alumina	25·28
Iron protoxide	3·47
Manganese protoxide	0·50
Lime	1·04
Magnesia	4·86
Potash	6·69
Soda	2·49
Loss	0·76
	100·00

Neither lithium nor fluorine were present.

The above results do not quite agree with any published analysis, nor do they afford a satisfactory formula; but it is apparently a variety of muscovite mica.

Another specimen of mica, apparently of the same kind, but of a rather darker colour and with less lustre, was examined with the following results:—

Analyses.

	I.	II.	Mean.
Water, combined	4·42	4·50	4·46
Silica	51·22	51·23	51·23
Alumina	27·29	27·41	27·35
Iron protoxide	2·45	2·75	2·60
Manganese	·34	—	·34
Lime	1·25	—	1·25
Magnesia	3·82	—	3·82
Potash	—	6·93	6·93
Soda	—	1·27	1·27
			99·25

The above corresponds to $2\left(\frac{1}{2}RO, \frac{1}{2} R_2O_3\right) 3\,SiO_2 + H_2O$.

Hornblende.—In the form of black and fibrous schistose masses, associated with white silvery mica and minute garnets, the three in alternating layers. From the Balade mine.

Pyroxene or *Augite.*—A rolled nodule, made up of confused masses of crystals. From Tonsjete Bay.

Glaucophane.—This rare variety of hornblende seems to be abundant in the neighbourhood of the Balade mine, as Mr. Pryor's collection contained several specimens some of which differ in colour, structure, and general appearance.

Only one specimen is crystallized; the crystals are in the form of dark blue-grey silky-looking prisms, seated upon a base of a micaceous schist, composed of mica, glaucophane, and garnets, with some quartz.

The prisms are about $\frac{1}{8}$ inch in diameter and from $\frac{1}{2}$ to $\frac{3}{4}$ inch long; they present no distinct faces, both the lateral and terminal faces being more or less rounded; the prisms are in fact merely bundles of lamellar or capillary crystals. Some of the prisms are completely isolated from the rest, whilst others are more or less interlaced and superimposed.

All the other specimens are massive, with a fibrous crystalline structure, of a peculiar violet colour, passing into a dark slaty blue on the one hand, and into a pale greyish colour on the other—the lighter violet varieties have a very beautiful silky lustre. The streak is of a pale bluish grey. Before the blowpipe it fuses, intumesces slightly, colours flame yellow, yields a dark glass; with sodium carbonate yields indications of manganese. Partly soluble in acids. $H = 6–7$.

This occurrence of glaucophane is of considerable interest, since it has hitherto only been met with in the Island of Syra, one of the Grecian Islands, and at Zermatt.

At Syra it is found associated with garnet, hornblende, and mica, in a mica-slate. The New Caledonia mineral is also associated with garnet and mica, in fact it forms in some cases the matrix of these minerals.

On analysis it was found to have the following composition:—

Analyses.

	I.	II.	Mean.
Water	1·42	1·34	1·38
Silica	52·71	52·88	52·79
Alumina	14·20	14·69	14·44
Iron protoxide	9·89	9·76	9·82
Manganese	traces	traces	traces
Lime	4·31	4·27	4·29
Magnesia	11·12	10·92	11·02
Potash	·95	·80	·88
Soda	5·15	5·38	5·26
	99·75	100·04	99·88

Sp. gr. 3·12.

For the sake of comparison I append the analysis of the mineral from the Isle of Syra, Dana's Descriptive Mineralogy, p. 244 (Schnedermann, J. pr. ch. xxxiv, p. 238), also an analysis by Bodewig of a specimen from Zermatt.

Analysis.

	Syra.		Zermatt.
SiO_2	56·49	SiO_2	57·81
Al_2O_3	12·23	Al_2O_3	12·03
FeO	10·91	Fe_2O_3	2·17
MnO	·50	FeO	5·78
MgO	7·97	MgO	13·07
CaO	2·25	CaO	2·20
Na_2O	9·28	Na_2O	7·33
K_2O	traces		
	99·63		100·39

Diallage.—A rolled nodule—no locality, probably from Tchio.

Serpentine.—The rock known as ophiolite or serpentine is very largely developed in New Caledonia, forming in fact mountain ranges; but the mineral known as noble or precious serpentine is not common.

Some of the serpentine has a very peculiar plum colour and plum-like bloom on its surface.

A specimen of the common massive serpentine was found to contain 0·78 per cent. of nickel oxide.[1]

Marmolite.—A foliated variety of serpentine of a green colour, translucent, in flat platy fibres, passing into an asbestiform variety, said to be associated with the chrome iron ore deposits at Tiebaghi on the west coast.

Talc.—Of a white silvery or pale green colour, highly lustrous, possessing a schistose structure, and containing long semi-transparent interlacing crystals of actinolite.

Balade mine.

Steatite.—Of a white colour, translucent, mixed with some serpentine; collected by Mr. Rossiter at Yate?

A green variety from Moira, also at the Balade mine.

Chlorite.—In masses of the usual dark olive-green colour, breaking with a crystalline fracture, presenting rosette-like groups of crystals; Balade mine.

Kaolin.—From Ombatche. Of a dazzling white colour, very friable, with a harsh feeling. A qualitative examination only was made of the specimen on its being found to be practically pure hydrated silicate of alumina, with but a trace of sesquioxide of iron.

With little preparation would probably be extremely well adapted for the manufacture of porcelain of the best quality.

[1] Nickel Minerals from New Caledonia. Jour. Roy. Soc., N.S.W., 1874, p. 80.

Allophane.—From a small island to the south of New Caledonia.

As an incrustation, of a pale blue colour; hardness about 3, brittle, is readily cut with a knife, yields a shining streak, adheres somewhat to the tongue, translucent, resinous lustre, fracture flat conchoidal.

Before the blowpipe it loses colour somewhat and becomes more or less white and opaque, splits up, but does not intumesce or fall to a powder; at first it imparted a pale green tinge to flame, infusible, in closed tube gives off water, and with microcosmic salt a skeleton of silica. When strongly ignited with cobalt nitrate a blue mass is left. Gelatinizes with hydrochloric acid.

Halloysite.—Of pale tints of grey, yellow, green, and brown—found in the crevices of the rocks at Yate.

At some future time I hope to examine some of these specimens rather more in detail; many of them appear to be well worth further investigation, but chemical analyses necessarily take a long time to complete.

In conclusion, my thanks are due to my friend Dr. Leibius, Senior Assayer of the Sydney Branch of the Royal Mint, for his kindness in making for me the seven analyses marked with his name, and to Dr. Helms for his assistance in analysing the chrome iron, the glaucophane and its included garnets and mica.

Notes on a Collection of Fossils from the Palæozoic Rocks of New South Wales.

Part I.

By R. Etheridge, Junr., F.G.S., &c., Corr. Member Roy. Socs., New South Wales, Victoria, and Tasmania.

[*Read before the Royal Society of N.S.W., 4 August, 1880.*]

INTRODUCTION.

When last in England Prof. A. Liversidge entrusted to my care, for presentation to the Geological Department of the British Museum, a collection of palæozoic fossils from various localities in New South Wales. Unforeseen circumstances, of a varied nature, have prevented my fulfilling a promise to describe these fossils, made to Prof. Liversidge, and I am now only able to partially carry this out, a portion of the collection still remaining to be worked out.

Two difficulties are pre-eminent in an undertaking of this kind. First, the unsatisfactory state of preservation of the specimens; and, secondly, the difficulties of identification which arise from the limited number of examples of any given form or forms. A proper comparison with known European or American species can hardly be effected, and sometimes results in the identification or opinion arrived at being either hasty or erroneous.

Class—ACTINOZOA.

Genus Rhizophyllum. Lindström, 1865.

(Kngl. Vet. Akad. Förhandl., 1865, No. 5, p. 287.)

Obs. Prof. De Koninck has described from the Upper Silurian rocks of Rockflat Creek, N. S. Wales, the internal cast of a coral very like that of a *Calceola*, but which he thinks should more properly be referred to the genus *Rhizophyllum*. This he has described as *R. interpunctatum*, but from the very nature of the fossil it will be at all times difficult to identify other specimens with it.

Prof. Liversidge has obtained from near Yass three specimens which equally resemble *Calceola* with that described by De Koninck. They have truncated bases, in one of which is seen traces of vesicular structure, so that in all probability our examples are also referable to *Rhizophyllum*, although from the much more contracted outline of the cone, as compared with *R.* (*?*) *interpunctatum*, I doubt very much if they should be referred to the latter.

One of the three specimens is more *Calceola*-like than the other two, which again resemble *Rhizophyllum* to a greater extent, and remind us very much of *R. Tennessee-ensis* (Roemer).

One of the more pyramidal specimens exhibits several scattered tubercules over the convex side of the corallum, representing the broken and scattered bases of rootlets. In both these examples the calices are filled with irremovable matrix, but in the more *Calceola*-like form the characters are to a certain extent exhibited. The central primary septum is visible, bordered on each side by from eighteen to twenty crenulations alternately larger and smaller.

Taking into consideration the difference in outline between our specimens and that of Prof. De Koninck, and the unsatisfactory figure of the latter, I am obliged to propose for the specimens gathered by Prof. Liversidge a distinctive name. If future researches should establish the identity of our respective forms, the name applied by me will of course become subservient to that given by Prof. De Koninck. For the present I provisionally describe these specimens as—

Rhizophyllum Australe. Sp. nov. Pl.—Figs. 7 and 8.

Sp. char. Corallum conical, having an almost semicircular section; the angles formed by the union of the convex and flat sides rounded; tapering to an apex more or less bluntly truncated, and slightly curved towards the convex side. Principal septum tolerably well marked, having on each side from eighteen to twenty other minor septal crenulations, alternately larger and smaller. Externally the surface of both faces is concentrically and coarsely wrinkled or ridged, with fine sharp lines or striæ between the wrinkles; here and there over the convex face of the corallum are a few scattered small tubercules, but no distinct trace of them is visible on the flat face. Structure apparently vesicular.

Obs. I should have liked to examine the microscopic structure of these corals more minutely than I have done, but the amount of material is too limited to permit of my breaking up either of the specimens; however, as it is, the worn truncated base of one distinctly shows traces of a vesicular structure. This would, following the researches of Dr. Lindström, recommend the reference I have made to the genus *Rhizophyllum* rather than to *Calceola* proper. This is also the view of my friend and co-writer Prof. H. A. Nicholson, to whom I submitted the corals when first they came into my hands.

Loc. Yass,—in rocks of Silurian age.

Class—CRUSTACEA.

Genus ENCRINURUS. Emmrich, 1845.

(Neues Jahrb. f. Mineral., 1845, p. 42.)

Encrinurus punctatus. Brünnich? Pl.—Figs. 11 and 12.

E. punctatus. Brün. Neues Jahrb. f. Min., 1845, p. 42.

E. punctatus. Salter. Mem. Geol. Survey, Gt. Brit. Dec. vii, 1853, No. 4, p. 6 (*for general synonomy*).

Obs. There are several pygidia and portions of a cephalic shield which so far as we can make them out appear to belong to this species rather than to any other. It has already been recorded as occurring in New South Wales, by Prof. De Koninck.[1] The best of the specimens (a tail) before me possesses all the characters of *E. punctatus*, the numerously ribbed axis, and smooth central space only occupied here and there by the tubercules, in this case four in number. I find on examining a series of specimens of this species in the British Museum that the number of these tubercules varies much in different individuals. Some from Dudley have four, as in the present case, others have five, and again six, whilst Salter describes as many as seven in *E. punctatus*. Furthermore, the latter states that each tubercule-bearing ring is separated by four other rings; but I find that this character also varies quite as much as the actual number of tubercules, two and three separating them quite as often as four.

Loc.—Bombala, in a highly fossiliferous shale of Silurian age.

Class—POLYZOA.

Genus PROTORETEPORA. De Koninck, 1877.

(Foss. Pal. Nouv.-Galles du Sud., pt. 3, p. 178.)

Obs. An infundibuliform example retaining the original basket-shape exemplifies in a marked degree the variability in the form and size of the meshes. At one point the fenestrules are quite oval, at another almost square, and fragments would well pass for distinct species. It is probably identical with that figured by Prof. De Koninck as *Protoretepora ampla* (Lonsdale), but differs to some extent from the typical illustrations given by Lonsdale.

Loc.—Singleton, in a light-coloured micaceous sandstone.

Class—PELECYPODA.

Genus ANODONTOPSIS. M'Coy, 1851.

(Annals. Nat. Hist., 2nd ser., 1851, vii, p. 53.)

Anodontopsis Australis. Sp. nov. Pl.—Fig. 6.

Sp. Char. Obliquely ovate, produced towards the posterior side; the anterior and posterior margins are convexly rounded, hinge-line straight, shorter than the width of the shell; beak sharp, prominent, and nearer the anterior than the posterior end. Immediately below the hinge-line are visible the elongated cavities left by the

[1] Foss. Pal. Nouv.-Galles du Sud.

cartilage plates, of which the posterior is somewhat the longer. Surface ornamented with concentric undulations or ridges, which broaden out towards the ventero-posterior margin.

Obs. So far as I am aware, the occurrence of the genus *Anodontoposis* has not hitherto been noticed in the palæozoic rocks of Australia, but I think we have in the present fossil a species of it. Setting aside the general resemblance in form to the described species of *Anodontoposis,* the identity of the above shell to this genus is indicated by the presence of the cartilage grooves under the hinge-line.

In form *Anodontopsis Australis* is between *A. quadratus* (M'Coy),[1] and *A. bulla* (M'Coy).[2] It is however more oblique and wider than either, and possesses a straighter hinge than the former; again, the obliquity is greater than in another species *A. angustifrons* (M'Coy).[2]

Loc.—Near Bombala, in a fossiliferous shale of Silurian age.

Genus Conocardium. Bronn, 1837.

(Lethæa Geognostica. Bd. i, p. 92.)

Conocardium. Sp. ind. Pl.—Fig. 9.

Obs. The collection contains a very interesting species of this genus, but unfortunately the only specimen. It has relations with *C. Hibernicum* (Sow.), but is distinct. It resembles the latter in the very truncate form of the end, but differs entirely by the total absence of any trace of the deep shelly border. Furthermore the tube which rises from the truncated end of *C. Hibernicum* does so from close under the hinge; in the present instance it is central, and the single line which proceeds from it to the ventral margin, representing the gape of the shell, here has a radiating line on each side of it. The produced end of the shell resembles that of *C. aliforme* (Sow.), but the end again differs. It is too much flattened and too heart-shaped for the latter species, and has too well-defined a periphery. We have only an imperfect single specimen, but in all probability this species will turn out to be a new type of the genus.

Prof. M'Coy has described an Australian species of *Conocardium,* viz., *C. Australis,*[1] which resembles our specimen in general form, and like it has an obliquely truncated end, although *C. Australis* appears to have no tubular prolongation, but in the place of it two impressed furrows radiating from the beak. In the present specimen there exists the broken base of a long tube, and below it two small radiating ridges. Another shell has been described from the Australian upper palæozoic rocks, which may be a species of *Conocardium*—the *C. ferox* (Dana), but it appears to be quite different from our fossil.

Loc.—Bungaralaby, Lake Bathurst. Carboniferous?

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[1] Brit. Pal. Foss., p. 272. [2] *Ibid.*, p. 271.

Genus PLEUROPHORUS. King, 1844.

(Annals Nat. Hist., xiv, p. 313.)

Pleurophorus Morrisii. De Koninck.

Orthonota? costata. Morris. Strzelecki's Phys. Descrip., N. S. Wales, 1845, p. 273, t. 11, f. 1 and 2.

Pleurophorus Morrisii. De Koninck. Foss. Pal. Nouv.-Galles du Sud, 1877, pt. 3, p. 281, t. 20, f. 5.

Obs. A small example of this species much incrusted with matrix, but with the shell preserved. I have not seen the internal hinge characters, but the general configuration would bear out Prof. De Koninck's reference to the genus *Pleurophorus* rather than to *Orthonota.*

Loc.—Wollongong, in sandstone; Carboniferous, or Permio-carboniferous?

Genus APHANAIA. De Koninck, 1877.

(Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 302.)

Obs. One valve of a shell before me (Figs. 3 and 4) appears to correspond to some extent with the characters of this genus, although not equally so with either of the species referred to *Aphanaia*, by Prof. De Koninck. From *A. Mitchelli* (M'Coy, *sp.*) it may be distinguished by the want of the posterior alate expansion, and the only valve we possess is much more attenuated towards the beak. It is this latter character and the general form which give it so much more the appearance of *A. gigantea* (De Kon.), and of which it may be the young. There is also a certain amount of resemblance between our shell and De Koninck's *Mytilus Bigsbyi.* Further specimens are required before this form can be definitely determined.

Loc.—Wollongong, in sandstone.

Class—GASTEROPODA.

Genus LOXONEMA. Phillips, 1841.

(Pal. Foss., Cornwall, Devon, &c., p. 98.)

Loxonema sulculosa. Phillips, Pl.—Figs. 1 & 2.

Melania sulculosa. Phil. Geology of Yorkshire, 1836, ii, p. 228, f. 1*a.*

Loxonema sulculosa. Morris. Cat. Brit. Foss., 1854, 2nd ed., p. 255.

Sp. Char. Shell elongate-conical, tapering gradually towards the apex, of at least seven whirls, and probably more. Whirls increasing in size gradually downwards, most convex a little below the middle, but each becoming flattened or somewhat concave just below the suture, which is moderately impressed. Surface of each whirl ornamented with from forty to fifty distinct, sharp, raised concavely-curved ridges or costæ, which are so disposed that if followed in a vertical line from whirl to whirl, assume a zigzag appearance, and are separated from one another by interspaces of at least three times their own width.

Obs. The presence of the "Gilbertson Collection" in the British Museum, wherein the type specimen of Phillips' *Loxonema sulculosa* is preserved enables me to point out the remarkably close resemblance existing between it and a shell from Bungaralaby (Pl. , f. 2). The only difference I am able to detect consists in the somewhat more slender form of the Australian variety; the type has four whirls preserved, the present specimen six. The great resemblance between the two consists in the flattening of each whirl just below the suture and in the characteristic ornamentation. In the former point both shells agree with *Loxonema constricta*, Martin, but otherwise differ. They also resemble *L. Lefebvrei* (De Koninck) to some extent, but in the latter the striæ or costæ are very much finer, more numerous, and less bent. Prof. Hall described some time ago and has lately figured several shells from the Devonian rocks of North America, which have a striking resemblance to the British and Australian forms, more especially the latter. *Loxonema pexata* (Hall)[1] is, indeed, very closely allied to our shell, whilst *L. terebra* (Hall)[2], although generally resembling it, is too coarsely ribbed. Again, *L. delphicola* (Hall)[3] is, although a more slender shell, almost equally near ours as *L. pexata*. These forms occur respectively in the Upper Helderberg, Hamilton, and Chemung groups of the North American Devonian, whilst *L. sulculosa* (Phill.), is in England a carboniferous limestone species. For the present, it appears to me that the most correct reference for the Australian shell will be to the latter, more especially as I have been able to make a direct comparison. They differ (so far as I can see) only in the Australian form having a little less robust aspect, and in possessing somewhat coarser ribs.

Loc.—Bungaralaby Creek, west side of Lake Bathurst.

In addition to the foregoing univalves there are some others, but all in such a sad state of preservation that it is impossible to atttempt an accurate determination. The best of these is an internal cast, probably that of *Pleurotomaria subcancellata* (Morris), from Black Head, Illawarra. The second which may be mentioned is a much waterworn example of a very large univalve, having somewhat the appearance of a *Maclurea*, but is in all probability a depressed and worn *Euomphalus*.

Loc.—Bungaralaby Creek, west of Lake Bathurst, in a dark blue limestone.

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[1] Pal. N. York, vol. v, atlas, t. 13, f. 17 and 18.
[2] *Ibid.*, t. 14, f. 6 and 7.
[3] *Ibid.*, t. 13, f. 19–25.

Class—PTEROPODA.

Genus Tentaculites. Schlotheim, 1820.

Obs. The late Rev. W. B. Clarke, F.R.S., &c., determined three species of this genus in the Australian palæozoic rocks,[1] viz., *T. annulatus*, *T. ornatus*, and *T. tenuis*, but as he did not attach authors' names to his specific determinations, it is difficult to understand whether he intended to imply by these names the species of Sowerby and Schlotheim respectively, or to regard them as new species of his own; but probably the former supposition is correct; it is however noteworthy that Prof. De Koninck did not describe any species of *Tentaculites* in his recent work on Mr. Clarke's New South Wales Fossils. Prof. Liversidge has forwarded to me two handsome specimens of a hard light-coloured rock crammed with the remains of a *Tentaculites*, Pl.—Fig. 10, but as most of the individuals composing these masses are preserved as sections of the tubes, and not in relief, it is difficult to express an opinion as to their identity; but in all probability they represent an undescribed form. The quantity in which this *Tentaculites* occurs in the bed from which the specimens before me were taken probably equals that described by Profs. James Hall and H. A. Nicholson, M.D. The former of these writers remarks[2] of *T. irregularis* (Hall)—"On this same specimen, which has a length of five inches and an average breadth of little more than one inch, more than five hundred individuals may be counted; and the layer beneath for the thickness of a quarter of an inch is composed almost entirely of these fossils, giving more than ten times as many as can be seen upon the surface. * * * * The layers thus covered are known in numerous places over an extent of country from thirty to fifty miles, showing the myriads of these creatures that flourished upon the bottom of the ancient sea." Prof. Nicholson states[3] that *T. fissurella* of the Devonian rocks of America is "remarkable as occasionally occurring in such extraordinary profusion as to actually form beds of limestone." In the Australian species the form of the shell is an elongated and slender one, the annulations are numerous, sharp, and project some distance laterally, but I have not been able to determine whether intermediate ornamenting striæ existed.

The preservation of this species in limestone has enabled me to study the structure of the shell-wall by means of thin sections prepared for the microscope. This subject does not appear to have been investigated to any great extent, one of the few writers who have described it being Dr. Richter of Saalfeld. In a paper on the Thuringian *Tentaculites*, he states that the structure was not apparent, unless certain columnar appearances visible may be so

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[1] S. Gold-fields, N. S. Wales, 1860, p. 286.
[2] Pal. New York, iii, p. 137.
[3] Man. of Palæontology, 2nd ed., ii, p. 52.

considered, although perhaps simple mineralization may account for it.[1] It will be seen from the following notes on the Australian *Tentaculites* that the latter of these suppositions is probably the correct one.

The late Mr. J. W. Salter also touched upon this subject in a paper on *Cornulites* and *Tentaculites,* read before the British Association in 1845. He described a laminar structure as existing at the thickened nodes or annulations of the shell, the texture being looser here than in other parts of the latter, thus showing a transition towards the structure of the genus *Cornulites.*[2]

The sections of the limestone forwarded by Prof. Liversidge, from the random manner in which the *Tentaculites* are scattered throughout it, naturally afford sections of the latter taken at various angles, longitudinal, horizontal, or oblique in various directions. All these agree in showing that the shell wall was distinctly traversed by small tubuli from the exterior, passing inwards, which, although generally distributed over the whole surface, are much more crowded together in the annulations or circular costæ of the shell. These tubuli, so far as I have examined them, do not penetrate quite through the shelly matter, but become lost in its substance. I have not observed any trace of septa. When the annulations of the tubes are cut through in vertical section they are seen to be densely crowded with these tubuli, which are not necessarily all of the same length, and in each annulation they appear to tend from the upper and lower margins towards the centre. When any fragment of the shell contained in the general mass of the limestone is sectioned parallel to the longer axis, the tubes are seen as small crowded black dots. Pl.—Fig. 10*a*.

The internal and external walls of the shells, or tubes, of *Tentaculites*, correspond with one another, the inner following the outline of the exterior, as will be seen by a glance at the enlarged figure of a portion of one side of a tube.

In one or two examples there does appear to be a division of the shelly matter into laminæ, which would give colour to Dr. Richter's observations on the presence of the columnar structure, but as it certainly is not present in all, I do not wish to lay too much stress on the point.

I hope to return to this interesting and neglected subject at a recent date, and compare the structure exhibited by these sections with that of *Tentaculites* from the Wenlock limestone and other Silurian deposits of various areas. This subject is one of very considerable interest, because by it we shall probably be able to satisfactorily determine the systematic position of the genus. For many years

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[1] Zeit. Deuts. Geol. Gesellschaft, 1854, vi, p. 279.

[2] Brit. Assoc. Report for 1845, pt. 2, p. 57.

Tentaculites was looked upon as the shelly case or tube of a *Tubicolar Annelide*, now it is regarded by the best authorities as the shell of a Pteropod.

If the structure exhibited by the Australian *Tentaculites* should prove to be constant throughout the genus, the following description of that of a Pteropod by the late Prof. Queckett will show how little the two have in common. In most of the genera of this class the shell[1] "is as transparent as glass, and almost structureless; but in a large species of *Creseis* it was found to be composed of two layers, the outer opaque and minutely granular, the inner somewhat fibrous, the fractured edges in most cases exhibiting portions of fibres, which extend beyond the outer granular layer." Should this *Tentaculites*, on further examination, prove to be specifically distinct from the numerous ones which have hitherto been described, I would propose for it the name *T. Liversidgei.*

Loc. and horizon—Holmes' Paddock, on the Macquarie, below Wellington, in a limestone of Silurian or Devonian age?

Class—BRACHIOPODA.

Genus SPIRIFERA. (Sowerby.) Phillips.

Spirifera disjuncta. J. de C. Sowerby, Pl.—Fig. 5.

S. disjuncta. J. de C. Sow., Trans. Geol. Soc., 1840, v, 2 ser., t. 53, f. 8, t. 54, f. 12 and 13.

S. disjuncta. Davidson, Mon. Brit. Dev. Brachiopoda, p. 23, t. 5, f. 1–12, t. 6, f. 1–5.

Obs. Prof. Liversidge has forwarded a white sandstone from near Wallerawang containing the casts of numerous Spirifers having all the appearance and characters of the above species. The hinge line of these shells is long, and the whole surface of the valves including the fold and sinus is crossed by a large number of fine, more or less equal, radiating ribs. The lengthened hinge and surface striation remind one much of both *Spirifera striata*, of the Carboniferous rocks, and of *Sp. disjuncta*, of the Devonian. As regards the first it approaches particularly the variety *attenuata* (J. de C. Sby.), but after consulting my friend, Mr. T. Davidson, F.R.S., I think the most appropriate reference will be to the Devonian form.

Spirifera disjuncta was first indicated as an Australian fossil by the late Mr. T. Stutchbury, who found it at Pallal, as stated in one of his Reports on the Geological Survey of N. S. Wales.[2] Since then the late Rev. W. B. Clarke obtained the species at Bowenfels, Sofala, Collins' Flat, &c.[3] The occurrence of *S. disjuncta*

[1] Lectures on Histology, 1854, ii, pp. 335–36.
[2] Parliamentary Blue Book, Dec. 1854, p. 19 (folio, London, 1855).
[3] Recherches Foss. Pal. Nouv.-Galles du Sud, 1876, p. 100.

at Wallerawang tends to bear out the views of Prof. Liversidge as to the age of certain beds in that neighbourhood. In a paper "On the Iron Ore and Coal Deposits at Wallerawang,"[1] he describes the deposits of iron ore as situated some six miles from that place, and near the junction of the Coal Measures with the Upper Silurian or *Devonian beds*, which there crop out to the surface.

Loc. and horizon—Walker's Point, Wallerawang, in a white sandstone of Devonian age.

Genus ATRYPA. Dalman.

Atrypa reticularis. Linn.

Atrypa reticularis (Linn. sp.) Davidson, Mon. Dev. Brach., p. 53, t. 10, f. 3 and 4.

Obs. A small cast of one of the many varieties of this species occurs in the fossiliferous sandstone of Bombala. It does not call for any further remark. *A. reticularis* had been previously met with in the Silurian rocks of Duntroon, and the Devonian of Yass and Kempsey, N. S. Wales,[2] and in the Devonian series of Bindi, Victoria.[3]

Loc. and horizon—Bombala, in a mudstone of Silurian age.

A. reticularis. var. *aspera.* Schlotheim.

A. reticularis, var. *aspera* (Schlotheim sp.) Davidson, Mon. Brit. Dev. Brach., p. 57, t. 10, f. 5–8.

Obs. A single and badly preserved example of this variety exists in Prof. Liversidge's collection. It is interesting only from the fact that, so far as I know, it has not hitherto been noticed in New South Wales rocks, although met with in the Devonian beds of Bindi, Victoria.[4]

Loc.—Collins' Flat, N. S. Wales.

