JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR

1890.

INCORPORATED 1881.

VOL. XXIV.

EDITED BY

THE HONORARY SECRETARIES.

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NOTICE.

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

NOTICE TO AUTHORS.

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

NOTICE.

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VOLUME XXIV.

The Royal Society of New South Wales.

OFFICERS FOR 1890-91.

Honorary President:
HIS EXCELLENCY THE RIGHT HON. LORD CARRINGTON, G.C.M.G., &c., &c., &c.

President:
A. LEIBIUS, Ph. D., M.A., F.C.S.

Vice-Presidents:
PROF. LIVERSIDGE, M.A., F.R.S. | W. A. DIXON, F.C.S., F.I.C.

Hon. Treasurer:
ROBERT HUNT, C.M.G., F.G.S.

Hon. Secretaries:
F. B. KYNGDON. | PROF. WARREN, M.I.C.E.

Members of Council:

HENRY DEANE, M.A., M.I.C.E.	H. C. RUSSELL, B.A., C.M.G., F.R.S.
ROBERT ETHERIDGE, JUNR.	PROF. ANDERSON STUART, M.D.
CHARLES MOORE, F.L.S.	H. G. A. WRIGHT, M.R.C.S.E., &c.

Assistant Secretary:
W. H. WEBB.

ROYAL SOCIETY OF NEW SOUTH WALES.

ACT OF INCORPORATION.

An Act to incorporate a Society called "The Royal Society of New South Wales." [16 December, 1881.]

WHEREAS a Society called (with the sanction of Her Most Gracious Majesty the Queen) "The Royal Society of New South Wales" has under certain rules and by-laws been formed at Sydney in the Colony of New South Wales for the encouragement of studies and investigations in Science Art Literature and Philosophy And whereas the Council of the said Society is at the present time composed of the following office-bearers and members His Excellency the Right Honorable Lord Augustus Loftus P.C. G.C.B. Honorary President The Honorable John Smith C.M.G. M.D. LL.D. President and Charles Moore Esquire F.L.S. Director of the Botanic Gardens Sydney and Henry Chamberlaine Russell Esquire B.A. (Sydney) F.R.A.S. F.M.S. (London) Government Astronomer for New South Wales Vice-Presidents and H. G. A. Wright Esquire M.R.C.S. Honorary Treasurer Archibald Liversidge Esquire Associate of the Royal School of Mines London Fellow of the Institute of Chemistry of Great Britain and Ireland and Professor of Geology and Mineralogy in the University of Sydney and Carl Adolph Leibius Esquire Doctor of Philosophy of the University of Heidelberg Fellow of the Institute of Chemistry of Great Britain and Ireland Honorary Secretaries W. A. Dixon Fellow of the Institute of Chemistry of Great Britain and Ireland G. D. Hirst Esquire Robert Hunt Esquire Associate of the Royal School of Mines London Deputy Master Sydney Branch Royal Mint Eliezer L. Montefiore Esquire Christopher Rolleston Esquire C.M.G. Preamble.

Charles Smith Wilkinson Esquire Government Geologist Members of the Council. And whereas it is expedient that the said Society should be incorporated and should be invested with the powers and authorities hereinafter contained Be it therefore enacted by the Queen's Most Excellent Majesty by and with the advice and consent of the Legislative Council and Legislative Assembly of New South Wales in Parliament assembled and by the authority of the same as follows :—

Interpretation clause

1. For the purposes of this Act the following words in inverted commas shall unless the context otherwise indicate bear the meaning set against them respectively—

"Corporation" the Society hereby incorporated.

"Council" the Members of the Council at any duly convened meeting thereof at which a quorum according to the by-laws at the time being shall be present

"Secretary" such person or either one of such persons who shall for the time being be the Secretary or Secretaries honorary or otherwise of the said Society (saving and excepting any Assistant Secretary of the said Society.)

Incorporation clause.

2. The Honorary President the President Vice-Presidents Officers and Members of the said Society for the time being and all persons who shall in manner provided by the rules and by-laws for the time being of the said Society become members thereof shall be for the purposes hereinafter mentioned a body corporate by the name or style of "The Royal Society of New South Wales" and by that name shall and may have perpetual succession and a common seal and shall and may enter into contracts and sue and be sued plead and be impleaded answer and be answered unto defend and be defended in all Courts and places whatsoever and may prefer lay and prosecute any indictment information and prosecution against any person whomsoever and any summons or other writ and any notice or other proceeding which it may be requisite to serve upon the Corporation may be served upon the Secretary or one of the Secretaries as the case may be or if there be no Secretary or if the Secretaries or Secretary be absent from the Colony then upon the President or either of the Vice-Presidents.

Rules and by-laws.

3. The present rules and by-laws of the said Society shall be deemed and considered to be and shall be the rules and by-laws of the said Corporation save and except in so far as any of them are or shall or may be altered varied or repealed under the powers for that purpose therein contained or are

or may be inconsistent or incompatible with or repugnant to any of the provisions of this Act or any of the laws now or hereafter to be in force in the said Colony.