Genus STROPHOMENA. Blainville.

Strophomena rhomboidalis. Wilckens, sp. ?

S. rhomboidalis (Wilckens, sp.) Davidson ,Mon. Brit. Sil. Brach., p. 281, t. 39, f. 1–21, t. 44, f. 1 *a* and *b*.

Obs. The collection contains two specimens of *Strophomena* from Bombala. The first of these appears to be one of the many forms of the above species, although from its decorticated nature some of the characters are obliterated. Mr. T. Davidson, F.R.S., has

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[1] Trans. R. Soc. N. S. Wales for 1874, p. 82.
[2] De Koninck, *loc. cit.*, pp. 33 and 97.
[3] M'Coy, in Couchman's Progress Report, Geol. Survey, Vict., for 1877, p. 158.
[4] M'Coy, *loc. cit.*, p. 158.

been kind enough to examine this and he considers the determination to be correct, but taking into consideration the state of preservation it is perhaps better to express the determination with a note of interrogation. The specimen is small, about the size of the variety figured from Craighead Quarry, near Girvan,[1] and somewhat resembles this. The radiating semi-ribs are numerous and crossed by a large number of the fluctuating crenulations seen in *S. rhomboidalis.*

The species has been met with before in New South Wales, at Rock Flat Creek, by the Rev. W. B. Clarke.[2]

Loc. and horizon—Bombala, in a mudstone of Silurian age.

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[1] Monograph, *loc. cit.*, t. 44, f. 1 *a* and *b*.
[2] De Koninck, *loc. cit.*, p. 28.

Explanation of Plate.

Fig. 1. *Loxonema sulculosa* (Phillips). The type specimen contained in the "Gilbertson Collection," British Museum, from the English Carboniferous limestone, for comparison with Fig. 2.

Fig. 2. *Loxonema sulculosa* (Phillips)? Carboniferous or Devonian? Bungaralaby Creek, Lake Bathurst.

Figs. 3 and 4. *Aphanaia ?* sp. ind. Wollongong sandstone. A much weathered cast. Fig. 3, exterior of valve. Fig. 4, reverse showing portion of hinge.

Fig. 5. *Spirifera disjuncta* (J. de. C. Sby.) A drawing taken from several casts of the exterior of the central valve. White sandstone of Walker's Point, Wallerawang. Devonian.

Fig. 6. *Anodontopsis Australis* (R. Etheridge, jun.) A characteristic specimen of one of the valves. Near Bombala. Silurian.

Figs. 7 and 8. *Rhizophyllum ? Australe* (R. Etheridge, jun.) Near Yass. Silurian. Fig. 7. the largest specimen, obverse and reverse, showing the truncated base, and, in the former case, the rounded side of the corallum, in the latter the flattened side. The convex side shows here and there the broken root-like bases of tubercles, Fig. 8. A smaller and shorter example, in which the interior of the calice and the septal ridges are well shown.

Fig. 9. *Conocardium*, sp. ind. A mutilated specimen from Bungaralaby, Lake Bathurst. Carboniferous? Showing a view of one valve, and the truncated end of both valves united.

Fig. 10. *Tentaculites*, sp. Portion of the weathered surface of a specimen, showing the manner in which individuals are scattered through the mass. Near Wellington.

Fig. 10*a*. An enlargement of a portion of one of the walls of a specimen, showing the tubuli clustered at the annulations of the shell, × 100.

Figs. 11 and 12. *Encrinurus punctatus* (Brünnich)? In a fossiliferous shale of Silurian age. Near Bombala.

N.B. —All the figures are of the natural size except Nos. 11 and 12, which are × $1\frac{1}{2}$.

Jour. Roy. Soc. N.S.W. Vol. 14 1880

Palæozoic, Fossils, New South Wales.

A Comparison between the Prospect and Kenny Hill Schemes, proposing a high-pressure Water Supply for Sydney.

By Mr. F. B. Gipps, C.E.

[*Read before the Royal Society of N.S.W., 6 October, 1880.*

The great importance and the general interest of the question of water supply to this metropolis are, I venture to say, a sufficient apology for engaging the attention of the members of this Society, while bringing before them a comparison between the Prospect and Kenny Hill schemes, embracing a high-pressure water supply for Sydney. If in the elaboration of my argument there should seem to you any grave defect of reasoning, I trust that you will not permit any such error of judgment to prejudice you against an impartial and unbiassed verdict on the whole merits of the comparison. The following prominent features in the two schemes commend themselves to an attentive consideration :—1. The area, storage capacity, and cost of the storage reservoir. 2. The length, character, and cost of the conduits, and their duty. 3. Their commercial and economical qualifications. 4. Their sanitary influence respectively.

Storage Reservoir.

The most essential point in a storage reservoir is its impounding capacity, or its actual volume available for the intended supply. This quantity must be estimated from its surface level to that level at which the outlet conduit is entered. The depth left for settlement of suspended matter must vary according to circumstances, such as the area of the reservoir or the purity of the water supplying it; but it should be carefully estimated, as any unnecessary depth simply implies waste of water. The reservoirs of Philadelphia forcibly illustrate the influence of different supply sources on this deposit or settlement, for whilst the supply that from the Schuylkill only gives $\frac{1}{4}$ inch annually, that from the Delaware River gives 1 inch. The accumulation of mud in the reservoirs of the New River Water Company, London, averages ·96 inch annually. The duty of a storage reservoir is to provide not only for any accident which may happen to the supply conduit and for the emergencies of different seasons, but more especially for the exhaustive demands on it of several consecutive years of excessive drought. The eminent hydraulic engineer, Mr. W. Clark, in his Report on the Commissioners' scheme for water supply to Sydney, in recognition of the above essential qualification of its storage reservoir, thus alludes to it:—"The prominent feature of the Upper Nepean Scheme is the Prospect reservoir; it resembles the Yan Yean in Victoria, and affords, like it, a very abundant artificial storage, so essential in a climate liable to extended periods of drought."

Prospect Reservoir.

The physical features of the Prospect Reservoir are thus described by Mr. Moriarty, Engineer-in-Chief of the Harbours and Rivers Department, and the designer of the Upper Nepean Scheme:—"The valley of Prospect at this part spreads out into a broad flat basin, bounded on the north-west and south by a semicircular amphitheatre of low hills forming the divisio aquarium of Botany Bay, the Hawkesbury, and Port Jackson. Lower down, where it is proposed to place the dam, the valley contracts to about 1¼ mile in width." The area and capacity of the reservoir are thus represented by the same writer:—"The reservoir at Prospect, when filled, would cover an area of 1,291 acres, and would contain in all 10,635 million gallons; but as it is proposed to draw off only the upper 25 feet of water, the quantity available for supply would be reduced to 7,110 million gallons, equal to nineteen months' supply for the present population of Sydney and suburbs, allowing 100 gallons per head per day. It would be of about the same superficial area as the Yan Yean, but considerably deeper, and would contain a much larger quantity of water. When full the water in the reservoir would stand at 195 feet above sea level, and might be drawn off to 170 feet above it, or 31 feet above the top level of the Crown-street reservoir. The whole of the valley consists of a strong retentive yellow and gray clay—the most suitable of all materials for the bottom of a reservoir—and there is abundant material of the same kind in the neighbourhood for the formation of the dam." The Prospect dam, as measured, is 7,904 feet long and 80 feet high. The cubical contents of its embankment, inclusive of clay puddle, is estimated at 2,044,450 cubic yards, and its cost, according to Mr. Moriarty, at £176,136, inclusive of pitching and outlet works. Its base, after removal of the surface soil, will rest on an even bed of firm shale. The price of the land is valued at £10,400.

Kenny Hill Reservoir.

The site of the Kenny Hill reservoir is near the summit of the western flank of the dividing range of the Nepean River and Campbelltown Valley, being the same range which the present canal line traverses to the Prospect reservoir. The canal line enters it at about 18½ miles from the starting point, in the Nepean

River, and the Campbelltown and Camden Road passes through it. In descending this flank towards the Nepean River the landscape displays numerous watercourses converging into a broad flat valley with small swamps in the centre, whilst lower down the view embraces a grand panorama of the Nepean Valley, with the Blue Mountain Range beyond. The comparative flatness of the upper valley in contrast to the steepness of its bounding ridges, and the gradual approach of two long concentric spurs from the north and south on the western flank of the proposed reservoir, offer unusual advantages for the impounding of a deep capacious storage lake. The reservoir at Kenny Hill when full would cover an area of 1,048 acres, after deducting 50 acres for a long spur which intrudes in the centre. Its capacity is estimated at 8,549,000,000 gallons, of which 8,110 million gallons would be available for supply. At its highest level the surface of the water would be 330 feet above sea level; when reduced 60 feet, to its lowest supply level, it would still have 56 feet higher elevation than Paddington reservoir, and 129 feet higher than Crown-street reservoir. The bed of the principal valley of the reservoir consists of retentive yellow and red clays, which, from superficial observation, appear to vary in thickness from 8 to 12 feet, and to rest on or cover a stratum of impervious ironstone. The occurrence of this stratum, owing to its resistance of all the weather influences which have tended to erode the surrounding strata of sandstone and shales, probably accounts for the formation of this flat valley at such an elevation. There is an abundance of excellent clay in the spur intruding in the centre of the basin for the construction of the dam, for which, from its vicinity, it offers especial advantages, whilst its removal would add considerably to the capacity of the reservoir. The dam, as measured, is 6,400 feet long and 80 feet high. The cubical contents of its embankment is estimated at 1,736,860 cubic yards, exclusive of 256,000 cubic yards of clay puddling. Its cost, inclusive of pitching and outlet works, in comparison with Mr. Moriarty's estimate of the Prospect dam, should not exceed £172,000 whilst the land would probably cost about £7,000.

Comparison of Reservoirs.

In comparing the Prospect and Kenny Hill reservoirs, it appears that the former has a larger area by 243 acres; that it impounds 2,086 million gallons in excess of the latter, but that its actual available capacity is 1,000 million gallons less; that its dam is longer by 1,500 feet, but the cubical contents are only 51,590 yards more; that its highest surface level is 195 feet above sea level, and its lowest available supply level 170 feet above sea level, between which levels it is estimated that 7,110 million gallons will be stored, whilst the highest surface level of the latter is

330 feet above sea level, and its outlet or lowest available level 270 feet above sea level, between which levels it is estimated that 8,110 million gallons will be stored; so that whereas in the former there will be a clear waste of water equivalent to three million gallons, in the latter there will be no waste, there being only sufficient depth left to provide for settlement of sediment. It cannot be termed imaginative in assuming the storage of three thousand million gallons unavailable for supply as a great waste of water, as, under any circumstances, such a great depth as 50 feet for settlement of suspended matter would be excessive, whilst with a water which, by careful analysis, only gives 4·6 grains of solid matter to the gallon it is still more beyond the limits of requirement. Supposing the amount of sedimentary matter at 2 grains per gallon and a constant inflow of seventy million gallons daily, it would take five years to cover 400 acres with 1 inch of deposit. The cost of the construction of the dams and outlet works and the purchase of the land shows only a difference of £7,000 in favour of the Kenny Hill dam and works. Both dams are solid embankments. The water from the Prospect reservoir is drawn off through a water tower into a tunnel excavated in solid rock through the hill on which the dam abuts on its eastern end. The outflow from the Kenny Hill reservoir is through a valve tower into two 36-inch pipes, laid in a tunnel of solid rock, which, entering the Nepean side of the dividing range, debouches on the Campbelltown side.

Service Reservoir.

Connected with the Kenny Hill storage reservoir, forming, in fact, a very important accessory to it, is a small supply or service reservoir, situated in a valley at its south-eastern extremity. Its area, as at present surveyed, is only 44 acres, which, with an average depth of 12 feet, would impound 144 million gallons. Its dam would be 1,120 feet long, 33 feet high, and would contain 66,000 cubic yards of earthwork. Its cost is estimated at £15,000. The surface level of this reservoir would be 372 feet above sea level. Its southern extremity almost intercepts the present canal line, at about 18½ miles from the entrance of the Nepean River tunnel. Whilst, in ordinary seasons, owing to the constant inflow from the canal, it would be capable of supplying the utmost requirements of Sydney, during seasons of drought it would only be taxed to the extent of three million gallons daily for the supply of Waverley and Woollahra. As the smallest quantity of water, during eight years of careful observation, which would have passed into the Prospect reservoir from the Nepean and Cataract Rivers in any one month was measured at 63 million gallons (followed next month by a flow of 1,382 million gallons), it may justly be presumed that an available storage of 120 million gallons would be amply sufficient to meet the demands of Waverley and Woollahra under any contingency. But to place its storage qualification for the above purpose beyond all doubt, the area of the supply reservoir might be largely increased by constructing a dam lower down in the valley 50 feet high, which I believe would impound an area of over 120 acres, or, with an average depth of 20 feet, 650 million gallons of water. The length of the dam, from observation, would not exceed 1,900 feet, whilst its cost would probably be less than £30,000.

Conduits.

The next feature in the respective schemes which claims our attention is the length, character, and cost of their conduits. Quoting from Mr. Clark's report, the length and character of the conduit *via* the Prospect reservoir may be briefly summarized as follows:—Tunnels, $10\frac{3}{4}$ miles; open conduit, $34\frac{1}{4}$ miles; aqueduct, 3 miles; pipes, $13\frac{1}{4}$ miles; reservoir, $1\frac{3}{4}$ mile,—giving a total distance of 63 miles. By a weir in the Upper Nepean River, $11\frac{1}{2}$ feet high and $436\frac{1}{2}$ feet above sea level, it is proposed to divert its waters into a tunnel 4 miles 35 chains long, capable, with a two feet fall per mile, of discharging 85 million gallons daily into the Cataract River, at Broughton Pass. Shortly below this point a weir $10\frac{1}{2}$ feet high will conduct the water into a tunnel 1 mile 64 chains long, capable of discharging 85 million gallons daily. From the point of exit of this tunnel, at 6 miles 30 chains from the Nepean River, the supply is conducted by open canal and a series of aqueducts and tunnels into the Prospect reservoir. These works are to be sufficiently capacious to allow of a delivery of 84 million gallons daily. Since Mr. Clark's report, I believe it has been determined to increase the size of the Cataract tunnel and canal as far as Prospect, so as to allow of a daily delivery of 120 million gallons. Beyond Prospect reservoir the conduit works are arranged as follows:—The supply, at the rate of 29 million gallons daily, is conducted by open canal for a distance of 3 miles 58 chains, and by an iron aqueduct for 7,989 feet, to a small reservoir. Thence a siphon pipe, 48 inches in diameter and 4,628 yards in length, capable of supplying $14\frac{3}{4}$ million gallons daily, crosses the valley of Duck Creek, and is followed by 1 mile 37 chains of open canal, which discharges into another small reservoir. From this point, at 10 miles from Sydney, and at an elevation of 164 feet above sea level, a 42-inch cast-iron pipe is proposed, capable of supplying Crown-street reservoir with twelve million gallons daily, whence it is intended to pump one million gallons to Paddington and 500,000 gallons to Waverley heights daily. The cost of these works, inclusive of a compensating dam below Menangle Bridge across the Nepean, is estimated by Mr. Clark at £1,170,768. That Mr. Clark regarded these estimates as approximate only may be inferred from the following remark on the lined and unlined construction of the canal:—"To bring these variable quantities into estimate with exactness is impossible, and even with requisite surveys and borings they can only be approximately ascertained. These surveys and borings could not be completed during the period of my visit." These estimates seem to have been based on the inference that most of the shale which the canal line crosses is horizontal, and even bedded, and of an impermeable character, rendering the lining of the conduit unnecessary. But there is much reason to doubt the correctness of such an assumption, as though in a bore-hole the shale beds might seem to lie horizontal, and be consequently impervious, there are good reasons for distrusting the evidence of sight. First—the shales occur on the flank of a ridge forming an anticlinal axis, which, wherever exposed, shows a most decided dip of the strata on either side; secondly—they are nearly always composed of thin alternate layers of hard and soft strata; and lastly—they are subject to rapid decomposition, owing to their being impregnated with salt, so that, unless lined, on being exposed to the atmosphere and a constant current of water they would admit of considerable leakage, and would be quickly undermined and eroded. The line of canal enters this shale at Woodhouse Creek, at 13 miles from the starting point in the Nepean River, and will probably traverse it for at least 15 miles. The whole of this distance will probably require masonry lining, which, at £2 7s. 6d. per cubic yard for side-walls and £2 per cubic yard for bottom pitching, will add £391,500 to the above estimate, raising the cost of construction of the above works to £1,562,258.

Conduit *via* Kenny Hill.

The character of the supply conduit for 18½ miles, where it enters the service reservoir of the Kenny Hill scheme, being identical with the Prospect conduit, needs no further description. From this point it consists entirely of cast-iron pipes. It is proposed to conduct the supply from the service reservoir through two 36-inch pipes, which for the first 691 yards are laid in a tunnel piercing the dividing range of the Campbelltown and Nepean valleys, and which about 1,000 yards further on join the supply mains from the storage reservoir, at a short distance below the end of the long tunnel. These mains, also 36 inches in diameter, having their valve tower near the centre of one of the principal eastern valleys of the reservoir, penetrate the above dividing range through a tunnel 2,500 yards in length. Shortly after leaving the tunnel, the pipe-line strikes nearly straight across the country in a north-easterly direction till it joins the surveyed pipe-line from Prospect, 8½ miles from Sydney. The country traversed is singularly well adapted for piping, presenting no engineering obstacles worthy of consideration, as may be seen from a study of its section. At about 400 feet from the tunnel the pipe-line crosses a small watercourse, 70 feet wide, with steep banks, by an aqueduct 130 feet long, and then ascends the gradual slope of a long spur running south-east from the prominent conical hill on the eastern boundary of the reservoir. By a slight deviation of my survey I believe it would cross this spur without any tunnel; but in any case it would only require a short tunnel of about 400 yards, after which it would descend for over $1\frac{1}{2}$ mile—the valley of one of the feeders of Bunbarry Curran Creek. At about 4 miles from the point of inlet it would cross Bow Bowing Creek, 70 feet wide, with steep banks on either side, by another aqueduct 130 feet long; and, half a mile further on, the pipe-line would cross under the Southern Railway line, at an elevation of 135 feet above sea level. It would then gradually ascend the western slope of the George's River Range, traversing this range till it runs out at the junction of Bunbarry Curran Creek with George's River—a little over 10 miles distant from the inlet tower. Here it crosses the river, which is 180 feet wide, with steep banks on either side, by an aqueduct 500 feet long, reaching from the top of the left bank to the top of the right bank, at a height of 40 feet above the river bed, and about 45 feet above sea level. At this point, owing to pressure of time and the dense nature of the scrub, I was compelled to abandon my survey; but from inquiry I am led to believe that there is no difficult country intervening between the next crossing of George's River, 4 miles (by map measurement) further on, and situated a short distance above the junction of Harris Creek, where, according to description, an aqueduct of about 700 feet would be required to span the river. The pipe-line would then ascend a low ridge and join the Prospect line at a point $27\frac{1}{2}$ miles distant from Kenny Hill reservoir, and $8\frac{1}{2}$ miles distant from Crown-street reservoir, at an elevation of about 64 feet above sea level. The length of the pipe-line from the Kenny Hill storage reservoir to Paddington is estimated at 31 miles, whilst that from the supply or service reservoir is estimated at 1 mile further, giving a total length of 32 miles of pipes.

Estimated Cost of Conduit.

The estimated cost of this line of conduit is as follows—Tunnel, 691 yards from service reservoir, at £15 per running yard, £10,365; tunnel, from storage reservoir, of 2,500 yards, at £15 per running yard, £37,500; cast-iron piping, 36-inch diameter, for the first section of 10 miles, 1 inch thick, capable of standing a safe head of 333 feet, or 144·20 lbs. per square inch, actually to be exposed to a head of 246 feet, or to a pressure of 106·25 lbs. per square inch, weight 946 tons per mile, cost, at £6 15s. per ton, landed in Sydney, £6,385 10s. for a single line of piping, or £12,771 for a double line; lead for joints, £800; trenching and laying, £3,000; carriage, at 30s. per ton, £2,838; giving a total of £19,409 per mile, or of £194,090 for 10 miles. For the second section of 6 miles across the valley of George's River the thickness of the pipes would be increased to $1\frac{1}{4}$ inch, capable of bearing a safe head of 412 feet, or a pressure of 178·39 lbs. per square inch, whilst it will only be actually exposed to a maximum pressure of 330 feet head, or of 142·89 lbs. per square inch; weight, 1,159 tons per mile; cost, at £6 15s. per ton, £7,823 5s. for a single line, or £15,646 10s. for a double line of piping, which, with lead at £800, laying at £3,000, carriage at £3,476, gives a total of £22,922 10s. per mile, or of £137,535 for the whole section. For the last section of 16 miles to Sydney the thickness of the pipes would be $1\frac{1}{8}$ inch capable of bearing a safe head of 375 feet, or a pressure of 162·38 lbs. per square inch, whilst the maximum pressure it will be exposed to is a head 295 feet, or of 127·74 lbs. per square inch; weight, 1,023 tons per mile; cost, at £6 15s. per ton, £6,905 5s. for a single line, and £13,810 10s. for a double line of pipes, which, with lead at £800, laying at £3,000, and carriage at £2,558, gives a total of £20,168 10s. per mile, or of £322,696 for the whole section. Besides the above sums, at least £500 per mile will have to be added for air and reflux valves, gates, &c., amounting in all to £16,000, also £35,000 for aqueducts, £10,000 for purchase of land, and £4,500 for clearing. The entire cost of the Kenny Hill scheme is estimated as follows:—Tunnels and conduit to service reservoir, as per Mr. Moriarty's estimate, but including an additional sum for 5 miles of lining, £207,906; service reservoir to impound 650 million gallons, dams, &c., £30,000; storage reservoir to impound 8,110 million gallons, dams, &c., as per Mr. Moriarty's rate of estimate, £172,000; land £7,000; tunnels from reservoirs, £47,865; 32 miles of a double line of 36-inch cast-iron pipes, £654,321; valves, gates, &c., £16,000; aqueducts, £35,000; cost of land and clearing, £14,500; reservoir at Petersham, £4,800; reservoir at Waverley, £8,000; reservoir at Woollahra, £5,000; compensation reservoir at Menangle at £10,000; survey and contingencies, £20,000; total, £1,232,392. The above safe-heads for the pipes are quoted from Beardmore's tables, and according to Humber they can be constantly exposed to that pressure.

Duty of Kenny Hill Scheme.

In an average season the service reservoir would be able to sustain the whole required supply, whilst the maximum duty of the pipes would be equal to the delivery of 23 million gallons daily to Crown-street, or 19 million gallons to Paddington, or 14·7 million gallons to Woollahra, or 10·07 million gallons to Waverley, whilst their minimum duty during a very protracted season of drought, when we might suppose the service reservoir reduced to 341 feet above sea level, and the storage reservoir to 280 feet above sea level, would be a delivery of two million gallons daily to Waverley, one million gallons to Woollahra, besides seven million gallons to Paddington, or 10·4 million gallons to Crown-street. The duty actually proposed for the pipes is to deliver during ordinary seasons, when the supply will balance the demand, two million gallons daily to Waverley heights, 325 feet above sea level, one million gallons to Woollahra, 276 feet above sea level (which one pipe would manage in fourteen hours), and thirteen millions of gallons to Paddington, 214 feet above sea level. The surplus water from the canal would flow over a weir on the western flank of the dam into the storage reservoir. During seasons of drought, or as soon as the supply failed to satisfy the demand, the service reservoir would be relieved from Paddington supply, and would be called on only to satisfy the three million gallons supply to the high level reservoirs. Even with a much more severe and protracted drought than we have on record, the water in the service reservoir, with such a moderate demand on it, would not be reduced in level by 20 feet, nor the surface level of the storage reservoir by 30 feet, but the pipes would even then be capable of delivering three million gallons to Waverley and Woollahra, and 8·6 million gallons to Paddington. But with the data supplied us of the rainfall on the watersheds of the Upper Nepean and Cataract Rivers, and of the actual flow of water in those streams, the result of careful observation extending over many years, it would be absurd to suppose such a contingency. The accompanying section shows at a glance the actual quantities which can be discharged into the various high and low service reservoirs in Sydney and suburbs from different levels in the supply and storage reservoirs at Kenny Hill.

Comparison of Conduit Lines.

In comparing the conduit lines of the two schemes, the advantages in favour of the Kenny Hill scheme line will be at once apparent. It is shorter in distance by nearly 13 miles, and therefore so much the less liable to damage; its cost of construction is less by £329,866; it has two channels of supply, so that a certain delivery would be ensured; it could be constructed in a much shorter time (by at once proceeding with the dam of the supply reservoir at Kenny Hill a supply from the Cataract River could actually be delivered in Sydney in two years, as a line of pipes could easily be laid within that time); but its great advantage, which far transcends all others, is that it will be able to deliver an ample supply to Waverley, Woollahra, the North Shore, in fact to the whole of Sydney and suburbs, by gravitation only. Whereas the duty of the Prospect scheme, as elaborated by Mr.

Clark, ensures only a low service supply of twelve million gallons daily to Crown-street, of which $1\frac{1}{2}$ million gallons is pumped to Paddington and Waverley, that of the Kenny Hill scheme ensures a supply of three million gallons daily under any cirumstances, to Waverley, Woollahra, and the North Shore, and in ordinary seasons thirteen million gallons besides to Paddington reservoir, which quantity would not be reduced to ten million gallons except under the most extraordinary and improbable circumstances. The advantage claimed for the Prospect scheme is its power of increment, at a much smaller cost. According to Mr. Clark's report, twenty-nine million gallons are brought within 14 miles of Sydney. To deliver this quantity into Crown-street would require two 36-inch diameter pipes in addition to the present proposed works, which, at the same estimate as for the pipe-line from Kenny Hill, would cost £293,265. But with one additional 36-inch pipe, the service reservoir at Kenny Hill could supply Crown-street with thirty-four million gallons, at an extra cost of £335,160 10s., or Paddington reservoir with 28·5 million gallons, during a favourable season, or the storage reservoir during a dry season, when reduced to the 300-feet level, could supply 27 million gallons to Crown-street, and 21 million gallons to Paddington; so that the actual difference would not exceed £41,895 10s. Whilst, with a yet larger increment, this difference would be reduced to a minimum, as the whole conduit as far as Prospect would have to be enlarged. That the pipes are equal to the duty accredited to them may be inferred from the fact alluded to in Mr. Moriarty's report—that in Boston two pipes of 30-inch diameter, with a grade of $2\frac{1}{2}$ feet per mile, deliver ten million gallons daily. Exception has been taken to this long line of piping, that if the water was brought to a sudden stop the great pressure from the water ram would infallibly burst the pipes, and that even the static pressure of such a column would require a thickness of over $1\frac{1}{2}$ inch to withstand it. Both of these objections seem to me more imaginative than real, as by a careful application of air momentum, relief and influx valves, such as always accompany the laying of a long pipe-line of large dimensions, the different thickness I have allowed would be amply sufficient. In fact, it would be just as reasonable to suppose that a sudden slip into the open canal would, by blocking it up, cause it to overflow and tear away its banks and devastate the country beneath it as to suppose such an objection to a long pipe-line. Mr. Clark, in his report on Mr. Manning's Loddon and Wingecarribee scheme, evidently anticipated no such danger, though twice the head and a longer pipe-line was proposed, for he writes as follows :—" The better plan in such a system is to control the flow of the water by a sluice placed at or near its upper end, while the pipe is left entirely open at its lower end. By this arrangement all danger of bursting a pipe by sudden stoppage of the flow of water would be avoided." Such a line of pipes would not be like an experiment, liable to failure, as we have had sufficient experience of their use in every part of the world. Melbourne is supplied from the Yan Yean by pipes having a head of over 300 feet. San Francisco has 34 miles of large supply piping, whilst in London itself some of the mains have a pressure of over 200 feet head. Relief valves could be so fixed that in no portion of the supply pipe need the pressure under any contingency exceed a fixed minimum, whilst reflux valves would prevent it emptying, supposing a fracture to occur in the deeper undulations. To diminish still further any chance of accident, an escape valve or sluice-gate might be fixed at the crossing of George's River, so that, on any fracture occurring nearer Sydney, any undue pressure from the closing of valves too suddenly might be obviated by allowing the water to escape into George's River; whilst, by using self-acting shut-off valves at the reservoirs, as adopted in the Dublin and Liverpool water-works, the flow into the piping from the reservoirs would be stopped in a few minutes after the occurrence of the fracture. Such ingenuity has been lately exercised in the invention of stop-valves that they can be adjusted at a distance by an electric wire, so that any chance of accident to a pipe conduit is now very remote.