Power to acquire and hold and to sell lands &c.

4. The Corporation shall have power to purchase acquire and hold lands and any interest therein and also to sell and dispose of the said lands or any interest therein and all lands tenements hereditaments and other property of whatever nature now belonging to the said Society under the said rules and by-laws or vested in Trustees for them shall on the passing of this Act be vested in and become the property of the said Corporation subject to all charges claims and demands in anywise affecting the same.

Ordinary business to be managed by the Council.

5. The ordinary business of the Corporation in reference to its property shall be managed by the Council and it shall not be lawful for individual members to interfere in any way in the management of the affairs of the Corporation except as by the rules and by-laws for the time being shall be specially provided.

Powers of Council.

6. The Council shall have the general management and superintendence of the affairs of the Corporation and excepting the appointment of President and Vice-Presidents and other honorary officers who shall be appointed as the by-laws of the Society shall from time to time provide the Council shall have the appointment of all officers and servants required for carrying out the purposes of the Society and of preserving its property and it may also define the duties and fix the salaries of all officers Provided that if a vacancy shall occur in the Council during any current year of the Society's proceedings it shall be lawful for the Council to elect a member of the Society to fill such vacancy for the unexpired portion of the then current year The Council may also purchase or rent land houses or offices and erect buildings or other structures for any of the purposes for which the Society is hereby incorporated and may borrow money for the purposes of the Corporation on mortgages of the real and chattel property of the Corporation or any part thereof or my borrow money without security provided that the amount so borrowed without security shall never exceed in the aggregate the amount of the income of the Corporation for the last preceding year and the Council may also settle and agree to the covenants powers and authorities to be contained in the securities aforesaid.

Liability of members.

7. In the event of the funds and property of the Corporation being insufficient to meet its engagements each member thereof shall in addition to his subscription for the

then current year be liable to contribute a sum equal thereto towards the payment of such engagements but shall not be otherwise individually liable for the same and no member who shall have commuted his annual subscription shall be so liable for any amount beyond that of one year's subscription.

Custody of common seal.

8. The Council shall have the custody of the common seal of the Corporation and have power to use the same in the affairs and business of the Corporation and for the execution of any of the securities aforesaid and may under such seal authorize any person without such seal to execute any deed or deeds and do such other matter as may be required to be done on behalf of the Corporation but it shall not be necessary to use the said seal in respect of the ordinary business of the Corporation nor for the appointment of their Secretaries Solicitor or other officers.

Certified copy of rules and by-laws to be evidence.

9. The production of a printed or written copy of the rules and by-laws of the Corporation certified in writing by the Secretary or one of the Secretaries as the case may be to be a true copy and having the common seal of the Corporation affixed thereto shall be conclusive evidence in all Courts of such rules and by-laws and of the same having been made under the authority of this Act.

Elections not made in due time may be made subsequently.

10. In case any of the elections directed by the rules and by-laws for the time being of the Corporation to be made shall not be made at the times required it shall nevertheless be competent to the Council or to the members as the case may be to make such elections respectively at any ordinary meeting of the Council or at any annual or special general meeting held subsequently.

Secretary may represent Corporation for certain purposes.

11. The Secretary or either one of the Secretaries may represent the Corporation in all legal and equitable proceedings and may for and on behalf of the Corporation make such affidavits and do such acts and sign such documents as are or may be required to be done by the plaintiff or complainant or defendant respectively in any proceedings to which the Corporation may be parties.

INDEX TO RULES.

RULES.

(Revised Oct. 1, 1879.)

Additional Rules adopted November 5, 1884, marked thus, XA. &c. Rule III. amended June 4, 1890.

Objects 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 *not* hold office for *more than two years*, but shall be eligible for re-election after the lapse of one year; *four* Vice-Presidents, a Treasurer, and one or more Secretaries, who, with *ten* 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 *ten* 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 *ten* 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.

VA. There shall be elected on the Council for each ensuing year, at least *three* and not more than *four* members of the Society who were not members of the Council for the previous year.

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 in the Council 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.

Entrance Fee and Subscriptions.

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.

IXa. The entrance fee and first annual subscription shall be paid within two months from the date of election ; otherwise the election shall be void.

The Council may, however, in special cases, extend the period within which these payments must be made.

IXb. Composition fees shall be treated as capital, and shall be devoted to the Building Fund Account, or invested.

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.

XIIA. Persons elected on or after the first day of October in any year shall pay the annual contribution as in advance for the following year, but in every case within two months after notification of their election has been made to them by the Honorary Secretary.

Members whose subscriptions are unpaid not to enjoy 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.

XIVA. Any member in arrears shall cease to receive the Society's publications, and shall not be entitled to any of the privileges of the Society until such arrears are paid.

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.

XXA. At the ordinary meetings of the Society nothing relating to its regulations or management, except as regards the election or ejection of members, shall be brought forward, unless the same shall have been announced in the notice calling the meeting, or be otherwise provided for in these Rules.