Commercial and Economical Qualifications.

Whilst the Prospect supply is only available for domestic purposes, and that on a limited scale, at the high levels, and at increased rates, that from Kenny Hill could be applied to many manufacturing and commercial purposes, to hydraulic elevators and motors, to brewing and chemical arts, to compressing air for tramway motors, to watering the streets, to public fountains, and last, but by no means least, to prevention of extensive fires. J T. Fanning, C.E., in his excellent work on hydraulics, remarks that the general introduction of public water-works on the constant supply system, with liberal pressure in the mains and house services throughout American towns and cities, has encouraged its liberal use in the household, so that the legitimate and economical domestic use of water is of greater average in the American cities than in any other country of the present time. Further on he adds that the use of water is steadily being popularized for its mechanical use. So that here is an argument greatly favouring a high-pressure in preference to a low-pressure system, that the artisan after completing his day's work will have during his leisure hours a power always available by which, with but little trouble, he can add considerably to his earnings. Whereas if water was only available for domestic use, as supplied from Crown-street, thirty gallons a head would be amply sufficient; if it could be supplied for the above purposes in sufficient quantity delivered at a high level, more than sixty gallons a head would be used, reducing the rates and adding largely to the income of the Corporation.

Sanitary Influence.

The last subject of consideration, but one of primary importance, is the sanitary influence of the respective schemes, by which I mean their power to remove or disseminate the causes of disease. With such an assurance of the purity of the waters of the Cataract and Nepean Rivers, the sources of supply, as their favourable analysis affords, it may be assumed by some that to question its healthiness is mere waste of time. So assuredly it would be, provided the same condition of water could be assured in its outflow into the city reservoirs as in its inflow from the sources. Unfortunately this is impossible, for in flowing through such a long line of canal as by the Prospect scheme, with such little fall for several miles, exposed to the heat of an almost tropical sun, it must soon acquire properties favourable to the development of vegetable and animal organisms prejudicial to human health, to which the surrounding air even would add numerous specimens. Amongst representatives of fauna we may anticipate the presence of protozoa, embracing infusoria and rhizopoda; of annuloida, embracing scolecida and rotifera; and of numerous classes of annulosa. The representatives of algæ will probably include bacteria, oscillatoria, desmidia, diatoma, conferva, some of them containing elements of decay, and, in union with other matter, of putrefaction. Most of these specimens, both of fauna and algæ, are microscopic, from which we may infer the great importance of submitting all tests of drinking water to a careful microscopic examination, besides trying them by chemical analysis. I have examined water, both from river and tank, clear and tasteless, which would undoubtedly have been pronounced pure by chemical analysis, yet which, on being submitted to the microscope, was seen to contain parasitic worms and bacteria in such quantities as to render it unfit for drinking purposes. In the air we have yet another fruitful source of disease, which, by wind, rain, and otherwise, may be conveyed into the waters of an open canal. From the observations of M. Miguel and M. Pasteur, it appears that eggs of bacteria and spores of moulds are always present in the air in considerable quantities. This is confirmed by Professor Tyndall, who adds that a few cubic centimètres of air will, in most cases, bring infection into the most diverse infusions; whilst Professor Huxley, in detailing his experiences, gives a note of warning which should deeply impress all those interested in the health of this and future generations. He assures us that "Diseases caused by what people, not wisely, call germs—*e.g.*, splenic fever, pig, typhoid, &c.—are caused invariably by bodies of the nature of bacteria. They could be cultivated through twenty or thirty generations, and then when given to the ox or pig would invariably give rise to the characteristic disease. We have no reason even to imagine that any body capable of causing disease by such means could be anything but a body having the nature of bacterium. Now, bacteria are just as much plants as mushrooms, cabbages, &c., so that we know under what condition they flourish and what they will do. Bacteria can be sown in Pasteur's solution just as easily as mustard and cress can be sown in the soil; in it they thrive, and the liquid becomes milky, and there is no known method by which, if one drop of Pasteur's solution was placed in a gallon of water its constituents could be estimated. Every cubic inch of such water would contain 50 or 100,000 bacteria, and one drop of it would be capable of exciting a putrefactive fermentation in any substance capable of undergoing that fermentation. For purposes of public health the human body may be considered as such a substance, and we may conceive such water as pure as may be as regards chemical analysis, and yet as deadly as prussic acid as regards the human body." Hence we may conclude that it would be very advisable to shorten the line of open canal as much as possible, in order to preserve the purity of the water, especially with the terrible example of the effects of a few germs on the population of Lausanne, in Switzerland. The typhoid fever which devastated that town, infecting a quarter of its inhabitants, was traced to germs from fever patients carried into the supply stream some miles above the town, which was exposed to all the oxydising influences of sun and to filtration through sand, and yet produced such deadly results. The shortening of the canal line can only be effected by the adoption of the Kenny Hill scheme, which, in comparison with the Prospect scheme, has an open conduit of about 12 miles, against 37 miles, or a clear difference in its favour of 25 miles. The high-pressure of the former scheme would also be a powerful aid in completely flushing the sewers and in rapidly disposing of any accumulated injurious matter in the side drains of the streets.

Lime Treatment.

The unfavourable comparison of the bright sparkling waters of Loch Katrine with the Canterbury water after treatment by Clarke's lime process, when, on being subjected by Professor Tyndall to a searching electric light, the former appeared to have been taken from a muddy pool, whilst the latter was clear and transparent, together with the experience in Dublin and elsewhere that some kinds of bone disease are due to want or deficiency of lime in water, these two facts should impress on us the necessity of applying a lime process to any scheme of supply which may be determined on for Sydney.

Recapitulation.

I have now completed my comparison of the two schemes, and it remains only to recapitulate the principal features in an epitomised form, that their comparative merits may be more clearly and concisely defined.

Prospect.

1. Area of reservoir, 1,291 acres; storage capacity available for supply, 7,110 million gallons; dam, 7,904 feet, or 119 chains 75 links long; height, 80 feet; total estimate of construction, inclusive of purchase of land and outlet works, £186,536.

2. Pumping and gravitation combined deliver 12 million gallons daily, 1 million of which is pumped to Paddington, ½ million to Waverley, and the remaining 10½ million gallons supply Crown-street, 141 feet above sea level, Newtown, and low service reservoirs; estimated cost, £1,562,268.

3. Length of conduit 63 miles; including 10¾ miles tunnelling, 37¼ miles open canal and aqueducts, 13¼ miles of piping, and 1¾ miles reservoirs. The canal beyond Prospect has only 6 inches fall per mile, which is insufficient to provide for sediment and to prevent the growth of noxious vegetation. Such a long line of canal is liable to accident from land-slips, to contamination, and will most probably cost much more than estimated, owing to the expensive lining required for a considerable distance.

4. An accident to the dam would entail the stoppage of all traffic on the southern line for some time, besides leading to great loss of life and destruction of property.

5. Low delivery at Crown-street reservoir, necessitating pumping stations at different smaller reservoirs to reach the high levels of the city and suburbs, and also the use of large mains and reticulating pipes.

6. Unequal water rates between high and low levels, arising from the necessity of pumping.

Kenny Hill.

1. Area of large impounding reservoir, 1,048 acres; storage capacity available for supply, 8,110 million gallons; dam, 6,400 feet long and 80 feet high; estimate of construction, inclusive of purchase of land and outlet works, at Mr. Moriarty's rates, £179,000; storage capacity of auxiliary or supply reservoir, 800 million gallons; cost, £30,000.

2. Gravitation only, which delivers through a double line of 36-inch pipes 2 million gallons to Waverley, 325 feet; 1 million gallons to Woollahra, 276 feet; and the 13 million gallons to Paddington, 214 above sea level, at an estimated total cost of £1,232,392.

3. Length of conduit, 50¼ miles, including 9¼ miles tunnelling, 11 miles of open canal and aqueducts, 32 miles of piping. The canal has nowhere less than 2 feet fall per mile, and from its comparative shortness is less liable to accident or contamination. The pipe-line being double will render any prolonged stoppage of supply from accident very improbable, while with proper precaution in construction, experience has shown that it is the safest kind of conduit, and, after construction, the most economical.

4. An accident to the dam would entail but little danger to life or property, as, by a tunnel connecting the reservoir with a wide lateral valley on the north, it could be completely drained into the Nepean River.

5. High delivery at Waverley, Woollahra, and Paddington, with its attendant advantages of smaller mains and reticulating pipes, and fewer distributing reservoirs at North Shore and elsewhere in the suburbs.

6. An equal rate for both high and low levels, and no risk to machinery.

7. Owing to want of pressure, this scheme would be ineffectual in preventing extensive conflagration, it would offer no benefits to manufacturers or mechanics, and would have barely sufficient head for flushing sewers.

7. Owing to its high pressure, this scheme would offer great advantages for extinguishing fires, for the manufacturer and mechanic, for public fountains and hydraulic lifts and motors, and for flushing sewers.

In the above synopsis it appears that the Prospect scheme only supplies twelve million gallons per diem, for a constructive expenditure of £1,562,268; but, supposing it had to raise the same quantity of water to Paddington, Woollahra, and Waverley, as the Kenny Hill scheme, its pumping expenses would be increased by at least £112,235. For true comparison the Kenny Hill scheme should be credited with this sum, showing a clear balance in its favour of £442,101. By using wrought-iron pipes instead of cast-iron a saving of from 15 to 20 per cent. would be effected. Considering the great importance of my subject, I fear I have been able to devote too little time to its elaboration, having taken but little over six weeks in surveys, preparations of plans, and of this paper, which has involved long and abstruse calculations. But I was compelled to hasten this paper, as the contracts are already let within sight of the spot proposed for the service reservoir at Kenny Hill, so that any further delay in preparing it might render it futile for any practical purpose. I would conclude with the earnest hope that it may have the effect of arousing united action to thoroughly investigate the merits of my proposed modification of the Upper Nepean scheme, while there is still time to do so.

Discussion.

Mr. Trevor Jones, City Engineer, in opening the discussion, said :—The subject of water supply for the city of Sydney is one that has been before the public for so long a time that unprofessional spectators may well be pardoned for exclaiming, "Enough of dispute—let us have a little water," and for being a little shy of entertaining new projects. The engineering faculty, both here and in the adjoining Colonies, while regretting the low head of pressure at which the Sydney supply is to be delivered after bringing it a distance of 63 miles, are fain to admit that the question has been handled in a scientific manner by trained men. When I entered on the duties of City Engineer, although recognising the talent that had conceived the scheme and the scientific manner in which it had been considered, I so far shared in the general regret that I made weekly incursions into the country with the faint hope that some modification would occur to me whereby a large storage capacity might be combined with a greater head of pressure than that obtainable by the Prospect scheme, for, notwithstanding the concurrence of Mr. Clark with the Commission that the pressure due to Crown-street is satisfactory, I am of a different opinion on that point, being satisfied that nothing short of a head of 90 or 100 feet above Crown-street will suffice for the numerous requirements of a city like Sydney. The present pressure is insufficient for extinguishing fires without the intervention of an engine—it is insufficient for the actuating of hydraulic lifts, cranes, lathes, pumps, grinding machinery, &c., &c. If 100 feet be added to the Crown-street level, then for all levels up to those of the heights of Darlinghurst, Surry Hills, Redfern, Balmain, Petersham and Paddington the fire-engine could be dispensed with, and firemen, instead of rushing to the fire station, harnessing horses, or raising steam and racing dangerously through the streets, would run to the fire, where the hose-reel would probably be all ready, brought there by their comrades living near the station, attach the hose and at once deluge the fire in its incipient state.

My examination of the country was brought as far down the line of conduit as Campbelltown without success, when Mr. Gipps showed me his proposal. In his company I visited the spot, and came to the conclusion that, althought it might not turn out so favourable as made out by Mr. Gipps, it might afford the desired delivery of 100 feet above Crown-street. Having read that Mr. Moriarty had said—I think in this very room—that notwithstanding his selection of Prospect as a site for a reservoir, if as suitable a site were found at a greater elevation he would be in favour of its adoption, I waited on that gentleman, and found that he had caused a survey of the Kenny Hill neighbourhood to be made, and on the face of that he pointed out that the capacity was not so great and that the dam would require twice as much earthwork as that at Prospect, and such other defects as that. I, who had only made a casual visit to the place, was fain to be content to abandon the idea. Since that time Mr. Gipps has re-surveyed the site, and made such alterations and new dispositions—and also discovered a pipe-track, which, being scaled on the plan, is shorter by 12 miles than the course by Prospect—as to make it appear that the Government might well bestow a careful survey on both reservoir and pipe-track, as, if proved correct, at least the coveted 100 feet extra pressure would be obtainable, along with ample storage capacity. The action of the City Council (whom I have the honor to serve in the capacity of City Engineer) on the previous day, in deciding to wait upon the Government with the request that they will cause the claims of the scheme to be thoroughly investigated, has decided me to refrain from any expression of opinion that might in any way tend to embarrass the inquiry; indeed, any opinion I might express as to the accuracy of the survey, the capacity of reservoir, contents of dam, or of the levels, would have no value (having only made two brief visits to the spot) when set against actual survey. I have recently learned that the Department has made such modifications as will increase the head at Crown-street —I am not aware to what extent; but, as the head at Prospect is only 170 feet, and from which must be deducted the necessary fall for delivery at a distance of 22 miles, the difference obtained must fall very short of the desired 240 feet above high-water-mark—in fact it can at most not be 10 feet. Not being able to bear testimony to the correctness of Mr. Gipps's levels or survey, I feel bound to state that his estimates give me the impression of being cut too low; but I do not think it necessary for him to show a saving in expenditure, as if the scheme is otherwise feasible the additional head obtained would, according to Mr. Clark's estimate, be cheaply procured at a cost of £150,000 over that of the Prospect scheme, that sum being the present value of the cost of pumping to the higher levels, without allowing anything for the more efficient fire service, power for machinery, and the use of smaller street mains. I also feel impelled to testify that, so far as I could investigate the site, the Kenny Hill Valley seemed to have a good sound bottom of retentive clay, and ample material for both dam and puddle-wall.

In the above I will, no doubt, be held to have subordinated the scheme for the irrigation of the county of Cumberland to that of the supply of Sydney. As City Engineer I hope I may be held excusable in this for two reasons—viz., that the primary object of the scheme was a gravitation system for Sydney; secondly, that I have from an actual experiment at Bacchus Marsh, in Victoria, found that the estimated cost per acre for preparing the ground for irrigation was such as to deter proprietors from using it. If in my eagerness for a high-pressure scheme for this city I have allowed myself to be troublesome to those carrying out the present scheme, my excuse is that having for over twenty-four years witnessed the beneficial results of such a scheme in about five towns of Victoria, I am very loth to be content with a low pressure system for this city. It would have been far more congenial for me to have concurred in what had been so liberally and well done by the Government, and to have done all I could to have promoted their views. It has been said that the introduction of a higher pressure in the mains would be disastrous in bursting them. This is true with regard to some of the mains laid in ground impregnated with salt; the iron in some of the pipes in such localities has been structurally changed to a kind of plumbago, and the present pressure is gradually destroying them; but the general run of pipes are the same thickness as those sustaining 300 feet head of pressure at present in Melbourne. Another source of annoyance would also make itself felt if a high-pressure obtained in the pipes—viz., the bursting of lead services. Every iron service-pipe is attached to the main by a length of

2 or 3 feet of lead piping, and this, instead of having been of the weight of 9 lb. per lineal yard, is only 5 lb. and no doubt a great many of these and some of the iron service-pipes, which are greatly corroded, will give way.

I have been told that the public will attach great importance to what I say this evening; I cannot but regret this, as however favourable I may be to the examination of the claims urged, I cannot speak of them professionally, not having laid a level or theodolite on the ground, and am here as a private citizen anxious for the securing of the best scheme, and the City Council have intimated their intention of urging on the Government the closest scrutiny of them before it is abandoned.

Mr. C. STUART said he had a resolution to propose which would bring the consideration by the Society of Mr. Gipps's scheme to a head, yet without restraining discussion upon the same. Of course the Commissioners who recommended the scheme now being carried out deserved every credit for the attention they had given to the subject, and the Government also deserved every credit for having obtained the services of an accomplished hydraulic engineer like Mr. Clark to guide their counsels on the same subject. Mr. Clark, as a scientific man had done his duty, and those at the head of the Treasury had done theirs; but there were two or three ways in which an engineer might be employed in determining upon the merits of a water scheme. There might be three or four schemes propounded to him to say which was the best, or he might be taken all over the country and then asked to find a site and route for himself, or, as was done in the present case, he might have an elaborate scheme put before him for his decision. He (Mr. Stuart) scarcely thought that justice was done to Mr. James Manning's scheme, for although the Government afforded some slight assistance, yet he did not have the assistance which was necessary to enable him to put the thing before a man like Mr. Clark in a proper scientific or professional form. Whatever Mr. Manning's project was worth, it was not presented to Mr. Clark in a way that he could make anything out of it. But now they had a scheme put before them which did look remarkably plausible—and Mr. Gipps appeared to have very patriotically resigned his official appointment in order that he might develop it. The works which were to be undertaken for the supply of water to Sydney were to last for centuries, and to be of such magnitude that a scientific body like the Royal Society should use its best efforts to have the best scheme adopted. Such an undertaking was not one to hurry over; and although the public might be impatient of the discussion the subject was causing, there could be no doubt the people would reap the benefit of it. He should therefore propose—"That the Royal Society of New South Wales, being fully alive to the great importance of a water service which should provide a plentiful supply of pure water to the city of Sydney and the rapidly increasing suburbs, and at the same time secure to the present and future manufactories of the Colony the invaluable advantage of hydraulic power, are of opinion that the Government should at once proceed to the full examination of the water scheme propounded by Mr. F. B. Gipps."

The CHAIRMAN pointed out that, unless the by-law of the Society ruling that notice must be given of every resolution were suspended, he could not receive the motion proposed by Mr. Stuart.

Mr. STUART then moved that the by-law the Chairman had referred to be suspended.

The CHAIRMAN remarked that the discussion on the question of water supply had better proceed, and the resolution which had been proposed thereon could be dealt with afterwards.

Dr. BELGRAVE congratulated the Society upon the action it had taken to ventilate the long deferred and highly important question of water supply, and bring it forcibly before the Government and the Country. When the question came before Parliament last session he had been under the impression that the Prospect scheme was to give high pressure by pumping, but he had since ascertained that it was only proposed to pump half-a-million gallons to Waverley and a very small quantity to Paddington, so that the service in Sydney would be essentially a low pressure one, which was totally unequal to the requirements of the city. The great advantages of a high-pressure scheme had been pointed out by Mr. Norman Selfe, in a paper which he read to that Society, showing that water was a motor of considerable value which had been well used in Victoria in the direction of mechanical appliances. It was also a motor which would increase its value to the community, and, if the high pressure system advocated by Mr. Gipps were carried out, would well serve many manufactories at Liverpool and other places equally well adapted for their establishment. At such places where there were great natural facilities for the development of industries a high-pressure service carried along the route Mr. Gipps proposed would be a powerful motor. With a low-pressure service we should be entirely deprived of revenue from that source, and this was a matter well worth consideration. The difference in the cost of the length of dams and capacity of reservoirs contemplated by Mr. Gipps's scheme was very satisfactorily met by the great economical advantages of his plan. Assuming that it would cost twice as much at the outset as the scheme at present accepted by Government, the difference would ultimately be made up by the value of the water as a motive power. There were some disadvantages no doubt, as Mr. Jones had pointed out, that would accrue from the adoption of the high-level service. He had no doubt that a different reticulation of the service-pipes would be required, and probably the renewal of the larger pipes; but this expense would be amply compensated for by the superior advantages arising from the use of water as a motive power. There were one or two questions, however, that he would like to be informed upon by Mr. Gipps. One of these was whether he had included in his estimate the £10,000 or £20,000 which would probably be required for the renewal of pipes, which would have to be replaced during the next few years; and if so, how many miles of piping he calculated would require tc be renewed. The use of open canals for the conveyance of water was very objectionable, as he had been convinced by his observations in London and elsewhere, for they were open to pollution by the most offensive matter, which became a fruitful source of disease, from much of which those districts supplied with water by enclosed pipes was free. The purity of the water, therefore, was of vital importance, and should be carefully borne in mind in discussing a scheme like that proposed. In that scheme, however, he did not notice that any reference was made to the position of his supply reservoir, or how much the reservoir was capable of extension, although for miles around there was a great watershed capable of impounding any quantity of water; indeed, the country was singularly suitable for a vast reservoir. He believed the regulations of the Society would not permit him to second the resolution, however much he might approve of what it proposed, yet he considered that Mr. Gipps's scheme called for further investigation by authorities having no connection, either by personal acquaintance or by professional interests, with those concerned in the question.

Mr. Goodlet and Mr. A. Dean spoke in favour of Mr. Gipps's scheme.

Dr Belgrave observed that the adoption of a high-pressure service would reduce fire insurance premiums to half the present rates. Such would be the certainty of extinguishing conflagrations within narrow limits. There would also be fountains in our public gardens, which people who had travelled on the Continent missed so much. There would be the means of watering the streets by means of pipes much more effectually than was done now. The tramcars might be driven as they were in Paris, by atmospheric pressure, instead of by the antiquated, noisy, steam motors; and in many other respects the high-pressure supply had very much to recommend it.

Mr. Jones said the ordinary pipes were for foundry pipes made strong enough to bear a high-pressure strain, and except some of those pipes, which were of very inferior iron, and those which were laid down in the early days of the Colony, none of the present reticulation would have to be taken up if the high-level proposal were carried out.

Mr. Gipps, in reply, said: I propose as briefly as possible to answer in detail the various objections which have been raised against my proposed modification of the Prospect scheme. It has been contended—1. That owing to the side and base of the storage reservoir at Kenny Hill being composed chiefly of shales the water would invariably be cloudy or muddy, and that in flowing direct through pipes it would be delivered in that condition to the different service reservoirs in Sydney; whilst by flowing through a long canal, as by the Prospect scheme, all matter in suspension would have time to settle, and the water would be delivered into Sydney in a much clearer condition. 2. That for irrigation purposes the Kenny Hill scheme is vastly inferior to the Prospect. 3. That a gravitation scheme from Bull's Hill reservoir has already been rejected by the Commissioners, owing to the expense of iron piping.

In answer to the first objection, I would point out that the physical and geological character of the country of the Prospect reservoir is nearly identical with that of the Kenny Hill reservoir, so that to admit of the correctness of the above deduction we shall have to assume that 5 miles of canal will be sufficient for settlement purposes. But experience in our river system has proved that the water in some of those which have as low a fall as 1 foot becomes muddy, and at times undrinkable or unfit for any domestic purposes, owing to heavy storms 60 or 80 miles higher up the stream. Supposing, however, such a desirable condition could be guaranteed by allowing the water to flow through an open canal, it must then be admitted that the accumulation of sediment in the bottom of the canal would necessitate its constant cleansing; and I think it must also be allowed that there is, in a sanitary point of view, a much stronger objection to the extension of such an open conduit, owing to the increased opportunities for the contamination of the water. In my remarks on the sanitary influence of the two schemes I drew especial attention to this fact; and I would add yet a few more experiences, the more deeply to impress its importance. It is now ascertained beyond doubt, through the patient investigations of Professors Krupp, Kolbe, and Pettenkofer, that cholera, dysentery, and yellow fever are propagated through the microscopic fungi from fæces of patients, and that they can be especially generated in a tropical climate, and through water can spread disease and mortality to a most alarming extent. So that the very channel which would, according to Professor Smith, favour the clearness of the water in one way, in another would expose it to the more deadly influences of contamination, aiding the putrefaction of the various organic substances, both animal and vegetable, which it would be impossible to keep out of an uncovered conduit. In direct answer to this objection, I think I can convince you that the water supplied from the Kenny Hill Reservoir would be clearer as well as purer. In the first place, it would flow direct into the service-reservoir in ordinary seasons, and the shales being laid with brick or masonry, the water for delivery would be almost as clear as when it entered the Nepean tunnel. Even storms would hardly affect the clearness of the water, owing to the rocky character of the sources of the Nepean to the point of supply. During heavy continuous rains a small catch-drain round the top of the reservoir would collect all drainage or denudatory matter and carry it off into another valley. One other sanitary advantage from high pressure I forgot to dwell on sufficiently—that of flushing sewers. A few years since, the Health Officer in California officially reported that 25 per cent. of the recent extraordinary mortality was due to the condition of the sewers, resulting from insufficient power for flushing.

With regard to irrigation, it appears to me the Kenny Hill scheme has a much greater advantage than the Prospect, as both the Nepean and Campbelltown valleys can be irrigated from the first, whilst the advantages for manufacturing purposes for both those places is incalculable. The supply for Sydney being drawn during ordinary seasons from the service reservoir, the whole of the surplus inflow, after providing for evaporation, would be available for irrigation or manufacturing purposes to the above places. The last objection, that a gravitation scheme from Bull's Hill Reservoir had been refused owing to the expense of piping, appears to me no reason why, with iron at such a much lower rate, it should be objected to now. From Mr. Moriarty's report to the Commissioners, it seems that the Bull's Hill reservoir was capable of storing only 4,636 million gallons, and that its surface level was 260 feet above sea-level. The area would be 535 acres, the dam $96\frac{1}{2}$ feet high, and would contain $2\frac{1}{4}$ cubic yards of earth. These are all such different conditions to those offered by the Kenny Hill scheme, having its reservoir 110 feet higher, its dam 16 feet lower, and its impounding area so much larger, as hardly to admit of comparison.

In answer to Dr. Belgrave, Mr. Gipps said that in his opinion the present pipes would do for his scheme. Self-acting valves could be applied to shut off too heavy a strain. The supply might be increased to any extent by the addition of 10 or 20 feet to the walls of the reservoir, for the contour of the country was most favourable to conserving an immense quantity of water. The extra outlay would not be large.

Mr. Poolman seconded Mr. Stuart's motion for the suspension of the by-law to allow the original resolution to be put to the vote. The motion was lost.

On Wells in Liverpool Plains.

By T. K. Abbott, P.M., Gunnedah.

[*Read before the Royal Society of N.S.W., 3 November, 1880.*]

Some few years ago, at the request of my friend Mr. Russell, I was induced to institute a series of inquiries with the view of ascertaining the depth at which the underground springs may be relied upon as permanent in the district in which I reside. I regret that I met with but little success at first, and found existing in the minds of the proprietors of runs a disinclination to impart the information desired. Gunnedah being nearly centrally situated in the Liverpool Plains, and the general character of the plains in the interior of this Colony being somewhat similar, I thought that if I could obtain reliable data as to the depth at which water was found in wells throughout this district, it would be a fair index of what might and probably would occur in other parts of the Colony where the surroundings were like. So little success did I meet with, and so slowly did the information I required come to hand, that this paper which should have been completed and read in 1877 has dragged "its slow length along" to the year 1880. Indeed, on many of the stations in this district I am mainly indebted to the free-selectors for whatever information I possess.

With a view of making the inquiry as complete as possible I caused to be printed the following paper, which was distributed throughout the district :—

1. Name of station ?
2. Position of well, parish and portion ?
3. Size of well ?
4. Character of surface ?
5. Notes of all strata passed through, including thickness and character to first water ?
6. Quantity and quality of first water, also remarks on its appearance, *i.e.* how it came—in rock, gravel, or otherwise ?
7. Like account of strata and water to bottom of well ?
8. Dip and amount of strata ?
9. State instances (if any) which have come to your knowledge where brackish water having been first struck has been passed through and fresh water found ?
10. Instances of the reverse (if any) within your knowledge ?

The object of these questions was to obtain reliable facts as to the flow of water beneath the surface of the earth. It is well known that rivers taking their rise in the mountains flow for many miles and are eventually lost in the plains. If it could be ascertained beyond doubt that these rivers may be reached by well-sinking or boring it would impart confidence in the permanence of the springs. I believe the area of the watershed of which the water passes Bourke, the Darling, Namoi, Barwin, Gwydir, and all their tributaries, is about 140,000 square miles. The average rainfall at and about Bourke would be 16 inches; thence towards the main range it gradually increases until the high stations have about 40 inches. "In Queensland, from which the Darling at Bourke drains very largely, the rainfall," Mr. Russell says, "would, I should think, be fully 40 inches." Estimating however the rainfall throughout at 16 inches, and reducing it over this large area in the usual way for evaporation and soakage, and in order to avoid the possibility of error reducing what remains by one-half, the river at Bourke *should be* 200 feet deep and 200 yards wide, and flow all the year round! At Bourke the river *is sometimes* nearly dry. Where then does all this water go?

It is with a view of assisting as far as I can over a limited area towards decisively solving this problem that I have undertaken the collection of facts regarding wells in this district. I can only at present supply a paper upon wells in the county of Pottinger. The information I possess respecting any other of the counties in this neighbourhood is of too meagre a character to submit.

I have obtained, by means of the forms I had printed and circulated, information regarding about 100 wells in the district of Gunnedah, and accompanying this paper I have prepared a plan showing the position of over 90 wells scattered over an area of country amounting to upwards of 2,000,000 (two million) acres. Those who have visited Liverpool Plains are of course aware that the largest and richest of the far-famed pastoral principalities are situated in this county. The plains are generally level; black soil; here and there isolated basaltic ridges of no great elevation; islands of timber and scrub, and sometimes sandstone formations occur.

The object I had in view in preparing the map showing the position of the wells, the general features of the country, and in the schedule attached giving the depth, strata, and all the information I possess, was to place before the members of this Society thoroughly reliable data—so far as it goes—upon which those more able than I may build up theories. My mission has been only to collect *facts*.

I cannot begin better than by giving a description of one of the most remarkable wells in the district, number 20 on the plan. It is at Bando head-station, at an elevation, I should say, of 100 or 150 feet above the plain. The country is basaltic; and immediately behind the well rises a range of mountains from 1,000 to 1,600 feet higher than the myall slope upon which the well is situated. The late manager, Mr. W. T. Keene, has obligingly furnished me with the following:—"Size of the well, 7 feet square; character of soil at surface, pipeclay; strata, unknown. This well is 90 feet deep, and has 90 feet of water in it. Its history is rather interesting. Prior to the timber being sapped in its immediate vicinity it was with difficulty that a team of bullocks could be watered. This was about thirteen years since, and during the late drought the well has overflowed continuously." I have frequently examined this well myself, and quite recently I was promised by the present manager the quantity of the overflow. The information has not, up to the present, I regret to say, been furnished. I should estimate the flow, however, at about 20 gallons per minute, and in thirteen years this would amount to sufficient, if conserved, to form a lake 4 feet in depth and 32 acres in extent. The character of the ridges is, as I have stated, basaltic; sparsely timbered with box and ironbark; and in addition to the remarkable overflow of this well which succeeded the ring-barking, several of the little previously dry watercourses are now trickling rills, and convey away from the range, in one instance at least, quite treble the quantity of the overflow from the well. Whether this remarkable state of things is occasioned by the sapping of the timber, or whether it occurs through the operation of natural causes, I am not prepared to state; but it appears somewhat remarkable that the well should have existed for several years and the watercourses retained their normal condition for a period extending over thirty years, only to develop into permanent springs and streams when the eucalypti were destroyed.

Instances of Salt Water.

Bearing upon question 9 in the form supplied, although not exactly in answer to it, Mr. Keene states:—"I knew of an instance on Colly Blue (Colly Blue is on Coomoo Coomoo Creek, *vide* plan) where an old well 65 feet caved in. The water in this well was limited and very brackish, and hardly fit for stock. A new well was sunk 12 feet to the east of the old one, and at 33 feet a bed of sand was pierced and an unlimited supply of excellent fresh water obtained." This fact appears to me to be valuable, as it would prove that the water below the surface is held in channels and may be obtained at very short intervals under widely varying conditions. In the well which caved in the water was obtained at

65 feet, brackish, limited, and unfit for human use. In the second, only 12 feet distant, water, excellent in quality and unlimited in supply, was obtained at 33 feet.

Beyond Bando head-station, and situated on the side of the same range of mountains, there are two remarkable springs called Tambar. These springs are about 100 yards apart, 4 miles from the plain, and elevated above it somewhere over 200 feet. In one the water is contained in a deep cup-like cavity in an otherwise dry and stony-looking spot, and flows across the main road from Boggabri to Coolah. The outflow from this spring varies considerably with the state of the weather. On bright sunny days the flow is only about 120 gallons per hour, and on a dull cloudy day (although no rain may be falling) the outflow sometimes reaches 400 gallons per hour. The second spring is situated about 40 feet lower than the one just described, and the outflow averages 1,200 gallons per hour. I carefully examined the range, and could not discover the existence of any sufficient catchment from which these springs might derive their supply. My observations lead me to the belief that the fountain-head is situated many miles from where the springs break forth. Upon the plain in front of Tambar some wells have been sunk 100 feet deep without obtaining water. Tambar is elevated over 200 feet above the plain, and the water flows from the surface.

At Bomera head-station there is a well, not numbered on the plan, only 6 feet deep, where the water almost always remains level with the surface, and the supply is practically inexhaustible. This well is distant about 12 miles in a south-westerly direction from Tambar, and is situated in a sandstone formation on a slope about 200 yards from a creek, the bed of which is 40 feet lower than the water in the well, and this creek is frequently dry. Some of the land in the vicinity has been cleared, but very little sapped. It appears to me to be similar in character to the spring at Tambar, and the fountain-head must, as in the other case, be many miles distant from where it flows. To the north-west of Bando there is a most remarkable spring at Garrawilla head-station, and upon a recent visit I availed myself of the opportunity to measure the outflow. I found that this spring yielded the enormous quantity of 9,600 gallons per hour. I rode over the spring where it makes its first appearance, and was surprised to find the ground quite hollow for a space of upwards of 100 acres, and upon listening attentively one could hear the sound of rushing water under foot. In many places there happened to be large fissures or holes in the ground, and the water could be seen rushing along on its subterranean course at a depth of about 3 or 4 feet from the surface. A large dam has been erected below this spring, and one of the most extensive sheep-washing establishments in the Colony is supplied with water by powerful engines from this dam. The whole area of the valley in which the spring arises does not exceed 2,000 acres, and the yield per annum at the rate quoted amounts to nearly eighty-five millions of gallons of water. There can be no doubt whatever that the source of this spring is far removed from the drainage area of the valley in which it occurs.

On Moredevil Station, near the source of Cox's Creek, many years ago, a well was sunk to a considerable depth. The exact depth I have been unable to ascertain, but believe it was about 80 feet. No sign of water was obtained before this level was reached, when, as the workmen broke through some hard rock, the water rushed in so rapidly that they were compelled to abandon their tools and make good their escape by means of a rope and windlass. In a few hours the well was filled to within 10 feet of the surface. Some years ago, as the well just described exhibited symptoms of caving in, another well was sunk about 80 yards easterly from the first. This well is 100 feet deep, and is situated higher on the slope by 4 or 5 feet than the first well. When the bottom was reached the water came as rapidly as on the first, and rose to within 4 feet of the surface, and on the following morning the first well had overflown, and a strong stream amounting to upwards of 300 gallons per hour was flowing from it. This has continued ever since, through all varieties of seasons, without cessation. I have obtained from Mr. Williams, the present manager of Moredevil, the following statement, which I cannot do better than give in his own words:—"I have measured the rate at which the water rises in both wells. The first is 6 feet × 6 feet, and I think 80 feet deep, and is situated within 20 yards of a spring where as a rule the water is on the ground. This is the well which overflows. January 5th, took out 5 feet of water; rose 30 inches in 50 minutes. January 6th, took 20 inches of water; took two hours to fill again. January 28th, took out 4 feet of water; rose 25 inches in 60 minutes. February 14th, took out 7 feet of water; rose 18 inches in 30 minutes. The above measurements were all made in fine weather. In rain or in cloudy weather the water rises very much faster. You will see that after taking out about 2 feet of water, the water rises much more rapidly than it does at the higher level. This is the case with both wells, as you will perceive by the following: No. 2 well, 10 feet × 8 feet, about 100 feet deep, situated about 80 yards from the spring, and the same distance from the spring in an easterly direction from both. The water in this well stands about 4 feet below the water in well No. 1. South of this about 20 yards, limestone is on the surface, and the ground rises gradually. On the lower ground below both wells, pipeclay is I may say on the surface; the depth to which it extends I don't know, but it is several feet. Water rises as follows: January 5th, took out 2 feet of water; the first 13 inches rose in 1 hour and 45 minutes; then 2 inches in 60 minutes; the remaining 9 inches at the rate of 1 inch per hour. January 8th, took out 1 foot of water; rose 1 inch per hour."

I have given Mr. Williams' statement exactly as it is written, and its value as a record cannot be doubted. My labours would have been considerably lessened, the results expedited, and my facts enhanced in value, had all the persons to whom I applied for information been as obliging as the late manager at Bando, and the managers of Bomera, Moredevil, and Trinkay. To those gentlemen my best thanks are due for the information they so promptly afforded.

It appeared strange to me that the weather should so much affect these wells and springs; and in turning the matter over in my mind I thought I had discovered the solution in the fact that on bright sunny days the trees must evaporate an enormous quantity of moisture, which upon dull days would be retained or rather not drawn from the earth. In the case of the springs at Tambar and Garrawilla, which must have their fountain-head far distant from where they appear, and the wells of which Mr. Williams gives the description, a little reflection will show that the cause of this alternation in the outflow cannot be ascribed to the influence of the vegetation. The springs at Tambar are on the side of a mountain, and 300 feet from the summit; and the springs in the wells at Moredevil are found at depths respectively of 80 feet and 100 feet, a depth to which no ordinary roots would penetrate.

Coomoo Coomoo is a station situated upon a creek of the same name, and there are a few remarkable wells upon it, which unfortunately I have not been able to fix upon the map. Near the head station there are two wells on the creek about 10 feet above its bed, and the water rises in each to within a foot or two of the top. The creek is often dry. Lower down there is another well not far from the same watercourse, which makes water at the rate of nearly 7,000 gallons per hour. Coomoo Coomoo Creek, as will be observed by the map, flows out on the plain, and in wet seasons forms Goran Lake a sheet of water some 25 to 30 miles round. This lake, which comes into existence during very wet seasons, and sometimes lasts for several years, forms in what appears to be a depression in the plain, the borders of which are markedly defined by a ridge of sand. The depth of the water varies from 3 to 7 feet. Several miles to the south-west, Trinkay scrub, celebrated for its ironbark forest, is situated. The soil is of a loose sandy character, and almost anywhere in the scrub good water can be obtained at a depth of from 13 to 20 feet. Its elevation is 50 to 60 feet above the lake, but the water held in reserve in the scrub never finds its way to the lake, as wells have been sunk between the two without finding water in any considerable quantity.

The well numbered 59 on the plan is situated on Wondoobah, and as will be seen by the Schedule, flows over the surface. It is sunk at the base of a conical isolated hill, to a depth of about 60 feet, and at an elevation above the level of the plain of 120 feet. It has continued to flow for fourteen or fifteen years. Well No. 57 on the plan is about 5 miles from No. 59, in a direct line between the latter and the plain, and about 100 feet lower. This well is described as follows :— 6 feet by 4 feet; first 100 feet red soil, with gravel layers containing fossilized bones; teeth of diprotodon found at 100 feet; from 100 feet to 150 feet all red clay; then 3 feet of drift containing little fresh water; 3 feet of clay same character, then boulders and gravel; 3 feet of whitish clay strata dipping slightly to the west." The total depth of this well is 159 feet, and as the surface is 100 feet lower than well No. 59 this would place the bottom 259 feet below the level of the flowing well above described.

With regard to the possibility of finding brackish or salt water, passing through it, and then obtaining a supply of fresh, my informants generally assert that instances have come within their knowledge of such cases. Well No. 86 (which is marked upon the plan, although it is in the county of Buckland) affords a remarkably good illustration of this. The description shortly is as follows :—"90 feet deep; at 50 feet salt water came in large quantities; at 90 feet unlimited supply of perfectly pure water in 5 feet of sand." Well No. 68 on plan is another illustration of the same experience. The description given me is :—"Size of well, 7 feet 6 inches by 7 feet 6 inches; 41 feet deep; 6 feet of black soil; 9 feet blue clay; 17 feet whitish clay and gravel; 7 feet of sand; 2 feet loose water-worn stones and sand mixed; first water at 25 feet, in clay and gravel; supply limited; quality hard and brackish; water at bottom fresh; supply abundant." I have no information of instances of the reverse, *i.e.* fresh water being found first and brackish afterwards, and most likely for the reason that as soon as fresh water is struck well-sinking ceases.

The watershed and general appearance of the country is about the same for the Mooki River and Cox's Creek. The plains extend some 30 miles from one to the other past Lake Goran, but in other places the fall is sharply defined by low scrubby ranges and abrupt basaltic mountains. The plains on each are generally the same loose black soil, in moderate and good seasons producing an abundant and luxurious vegetation. With 25 wells on the western watershed of the Mooki, I find the average depth to be 46½ feet, and the average depth of water in each well 13¼ feet. In 40 wells on the eastern watershed of Cox's Creek, extending over nearly 70 miles, I find the following averages: Depth of well, 70 feet; depth of water in well, 18 feet. The average of 24 wells on the western watershed of Cox's Creek is as follows :—Depth of well, 62 feet; depth of water in each well, 22 feet. I may here mention that west of Cox's Creek, at a distance of 10 miles or less, loose sandy soil is encountered, and water, I am credibly informed, can be obtained almost anywhere at from 10 to 20 feet from the surface. A sandstone formation extends to the Castlereagh, and is covered with perhaps the grandest iron-bark forest in the Colonies. Of the 89 wells situated on the western watershed of the Mooki and the eastern and western watersheds of Cox's Creek, the average depth is 63 feet 6 inches, and the depth of water for each well is 17 feet 6 inches. From one end to the other along Cox's Creek an unlimited supply of good water may be obtained at an average depth of 50 feet. Of the 89 wells of which I have spoken as lying on the watershed of Cox's Creek and the Mooki, I find that 73 bottomed in sand or gravel with an abundance of good fresh water. Six bottomed in clay, with water brackish or salt; eight on rock, with water hard to brackish; one in sand, with water bitter; and one in rock, with water good. The average depth of these last 16 wells I find to be 90 feet; three of them reaching the depth of 170, 159, and 130 feet respectively. It will be observed from these facts that water may be obtained at a moderate depth in sand or gravel almost anywhere in the county of Pottinger. Of course I am aware that the information I have been able to collect is only a small drop in the bucket of knowledge required before generalization can be indulged in. If however I am right in believing that Liverpool Plains bear a close similarity to all other of the great plains of the interior, it would be fair to assume that whatever may be successfully accomplished here may also be reached in other districts.

The methods adopted for drawing water from many of these wells, even at the present day, are in many instances of the most primitive kind. An implement known by the name of a "whip" is not infrequently used. A long pole fastened midway in an upright forked stick, and with a weight attached to one end and a bucket to the other, is suspended over the well. By pulling upon the rope the bucket is lowered into the water, and then releasing it, the weight on the opposite end of the pole serves to elevate the water. Many thousands of sheep are watered in this manner. Signs however of an awakening to the benefits of civilization are becoming apparent; and on three or four stations wind-engines are already erected and doing good work.

Of the economic value of wells so large as those generally sunk I entertain grave doubts. The only benefit that I can see to be derived from a large well is where the vein of water is weak and a large soakage surface is required; where however, as in most of the wells of this district, the supply of water is inexhaustible, the superior value of a small well properly tubed would soon be manifested. I have very little doubt that with boring machines, wells

16 inches in diameter could be made (and at one-tenth the cost) which would supply the place of any of the large wells. In most good wells the water shows a tendency to rise to the surface, and in some cases does actually rise and flow over. If wells were bored and tubed so that the water if it did rise could not escape through layers of sand or the fissures in the various strata, the chances of having flowing wells would be considerably increased. At any rate, in attempting to solve the problem "Where does our rainfall go?" boring machines must be called into requisition, and it may happen, when our store of general knowledge has been added to by information similar to that which I have endeavoured to place before this Society to-night, collected from all parts of the Colony, the vast interior plains about the Darling may be rendered as profitable and productive as any other of the more favoured portions of this great land. Lieutenant Maury, in his celebrated work on "Oceanic Currents," begins with the startling sentence "There is a river in the ocean." It may fall to the lot of some member of our Royal Society to exclaim at no distant date "There are rivers in the earth," and, with the assistance of those who are in a position to render it, to indicate their locality, the depth at which they may be found, and how rendered serviceable to mankind.

Postscript.—The map which accompanies this paper has been kindly prepared by Messrs. Goodwin, Licensed Surveyor, and A. P. D. Hamilton, Land Agent; its accuracy may therefore be relied upon.

SCHEDULE.

No. on Plan.	Size.	Depth to water.	Depth of water.	Total depth.	General particulars.
1	..	0	6	6	Bomera Station; in sand; 6 feet deep, with an unlimited supply. Surface undulating.
2	..	54	24	78	Black soil flat; black soil 8 ft.; red soil 10 ft.; 6 ft. blue rock; water 6 ft. from top of rock; short supply.
3	..	19	10	29	Black soil flat close to creek; black soil 4 ft.; red soil 15 ft.; gravel 10 ft.; water in gravel, abundant.
4	..	8	10	18	Red soil flat; red soil 10 ft.; gravel 8 ft.; good supply; water in gravel, abundant.
5	..	62	20	82	Red soil; Appletree Flat; 77 ft. red soil; 4 ft. 8 in. sand; water in sand, inexhaustible.
6	..	68	15	83	Red soil; 78 ft. red soil; 4 ft. 6 in. sand; plentiful supply, fresh water.
7	..	12	10	22	Black soil flat near Bundella Creek; black soil 6 ft.; red clay 10 ft.; cemented gravel and large boulders 6 ft.; plenty.
8	..	15	10	25	Red soil, Appletree Flat; red soil 8 ft.; clay 10 ft.; cemented gravel and boulders, very hard, 7 ft.; inexhaustible.
9	..	37	20	57	Box flat, red soil close to Tamilies Creek; red soil 20 ft.; yellow clay 10 ft.; cemented gravel 9 ft.; abundant supply.
10	..	12	10	22	Black soil, box flat; black soil 10 ft.; red clay 10 ft.; cemented gravel 5 ft. 6 in.; good supply, fresh water.
10A	..	23	7	30	Black soil flat; black soil 6 ft.; red soil 6 ft.; cemented gravel and boulders, very hard, 10 ft.; abundant water.
10B	..	23	7	30	Box flat; red soil 20 ft.; clay 10 ft.; cemented gravel 9 ft.; good supply, fresh water.
11	..	30	4	34	Black soil plain; black soil 5 ft.; red soil 25 ft.; gravel 4 ft.; plentiful supply fresh water.
12	..	29	3	32	Black soil plain; black soil 5 ft.; red soil 24 ft.; gravel 2 ft.; plentiful supply, excellent water.
13	..	40	30	70	Edge of black soil plain; red soil 30 ft.; sandstone rock 40 ft. into gravel; plentiful supply, excellent water.
14	..	10	10	20	In bed of Coxe's Creek; sand 20 ft.; excellent water, grand supply.
15	..	35	40	75	In watercourse of Coxe's Creek; strata unknown; water in sand; excellent quality, good supply.
16	..	55	20	75	Black soil, old watercourse; strata unknown; water in gravel; will water 10,000 sheep; excellent and unlimited.
17	..	4	77	81	Level plain; stiff black soil $4\frac{1}{2}$ ft.; gritty sand 5 in.; reddish soil 29 ft.; sand 20 in.; 51 ft. clayey marl; water in gravel; good: at 80 ft. found kangaroo bones and bivalve shells.
18	..	31	2	33	Level plain; sandy loam 31 ft.; pure sand 2 ft.; water like sea-water; mineral smell disappearing on exposure to air.
19	..	55	20	75	Black soil, on edge of lagoon; strata not known; excellent water, unlimited supply.
20	..	0	90	90	Pipeclay at surface; strata unknown; overflowed thirteen or fourteen years ago in consequence of ringbarking.
21	..	65	5	70	Even surface; clayey black soil; strata unknown; water slightly hard, came in rock.
22	..	15	15	30	Undulating surface; stony black soil; quality of water fair; came in stones and gravel.
23	..	22	36	58	Level surface; black soil; plenty of water; slightly hard; came in clay and gravel.
24	..	30	8	38	Black soil plain; black soil 6 ft.; loam 24 ft.; 8 ft. pure sand; quantity unlimited, quality excellent.
25	..	55	15	70	Black soil, myall country; black soil 15 ft.; hard blue rock 65 ft.; water not abundant or good.
26	..	45	15	60	Open plains; black soil 55 ft.; 5 ft. sand; water fresh; supply unlimited.
27	..	55	15	70	Open black soil plains; black and red soil 70 ft.; sand 5 ft.; supply inexhaustible.
28	..	55	15	70	Same as last.
29	..	55	15	70	Same as last.
30	..	55	12	67	Black soil plain; black soil 67 ft.; bottomed in soft sandstone rock; supply excellent.
31	..	60	20	80	Black soil 70 ft.; soft sandstone 10 ft.; from top of sandstone water supply excellent.
32	..	55	15	70	Same as 27.
33	..	55	15	70	Same as 27.
34	..	116	14	130	Black soil 130 ft.; reddish clay 10 ft.; supply limited and not good.
35	..	60	10	70	Black soil 60 ft.; drift 10 ft.; water supply not very good.
36	..	50	20	70	Open plain; black soil 60 ft.; sand 10 ft.; supply excellent.
37	..	60	10	70	Ironbark country; black soil, 65 ft.; sand 5 ft.; supply excellent.

SCHEDULE—*continued.*

No. on Plan.	Size.	Depth to water.	Depth of water.	Total depth.	General particulars.
38	..	60	10	70	Same as 37.
39	..	55	15	70	Same as 37.
40	..	2	8	10	In sandstone country; sand 10 ft.; water supply inexhaustible, quality excellent.
41	..	55	15	70	Exactly similar to 27.
42	..	55	15	70	Exactly similar to 27.
43	..	51	15	66	
44	..	40	20	60	
45	..	40	20	60	
46	..	55	15	60	
47	..	51	14	65	
48	..	55	15	60	
49	..	70	10	80	Edge of open plains; black soil 50 ft.; rock 10 ft.; clay, gravel interspersed 15 ft.; sand 5 ft.; water rose 60 ft.
50	..	125	5	130	Edge of plain; reddish clay; strata unknown; water supply not good.
51	..	50	14	64	
52	..	50	10	60	Plain; 16 ft. black soil; 1 ft. red sand; 5 ft. black soil; 1 ft. 6 in. red sand; 12 ft. black soil; 20 ft. flint and rotten sandstone with layers of clay; water slightly brackish; improving.
53	..	80	20	100	Open black soil plain; water in sand, supply unlimited.
54	..	160	10	170	On island of timber in plain; light red soil 10 ft.; hard blue rock 160 ft.; water supply not good; through joints of rock.
55	..	94	10	104	Forest country; clay 60 ft.; 30 ft. decomposed schistose rock; 2 ft. lignite; 50 ft. basaltic rock; spring in veins of hard bluish rock; limited.
56	..	90	10	100	Forest country; red soil; clay interspersed with drift sand 100 ft.; 10 ft. of water, very bitter, in fine drift sand and clay; improves with use.
57	..	147	12	159	Box forest; 100 feet red clay and gravel layers containing fossilized bones; teeth of Diprotodon at 100 ft.; 50 ft. red clay; 3 ft. drift with fresh water; 3 ft. clay and then 3 ft. whitish clay and boulders.
58	..	0	60	60	Black soil; 120 ft. above level of plain; strata unknown; black soil and clay and then gravel and boulders; water flows over top of well; very good.
59	..	0	30	30	Stony forest; strata unknown; well 30 ft. deep with 30 ft. of water; came in slate, and larger supply in gravel.
60	..	41	30	71	Black soil; 7 ft. black soil; 64 feet rotten rock, hardening as sinking proceeded; excellent and good supply of water; came through fissure in rock.
61	..	110	10	120	Light gravelly soil; strata unknown; limited supply brackish water, unfit for human use, stock drink it warily.
62	..	77	10	87	Black soil plain; 76 ft. black soil, traces of lime and bones; 3 ft. gravel; 8 ft. limestone and gravel with water; water good, about 5,000 gals. in 24 hours.
63	..	16	24	40	Limestone formation, 12 ft. loose soil; 4 ft. limestone boulders; water good; not a strong spring in gravel and boulders.
64	..	44	3	47	Black soil, old watercourse; 32 ft. black soil; 10 ft. reddish clay; 3 ft. stones and boulders; water in boulders and gravel, limited.
65	..	....	....	57	Old watercourse; 12 ft. black soil; 20 ft. jointy blue rock; 25 ft. hard rock; small stream in jointy rock; no water at bottom.
66	..	85	51	136	Black soil one mile from a mountain; 40 ft. black soil; 10 ft. stones and gravel; 30 ft. red soil; 5 ft. cement; 51 ft. limestone boulders and gravel, water in these.

SCHEDULE—*continued.*

No. on Plan	Size.	Depth to water.	Depth of water.	Total depth.	General particulars.
67	..	84	6	90	Open downs; limestone and red soil 84 ft.; brackish water; (several wells have been sunk around this, all as salt as the sea) near Lake Govan.
68	..	25	16	41	Open plain; 6 ft. black soil; 9 ft. blue clay; 17 ft. whitish clay and gravel; 7 ft. sand; 2 ft. waterworn stone and sand; first water brackish at 25 ft.; water at bottom excellent.
69	..	20	5	25	Open plain; 9 ft. alluvial black soil; 6 ft. blue clay; 10 ft. sand; water fresh, abundant.
70	..	28	12	40	Open plain; 12 ft. alluvial black soil; 16 ft. whitish clay and gravel; 12 ft. of sand; water fresh and abundant.
71	..	19	5	24	Rich black soil plain; 10 ft. black soil; 14 ft. sand; rock at bottom; water in sand, unlimited.
72	..	40	1	41	Open plain; 12 ft. black soil; 28 ft. yellow clay; 1 ft. sand; first water in sand salty, now good.
73	..	21	18	39	Rich black soil plain; 10 ft. black soil; 11 ft. sand; water at 21 ft. slightly brackish; 18 ft. fine drift sand; water abundant, fresh.
74	..	22	8	30	Rich black soil plain; 12 ft. black soil; 10 ft. whitish clay and gravel; 8 ft. sand; water in sand; fresh, supply abundant.
75	..	24	13	39	Open rich plain; 10 ft. alluvial black soil; 12 ft. whitish clay and gravel; 15 ft. sand; first water in sand; fresh, supply abundant.
76	..	15	8	23	Rich open plain; 10 ft. black soil; 15 ft. sand and mussel shells; 1 ft. red clay; water very salt and bitter.
77	..	41	11	52	Box and rosewood forest; alluvial soil loam 4 ft.; 20 ft. red clay and gravel; 16 ft. sand; 11 ft. drift and gravel; 1 ft. red clay; water very salt and bitter.
78	..	25	1	26	Rich black soil plain; 10 ft. black soil; 15 feet sand and mussel shells; 1 ft. red clay; water very salt and bitter.
79	..	29	9	38	Rich open plain; 9 ft. black soil; 18 feet whitish clay and gravel; 9 ft. sand; water abundant.
80	..	24	4	28	Rich black soil plain; 2 ft. black soil; 12 feet whitish clay and gravel; 4 ft. sand; water in sand, fresh and abundant.
81	..	35	25	60	Open plain; loam 50 ft.; drift 10 ft.; water abundant.
82	..	35	25	60	Open plain; loam 45 ft.; drift 15 ft.; 25 ft. fresh good water.
83	..	35	25	60	Open plain; 45 ft. loam; 5 ft. drift; 25 ft. fresh good water.
84	..	35	5	40	Open plain; 40 ft. loam; no sand; water not plentiful.
85	..	30	5	35	Open plains; 35 ft. loam; no sand; water not plentiful.
86	County Buckland.				Myall timber; 50 feet reddish clay; large supply salt water; 35 f clay and gravel; 5 ft. sand; inexhaustible supply, fresh water.
87	..	....	....	..	Black soil plain; black soil 5 ft.; yellow clay and sand 40 ft.; sand 4 ft.; 30 ft. clay; 8 ft. sand; water inexhaustible.
88	..	....	....	..	Box timber; lime, sand, gravel, 5 ft.; water abundant.
89	..	....	....	..	(In county of Nandewar.)
90	..	....	....	..	Near Dividing Range, Coxe's and Borah Creeks; about 40 ft. deep; water supply in sand, abundant.
91	..	....	....	..	On plain; black soil; gravel; sand; strata unknown; water inexhaustible, in gravel and sand.
92	..	....	....	..	Box and yellow-jacket forest; black soil 14 ft.; gravel 11 ft.; water inexhaustible.
93	..	....	....	..	Box forest between ridges; crystal quartz; limestone; bluestone; strata unknown; water at 20 ft.
94	..	....	....	..	On southern slope of box ridges; strata unknown; water in gravel and rock, rose to within 10 ft. of surface.
95	..	....	....	..	
96	..	....	....	..	
97	..	....	....	..	
98	..	....	....	..	
99	..	....	....	..	

[Map.]

PLAN
OF REFERENCE TO
A REPORT ON
WELLS
BY T. K. ABBOTT ESQ.
COUNTY OF POTTINGER
PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.
TAMBA SPRINGS
BANDO
GOOLHI
BOCCABRI
GUNNEDAH
CARROLL
TURRAWAN
TRINKEY
Very
Dense
Scrub
SCRUB
TRINKEY PLAIN
MERRIGULA PLAIN
SPRING RIDGE PLAIN
GORAN
LAKE
THE NAMOI RIVER
BREEZA PLAIN
RIVER
MOOKI
LIVERPOOL PLAINS
OPEN PLAINS
BINNALONG PLAINS
COLLYBORAH PLAINS
Cox's Melville Creek
Mitchells Creek
Coomoo Creek
Yarraman Creek
Tulla Mullen Creek
PEEL RIVER
BLACK JACK
(4034-80)

PROCEEDINGS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 12 MAY, 1880.

ANNUAL GENERAL MEETING.

Charles Moore, F.L.S., V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The Annual Report of the Council was then read as follows :—

"In presenting the Report for 1879, the Council has the pleasure to congratulate the members on the continued and increasing prosperity of the Society. The number of new members elected during the year is fifty-one, the number of members which the Society has lost by death is four, by resignation ten, and by removal from the lists on account of the non-payment of the annual subscription eleven, thus leaving the actual increase in the year twenty-six, and making the total number of ordinary members upon the roll to date 430. During the year the Society has elected the following gentlemen as honorary members, viz. :—Mr. George Bentham, F.R.S., V.P.L.S., C.M.G., &c., the Royal Gardens, Kew ; Dr. Charles Darwin, F.R.S., M.A., F.G.S., F.L.S., &c., Beckenham, Kent ; Professor Huxley, F.R.S., LL.D., F.G.S., F.Z.S., F.L.S., &c., Royal School of Mines, South Kensington ; Professor Owen, C.B., M.D., D.C.L., LL.D., F.L.S., V.P.Z.S., &c., the British Museum ; making the total number of honorary members nineteen. Mr. R. Etheridge, jun., F.G.S., &c., of the British Museum, has been elected a corresponding member of the Society. The Council has the satisfaction to report to the Society that vol. xii, for 1878, has been duly distributed to all the members, and that vol. xiii will very shortly be ready. Financially the Society's affairs are in a satisfactory condition. The Council has also to announce that in accordance with the resolution of the Society passed at the general meeting held on 1st October, 1879, it has ordered a pair of dies for the Clarke memorial medal, at a cost of 100 guineas, which Messrs. J. S. and A. B. Wyon promise to have completed in about six months from this date; after this is paid, a balance of £200 will be left, which the Council propose for the present to leave in the Bank as a fixed deposit, at 6 per cent. At the Council meeting held on April 28, it was unanimously resolved to award the Clarke memorial medal for the year 1878 to Professor Owen, C.B., &c.; for the year 1879, to Mr. C. Bentham, C.M.G., &c.; and for 1880, to Professor T. H. Huxley, LL.D., Sec. Roy. Soc., London, for their valuable contributions to the knowledge of the palæontology, botany, and natural history respectively of Australia. During the past year the Society has received 664 volumes and pamphlets as donations and exchanges, against which it has distributed 523 volumes and pamphlets, as per list. In addition it has subscribed to thirty-six scientific journals and publications, and has purchased several works of reference. In the early part of the year the whole of the by-laws and regulations were revised by a Committee appointed for that purpose; the rules as revised will be incorporated with the forthcoming volume. During the year the Society has held eight meetings, and the majority of the Sections have held regular monthly meetings. The report of the curators of the geological cabinet shows that it contains thirty-six specimens, and the Society's microscopical cabinet now contains about 200 slides."

The following Financial Statement for the year ending 30th April, 1880, was presented by the Honorary Treasurer:—

GENERAL ACCOUNT.

Receipts.

	£	s.	d.	£	s.	d.
To Balance in Union Bank 30th April				58	0	2
,, Subscriptions and entrance fees, from 1st May, 1879, to 30th April, 1880	463	9	0			
,, Government Grant, on subscriptions paid from 1st January, 1879, to 31st December, 1879, total, £473 11s.	236	15	6			
,, Proportion of Gas Account paid by Academy of Art, to 31st April, 1879	10	0	0			
,, Hire of hall and rooms to sundry Societies	16	11	0	726	15	6
				£784	15	8

Expenditure.

	£	s.	d.
By Temporary laying on gas in large Hall of University for conversazione	15	0	0
,, Refreshments for 815 persons at conversazione	61	2	6
,, Sundry expenses—conversazione	33	17	5
,, Furniture and effects	73	5	8
,, Books	42	12	1
,, Printing....	36	1	6
,, Engraving illustrations for Journal	25	17	6
,, Stationery	21	6	7

EXPENDITURE—*continued.*

	£	s.	d.	£	s.	d.
By Book-binding	11	7	1			
,, Advertisements	25	11	11			
,, Reporter (discussions on papers)	6	6	0			
,, Delivering Society's Journals to members ...	4	15	6			
,, Petty cash and postage	32	0	0			
,, Freight, carriage, packing-cases, &c.	10	15	3			
,, Insurance on books and furniture	1	5	0			
,, Gas Account	21	6	9			
,, Assistant Secretary's salary to 30th April, 1880 (12 months)	97	6	8			
,, Housekeeper, to April 30, 1880	10	0	0			
,, Ditto for survey examinations	1	2	6			
,, Ditto refreshments at monthly meetings	14	4	0			
,, Covering and packing exchanges and presentations to Foreign Societies	7	10	6			
,, Exchange on country cheques	0	14	0			
				553	8	5
,, Entrance fees transferred to Building A/c.	47	5	0			
,, Hire of rooms	16	11	0			
,, Interest, rates, and insurance	129	1	0			
				192	17	0
,, Balance in Union Bank, 30th April, 1880				38	10	3
				£784	15	8

NOTE.—Vouchers for the sums mentioned in the note to last year's Balance Sheet have been produced.

H. G. A. WRIGHT, Honorary Treasurer.
W. H. WEBB, Assistant Secretary.

Audited—
R. A. A. MOREHEAD.
A. S. WEBSTER.
30th April, 1880.

BUILDING FUND ACCOUNT.

RECEIPTS.

	£	s.	d.	£	s.	d.
To Amount at fixed deposit in Union Bank	200	0	0			
,, Balance in Union Bank, 30th April, 1879	5	9	6			
				205	9	6
,, Rent of hall to Academy of Art	200	0	0			
,, Hire of rooms to sundry Societies	16	11	0			
				216	11	0
,, New members' entrance fees, transferred from General Account	47	5	0			
,, Interest, rates, and insurance, transferred from General Account	129	1	0			
				176	6	0
,, Interest on fixed deposit £100, due 21st February, 1880	6	10	0			
,, Ditto ditto £100, due 30th April, 1880	6	0	0			
				12	10	0
				£610	16	6

Expenditure.

	£ s. d.	£ s. d.
By City rates	4 1 0	
,, Interest on £2,000 @ 6% to 31st March, 1880	120 0 0	
,, Insurance on building	5 0 0	
		129 1 0
,, Amount at fixed deposit, 1st May, 1879 ...	100 0 0	
,, ,, ,, 13th Dec., 1879 ...	100 0 0	
,, ,, ,, 2nd Feb., 1880 ...	100 0 0	
		300 0 0
,, Balance in the Union Bank, 30th April, 1880		181 15 6
		£610 16 6

H. G. A. WRIGHT, Honorary Treasurer.
W. H. WEBB, Assistant Secretary.

Audited,—
R. A. A. MOREHEAD.
A. S. WEBSTER.

30th April, 1880.

STATEMENT OF ASSETS AND LIABILITIES FOR THE YEAR ENDING 30TH APRIL, 1880.

Assets.

	£ s. d.
To Balance in Union Bank to credit of General Account	38 10 3
,, Subscriptions and entrance fees due	34 13 0
,, Furniture, painting, books, &c.—value unknown—taken as insured	1,000 0 0
,, Rent of room due from Sr. Simonetti	13 0 0
,, Hire of hall due from Sr. Simonetti	1 1 0
,, ,, ,, University Musical Society	2 2 0
,, ,, ,, Dr. Renwick	1 1 0
,, ,, ,, Mr. H. C. Dangar	1 1 0
,, ,, ,, ,, Barton, M.L.A.	1 1 0
,, ,, Rooms due for Survey Examination	5 17 0
,, Academy of Art—proportion of Gas Account due from May, 1879, to May, 1880	10 0 0
,, Premises in Elizabeth-street (cost of purchase)	3,525 0 0
,, Balance in Union Bank to credit of Building Fund Account	181 15 6
,, Amount of fixed deposits ,, ,,	300 0 0
	£5,115 1 9

Liabilities.

	£ s. d.
By Trübner & Co.—Periodicals	47 9 8
,, By Alexander Dean—Bookcases in Library, and alterations to building, &c.	143 5 1
,, Savings Bank—Loan on mortgage	2,000 0 0
,, Balance of Assets over Liabilities	2,924 7 0
	£5,115 1 9

H. G. A. WRIGHT, Honorary Treasurer.
W. H. WEBB, Assistant Secretary.

Examined—
R. A. A. MOREHEAD.
A. S. WEBSTER.
30th April, 1880.

The statement was adopted.

Dr. P. Sydney Jones and Mr. A. S. Webster were elected 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 THE RIGHT HON. LORD AUGUSTUS LOFTUS, G.C.B., &c., &c., &c.

PRESIDENT:

HON. PROFESSOR SMITH, C.M.G., M.D., &c., &c.

VICE-PRESIDENTS:

CHARLES MOORE, F.L.S.
H. C. RUSSELL, B.A., F.R.A.S., &c.

HONORARY TREASURER:

H. G. A. WRIGHT, M.R.C.S.E.

HONORARY SECRETARIES:

PROFESSOR LIVERSIDGE, F.C.S., F.G.S., &c., &c.
DR. ADOLPH LEIBIUS, F.C.S.

COUNCIL:

DIXON, W. A., F.C.S.
HIRST, G. D.
HUNT, ROBERT, F.G.S.
MONTEFIORE, E. L.
ROLLESTON, C., C.M.G.
WILKINSON, C. S., F.G.S.

The following gentlemen were duly elected ordinary members of the Society:—

Dixson, Craig, M.B., C.M., Edin., M.R.C.S., Eng., Sydney.
Dixson, Thomas, M.B., C.M., Edin., Sydney.
Moses, David, Forest Lodge.
Sandy, James, Ashfield.
Wilkinson, Robt. Bliss, Sydney.

The certificates of four new candidates were read for the second time, and of ten for the first time.

The Chairman announced that a number of copies of two works by Dr. Schomburgk, of Adelaide, had been received from the author for distribution amongst the members upon application, viz.:—

1. "On the Naturalized Weeds and other Plants in South Australia."
2. "On the Urari; the Death Arrow Poison of the Macusis, an Indian Tribe in British Guiana."

Also, that a small apparatus the invention of Dr. Urban Pritchard, intended to facilitate the preparation of animal tissue for microscopic examination, had been presented to the Society by Mr. R. A. A. Morehead.

Three hundred and twelve donations were laid upon the table.

The following letters from Mr. Darwin and Professor Owen were read :—

Down, Beckenham, Kent.
Railway Station, Orpington, S.E.R.,
28 October, 1879.

Dear Sir,

I beg leave to acknowledge the receipt of your courteous letter of August 7, in which you announce to me that the Royal Society of New South Wales has conferred on me the honour of electing me one of their honorary members. I request that you will be so good as to express to the Council my acknowledgments and thanks for this honour.

I remain, dear sir,
Yours faithfully and obliged,
CHARLES DARWIN.

To A. Liversidge, Esq., Hon. Sec. Royal Society.

My dear Sir, London, British Museum, 27 October, 1879.

I have been favoured by your obliging letter of August 7th, 1879, conveying to me in gratifying terms my election as honorary member of the Royal Society of New South Wales. This mark of the sense of the general meeting of the Society of the value of my scientific labours I receive as an ample reward ; the more encouraging to me as coming from the Colony from which I have received some of the most interesting subjects of those labours. I return my most grateful and respectful acknowledgments.

Believe me, faithfully yours,
RICHARD OWEN.

Professor Liversidge, F.L.S., G.S., &c., Hon. Sec.

Upon the recommendation of the Council, Sir Joseph Dalton Hooker, M.D., K.C.S.I., C.B., F.R.S., &c., Director of the Royal Gardens, Kew, was unanimously elected an honorary member of the Society.

The names of the Committee-men of the different Sections of the Society were announced, viz. :—

Microscopy.—Chairman : Dr. Morris. Secretary : P. Pedley. Committee : H. G. A. Wright, M.R.C.S. ; G. D. Hirst ; W. MacDonnell ; and F. B. Kyngdon.

Literature and Fine Arts.—Chairman : E. L. Montefiore. Secretary : Percy E. Williams. Committee : G. A. Morell, C.E. ; L. W. Hart ; A. L. Jackson ; and Trevor Jones.

Medical.—Chairman : Alfred Roberts, M.R.C.S. Secretaries : Drs. Sydney Jones and H. N. M'Laurin, M.A. Committee : Drs. Cox, Schuette, Fortescue, and H. G. A. Wright, M.R.C.S.

Mr. Charles Moore, F.L.S., V.-P., then read his address.

WEDNESDAY, 2 JUNE, 1880.

Hon. J. Smith, C.M.G., V.-P., in the Chair.

There were about fifty members present.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen were duly elected corresponding members of the Society, viz. :—

Hyde Clarke, Esq., V.-P., Ethnological Institute, London.
Major-General Sir Edward Ward, K.C.M.G., R.E., London.
F. B. Miller, Esq., F.C.S., Melbourne Mint.

And the following as ordinary members, viz. :—

Bush, Thos. James, Sydney.
Haege, Hermann, Sydney.
Hodgson, Wilfred, M.D., Sydney.
Willis, Rev. Robt. Speir, Manly.

The certificates of ten new candidates were read for the second time, and of five for the first time.

The Chairman stated that, at the request of the Council, he wished to bring before the Society the desirability of lessening the debt upon the building, and regretted that out of more than four hundred (400) members only about one hundred had subscribed to the Building Fund; he said it was necessary members should more generally subscribe to the fund, and that if they did so the removal of the debt should be an easy matter, as the Government had agreed to grant a pound for every two pounds collected.

Mr. Clarendon Stuart asked whether the President was aware that one of the candidates presided at the ballot box at the election of officers and Council on the 12th May last?

The Chairman in reply stated that it was part of the business of the meeting supposed to be presided over by the Chairman of the evening, but in order that the other business might go on, a member of the Council was deputed to preside in place of the Chairman at the ballot, which for convenience had to be conducted in the library. He saw no impropriety in a member of the Council so presiding, even although the same member happened to have been proposed as a candidate.

Mr. Stuart explained that he did not intend to suggest that there was any impropriety in the proceedings, and he did not think that the results of the ballot were affected in any way.

Ninety-one donations were laid upon the table, also a plaster bust of Humboldt, presented by Herr Kretschmann.

Mr. John Tebbutt, F.R.A.S., then read two papers, viz. :— "On the Longitude of the Sydney Observatory," and on "The Opposition and Magnitudes of Uranus and Jupiter."

Professor Liversidge then read a paper by Mr. E. A. Rennie, M.A., B.Sc., &c., London, "On the Acids of the Native Currant.

Mr. H. C. Russell, B.A., F.R.A.S., then read a paper on "Some New Double Stars, with remarks upon several Binaries."

Some geological specimens were exhibited by Mr. Makin, of Berrima.

WEDNESDAY, 7 JULY, 1880.

Hon. Professor Smith, C.M.G., V.-P., in the Chair.

There were between thirty and forty members present.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society :—

Beattie, Joseph A., Lic. K. and Q. Coll. Phys., Ireland ; Lic. R. Coll. Surg., Irel., Parramatta.
Brown, John Studd, Dubbo.
Cox, George Henry, M.L.C., Sydney.
Gardiner, Rev. Andrew, M.A., Sydney.
Iredale, Lancelot F. U., Gunnedah.
Mackenzie, R., North Shore.
Marano, G. V., M.D., Univ. Naples, Sydney.
Plummer, John, Sydney.
Winter, Irving, Carroll.

The certificates of five new candidates were read for the second time, and of five for the first time.

At Professor Huxley's request, Professor Liversidge apologized for the former's non-acknowledgment of his election as an honorary member. Professor Liversidge read an extract from a letter in which Professor Huxley expressed his regret for the delay owing to press of engagements, and begged that his best thanks be conveyed to the Society for the honour conferred upon him, and stated his readiness at all times to give his services to forward the objects of the Society.

Professor Liversidge then read a paper by Baron Ferdinand von Mueller, K.C.M.G., F.R.S., &c., "On a Catalogue of Plants collected during Mr. Alex. Forrest's Geographical Exploration of North-west Australia in 1879."

Mr. John Tebbutt, F.R.A.S., then read a paper on "The Orbit Elements of Comet I, 1880, Great Southern Comet," the same being illustrated by a model.

Professor Liversidge then read a paper by Mr. W. E. Abbott, on "Ringbarking and its Effects."

Mr. Charles Moore and the President remarked that Mr. Abbott's statements were not quite in accordance with the opinions of certain other writers upon the subject.

Dr. Leibius exhibited one of the cells used by Dr. Warren De la Rue, and Dr. Hugo Mueller, of London, for their chloride of silver battery.

WEDNESDAY, 4 AUGUST, 1880.

Hon. Professor Smith, C.M.G., President, in the Chair.

There were between thirty and forty members present.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society :—

Finlayson, David, Sydney.
Forbes, Alexander Leith, M.A., Ashfield.
Hill, John James, J.P., L.R.C.P.E., and L.F.P. and S.G.L.M., Lambton, Newcastle.
Hill, Joseph Higham, M.D., Univ. Brussels, F.R.C.S. Edin., &c., Sydney.
Rome, Robert, Sydney.

The certificates of five new candidates were read for the second time, and three for the first time.

The Hon. TREASURER announced that a circular had been issued to members in June last, asking for subscriptions to the Building Fund, and that in response thereto he had received the sum of £67 14s. from twenty-eight members, also that several gentlemen had promised to double their subscriptions until the debt was paid off.

Sixty-two donations were laid upon the table.

The PRESIDENT, on behalf of the Council, gave notice of motion that, at the next general meeting, a resolution would be moved that the number of members be limited to 500.

Dr. LEIBIUS then read the introduction of a paper by Mr. R. Etheridge, junr., F.G.S., entitled "Notes on a Collection of Fossils from the Palæozoic Rocks of New South Wales."

Mr. C. S. WILKINSON then read a paper by Dr. Ottaker Feistmantel, "On Geological Observations made in 1876, in Queensland, New South Wales, Victoria, and Tasmania."

Mr. H. C. RUSSELL then described "A new method of printing Barometer and other Curves."

Mr. C. S. WILKINSON exhibited a piece of flexible sandstone found at Agra, in India.

WEDNESDAY, 1 SEPTEMBER, 1880.

Hon. PROFESSOR SMITH, C.M.G., President, in the Chair.

There were about forty members present.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society :—

Halligan, Gerald H., Marrickville.
Low, Andrew S., Merrylands.
McKinney, Hugh Giffen, Newtown.
Manfred, Edmund C., Goulburn.
Oakes, Arthur W., M.B., Mast. Surg. L.R.C.P. and L.R.C.S., Edin., Woollahra.

The certificates of three new candidates were read for the second time, and one for the first time.

Twenty-five donations were laid upon the table.

It was moved that the number of members be limited to 500.

The resolution was carried unanimously.

Professor LIVERSIDGE announced that he had received various documents from the Committee of Organization for the next Geological Congress to be held at Bologna, in Italy, in October, 1881, with a request that he would make the arrangements known as far as possible in Australia. In his capacity as representative for Australasia, he had also sent these notices out to the various Societies in the other Colonies, and would be willing to receive the names of any who wished to become members of this Conference.

Mr. RUSSELL explained that the paper by Mr. T. K. Abbott on "Water Supply from Wells" had not been received, and it would therefore have to be postponed.

Professor LIVERSIDGE read a paper on "Hot Spring Waters from New Britain and Fiji"; also one on "The Composition of Cast-iron acted on by Sea-water."

Mr. H. C. RUSSELL read a paper on "A new Barometer Table," and said that the table had that day been brought into operation for the first time.

Mr. RUSSELL distributed copies of an improved weather map.

Professor LIVERSIDGE described and exhibited a collection of minerals received from the Balade and other mines in New Caledonia.

WEDNESDAY, 6 OCTOBER, 1880.

Hon. J. SMITH, C.M.G., President, in the Chair.

There were about fifty members present.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

Ferguson, James W., Sydney.
Jackson, Robert, Sydney.
Paling, W. H., South Kingston.

The certificates of one new candidate were read for the second time, and of eight for the first time.

Forty-two donations were laid upon the table.

A letter was read by Professor LIVERSIDGE from Major-General Sir Edward Ward, R.E., acknowledging his election as a corresponding member of the Society; also one from Sir JOSEPH DALTON HOOKER, M.D., K.C.S.I., C.B., F.R.S., of the Royal Gardens, Kew, acknowledging his election as honorary member.

Yelverton, Bournemouth, 9 August, 1880.

My dear Sir,

I have just received with pleasure your letter of the 7th June, informing me that the Royal Society of New South Wales have unanimously elected me one of their corresponding members. I cannot flatter myself that this high honour is my due on account of my scientific attainments, nor can I hope by any future act of mine to show myself worthy of it. I accept it, however, gratefully as a generous recognition of the interest which I felt in the infant growth of the Society, and, with pleasure, as a sympathetic bond of union between me and those who now labour in the cause of science in New South Wales. Will you kindly convey my thanks to the Royal Society as to an old friend from whom it is a pleasure to receive a favour, and

Believe me, yours faithfully,
ED. WARD.

To A. Liversidge, Esq., Hon, Sec. Royal Society, N. S. Wales.

Royal Gardens, Kew, 5 July, 1880.

My dear Sir,

I have the honour of acknowledging the receipt of your letter of 12 May, informing me that the Royal Society of New South Wales has elected me an honorary member of their body; and of requesting that you will convey to the President and Fellows of the Society my sincere thanks for the distinction which they have conferred upon me, together with my assurance that I feel it to be both an honour and a privilege to be associated with a society of gentlemen representing so high a scientific position as Australia's oldest Colony has attained to. Their flattering recognition of my efforts to advance the botany of Australia is very acceptable, and I thank them for it. The volume of the Society's Journal has safely reached my hands, and I find the first article to be specially interesting to me.

Believe me, my dear Sir, most faithfully yours,
JOS. D. HOOKER.

A. Liversidge, Esq., Hon. Sec. Royal Society of N. S. Wales.

The President remarked that it was gratifying to find that the small honours which the Society was able to give had been so much appreciated.

Professor Liversidge then read a paper on "The Composition of Coral Limestone." Some remarks upon the same were made by the Rev. J. E. Tenison-Woods, F.G.S., &c.

Mr. W. A. Dixon, F.C.S., read a paper upon the "Inorganic Constituents of the Coals of New South Wales."

Dr. Leibius read a paper by Mr. F. B. Gipps, on "A comparison between the Prospect and Kenny Hill Schemes of Water Supply for Sydney."

It was resolved that the discussion upon Mr. Gipps's paper be adjourned till the next Wednesday.

The Chairman announced that the Council had decided to give in the Society's Hall a meeting of a different character from the usual form of monthly meeting, and he had been requested by the Council to invite the members to meet them that day fortnight; there would be a notice in the newspapers, but it was not the intention to send out circulars; those present would take this notice. The members of the Council intended to take upon themselves the necessary expenses. The meeting would be of an informal conversational character. No papers would be read, but a few objects of interest would be laid out for inspection. The usual annual conversazione would not be held this year, chiefly because it was a very expensive entertainment, and the Society had recently been put to large expenses connected with the alterations in the building.

He trusted there would be a good gathering at the proposed meeting, and regretted they could not invite the ladies, as the Society's rooms would not be large enough.

WEDNESDAY, 13 OCTOBER, 1880.

ADJOURNED ORDINARY MONTHLY MEETING.

Hon. Professor Smith, C.M.G., President, in the Chair.

There were about fifty members present.

The following gentlemen took part in the adjourned discussion upon Mr. Gipps's paper :—Mr. Trevor Jones, Mr. Clarendon Stuart, Dr. Belgrave, Professor Smith, Mr. Goodlet, Mr. Alexander Dean, and Mr. Poolman; Mr. Gipps replied.

WEDNESDAY, 27 OCTOBER, 1880.

SPECIAL MEETING.

Hon. Professor Smith, C.M.G., President, in the Chair.

There were about 100 members present.

A lecture was delivered before the members of the Society by William Lant Carpenter, B.A., B.Sc., F.C.S., London, "On Daily Practical Applications of Electricity in America."

The President conveyed the thanks of the Society to Mr. Carpenter for his interesting lecture.

WEDNESDAY, 3 NOVEMBER, 1880.

Hon. Professor Smith, C.M.G., President, in the Chair.

There were about thirty members present.

The minutes of the last meeting were read, but being incomplete were not signed.

The following gentleman was duly elected an ordinary member of the Society :—

Scrivener, Charles Robert, Middle-street, Marrickville.

The certificates of eight new candidates were read for the second time, and of five for the first time.

Thirty donations were laid upon the table.

A letter was received from the Ashfield Municipal Council, thanking the Society for the action it had taken with respect to Mr. F. B. Gipps's paper upon "The Water Supply for Sydney."

Professor Liversidge read a paper on "Some New South Wales Minerals," and one on "Piturie." The papers were illustrated by specimens and preparations of "Piturine" and of its salts.

Some remarks upon the latter were made by Mr. Charles Moore, F.C.S., and the Chairman.

Mr. W. A. Dixon, F.C.S., then read a paper on "Salt-bush and Native Fodder Plants."

Mr. Russell then read a paper by Mr. T. K. Abbott, P.M., Gunnedah, on "Wells in the Liverpool Plains."

Two specimens of serpentine rock from Port Macquarie, presented to the Society by Mr. P. N. Trebeck, were exhibited.

WEDNESDAY, 1 DECEMBER, 1880.

Hon. J. Smith, C.M.G., President, in the Chair.

There were about forty members present.

The minutes of the monthly meeting, held October 6, the adjourned meeting, October 13, the special meeting, October 27, and the last meeting, November 3, were read and signed.

Mr. W. G. Murray suggested that the minutes of discussions should be limited to the mere record of the names of speakers, but resolutions and notices of motion to be entered *in extenso.*

The following gentlemen were duly elected ordinary members of the Society :—

Blackmann, C. H. E., Sydney.
Caird, George C., Woollahra.
Colyer, Henry Cox, Sydney.
Hern, Charles E., Woollahra.
Leask, John L., M.B., C.M. (Edin.), Sydney.
Morris, Alfred, Sydney.
Palmer, Joseph, Sydney.
Riddell, C. E., Union Club, Sydney.

The certificates of five new candidates were read for the second time, and of four for the first time.

Messrs. W. G. Murray and P. N. Trebeck were appointed Auditors of the accounts to be laid before the Society at the annual meeting.

Fifty-six donations were laid upon the table, and the thanks of the Society ordered for the same.

The Chairman announced that a draft Act of Incorporation had been prepared, and would be submitted to the consideration of the members at an adjourned meeting.

Mr. H. C. Russell, B.A., F.R.A.S., then read a paper on "Some Recent Changes on the Surface of Jupiter," also one upon "Thunder and Hail Storms."

Mr. G. D. Hirst then read a paper entitled "Remarks on the Colours of Jupiter's Belts, and some changes observed thereon during the Opposition of 1880."

It was resolved that the meeting be adjourned to the 8th instant.

WEDNESDAY, 8 DECEMBER, 1880.

ADJOURNED MONTHLY MEETING.

Hon. PROFESSOR SMITH, C.M.G., President, in the Chair.

The certificates of four new candidates were read for the first time.

Professor LIVERSIDGE read a paper on "A specimen of fossilized Wood," from Inverell, N.S.W.

Some remarks upon the same were made by Messrs. C. S. WILKINSON and W. A. DIXON.

Professor LIVERSIDGE then read a paper on "The Composition of some New South Wales Coals."

A discussion followed, in which the following gentlemen took part, viz. :—Messrs. A. DEAN, C. S. WILKINSON, ALEXANDER STUART, W. A. DIXON, Hon. E. A. BAKER, and the CHAIRMAN.

The titles of the following papers by Professor LIVERSIDGE were read, viz. :—

1. On "The Composition and Microscopic Structure of some New South Wales Rocks."
2. "The Barratta and Bingera Meteorites."

The draft Act for the incorporation of the Society was read by Professor LIVERSIDGE.

It was moved by Mr. C. ROLLESTON, C.M.G., seconded by Mr. H. C. RUSSELL, and duly carried, that the draft as read be approved.

The proof of a geological sketch map of New South Wales, compiled from the original map of the late Rev. W. B. Clarke, M.A., F.R.S., by Mr. C. S. Wilkinson, was exhibited to the Society by the Hon. E. A. Baker, Minister for Mines.

A new electric constant bichromate battery was exhibited by Mr. H. C. Russell, B.A., F.R.A.S.; five cells were shown in action, these were sufficient to keep six inches of No. 20 platinum wire at a white heat. Mr. Russell explained that the constancy of the battery is obtained by allowing the fresh solution to flow into the cells at the top whilst the exhausted solution is drawn off at the bottom; the solution is thus kept constantly renewed.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1880.

The names of the Donors are in *Italics.*

TRANSACTIONS, JOURNALS, REPORTS, &c.

ABERDEEN :—The Aberdeen University Calendar, 1880–81.
The University.

ADELAIDE :—Addresses delivered at the laying of the Foundation Stone of the South Australian Institute, 7 Nov., 1879.
Annual Report South Australian Institute, 1879–1880.
The Board of Governors, South Australian Institute.
Transactions and Proceedings and Report of the Philosophical Society of Adelaide, South Australia, for 1878–79.
Transactions and Proceedings and Report of the Royal Society of South Australia. Vol. III, 1879–80. *The Society.*
Report on the Progress and condition of the Botanic Garden and Government Plantations during the year 1879.
Dr. Schomburgk.
Meteorological Observations made at the Adelaide Observatory during the year 1878. *The Government Observer.*
The Adelaide University Calendar for the Academical Year 1881.
The Registrar, Adelaide University.

ALBANY :—Eighty-eighth, Eighty-ninth, Ninetieth, Ninety-first, and Ninety-second Regent's Report of the University of the State of New York.
Twenty-seventh, Twenty-eighth, Twenty-ninth, Thirtieth, and Thirty-first Annual Report of the New York State Museum of Natural History.
Fifty-eighth, Fifty-ninth, Sixtieth, and Sixty-first Annual Report of the Trustees of the New York State Library.
Report of the Special Committee of the Assembly on the Normal School.
The Trustees of the State Library, Albany, New York.

AMSTERDAM :—Jaarbock van de Koninklijke Akademie van Wetenschappen gevestig-d in Amsterdam, 1878.
Verslagen en Mededeelingen der Koninklijke Akademie van Wettenschappen Afdeeling Natuurkunde Tweede Reeks, Veertiende Deel.
Royal Academy of Sciences, Amsterdam.

BELOIT :—Geology of Wisconsin. Vol. II, 1873–1877.
Atlas accompanying above. *The Chief Geologist, Wisconsin*

BERLIN :—Monatsbericht der Koniglich Preussischen Akademie der Wissenschaften zu Berlin.
July, August, September, October, November, December, 1879.
January, February, March, April, May, June, August, 1880.
The Academy.

BISTRITZ :—VI. Jahresbericht der Gewerbeschule zu Bistritz in Siebenbürgen. *The Directors*

BOSTON :—Proceedings of the American Academy of Arts and Sciences.
New Series, Vol. V. Whole Series. Vol. XIII, Parts II and III.
,, ,, VI. ,, ,, XIV. *The Academy.*
Proceedings of the Boston Society of Natural History.
Vol. XIX, Parts III and IV.
,, XX, Part I.
Memoirs of the Boston Society of Natural History.
Vol. III, Part I. Numbers 1 and 2. *The Society.*

BRAUNSCHWEIG :—Jahresbericht des Vereins für Naturwissenschaft zu Braunschweig, 1879–80. *The Society.*

BRISBANE :—Report of the Acclimatization Society of Queensland, for the year 1879.
Report upon Economic Tropical Horticulture in Northern Queensland, by L. A. Bernays, F.L.S. *The Society.*

CAEN :—Mémoires de l'Académie Nationale des Sciences, Arts, et Belles Lettres de Caen, 1879. *The Academy.*

CALCUTTA :—Memoirs of the Geological Survey of India—
Vol. XVI. Part 1.
XV. ,, 2.
XVII. Parts 1 and 2.
Do. (Palæontologia Indica) Series XIII Part 1.
,, II ,, 4.
,, XIV ,, 1.
,, X Parts 4 and 5.
Records of the Geological Survey of India—
Vol. XIII. Parts 2 and 3 and 4.
XII. ,, 1 and 2.
Scientific Results of the Second Yarkand Mission Rhynchota, by W. L. Distant. *The Superintendent of the Geological Survey of India.*
Proceedings of the Asiatic Society of Bengal—
Nos. 5, 6, 7, 8, 9 and 10. 1879.
Nos. 1, 4, 5, 6. 1880.
Journal of the Asiatic Society of Bengal—
Vol. XLVIII. Part I. Nos. 1, 2, 4. 1879.
,, ,, II. No. 2. 1879.
XLIX. ,, I. Nos. 1 and 3. 1880.
,, ,, II. No. 1. 1880.
Extra number to Part I, for 1878.
Descriptions of new Indian Lepidopterous Insects. Part I. *The Society.*

CAMBRIDGE (Mass.), U.S.A. :—Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge (Mass).
Vol. V. Nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, and Index.
VI. ,, 1 and 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.
VII.
Annual Report of the Curator of the Museum, 1879-80.
The Terrestrial Air-breathing Mollusks of the United States and the adjacent territories of North America. By W. G. Binney. 1 vol. text and 1 vol. plates. *The Museum.*
Psyche (organ of the Cambridge Entomological Club, Mass.)
Vol. 3. Nos. 69, 70, 71, 72, 73, 74, 75, 76, 77. *The Editors.*

CAPE TOWN :—The Transactions of the South African Philosophical Society.
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(Names of Donors in Italics.)

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Marburg.—*Gesellschaft zur Beförderung der Gesammten Naturwissenschaften in Marburg. Nos. 1, 2, 3, 4.

,, *The University. Nos. 1, 3, 4, 5.

Mulhouse.—*Industrial Society. Nos. 1, 3, 4, 5.

Munchen.—*Königliche Akademie der Wissenschaften in München. Nos. 1, 2, 3, 4, 5.

Stuttgart.—*Königliches Statistich-Topographisches Bureau zu Stuttgart. Nos. 1, 2, 3, 4, 5.

Wurttemberg.—*Der Verein für Vaterländische Naturkunde in Württemberg. Nos. 1, 2, 3, 4.

HUNGARY.

Bistritz (in Siebenburgen).—*Direction der Gewerbeschule. Nos. 1, 2, 3, 4, 5.

Zagreb (Agram).—*Société Archéologique. Nos. 1, 3, 4.

ITALY.

Bologna.—Accademia delle Scienze dell' Istituto. Nos. 1, 3, 4, 5.

,, University. Nos. 1, 3, 4, 5.

Florence.—Società di Anthropologia e di Ethnologia. No. 1.

,, Società Entomologica Italiano. No. 1.

Genoa.—Museo Civico di Storia Naturale. Nos. 1, 3, 4.

Milan.—Reale Istituto Lombardo di Scienze Lettere ed Arti. Nos. 1, 3, 4, 5.

,, Società Italiana di Scienze Naturali. Nos. 1, 3, 4, 5.

Modena.—*Académie Royale des Sciences, Lettres et Arts de Modene. Nos. 1, 3, 4, 5.

Naples.—Società Reale Accademia delle Scienze. Nos. 1, 2, 3, 4, 5.

,, *Zoological Station (Dr. Dohrn). No. 1.

Palermo.—Accademia Palermitana di Scienze Lettere ed Arti. Nos. 1, 3, 4, 5.

,, Reale Istituto Technico. Nos. 1, 3, 4, 5.

Pisa.—*Società Toscana di Scienza Naturale. Nos. 1, 2, 3, 4, 5.

Rome.—Accademia Pontificia de 'Nuovi Lincei.—Nos. 1, 3, 4, 5.
,, Circolo Geographico d'Italia. Nos. 1, 3, 4.
,, Osservatorio del Collegio Romano. No. 1.
,, *R. Accademia die Lincei. Nos. 1, 2, 3, 4, 5.
,, *R. Comitato Geologico Italiano. Nos. 1, 3, 4, 5.

Siena.—R. Accademia de Fisiocritici. Nos. 1, 3, 4, 5.

Turin.—Reale Accademia delle Scienza. Nos. 1, 3, 4, 5.
,, Regio Osservatorio della Regio Universita. No. 1.

Venice.—*Reale Istituto Veneto di Scienze Lettere ed Arti. Nos. 1, 2, 3, 4, 5.

JAPAN.

Yokohama.—*Asiatic Society. Nos. 1, 2, 3, 4.

NETHERLANDS.

Amsterdam.—*Académie Royale des Sciences. Nos. 1, 2, 3, 4, 5.

Haarlem.—*Société Hollandaise des Sciences. Nos. 1, 2, 3, 4, 5.
,, *La Bibliothèque du Musée Teyler. Nos. 1, 3, 4, 5.

NORWAY.

Christiania.—*Kongelige Norske Fredericks Universitet. Nos. 1, 2, 3, 4, 5.

RUSSIA.

Moscow.—*La Société Impériale des Naturalistes. Nos. 1, 2, 3, 4.

St. Petersburg.—* L'Académie Impériale des Sciences. Nos. 1, 2, 3, 4, 5.

SPAIN.

Madrid.—Instituto geografico y Estadistico. Nos. 1, 2, 3, 4.

SWEDEN.

Stockholm.—*Kongliga Svenska Ventenskapo-Akademie. Nos. 1, 2, 3, 4.
,, The University. Nos. 1, 3, 4, 5.

SWITZERLAND.

Geneva.—*Institute National Genevoie. Nos. 1, 2, 3, 4, 5.

Lausanne.—*De la Société Vaudoise des Sciences Naturelles. Nos. 1, 2, 3, 4.

Neuchatel.—*Société des Sciences Naturelles. Nos. 1, 2, 3, 4.

Number of Publications sent to	Great Britain...	274
,, ,,	The Colonies and India ...	147
,, ,,	America	168
,, ,,	Europe	386
,, ,,	Asia (Japan)	4
,, ,,	Editors of Periodicals	34
	Total	1,013

The Society's House, Sydney,
November 22nd, 1880.

A. LIVERSIDGE, } Hon. Secretaries.
A. LEIBIUS, }

REPORTS FROM THE SECTIONS

(IN ABSTRACT.)

REPORTS FROM THE SECTIONS

(IN ABSTRACT).

Sections A, B, C, D, and F, did not meet in 1880.

SECTION E.—MICROSCOPICAL SCIENCE.

14 APRIL, 1880.

Mr. H. G. A. Wright, M.R.C.S , in the Chair.

The minutes of the previous meeting were read and confirmed.

The following Committee was elected for the ensuing year:—Chairman: Dr. Morris. Secretary: Mr. P. R. Pedley. Committee: Messrs. H. G. A. Wright, G. D. Hirst, W. Macdonnell, F. B. Kyngdon.

It was resolved to hold the meetings of the Section on the evening of the second Wednesday in each month.

The meeting then adjourned.

WEDNESDAY, 17 MAY.

Dr. Morris in the Chair.

It was resolved that application be made to the General Council for the purchase of a microscopical object cabinet to hold 1,000 slides.

Mr. T. E. Hewett exhibited a series of eighteen (18) slides of *Entomostraca*, fifteen of which were undescribed and new to science.

Dr. Morris called the attention of the meeting to two slides of microscopic tracings of Lissajous' curves, engraved by Mr. G. R. West, of London. These slides constitute very beautiful test-objects for medium power objectives, affording studies in illumination and in certain paradoxical and deceptive appearances, even surpassing in beauty and brilliancy, and stereoscopic effect, the larger curves which are so well known and so much admired.

Mr. W. Macdonnell exhibited a new and improved form of air-pump and Swift's new form of camera lucida.

Mr. P. R. Pedley exhibited two species of parasites of the black ibis and a series of stained physiological preparations.

WEDNESDAY, 9 JUNE, 1880.

Dr. Morris in the Chair.

Mr. H. G. A. Wright exhibited Tolles' $\frac{1}{10}$th duplex front objective, which had been made to his special order. With this objective Mr. Wright resolved a number of the most difficult diatom test objects, including *A. pellucida* and *N. oxyphillum* in balsam. Mr. H. O. Walker exhibited specimens of *Volvox globator* from the Botany Swamp. Mr. T. E. Hewett exhibited a piece of colonial selenite, a remarkably fine specimen, and also drew the attention of the meeting to an improved form of Bramhall's illuminator, with a highly polished silver reflecting surface. Mr. Brindley exhibited a series of polariscopic objects, and Mr. Pedley a rich and varied collection of aquatic entomostraca.

WEDNESDAY, 14 JULY, 1880.

Mr. H. G. A. Wright, M.R.C.S., in the Chair.

Among the objects exhibited by the members present was a preparation of fossil diatoms from a recently discovered deposit near Tamworth, by Mr. H. O. Walker, and beetle by Mr. F. B. Kyngdon, a species of *Atractus*, in its larval and pupal forms, and as a perfect insect, badly afflicted with acaridæ. Mr. G. D. Hirst exhibited Prof. Smith's vertical illuminator, which he recommended as a very desirable form of illumination for high-angled immersion objectives. The performance of this illuminator on *F. saxonica* and other difficult test objects was most gratifying.

WEDNESDAY, 11 AUGUST, 1880.

Dr. Morris in the Chair.

Mr. H. Sharp exhibited photographs of *A. pellucida*, executed by Mr. Tolles of Boston, showing the transverse striæ resolved from end to end of valves by $\frac{1}{4}$th and $\frac{1}{10}$th inch objectives of his own construction.

The Chairman exhibited a preparation of *Odium albicans* from a patient's tonsil. This fungoid growth possesses considerable interest from the fact that to the unaided eye it presents a very similar appearance and may readily be confounded with diphtheritic exudations. Dr. Morris also exhibited a gathering of true *N. rhomboides* from Manly. Mr. T. E. Hewett exhibited an interesting collection of mites; and Mr. Pedley, a number of microscopic marine crustaceans.

WEDNESDAY, 7 SEPTEMBER, 1880.

Dr. Morris in the Chair.

Professor Liversidge presented for distribution amongst the members of the Section two samples of diatomaceous deposits, the one from the Richmond River, N.S.W., and the other from Santa Maria, California. Dr. MORRIS read some notes on an encisted *Filaria*, found in the flesh of the bullock, and exhibited the cyst and portions of the mature and embryo worm under the microscope. The cyst is formed of dense white fibrous tissue, encased in which is found the mature worm with interlaced meshes of tissue corresponding with the folds of the worm. The cyst is about the size of a large Barcelona nut, and many contain more than one mature worm, which worm is completely filled with encapsuled and free embryos. It is impossible to ascertain with any degree of certainty how many embryotic worms each mature *Filaria* may contain, but they may be numbered by hundreds of thousands.

Mr. PEDLEY exhibited a number of slides of parasitic *Ixodes*.

WEDNESDAY, 13 OCTOBER, 1880.

Dr. MORRIS in the Chair.

A donation to the Society's Cabinet was received from Mr. T. E. HEWETT of six slides of insect preparation mounted in glycerine. Mr. T. E. HEWETT read a note on a species of *Cyperidium* remarkable for showing a phosphorescent light when irritated; he had found this species in Port Jackson, and proposed to call it *Cyperidium phosphorescens*.

Dr. MORRIS exhibited a number of slides of a species of *N. rhomboides* mounted in different media. He stated that having made a long series of experiments, he found that the visibility of the shallow markings on the very difficult *rhomboides* depended greatly on the medium used for mounting; mounted dry, and in Canada balsam, the highest angled lenses of Tolles and Zeiss resolved them only with the greatest difficulty and but very faintly, whereas when using as a medium various combinations of bisulphide of carbon with phosphorus, oil of cassia, and sulphur, the valves were resolved with the greatest ease. The meeting had an opportunity of testing the accuracy of Dr. Morris's observations by direct comparison of valves of this *rhomboides* mounted dry, and in Canada balsam, with preparations of the same valves in the medium proposed by him; that particularly recommended being bisulphide of carbon, oil of cassia, and phosphorus, as safest to work with. The superior definition of the markings in this medium was acknowledged by all present.

WEDNESDAY, 10 NOVEMBER, 1880.

Dr. MORRIS in the Chair.

Mr. PEDLEY presented six slides for the Society's Cabinet, and reported a further donation of two slides from Mr. H. O. Walker.

Dr. WRIGHT called the attention of the meeting to a $\frac{1}{10}$ of an inch objective of Mr. Tolles' construction, of 100° angular aperture, and claimed that no amount of deep eye-piecing could break it down. He exhibited a *Podura* scale amplified to 2,000 diameters without in any way impairing the defining power of the objective.

Dr. MORRIS exhibited *A. pellucida* resolved in Canada balsam medium, and also in a preparation of bisulphide of carbon and phosphorus.

Mr. BRINDLEY exhibited some slides of local *Foraminifera.*

DONATIONS TO THE SOCIETY'S CABINET.

Mr. T. E. HEWETT :—Spiracle of larva of moth; antenna of moth; *Malophagus ovinus ;* Sp., caprella ; *Limnardia sorida ;* parasite of magpie-lark.

Mr. H. O. WALKER :—*Achnanthes longipes* ; palate of slug.

Mr. P. R. PEDLEY :—Nervous membrane investing spinal cord of cow ; section of human scalp ; section of rush, fungus, spiracles of caterpillar, and gizzard of black cricket.

SECTION G.—LITERATURE AND FINE ARTS, INCLUDING ARCHITECTURE.

FRIDAY, 16 APRIL, 1880.

Mr. E. L. MONTEFIORE in the Chair.

The minutes of the previous meeting were read and confirmed.

The following officers were elected :—Chairman : Mr. E. L. MONTEFIORE. Secretary : Mr. PERCY E. WILLIAMS. Committee : Messrs. L. W. HART, A. L. JACKSON, TREVOR JONES, and G. A. MORRELL.

FRIDAY, 28, MAY, 1880.

Mr. E. L. MONTEFIORE in the Chair.

Mr. MONTEFIORE laid on the table etchings by Vion, Faruffini, Ballin, and others ; an original landscape in black and white by Gainsborough ; and studies in chalk by Domenico, Pellegrino Tebaldi, and Padouanino.

Rev. Mr. HORTON exhibited a rare German work on Heraldry, published at Nurenberg in 1696.

Mr. L. W. HART produced photo-types of the Katoomba Falls, Weatherboard, and general mountain scenery.

Mr. CLARENDON STUART exhibited several chromo-lithos by Spithover, of Milan, representing pavements, basilicas, &c., of public buildings in that city.

An interesting and animated discussion took place on the various literary and art topics of the day, during which Mr.

STUART drew attention to a work on "The Bronze Ornaments of the Palace Gates from Balawat," published under the sanction of the Trustees of the British Museum.

It was resolved that the Council should be applied to for a copy of the work for the use of the Section.

Copies of the proceedings of the Society of Biblical Archæology were laid on the table by Mr. STUART.

FRIDAY, 30 JULY, 1880.

Mr. E. L. MONTEFIORE in the Chair.

The Secretary read a letter from the Council declining to accede to the application of the Section to procure a copy of the work on the Bronze Gates of Balawat, whereupon Mr. STUART stated he would present his own copy to the Section on its arrival from England.

The Secretary laid on the table the first number of a work on Decorative Art.

Mr. MONTEFIORE exhibited some curious and interesting works, including an illustrated edition of Butler's Hudibras, published in 1709; an essay on Comic Painting, 1788; and fifteen drawings by Henri Regnault.

Mr. TREVOR JONES read an interesting paper on "Light and Colour, a treatise on some of their properties, physical, and artistic," illustrated by diagrams and experiments.

SECTION H.—MEDICAL SCIENCE.

A preliminary meeting of this Section was held on 16th April, 1880, at which the following officers were appointed :—Chairman : Mr. ALFRED ROBERTS. Secretaries : Dr. JONES, Dr. MACLAURIN. Committee : Messrs. WRIGHT, FORTESCUE, COX, and SCHUETTE.

Meetings of the Section were held on the second Friday in each month, at which specimens were exhibited, papers read, and subjects of professional interest discussed.

A paper by Dr. Manning on the Causation of Insanity, read on August 13th, 1880, was recommended for publication in the Society's Journal.

P. SYDNEY JONES, } Hon. Secretaries.
H. N. MACLAURIN, }

The Causation and Prevention of Insanity.

By F. Norton Manning, M.D., &c., &c.

[*Read before the Medical Section of the Royal Society of N.S.W., 10 September, 1880.*]

It is one of the glories of our profession that its members have not only been foremost in recognising the importance—but have been the chief workers in the field—of preventive medicine, that they have discerned that prophylaxis has a higher aim than therapeutics, and that "there is a larger and loftier success in preventing the diseases of communities than in curing the diseases of individuals." In mental, as in physical disease, there is more scope for the physician in prevention than in cure, and it is in this direction I would ask your attention this evening. The causation and prevention of insanity is a subject of such importance that I need not apologise for its introduction.

As a text for my observations, I place before you two tables which have been prepared with some care, and concerning which some explanatory remarks are necessary. The first of these shows the assigned causes of insanity in 3,077 patients admitted into the Hospital for the Insane at Gladesville, from January 1st, 1869, to December 31st, 1878, a period of ten years. This table has been prepared from the case books of the Hospital, and I have to thank my friend Dr. Beattie for placing it in its present shape. The causes assigned in the papers forwarded with the patients, often conjectural, and sometimes absurd, have been supplemented by inquiries from relatives and from the patients themselves, and corrected by the light thrown on the cases by their subsequent history and progress. The second table is more elaborate and more important, not only as embracing larger numbers, but as based on an improved classification. It sets forth the assigned causes of insanity in 13,309 patients admitted into English asylums of all classes during the year 1878, and is the first attempt in this direction on the part of the English Commissioners in Lunacy, who acknowledge their indebtedness to the Medical Superintendents of Institutions for the Insane throughout the Kingdom. The percentages for both tables have been calculated in my office.

It will be seen that in the Gladesville table there is no distinction between predisposing and exciting causes, whilst in the English table these are distinguished, and are both tabulated where both are found to exist, with a result that the aggregate of the total causes, including those unknown, exceeds the whole number of patients by exactly 30 per cent. In comparing the percentages in the Gladesville and English tables, it should therefore be remembered that the latter are greater than the former by 30 per cent. or $\frac{1}{3}$ from this cause. With this in mind, and with some corrections necessary, owing to the somewhat different method of classification, it will be seen that though some causes are more potent in this than in the mother country, in others there is a singular agreement in the percentages. Taking the main divisions moral and physical, it appears that in New South Wales 16·9 per cent. of the insanity was due to moral, and 57·6 per cent. to physical causes; an addition of 30 per cent. to each of these brings the figures very near the English percentages. It is not my intention to analyse minutely these epitomes of human misery, or to take up seriatim each of the causes of mental disturbance here set forth; still less is it my desire to dogmatise on a subject so intricate. Deep set hereditary predisposition, morbid susceptibilities to disease, and the marvellous ingrained weakness of human nature, go with numerous depressing influences, moral and physical, to make up that complex concurrence of conditions which results in insanity. The causes lie too deep to be gathered by mere surface investigation, and can seldom be packed into a word or a sentence. A patient accumulation of an extensive series of data is required for the proper elucidation of this question. The tables I have placed before you are a step in this direction, and such evidence as can be deduced from them must be regarded as a small contribution towards a large subject. I shall pass over at once the majority of the so-called moral causes of insanity, because these come but little within our province as physicians, because I believe that in the majority of cases it is only when there is physical predisposition that these causes become operative, and because it is certain that with increasing knowledge the number classified under these headings is diminishing. "Domestic trouble" is no uncommon experience, "mental anxiety" falls to the lot of most men and women, and "adverse circumstances" to not a few. The strain falls on almost all—the weak give way, and it is this weakness which, in reality, constitutes the chief cause of the insanity.

The first causes to which I would direct your attention appear in the Gladesville but not in the English table. They are isolation and nostalgia, to which, conjointly, 3·9 of the cases are attributed. I mention the two together because they have something in common. The cases of pure nostalgia have been few and have occurred entirely among other than English-speaking people, Swiss, Danes, Italians, and Chinese. All spoke English most imperfectly, and were isolated in this respect, as well as in being far from home and in a strange country. The cases due to isolation included shepherds whose occupation some years ago was of the most lonely character in all, and is still so in some districts of the Colony. Happily, however, with the increase of fencing, and with increasing population, this form of isolation, which was formerly a fruitful cause of insanity, is rapidly decreasing. Isolation in another form was first brought under my notice by observing that a large proportion of the patients admitted had no relatives or friends nearer than the old country. By a return, which I have had prepared during the last few weeks, I find that more than one half—1,038 out of 2,036—of the inmates of our institutions for the insane on June 30 last were, so far as is known, absolutely friendless; that upwards of 200, or 10 per cent., are foreigners; and that only about 900 are known to have friends or relatives in this Colony. This isolation, which is something terrible to a new emigrant, and which lasts often for years, is kept up by the disparity of the sexes, which at the close of 1879 stood at 409,665 males and 324,617 females, and to some extent prevents marriage; and it is fostered by the peculiar mode of life both of the miner and the bushman, by the shifting from place to place with the seasons in search of work, and by the restlessness which seems an inherent feature of colonial existence at present.

The absence of all near home ties and all active sympathy, together with the constant change of associates, leads on the one hand to a dwarfing of all those better feelings which are fostered and flourish in home life, and on the other to the development of a miserable selfishness, to a concentration of all thought in one unwholesome direction, to a suspicion and distrust of ever-changing comrades, and at last to evil habits, to introspection, to hypochondriasis, and to the development of delusions of suspicion and fear, which are prominent symptoms in this class of cases. Isolation is most potent as a cause of insanity, as might be expected among men, but it is found among women also, many of whom have landed in this country quite friendless, and a large number of whom, in an after stage of life, live in terrible isolation, surrounded by some real and some imaginary dangers, in homesteads in the distant bush, from which their husbands are frequently absent as shearers, teamsters, &c., for long periods.

A system of family, instead of isolated, emigration, would do much to prevent this cause of insanity, and the present system of assisted immigration, by which persons come out to the charge and partly at the expense of friends, is decidedly better in this regard than one which lands on our shores a number of friendless strangers. With increasing population, with less disparity in numbers between the sexes, with more settled modes of life, and with the growth of a native-born population, this cause of insanity will no doubt lessen and in time disappear.

Intemperance in drink appears in the English statistics as causing a percentage of 14·6, and in the Gladesville the percentage stands at 8·3. It must be remembered that 30 per cent.

must be subtracted from the former to make these proportions of equal value in the two tables. This will give nearly 10 per cent. as the English rate, and represents, I believe, fairly the proportion of insanity due directly or indirectly to this cause. I attach the more value to these statistics because they have been collected by a number of independent observers, and are therefore free from the chance of error due to individual and unconscious bias which besets all statistics drawn up by one person. For some years past I have read everything I could find to read on this subject, have now no small personal experience bearing on this question, and have come to the conclusion that the effect of intemperance as a cause of insanity has been largely exaggerated. I put aside at once all that intemperance of statement which seems to be inseparable from the habitual denunciation of intemperance in drink. There is in this nothing but vague and sensational declamation unsupported by any attempt at proof. To a certain class of mind drunkenness is the root of all evil, and some of our professional brethren have not been free from an unconscious exaggeration of statement on this subject. The earlier statistics, which set down at least 25 per cent. of all insanity as caused by intemperance in drink, have been proved to be erroneous by statistics taken over a wider field, and by many unprejudiced observers, and the startling statements of Dr. Howe, that almost all cases of idiocy were due to drunkenness in the parents, which to some extent shifted the ground and upheld the idea that drink was an enormous indirect factor of insanity, have been disproved by the researches of Dr. Grabhan, of the Earlswood Asylum, Dr. Bucknill, and other writers. To quote the words of an asylum physician in a neighbouring Colony, "intemperance is a cause so readily seized, so easily packed into a word, comes so easily under the notice of a patient's family, his friends, or the public, that a few striking instances engross the mind, and unconsciously count for many a dozen others, which without obvious cause enter unnoticed into the asylum." In not a few instances in my experience, the intemperance stated to be a cause was really a symptom—one of the evidences of a loss of self-control—due to brain disease manifestly existent at an antecedent date to the outbreak.

The strongest argument next to that derived from such statistics as I lay before you, that intemperance is not so potent a cause of insanity as is generally supposed, is to be derived from pathology. I would ask what is your experience as medical practitioners as to the pathological condition of the habitual drunkard, and I think you will answer that such cases die of liver and kidney disease, of apoplexy or of delirium tremens (a very different thing to insanity), but that they do not in any considerable proportion go mad. The proliferation of connective tissue is one of the prominent pathological changes produced by alcohol in the structure of numerous organs where its effects have been carefully studied. The brain and nerve structure of lunatics should present a corresponding condition if the cause of insanity were drink. The post-mortem rooms of hospitals for the insane afford little or no evidence of this except in one or two special forms of disease, and it is rare in my experience to find in patients dying in these institutions the peculiar changes in liver and kidney which are known to be due to alcoholism, and which should be abundantly frequent if these patients had been drunkards. The quality of the drink and the mode in which it is taken has perhaps a larger share in the production of insanity, at all events in this Colony, than the quantity. The quality of the beverages supplied in roadside and up-country public-houses, and even in Sydney and the larger towns is, as I need hardly remind you, abominably bad. Apart from fusel oil and other products of recent and imperfect distillation, direct adulteration is largely practised. Kerosene, tobacco, cocculus indicus, and other deleterious substances, are freely used, and there can be no doubt that these poisons, to use the language of the Laureate:

> "Confuse the chemic labour of the blood,
> And tickling the brute brain within the man's,
> Make havock among those tender cells."

The system of drinking which is almost unknown in older countries has also not a little to answer for. Short and reckless outbursts of drinking, alternate with prolonged and often compulsory periods of abstinence. These horrible orgies on bad liquor may, and no doubt not unfrequently do, result in insanity.

Though I believe that the amount of insanity caused by drink has been exaggerated, still the amount given in these statistics calls for earnest consideration. In round numbers 10 per cent. is set down as due to this cause, and 200 out of the 2,000 persons now under care must be considered to have become insane from intemperance in drink. Calculating the cost of construction in our hospitals for the insane at from £150 to £200 per bed, and with the high price of labour it has not been much less, we have a primary outlay for these 200 cases of from £30,000 to £40,000, and an annual maintenance rate of upwards of £6,000 a-year. The prevention of insanity due to drink becomes in this aspect a vast social as well as a medical problem—the solution of which is, I think, to be largely found—

1st. In the reduction of the number of public-houses, so as to lessen unwholesome competition;

2nd. In the thorough and frequent inspection of all liquors sold;

3rd. In the introduction into common use of sound light wines, the many forms of effervescent drinks, and more than all of ice. The common use of iced water in America, where it can be obtained in every railway carriage and in every village, has done more I believe to reduce intemperance than anything else;

4th. In better and more wholesome modes of preparing food, which even in our hotels is often so uninviting and monotonous as to disgust and lead, not only to drinking habits, but to dyspepsia and chronic ill health, of which I shall have something to say further on.

Sexual intemperance appears in the English table as responsible for about 1 per cent. of the cases, and though it is not perhaps a very frequent cause of insanity itself, it is worth the consideration of medical practitioners as the cause of various nervous affections which may conduce to insanity, either in the individual or his offspring. In my position as Medical Superintendent of Gladesville I was not unfrequently consulted by persons suffering from hypochondriasis and other forms of nervous affection, and in a considerable proportion I ascertained that there was sexual intemperance. In some cases of insanity admitted into the Hospital, and especially in elderly men with young wives, I have with good reason attributed recovery to the temporary and enforced continence.

Lallemand was the first to point out the influence of seminal discharges on certain forms of vesania, and though like almost all specialists he no doubt exaggerated their influence, he did good service in showing that hypochondria, moral prostration, and true melancholy were sometimes due to this cause. The effects of sexual intemperance in lawful or unlawful channels must be differentiated from masturbation, because to the latter is added a secret, shameful, and moral cause of degradation, and the form of insanity due to this cause differs in some respects from that due to sexual intemperance only. You will perceive that masturbation is credited with 1·7 per cent. in the Gladesville and 1·2 per cent. in the English tables, and these rates will doubtless seem small to all who have read a certain kind of sensational literature, which itself by the way has done more to cause insanity than the practices which it denounces. There is little doubt but that masturbation has been too frequently cited as a cause of insanity by observers who are without the breadth of view which can only be gathered by a complete scientific and medical education. It is frequently seen in the course of insanity as a symptom, especially in acute mania, since with the evanescence of reason and its controlling power comes a temporary subservience to animal propensities and seminal habits. But the practice ceases with the re-enthronement of the controlling power. I have repeatedly known it to exist in the course of attacks of mental aberration, and ascertained that it was not only discarded but regarded with due abhorrence after recovery.

A reference to the tables will show you the small amount of insanity said to be due to venereal disease—0·4 per cent. in one and 0·6 per cent. in the other. It has been to me a frequent wonder that more cases of insanity were not due to syphilis, and it is certainly curious that in 4,000 admissions primary syphilis was only seen in three cases.

Sunstroke, as might be supposed, is a cause of insanity in a much greater degree in New South Wales than in England. It appears in the English table as causing 1·3 per cent., but it should be remembered that this includes numerous cases where the attack has occurred abroad; soldiers sent from India to the wards for the Army Department at Grove House, Bow; sailors invalided from foreign stations, and admitted to the Hospital for the Insane at Yarmouth; besides isolated cases sent from hot countries under medical advice. Practically sunstroke, as a cause of insanity, in England, is almost unknown. It is far otherwise in this Colony. Five per cent. of the total number of cases are accredited to it, and I think with good reason. The effect of sun- or heat-stroke in the production of disease is not sufficiently appreciated. Many slight attacks of illness assigned to other causes are I believe due to the effect of heat and glare on the cerebral circulation. The enormous power of the sun's rays is well shown by the observation of Mr. Russell, the Government Astronomer. The thermometer with a black bulb placed in black cotton wool not infrequently in the summer-time reaches the boiling point, and on one occasion a thermometer graduated to 234 burst under these conditions. It is in the power of physicians to prevent much mischief by inculcating greater care in avoiding exposure, by insisting on a more rational head covering for the summer months than a black stove-pipe hat, and by pointing out that after an attack of sunstroke alcohol is an absolute poison, and cannot be taken with impunity in even small quantities. A person who has once suffered from sunstroke must be either a teetotaller or a lunatic. There is, I believe, no middle standpoint.

Accident or injury to the head is mentioned in both tables as a cause of insanity. In some cases it is a direct, but it is more often a predisposing, cause. It is in cases predisposed by injury that sunstroke, intemperance, excitement, and other causes light the fire which has been already laid. Where injury to the skull exists a caution as to the avoidance of exciting causes may not infrequently save from further danger. During the year 1872 I took some trouble to examine every patient admitted, and found marks of injury to the head more or less severe in 30 per cent.

I do not propose to dwell on the puerperal state—pregnancy, parturition, and lactation—as a cause of insanity, but I think it may be well to put on record my opinion that lactation prolonged beyond the ordinary time, or continued by delicate women even up to the ordinary period, is more frequently a cause of insanity in this country than in England. In the English table it is set down as causing less than 1 per cent. Unfortunately in the Gladesville tables the causation is not so fully differentiated. Lactation is included under the general heading of the puerperal state, and I have not found time to re-examine the case books with a view of ascertaining the exact proportion attributed to this cause alone. I feel sure, however, from the prominence which it has assumed in my mind as a cause of insanity, that the proportion is greater here than in England. Probably the enervating climate and the want of milk and good digestible food in the up-country districts help to render lactation more depressing than in England, and suggest a shortening of the period and greater attention to diet as necessary.

From this point the tables having been prepared on a somewhat different plan become more difficult to compare, though on close examination and on grouping the causes, there is seen to be a close agreement in some of the percentages. For instance, fevers, privation, uterine and ovarian disease, and other bodily disorders, in the English table, give together a percentage of 13·7, whilst fever, chronic ill health, want, phthisis, and epilepsy, in the Gladesville tables, give together exactly the same figures.

It is only during comparatively late years that progress has been made in the idea of an intimate correlation, of a relation of cause and effect between affections of organs far removed from the encephalon and disorders of the mind. The influence of uterine and ovarian affections, disorders of the digestive functions, lesions of the stomach and intestinal canal, affections of the liver, heart disease, pulmonary phthisis, are now among the best recognised causes of mental aberration; and we know to-day that there is not a single part of the economy, lesions of which may not bring about psychical disorder in predisposed subjects. The ascending course of some diseases of the spinal cord towards the brain by which ataxic and paraplegic subjects become in time dements is also almost universally recognised, and, to use the language of a distinguished French professor of mental medicine—"Clinical observers have, so to speak, shifted the axis of mental medicine, and we no longer gravitate round psychology. The diseases of the body and brain, and not merely the perturbations of the understanding, command our attention and treatment."

I have been greatly struck with the number of cases admitted into Gladesville with symptoms of dyspepsia, and with what for want of a better term is designated in the table "Chronic ill-health," and I cannot but attribute a considerable proportion of these to the want of varied and properly cooked meals. I doubt if there is any country in the world where with abundance of food there is less variety or less evidence of civilization in its preparation. Salt meat and damper are still a frequent if not the continuous dietary of large numbers. Fresh meat is cooked in a manner glaringly monotonous; milk is untasted by a large proportion of the up-country population for months together, and vegetables except potatoes are an infrequent luxury for which numbers have to thank the itinerant Chinaman; whilst tea, black, milkless, and often sugarless, is drunk at every meal and in quantities which take away appetite for the more solid and too often unappetising viands.

It is no wonder that women, especially during lactation, break down under such a regimen, that men feel a crying, physical, or physiological want which drives them to bursts of hard drinking, or that the digestive powers fail, and with them the nourishment of the brain as well as other organs.

A bountiful, a varied, and a nutritious diet is in many cases of service in warding off threatened attacks of insanity, or arresting in its early stages, and this with attention to special symptoms denoting bodily ailment is the main agent in the recovery in not a few advanced cases. With better modes of carriage and with denser population we shall in time no doubt get a more varied dietary, and it is to be hoped that cookery will be taught as a special and compulsory subject in the projected High Schools for Girls, and in the higher classes of our public schools.

In the Gladesville table epilepsy is given as a factor to the extent of 5·9 per cent., but in the English table this cause is grouped, as it seems to me unwisely, among other bodily diseases or disorders. I find, however, from some statistics given by the English Commissioners in 1876, that epilepsy is credited with 6·5 per cent., so that probably the potency of this affection in the production of insanity is about the same in both countries. An interesting point in connection with this affection is its strong hereditary character, and its tendency to run off in offspring into kindred neuroses or even into idiocy or insanity. In the January number of "Brain" for 1880 is an elaborate article by Mr. Henry Clarke, surgeon to the Wakefield Prison, on heredity in epileptic criminals, and though possibly the hereditary nature of the malady may be more marked in criminal than in other classes, this paper shows its extreme character and potency. In 119 epileptics, particulars of whose cases were inquired into with the most painstaking diligence, 54, or 45 per cent. showed hereditary influence direct or collateral, and these 54 epileptics were proved to have no less than 124 epileptic relatives, one having as many as eleven, and several four or five each. Dr. Gowers, in his Gulstonian lectures, published in the *Lancet* during the current year, states that out of 1,250 epileptics who came under his care at the National Hospital for Epilepsy and Paralysis, he found distinct hereditary influence in 452, or 36 per cent. Mr. Clarke's researches at

Wakefield further showed that the number of direct hereditary epileptics is much greater among women than men, and that the epileptic strain is transmitted more strongly by the female sex, thus bearing out the statements of Trousseau on this subject.

With regard to the connection between epilepsy and insanity, no less than 24 per cent. of Mr. Clarke's non-insane epileptics had insane relatives, whilst 41 per cent. of the whole and 66 per cent. of the women were descended from insane parents. Out of Dr. Gowers' 1,250 cases 157 were known to have insane relations. The question of the marriage of epileptics is sometimes submitted to medical practitioners, and in my opinion should be invariably answered in the negative.

The hereditary transmission of insanity is a subject of the most profound interest, both from a medical and social standpoint, and to a medical superintendent of a hospital for the insane it is a duty increasing in interest with each year's experience to trace out the relationships of present and former patients. I have had under my care at various times five sons of a mother who died at Gladesville under my predecessor; a brother and sister, two children of the former, and one of the latter have passed through my wards; three sisters; two sisters, and a child of one of them; a mother and two children have at different times been under treatment. And the instances in which two of a family have been under care are innumerable. Even the relatives who come to visit patients frequently display marked forms of neurosis and are in this respect an interesting study to the medico-psychologist. The Gladesville statistics are however, as might be expected, much less complete in this particular than the English ones, and give only 7·2 per cent. as due to hereditary influence. The reason of this is not far to seek. In a former part of this paper I have stated that nothing whatever is known of the relatives of upwards of 1,000 out of 2,000 patients now under care, and, as might be expected, in a very large proportion of those who have friends, such friends have little or no knowledge of the family history or of relatives in far-away lands. In many cases husbands know nothing whatever of the families of their wives, and in not a few cases I have found that neither patients nor their friends could tell me even the nationality of the grand-parents. The statistics obtained in England, where the family history of almost every patient can be traced, afford much more complete and conclusive evidence as to the hereditary character of the malady. In the English tables now before you hereditary influence was ascertained in 17·5 of the cases admitted, and some medical superintendents who have specially inquired into and studied this subject place the percentage as much higher. Dr. Savage, of Bethlehem, shows a percentage of 34 per cent., or 375 out of 1,072 patients admitted under his care. Dr. Needham, of York, gives 31 per cent., or

334 out of 1,029 admissions; whilst in Dr. Thurnam's well-known statistics of the "Retreat," 153 cases were known to be due to heredity out of 469, or nearly one-third. Similar statistics have been published in Scotland, and the Inspectors of Lunatic Asylums in Ireland, in their 27th Report, call attention to and give statistics on this subject. This intense hereditary influence has been noticed abroad as well as in Great Britain and Ireland. Esquirol observes, that of all diseases insanity is the most hereditary, and gives figures showing that in one-fourth of the total number of cases coming under his care this influence was ascertained. Guislain estimates it at one-fourth in Belgium, and Damerou in Holland traced it in 187 cases out of 773 admissions, or about one-fourth. There is reason to fear that the proportion of insanity due to hereditary influence is steadily increasing. Dr. Ball, Professor of Mental Medicine at the University of Paris, in a lecture recently published in the *Lancet*, speaks confidently of "the greater and greater preponderance of heredity in mental aberration," and so long ago as 1872 the Inspectors of Lunatic Asylums in Ireland, in an elaborate report, after pointing out that there was then as large if not larger aggregate of insanity among a population of little more than five millions as there was in 1864, when the population numbered six millions, go on to say, "it is idle to disguise the fact that it is an affection of hereditary and progressive tendency, and to no inconsiderable extent through imbecile females, particularly in the humbler classes of society." It is a sad and striking fact that insanity itself, or a condition of brain strongly predisposing to it, is a legacy left to hundreds by their progenitors, and it is no small part of the benefit which institutions for the insane confer upon the community that they check in a very large degree the propagation of a malady so hereditary in its character. A diffusion of a knowledge of the terrible hereditary character of insanity may do something to prevent imprudent marriages, but unfortunately it is not with the prudent and thoughtful that we have to deal. It is with the wayward, the impulsive, and the improvident, with brains bearing subtle mischief in their recesses, and but little likely to look beyond selfish gratification. The time has not yet arrived for legislative interference. In time to come however, when the liberty of the subject is made more subordinate to the welfare of the community, it will perhaps be found expedient in the interest of future generations to insist on prolonged isolation or operative interference in the case of all persons who have been afflicted with mental disease. In the meantime, to quote the words of Dr. Blandford, "it behoves a physician before whom the terrible results of imprudence in this direction are paraded day by day to hold out a warning and to point out the evils which result from imprudent union, and the immense amount of insanity itself, as

well as epilepsy, chorea, neuralgia, and other nerve disorders, transmitted from parent to offspring." It is, in my opinion, not too much to say that any person who marries, except under very special circumstances, after such a marked and prolonged attack of mental derangement as required hospital treatment, commits a crime against posterity.

Five per cent. of the cases in the Gladesville and 4·8 per cent. in the English table are stated to be congenital in origin. Among the causes of congenital mischief are said to be a condition of intoxication or epilepsy on the part of parents during coition or conception; the marriage of near kin; ill health, injuries, persistent sickness, emotional excitement, anxiety and fright on the part of the mother during pregnancy; injurious compression of the cranial bones and brain from contracted passage or protracted labour; the misuse of forceps; and suspended animation after birth, the latter considered by Dr. Langdon Down to be a frequent cause. As to drunkenness or epilepsy during coition or conception as a cause of congenital mental defect, I must confess that I am sceptical, and the truth must be difficult to prove.

The effect of the marriage of near kin has been debated at very considerable length. Huth, whose elaborate work on this subject is well known, and whose opinions have been widely adopted outside our profession, scouts the idea that consanguineous marriages are harmful, and answers the question whether consanguineous marriages give a greater proportion of unhealthy children than non-consanguineous marriages with a decided negative, stating that even where the marriages of blood relations are habitual, deterioration even through the chance accumulation of an idiosyncrasy, practically does not occur oftener than in other marriages. Other observers have, however, come to a different conclusion, and I would commend to your attention a thoughtful paper on the intermarriage of relations, full of statistics and arguments, by Dr. Nathan Allen, and originally published in the Quarterly Journal of Psychological Medicine for April, 1869, which to my mind affords conclusive evidence that such marriages do result in idiocy, epilepsy, deafmutism, and other forms of neurotic disease. Dr. Mitchell, one of the Commissioners in Lunacy for Scotland, who is perhaps as well qualified to form an opinion on this subject as any one in Great Britain, estimates 10 per cent. of the idiocy in Scotland to consanguineous marriage. My own experience on the subject is limited; but in the few cases in which two imbecile children in one family have come under my observation the parents have been always nearly related, and in the only instance in which I have known three children in one family idiotic I obtained evidence that they were the offspring of the incestuous union of brother and sister. The conclusions I have arrived at, and in which I think you will agree, are that consanguineous marriages have a tendency to strengthen and develop in the offspring individual peculiarities of the parents, both mental and physical, whether morbid or otherwise, and therefore in practice they do often induce degeneration; and also that by means of a proper regard to known facts relating to hereditary transmission, a physician may predict with accuracy the probable result, as regards the health of the offspring, of a marriage of blood relations in any particular case, if he be only sufficiently acquainted with the hygienic history of the family. It is to be much regretted that medical advice on this subject is not more often sought and more often acted on. It would be well in many cases if the family physician could forbid the banns.

On the other causes of congenital defect which I have mentioned it is not my intention to enlarge.

The influence of modern civilization in the production of insanity is an interesting question. There is little doubt, though insanity is of all times and all ages, that savage races are comparatively little liable to it, and that their mode of life, in which the survival of the fittest obtains to its fullest extent, prevents anything like hereditary transmission, or the increase of insanity or idiocy by accumulation. In the idyllic calm of life in Madagascar, and where, by the way, it appears that insane persons are not destroyed as among some savage races, there is no need for a lunatic asylum among a population estimated at upwards of 5,000,000. In the days of American slavery—when all the physical wants of the slave were attended to; when there was no outlet for mental activity, or need for mental anxiety; when, indeed, the lives of these people were those of children—coloured inmates of asylums in the Southern States were few in number. In the States of Georgia and Virginia the number of insane among the coloured population was, it is stated by competent witnesses, at no time prior to emancipation, more than eighty out of a population of 800,000; whilst it appears from recent asylum reports that there are now more than 800 insane persons of this race in these two States. It has been well said that it is better to be civilized and free with even a large chance of becoming insane than to be a savage or a slave without this; but the question remains whether the amount of insanity due to our modern civilization is not excessive, and to a large extent preventible. Insanity certainly was well known in all past epochs of civilization, and ancient literature, sacred and profane, teems with mention of it and illustration of its phases; but there is good reason to think that our civilization, in its varied and higher developments as well as in its manufacture of pauper and struggling classes, and especially in its many expedients for rendering possible, and prolonging the existence of those least fitted to survive and multiply, has caused and is still causing a higher percentage of insanity than was known in former times.

In no epoch has, what for want of a better expression, I will term "mental excess," been more prevalent than in this. Newspapers, medical and lay, have frequently of late pointed out the evils of our present system of stuffing our youth and making all boyhood and girlhood one long period of cramming for examination. The examinations at the London and other Universities and for professions have become almost encyclopedic in their range. The whole system tends to confuse and distract the mind, to unfit it for the work of the world, to stunt originality, and to induce what has not inaptly been termed "brain-fog." Where there is no absolute break-down at the time, and instances of this are much more frequent than is commonly supposed, seeds are planted for the growth of mental disorder later in life, and many a brain is upset which had it been subjected to more moderate pressure would have escaped unharmed. I know no stronger evidence as to the evil done by overwork at schools and competitive examinations than that of Dr. Andrew Clarke, who states that he has discovered temporary albuminuria in 10 per cent. of the candidates sent to him for examination as to physical health after passing the Civil Service examination for India.

Next comes the high pressure, the fever and fret of professional and business life, the haste, competition, and all-pervading disquiet, which has had no parallel in other times. The over-work connected with business, the severe mental labour of the professions, the anxiety, excitement, and harass of the mercantile world, all these are tangible factors of mental disease, though in most instances it is difficult to tabulate the cause. It behoves us, I think, as physicians, to inculcate some pause and leisure in life, and to encourage the tendency which happily exists in this Colony to indulge in out-door sports and amusements of every kind.

In the English table 22·8 per cent., and in the Gladesville table 25·9 per cent. of the causes are set down as "unascertained." The greater percentage in the Gladesville table is due to the defective means we have for obtaining trustworthy information by questioning relatives and friends, and to causes which I have already indicated. The large proportion in both is, I apprehend, due to the fact that the development of insanity generally requires a concurrence of several adverse incidents, and that many cases cannot be attributed to any one special event. It is better, I think, to be seeking for a solution of the problem than to set forth a fancied knowledge, and it need disturb our complacency but little to find that the solution of some of the most difficult questions in morbid psychology is, as yet, beyond us.

TABLE showing the assigned causes of Insanity in 3,077 Patients (being 1,941 Male and 1,136 Female) admitted into the Hospital for the Insane, Gladesville, from 1st January, 1869, to 31st December, 1878, being a period of ten years.

	Number.			Proportion per cent. to the total number admitted.			
	M.	F.	Total.	M.	F.	Total.	
Moral—							
E.G. Domestic trouble	53	80	133	2·7	7·0	4·3	16·9 per cent.
Mental anxiety	131	49	180	6·7	4·3	5·8	
Religious excitement	27	17	44	1·4	1·5	1·4	
Disappointment in love	4	22	26	0·2	2·0	0·8	
Fright and shock	8	13	21	0·4	1·1	0·7	
Isolation	92	20	112	4·7	1·8	3·6	
Nostalgia	7	3	10	0·4	0·3	0·3	
Physical—							
E.G. Intemperance	193	64	257	9·9	5·6	8·3	57·6 per cent.
Syphilis	8	6	14	0·4	0·5	0·4	
Onanism	51	..	51	2·6	..	1·7	
Sunstroke	134	28	162	6·8	2·4	5·2	
Injury to the head	75	9	84	3·8	0·8	2·7	
Puerperal	..	143	143	..	12·1	4·6	
Climacteric	..	38	38	..	3·3	1·2	
Fever, chronic ill-health and want	110	113	223	5·7	9·9	7·2	
Phthisis	14	2	16	0·7	0·1	0·5	
Epilepsy	115	66	181	5·9	5·8	5·9	
Cancer and other diseases of the skull and brain	91	14	105	4·7	1·2	3·4	
Excess of opium	11	..	11	0·6	..	1·3	
Old age	56	38	94	2·9	3·3	3·0	
Hereditary taint	130	91	221	6·7	8·0	7·2	
Congenital	85	69	154	4·4	6·0	5·0	
Unascertained	546	251	797	28·1	22·1	25·9	25·9 per cent.

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TABLE showing the Assigned Causes of Insanity in 13,300 Patients (being 6,666 Male and 6,643 Female) admitted into English Asylums and Licensed Houses during the year 1878. From thirty-third Report of English Commissioners in Lunacy.

	As predisposing cause. *			As exciting cause. *			As the disposing or exciting cause (when these could not be distinguished). *			Total. †			Proportion per cent. to the total number of Patients admitted during the year.			
	M.	F.	Total.	M.	F.	Total.	M.	F.	Total.	M.	F.	Total.	M.	F.	Total.	
Moral :—																
Domestic trouble (including loss of relatives and friends)	38	65	103	172	475	647	47	114	161	257	654	911	3·8	9·8	6·8	23·7 per cent.
Adverse circumstances (including business anxieties and pecuniary difficulties)	77	25	102	324	171	495	83	23	106	484	219	703	7·2	3·2	5·2	
Mental anxiety and "worry" (not included under the above heads) and overwork	58	32	90	310	242	552	89	63	152	457	337	794	6·8	5·0	5·9	
Religious excitement	8	7	15	131	124	255	20	33	53	150	164	323	2·3	2·4	2·4	
Love affairs (including seduction)	6	15	21	32	150	182	5	36	41	43	201	244	0·6	3·0	1·8	
Fright and nervous shock	7	16	23	63	99	162	15	24	39	85	139	224	1·2	2·0	1·6	
Physical :—																
Intemperance and drink	137	48	185	980	371	1,351	303	112	415	1,420	531	1,951	21·3	7·9	14·6	84·2 per cent.
Do. sexual	15	15	30	46	33	79	33	11	44	94	59	153	1·4	0·8	1·1	
Venereal disease	39	7	46	16	14	30	6	8	14	61	29	90	0·9	0·4	0·6	
Self-abuse (sexual)	18	..	18	114	11	125	27	3	30	159	14	173	2·3	0·2	1·2	
Over-exertion	12	8	20	42	40	82	11	10	21	65	58	123	0·9	0·8	0·9	
Sunstroke	62	3	65	79	9	88	22	2	24	163	14	177	2·4	0·2	1·3	
Accident or injury	115	20	135	145	43	188	79	11	90	339	74	413	5·0	1·1	3·1	
Pregnancy	..	18	18	..	53	53	..	7	7	..	78	78	..	1·1	0·5	
Parturition and the puerperal state	..	40	40	..	347	347	..	80	80	..	467	467	..	7·0	3·5	
Lactation	..	15	15	..	101	101	..	14	14	..	130	130	..	1·9	0·9	
Uterine and ovarian disorders	..	25	25	..	122	122	..	42	42	..	189	189	..	2·8	1·4	
Puberty	3	4	7	8	30	38	1	6	7	12	40	52	0·1	0·6	0·3	
Change of life	..	84	84	..	132	132	..	32	32	..	248	248	..	3·7	1·8	
Fevers	10	12	22	27	29	56	17	7	24	54	48	102	0·8	0·7	0·7	
Privation and starvation	20	14	34	59	78	137	21	20	41	100	112	212	1·5	1·6	1·5	
Old age	115	120	235	40	79	119	81	75	156	236	274	510	3·5	4·1	3·8	
Other bodily diseases or disorders	135	141	276	264	311	575	267	232	499	666	684	1,350	9·9	10·2	10·1	
Previous attacks	644	871	1,515	18	20	38	82	97	179	744	988	1,732	11·1	14·8	13·0	
Hereditary influence ascertained	1,091	1,251	2,342	..	..	..	..	..	..	1,091	1,251	2,342	16·3	18·8	17·5	
Congenital defect ascertained	395	249	644	..	..	..	..	..	..	395	249	644	5·9	3·7	4·8	
Other ascertained causes	25	9	34	121	20	141	34	17	51	180	46	226	2·7	0·6	1·6	
Unknown	..	..	..	..	..	..	..	..	..	1,529	1,506	3,035	22·9	22·6	22·8	22·8 per cent.
	3,030	3,114	6,144	2,991	3,104	6,005	1,243	1,079	2,322	8,793	8,803	17,596				

* With reference to the above distinction between "predisposing" and "exciting" causes, it must be understood that no cause is enumerated more than once in the case of any individual patient.

† These totals represent the entire number of instances in which the several causes, either alone or in combination with others, were statedto have produced the mental disorder. The aggregate of these totals including "unknown" will of course exceed the whole number of patients admitted. The excess is owing to the combinations.

APPENDIX.

ABSTRACT OF THE METEOROLOGICAL OBSERVATIONS TAKEN AT THE SYDNEY OBSERVATORY.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, $10^h\ 4^m\ 50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

JANUARY, 1880.—GENERAL ABSTRACT.

Barometer At 32° Faht.	Highest Reading... ...	30·141 inches on the 27th, at 12 noon.
	Lowest Reading	29·147 inches on the 8th, at 6 p.m.
	Mean Height	29·776.

(Being 0·007 greater than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	14·6 lbs. on the 26th.
	Mean Pressure	0·9 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 21 years, E.N.E.)

Temperature	Highest in the Shade ...	93·1 on the 8th.
	Lowest in the Shade ...	56·6 on the 10th.
	Greatest Range	23·5 on the 8th.
	Highest in the Sun ...	154·9 on the 8th.
	Lowest on the Grass ...	49·7 on the 10th.
	Mean Diurnal Range ...	13·4
	Mean in the Shade ...	71·5

(Being 0·2 greater than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	85·7 on the 17th.
	Least	53·0 on the 11th.
	Mean	70·8

(Being 1·8 less than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days... ...	10
	Greatest Fall	0·528 inch on the 25th.
	Total Fall...	0·697 „ 65 feet above ground.
		1·126 „ 15 in. above ground.

(Being 2·495 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	6·700 inches.
Ozone	Mean Amount	6·5

(Being 1·6 greater than that in the same month on an average of the preceding 21 years.)

Electricity ...	Number of Days Lightning	8
Cloudy Sky ...	Mean Amount	6·0
	Number of Clear Days ...	0
Meteors ...	Number observed ...	0

Remarks.

The weather has been fine and warm generally, with a small rainfall, excepting at a few places on the coast and high lands. At Sydney the highest shade temperature was 93·1 and inland at Til Til 115·8, and the greatest fall of rain was 4·750 inches at Kurrajong Heights.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10^h 4^m $50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

FEBRUARY, 1880.—GENERAL ABSTRACT.

Barometer ...	Highest Reading... ...	30·151 inches on the 2nd, at 10·20 a.m.
At 32° Faht.	Lowest Reading	29·504 „ on the 13th, at 5 p.m.
	Mean Height	29·825

(Being 0·050 greater than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	6·5 lbs. on the 28th.
	Mean Pressure	0·4 lb.
	Number of Days Calm ...	1
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 21 years, S.)

Temperature	Highest in the Shade ...	79·7 on the 14th.
	Lowest in the Shade ...	60·7 on the 19th.
	Greatest Range	14·6 on the 5th.
	Highest in the Sun ...	147·9 on the 19th.
	Lowest on the Grass ...	57·5 on the 2nd.
	Mean Diurnal Range ...	9·1
	Mean in the Shade ...	70·8

(Being the same as that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	100·0 on the 12th.
	Least	56·0 on the 6th.
	Mean	81·2

(Being 6·5 greater than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days	20 rain and 4 dew.
	Greatest Fall	0·888 inch on the 9th.
	Total Fall...	2·216 „ 65 ft. above ground. 3·565 „ 15 in. above ground.

(Being 3·051 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	3·492 inches.
Ozone	Mean Amount	7·1

(Being 2·0 greater than that in the same month on an average of the preceding 20 years.)

Electricity ...	Number of Days Lightning	1
Cloudy Sky ...	Mean Amount	8·3
	Number of Clear Days ...	0
Meteors ...	Number observed ...	0

Remarks.

Pressure and temperature this month have been close to the averages. In the country districts the temperature has been moderate for the season. At Sydney the rainfall has reached little more than half the average, and generally over the Colony has been unequal. The district north of the Lachlan River, and especially the western slopes of the mountains had abundant rains, reaching a maximum of 10 inches at Pangee, and west of the Darling a maximum of 6¼ inches at Mena Murtee, but at other places the rainfall was very light and at Goonoo Goonoo no rain fell, and at the other stations in that district very little was recorded.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, $10^h\ 4^m\ 50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

MARCH, 1880.—GENERAL ABSTRACT.

Barometer ...	Highest Reading... ...	30·065 inches on the 13th, at 8·40 a.m. and on the 20th, at 9.35 a.m.
At 32° Faht.	Lowest Reading	29·475 inches on the 25th, at 5·15 a.m.
	Mean Height	29·793

(Being 0·102 less than that in the same month on an average of the preceding 21 years.)

Wind... ...	Greatest Pressure ...	9·2 lbs. on the 25th.
	Mean Pressure	0·4 lb.
	Number of Days Calm ...	1
	Prevailing Direction ...	N.E.

(Prevailing direction during the same month for the preceding 21 years, N.E.)

Temperature	Highest in the Shade ...	82·3 on the 31st.
	Lowest in the Shade ...	58·7 on the 14th.
	Greatest Range	18·4 on the 31st.
	Highest in the Sun ...	140·5 on the 6th.
	Lowest on the Grass ...	53·4 on the 14th.
	Mean Diurnal Range ...	11·2
	Mean in the Shade ...	69·9

(Being 0·4 less than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	97·0 on the 30th.
	Least	54·0 on the 13th.
	Mean	79·3

(Being 2·7 greater than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days	17 rain and 3 dew.
	Greatest Fall	1·213 inches on the 26th.
	Total Fall	4·817 „ 65 feet above ground.
		6·185 „ 15 in. above ground.

(Being 0·998 inches greater than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	2·802 inches.
Ozone... ...	Mean Amount	7·0

(Being 1·8 greater than that in the same month on an average of the preceding 20 years.)

Electricity ...	Number of Days Lightning	7
Cloudy Sky...	Mean Amount	7·3
	Number of Clear Days ...	0
Meteors ...	Number observed ...	0

Remarks.

Early this month floods were reported from several places. At Lismore, Richmond River, the water rose rapidly on February 21st, and reached its greatest height (40 feet above ordinary level) at 4 p.m., on 22nd; boats were plying about the streets, and much damage was done. On March 10th the river at Brewarrina had risen 6 feet, owing to flood-waters from the Namoi and Barwan, and the Baloon River was so high that much stock had to be removed from the low country. On March 4th heavy floods were reported on the Comet and Fitzroy Rivers, and in Victoria heavy floods occurred about February 27th. The captain of one of the coasting steamers reports that, from the end of January to about February 20th, a bank of clouds and rain was found regularly at Green Cape, fine weather south of it, and rain to north, and the margin not seen to move at all. Along the coast rain has been abundant, reaching a maximum of 11·63 in. at Cordeaux River. Inland the fall has been very small, as will be seen by the accompanying table. At Sydney 6 inches of rain fell during 20 days of the month, most in light showers. Temperature and barometer are close to the average for this month.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

APRIL, 1880.—GENERAL ABSTRACT.

Barometer ...	Highest Reading... ...	30·372 inches on the 11th at midnight.
	Lowest Reading	29·580 ,, on the 5th., at 2·50 p.m.
	Mean Height	29·940

(Being 0·011 greater than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	8·4 lbs. on the 7th.
At 32° Faht.	Mean Pressure	0·5 lb.
	Number of Days Calm ...	5
	Prevailing Direction ...	N.E.

(Prevailing direction during the same month for the preceding 21 years, W.)

Temperature	Highest in the Shade ...	83·8 on the 5th.
	Lowest in the Shade ...	52·6 on the 26th.
	Greatest Range	20·1 on the 5th.
	Highest in the Sun ...	140·4 on the 5th.
	Lowest on the Grass ...	46·5 on the 26th.
	Mean Diurnal Range ...	10·7
	Mean in the Shade ...	64·9

(Being the same as that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	100·0 on the 2nd.
	Least	53·0 on the 30th.
	Mean	76·5

(Being 1·0 less than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days... ...	20 rain and 3 dew.
	Greatest Fall	1·233 inches on the 2nd.
	Total Fall... ...	3·071 ,, 65 ft. above ground.
		4·234 ,, 15 in. above ground.

(Being 2·455 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	2·586 inches.
Ozone... ...	Mean Amount	7·5 ,,

(Being 2·1 greater than that in the same month on an average of the preceding 20 years.)

Electricity ...	Number of Days Lightning	6
Cloudy Sky ...	Mean Amount	7·3
	Number of Clear Days ...	0
Meteors ...	Number observed ...	3

Remarks.

The temperature has been about the average and the weather seasonable. At Sydney the rainfall was less than the average for this month, but still abundant. In the North-western Districts especially, abundant rains have fallen; 9 inches are reported from Gunnedah and nearly 8 from the "Meadows," Cobar.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

MAY, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading... ...	30·142 inches on the 5th, at 10 a.m.
	Lowest Reading	29·367 „ on the 26th, at 4·35 a.m.
	Mean Height	29·779

(Being 0·134 less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	31·2 lbs. on the 8th.
	Mean Pressure	0·9 lb.
	Number of Days Calm ...	9
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 21 years, W.)

Temperature	Highest in the Shade ...	74·7 on the 2nd.
	Lowest in the Shade ...	45·1 on the 30th
	Greatest Range	22·7 on the 21st.
	Highest in the Sun ...	116·6 on the 3rd.
	Lowest on the Grass ...	38·7 on the 30th.
	Mean Diurnal Range ...	14·5
	Mean in the Shade ...	57·8

(Being 0·6 less than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	98·0 on the 21st.
	Least	50·0 on the 11th.
	Mean	70·5

(Being 5·9 less than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days... ...	7 rain and 10 dew.
	Greatest Fall	0·302 inches on the 26th.
	Total Fall... ...	0·317 „ 65 ft. above ground.
		0·586 „ 15 in. above ground.

(Being 4·887 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	2·328 inches
Ozone	Mean Amount	7·1 „

(Being 1·9 greater than that in the same month on an average of the preceding 20 years.)

Electricity ...	Number of Days Lightning	8
Cloudy Sky ...	Mean Amount	5·0
	Number of Clear Days ...	1
Meteors ...	Number observed ...	10

Remarks.

The weather this month has been fine and very dry generally over the Colony. In Sydney the fall of rain was nearly five inches less than the average for this month. The temperature also has been low, at Sydney 0·6 below the average, and at very many of the Country Stations the average of the minimum temperature has been below 40°. On the 8th, 9th, and 10th strong westerly winds prevailed, and on the 9th the total miles recorded was 625.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

JUNE, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·169 on the 12th, at 10·15 a.m.
	Lowest Reading	29·569 on the 15th, at 3·40 p.m.
	Mean Height	29·903

(Being 0·022 inch less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure... ...	15·1 lbs. on the 17th.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	4
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 21 years, W.)

Temperature	Highest in the Shade ...	68·0 on the 14th.
	Lowest in the Shade ...	39·8 on the 20th.
	Greatest Range	23·2 on the 25th.
	Highest in the Sun ...	106·1 on the 14th.
	Lowest on the Grass ...	33·8 on the 20th.
	Mean Diurnal Range ...	14·2
	Mean in the Shade ...	52·8

(Being 1·7 less than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount	96·0 on the 5th.
	Least	50·6 on the 16th.
	Mean	74·4

3·1 less than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days	6 rain, 14 dew.
	Greatest Fall	0·350 inches on the 5th.
	Total Fall	0·417 ,, 65 ft. above ground.
		0·614 ,, 15 in. above ground.

(Being 5·001 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	1·600 inch.
Ozone ...	Mean Amount	6·1 inches.

(Being 0·5 greater than that in the same month on an average of the preceding 21 years.)

Electricity ...	Number of Days Lightning	6
Cloudy Sky ...	Mean Amount	3·4
	Number of Clear Days ...	4
Meteors ...	Number observed ...	4

Remarks.

At Sydney the temperature has been unusually low, the mean 1·7 less than the average, and the temperature upon the grass fell to 33·8 on the 20th. Westerly winds have prevailed, and the rainfall has been very light, only 0·614 or 5 inches below the average. In the country similar conditions were recorded. The minimum temperatures have in nearly all cases been below 40°, and in several below 30°. At seventy-nine stations the rainfall was less than 1 inch, and at four no rain fell; and at no place in the Colony has there been a heavy fall, the greatest fall recorded for the month being 3·35 inches at Kyamba. At Bendemeer and other places the cold was so severe that jugs of water placed inside the houses were frozen hard during the night.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, $10^h\ 4^m\ 50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

JULY, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·494 on the 11th.
	Lowest Reading	29·589 on the 2nd.
	Mean Height	29·906

(Being 0·033 inch less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure	15·7 lbs. on the 19th
	Mean Pressure	0·4 lb.
	Number of Days Calm ...	9
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 21 years, W. and N.W.)

Temperature	Highest in the shade ...	67·1 on the 27th.
	Lowest in the Shade ...	38·8 on the 7th.
	Greatest Range	26·1 on the 31st.
	Highest in the Sun ...	110·0 on the 27th.
	Lowest on the Grass ...	31·4 on the 29th.
	Mean Diurnal Range ...	15·0
	Mean in the Shade ...	51·0

(Being 1·4 less than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount	98·0 on the 13th.
	Least	43·0 on the 27th.
	Mean	73·8

(Being 1·2 less than that of the same month on an average of the preceding 21 years.)

Rain	Greatest Fall	0·255 inch on the 16th
	Number of Days	10 rain and 9 dew
	Total Fall	0·397 inch, 65 ft. above ground. 0·762 ,, 15 in. above ground.

(Being 3·679 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	1·870
Ozone	Mean Amount	6·4

(Being 0·8 greater than that in the same month on an average of the preceding 19 years.)

Electricity ...	Number of Days Lightning	5
Cloudy Sky ...	Mean Amount	4·3
	Number of Clear Days ...	8
Meteors ...	Number observed ...	6

Remarks.

The weather this month has been cold and dry generally over the Colony. At Sydney the rainfall was only 0·762, and this is a fair index of the rainfall in the majority of Country Stations.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

AUGUST, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading ...	30·299 on the 16th, at 9·40 a.m.
	Lowest Reading	29·433 on the 8th, at 2·2 p.m.
	Mean Height	29·854

(Being 0·087 inch less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	42·3 lbs. on the 10th.
	Mean Pressure	1·1 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.N.W.

(Prevailing direction during the same month for the preceding 21 years, W.)

Temperature	Highest in the Shade ...	79·3 on the 21st.
	Lowest in the Shade ...	41·4 on the 13th.
	Greatest Range	28·0 on the 17th.
	Highest in the Sun ...	125·8 on the 20th.
	Lowest on the Grass ...	32·9 on the 13th.
	Mean Diurnal Range ...	17·2
	Mean in the Shade ...	57·4

(Being 2·7 greater than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	93·0 on the 30th.
	Least	30·0 on the 20th.
	Mean	63·6

(Being 8·5 less than that of the same month on an average of the preceding 21 years.)

Rain	Greatest Fall	0·586 inch on the 2nd.
	Number of Days	2 rain and 7 dew.
	Total Fall...	0·474 inch, 65 feet above ground. / 0·612 inch, 15 in. above ground.

(Being 2·531 inches less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	3·562
Ozone	Mean Amount	7·9

(Being 2·4 greater than that in the same month on an average of the preceding 19 years.)

Electricity ...	Number of Days Lightning	8
Cloudy Sky ...	Mean Amount	3·8
	Number of Clear Days ...	4
Meteors ...	Number observed ...	4

Remarks.

The temperature this month has been high, 2·7 above the average; but the dry weather still continues and only 0·612 was recorded at Sydney; and it is a remarkable fact that in the country districts only 19 stations out of 178 had 1 inch or more of rain; and the greatest fall was only 2·910 inches at Orange.

GOVERNMENT OBSERVATORY, SYDNEY

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

SEPTEMBER, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading... ...	30·312 inches on the 8th, at 9·37 a.m.
	Lowest Reading	29·228 „ on the 21st, at 5·13 a.m.
	Mean Height	29·858

(Being 0·021 inches less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	19·2 lbs. on the 17th.
	Mean Pressure	0·8
	Number of Days Calm ...	0
	Prevailing Direction ...	S.

(Prevailing direction during the same month for the preceding 21 years, W.)

Temperature	Highest in the Shade ...	83·3 on the 24th.
	Lowest in the Shade ...	47·9 on the 3rd.
	Greatest Range	29·3 on the 24th.
	Highest in the Sun ...	128·7 on the 21st.
	Lowest on the Grass ...	38·8 on the 3rd.
	Mean Diurnal Range ...	12·9
	Mean in the Shade ...	59·6

(Being 0·9 greater than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	99·0 on the 15th.
	Least	36·0 on the 24th.
	Mean	77·0

(Being 6·9 greater than that of the same month on an average of the preceding 21 years.)

Rain	Greatest Fall	2·036 inches on the 16th.
	Number of Days... ...	13 rain and 7 dew.
	Total Fall...	4.238 inches, 65 ft. above ground. 6·120 „ 15 in. above ground.

(Being 2·905 inches greater than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	2·768
Ozone	Mean Amount	7·7

(Being 2·0 greater than that in the same month on an average of the preceding 19 years.)

Electricity ...	Number of Days Lightning	4
Cloudy Sky ...	Mean Amount	5·8
	Number of Clear Days ...	2
Meteors ...	Number observed ...	0

Remarks.

The temperature this month has been slightly above the average, and the rainfall generally abundant. At Sydney the amount was 6·120, or 2·905 greater than the average for this month. In the country districts the greatest fall was 11·73 inches at Port Macquarie. The south-western districts however received little rain, and in some few places none fell.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, $10^h\ 4^m\ 50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

OCTOBER, 1880.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading... ...	30·160 inches on the 7th, at 9·30 a.m.
	Lowest Reading	29·052 „ on the 23rd, at 11·40 a.m.
	Mean Height	29·778

(Being 0·056 inch less than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	17·4 lbs. on the 12th.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	S.

(Prevailing direction during the same month for the preceding 21 years, N.E.)

Temperature	Highest in the Shade ...	89·7 on the 30th.
	Lowest in the Shade ...	46·4 on the 1st.
	Greatest Range	31·1 on the 30th.
	Highest in the Sun ...	146·5 on the 31st.
	Lowest on the Grass ...	41·4 on the 1st.
	Mean Diurnal Range ...	13·8
	Mean in the Shade ...	61·1

(Being 2·4 less than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	100·0 on the 21st.
	Least	37·0 on the 2nd.
	Mean	69·5

(Being 0·8 greater than that of the same month on an average of the preceding 21 years.)

Rain	Greatest Fall	1·022 inches on the 21st.
	Number of Days	16 rain and 3 dew.
	Total Fall...	0·877 inch, 65 feet above ground. 2·370 inches, 15 in. above ground.

(Being 0·442 inch less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	3·720
Ozone	Mean Amount	7·7

(Being 2·1 greater than that in the same month on an average of the preceding 20 years.)

Electricity ...	Number of Days Lightning	9
Cloudy Sky ...	Mean Amount	6·1
	Number of Clear Days ...	2
Meteors ...	Number observed ...	1

Remarks.

The temperature this month at Sydney has been 2·4 less than the average. The rainfall generally was small, but not much below the average for this month.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10^h 4^m $50{\cdot}81^s$; MAGNETIC VARIATION, 9° 25′ 2″ East.

NOVEMBER, 1880.—GENERAL ABSTRACT.

Barometer ... 33° Faht.	Highest Reading... ...	30·042 inches on the 6th, at 11·35 p.m., and 7th, at 10 a.m.
	Lowest Reading	29·291 inches on the 14th, at 3·23 p.m.
	Mean Height	29·759

(Being 0·038 inches less than that in the same month on an average of the preceding 21 years.)

Wind... ...	Greatest Pressure ...	23·1 lbs. on the 14th and 29th
	Mean Pressure... ...	0·9 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	S.

(Prevailing direction during the same month for the preceding 21 years, S.)

Temperature	Highest in the Shade ...	94·9 on the 14th.
	Lowest in the Shade ...	53·3 on the 21st.
	Greatest Range	32·2 on the 14th.
	Highest in the Sun ...	149·1 on the 14th.
	Lowest on the Grass ...	46·5
	Mean Diurnal Range ...	14·1
	Mean in the Shade ...	66·8

(Being 0·2 greater than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount ...	99·0 on the 9th.
	Least	33·0 on the 15th.
	Mean	75·3

(Being 6·0 greater than that of the same month on an average of the preceding 21 years.)

Rain	Greatest Fall	1·232 inches on the 9th.
	Number of Days	13 rain and 3 dew.
	Total Fall...	1·447 inch 65 ft. above ground. 2·560 inches 15 in. above ground.

(Being 0·891 inch less than that of the same month on an average of the preceding 21 years.)

Evaporation	Total Amount	4·476
Ozone	Mean Amount	7·6

(Being 2·2 greater than that in the same month on an average of the preceding 20 years.

Electricity ...	Number of Days Lightning	4
Cloudy Sky ...	Mean Amount	6·7
	Number of Clear Days ...	2
Meteors ...	Number observed ...	2

Remarks.

The weather this month has been very dry, and at the great majority of observing stations the rainfall has been much less than 1 inch. A part of the S.E. coast, however, had abundant rain. Bodalla reports the greatest amount, viz., 8·520 inches.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE, 33° 51′ 41″; LONGITUDE, 10h 4m 50·81s; MAGNETIC VARIATION, 9° 25′ 2″ East.

DECEMBER, 1880.—GENERAL ABSTRACT.

Barometer ... At 82° Faht.	Highest Reading... ...	30·101 inches on the 19th, at 10 a.m.
	Lowest Reading	29·204 „ on the 15th, at 9·13 p.m.
	Mean Height	29·771

(Being 0·028 inch greater than that in the same month on an average of the preceding 21 years.)

Wind	Greatest Pressure ...	33·6 lbs. on the 31st.
	Mean Pressure	1·0 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	N.E.

(Prevailing direction during the same month for the preceding 21 years, N.E.)

Temperature	Highest in the Shade ...	88·9 on the 3rd.
	Lowest in the Shade ...	53·9 on the 9th.
	Greatest Range	29·3 on the 13th.
	Highest in the Sun ...	151·9 on the 13th.
	Lowest on the Grass ...	49·5 on the 9th.
	Mean Diurnal Range ...	14·6
	Mean in the Shade ...	70·0

(Being 0·5 greater than that of the same month on an average of the preceding 21 years.)

Humidity ...	Greatest Amount... ...	93·0 on the 4th.
	Least	28·0 on the 13th.
	Mean	66·8

(Being 3·2 less than that of the same month on an average of the preceding 21 years.)

Rain	Number of Days	8 Rain
	Greatest Fall	0·360 inch on the 5th.
	Total Fall	{ 0·530 „ 65 feet above ground.
		{ 0·779 „ 15 in. above ground.

(Being 1·511 inch less than that of the same month on an average of the preceding 21 years.)

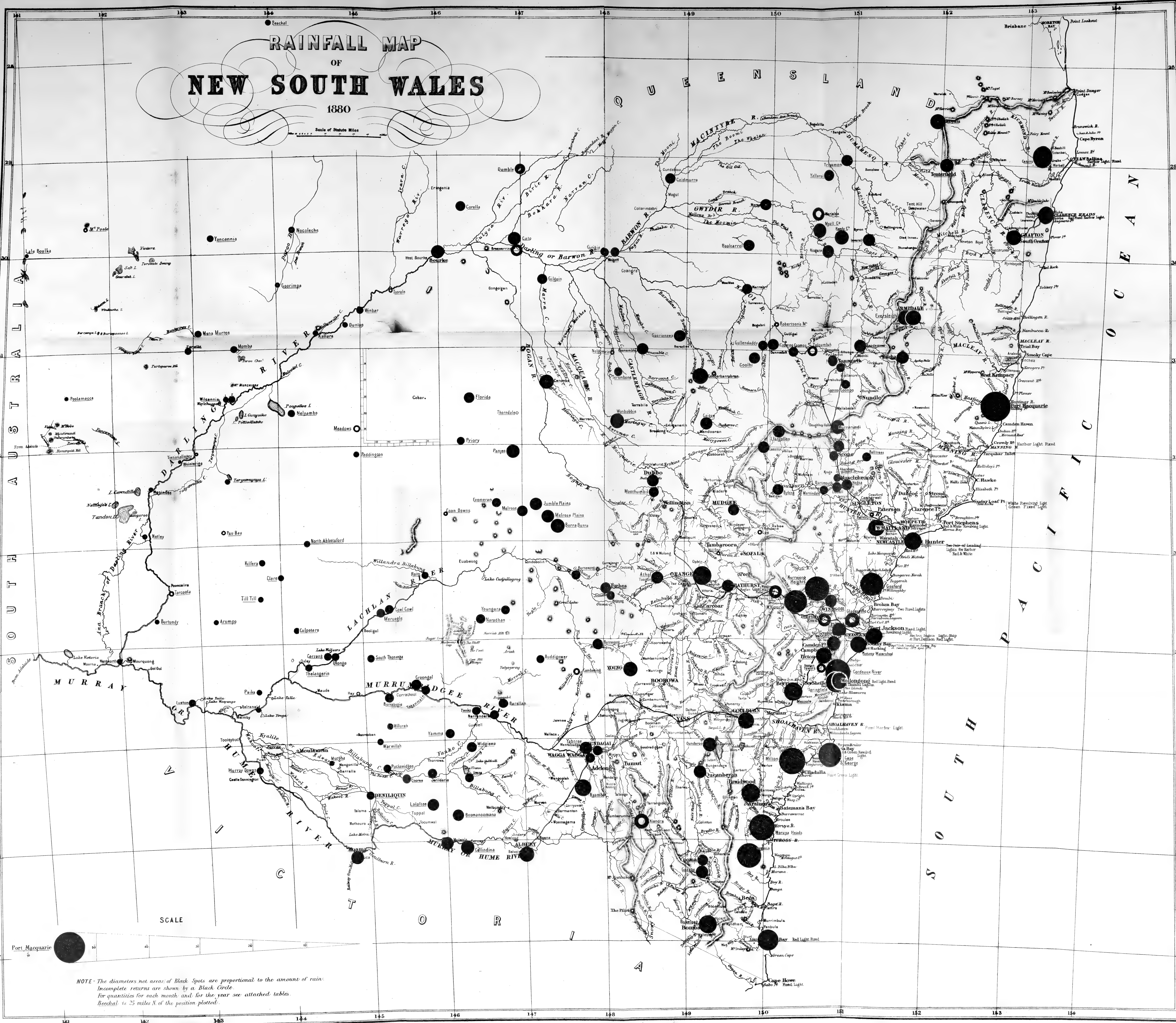
Evaporation	Total Amount	6·323
Ozone	Mean Amount	6·6

(Being than that in the same month on an average of the preceding years.)

Electricity ...	Number of Days Lightning	4
Cloudy Sky ...	Mean Amount	5·4
	Number of Clear Days ...	0
Meteors ...	Number observed ...	2

Remarks.

The temperature has been moderate, only 0·5 above the average, and the highest shade less than 90° at Sydney; the rainfall 0·779 is less than the average by 1·511 inches. The majority of the stations had a similar short supply; but part of the Northern districts had fine rains, the heaviest being 3·870 inches at Warialda.



Surveyor Generals Office, Sydney N.S.W. 1881

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Sydney: homas Richards, Government Printer.—1881.