XXB. A special meeting of the Society may be called by the Council, provided that seven days notice be given by advertisement, or shall be so called on a requisition signed by at least twenty-five members of the Society, to consider any special business thus notified.

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.

XXIIIA. The President or Hon. Secretaries, or any three Members of the Council, may call a meeting of the Council, provided that due notice of the same has been sent to each Member of the Council at least three days before such meeting.

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.

XXVIA. The original copy of every paper communicated to the Society, with the illustrative drawings, shall become the property of the Society unless stipulation be made to the contrary; and authors shall not be at liberty, save by permission of the Council, to publish the papers they have communicated, until such papers or abstracts of them, have appeared in the Journal or other publications of the Society.

XXVIb. If any paper of importance is communicated during the recess, the same may be ordered for publication by the Council without being read to the Society.

Management of Funds.

XXVII. The funds of the Socicty 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. Two 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.

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* Applicants for money grants are required to supply the following information:—

1. The nature of the research and the scientific results expected to follow therefrom.
2. The amount asked for.
3. Whether any previous grant has been received from any source, and, if so, with what results.
4. Whether any portion of the grant is to be devoted to personal remuneration.
5. What apparatus (if any) of permanent value will be required.

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 K—Civil and Mechanical Engineering.

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 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. The Library shall be open for consultation and for the issue and return of books daily (except Saturday), from 9·30 a.m. to 1 p.m., and 2 to 6 p.m., and on Saturdays from 9·30 a.m. to 1·30 p.m.

1A. The Library will not be open on public holidays.

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.

4A. Dictionaries, Encyclopædias, and other works of reference and cost, Atlases, Books and Illustrations in loose sheets, Drawings, Prints and unbound numbers of Periodicals and Works, Journals, Transactions and Proceedings of Societies or Institutions, Works of a Series, Maps or Charts, are not to be removed from the Library without the written order of the President or one of the Hon. Secretaries.

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.

7. No stranger shall be admitted to the Library except by the introduction of a member, whose name, together with that of the visitor, shall be inserted in a book kept for that purpose.

8. Members shall not lay the paper upon which they are writing on any Book or Map.

No tracings shall be made without express permission from the Hon. Secretaries.

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 .

N.B.—This certificate must be signed by three or more members, to two of whom the candidate must be personally known. The candidate must be at least twenty-one years of age. This certificate has to be read at three ordinary general meetings of the Society

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,
Sydney, 18 .

Sir,

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.

Address Signed,
Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's House,
Sydney, 18 .

Sir,

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,
Sydney, 18 .

Sir,

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,
Sydney, 18 .

Sir,

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 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.

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.

‡ Life Members.

Elected.		
1877		Abbott, The Hon. Joseph Palmer, M.L.A., Speaker of the Legislative Assembly, Castlereagh-street.
1877	P 1	Abbott, Thomas Kingsmill, S.M., Central Police Office, Sydney.
1877	P 4	Abbott, W. E., 'Abbotsford,' Wingen.
1888		Adair, John Frederick, M.A., Late Fellow Pembroke College *Cantab.*, 9 Richmond Terrace.
1877		Adams, Francis, Australian Joint Stock Bank, Sydney.
1864		Adams, P. F., Liverpool.
1878		Alexander, George M., 40 Hunter-street.
1890		Allan, Percy, Assoc. M. Inst. C.E., Public Works Department, Sydney.
1868		Allerding, F., 25 Hunter-street.
1856		Allwood, Rev. Canon, B.A. *Cantab.*, 'Rocklands,' Edgecliff Road, Woollahra.
1885		Allworth, Joseph Witter, District Surveyor, East Maitland.
1881		Amos, Robert, 'Renneil,' Elizabeth Bay Road.
1877		Anderson, H. C. L., M.A., Director of the Department of Agriculture, 'Aberfeldie,' Summer Hill.
1890		Anderson, William, Geological Survey, Department of Mines, Sydney.
1887		Armstrong, William Harvey, 'Woodlawn,' Henrietta-street, Waverley.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1877		Baker, E. A., M.L.A., Erith Colliery, Bundanoon.
1878		Balfour, James, 'Moyne Hall,' Gower-street, Summer Hill.
1881		Barff, H. E., M.A., Registrar, Sydney University.
1878		Barker, Francis, 10 - 14 Loftus-street, p. r. 'Medford,' Harrow-street, Petersham.
1886		Barker, W. Mandeville, Longueville Chambers, Young-st.
1888		Barling, Joseph, Under Secretary, Public Works Department, Phillip-street.

Elected.		
1875		Bartels, W. C. W., Union Club, Sydney.
1876		Bassett, W. F., M.R.C.S. *Eng.*, George-street, Bathurst.
1878		Bayley, G. W. A., 135 Queen-street, Woollahra.
1888		Bedford, Alfred Percival, Manager Permanent Trustee Co., of N.S.W., 99A Pitt-street.
1868		Beilby, E. T., 91 Pitt-st., p.r. 50 Macleay-street, Potts' Point.
1875		Belgrave, Thos. B., M.D. *Edin.*, M.R.C.S. *Eng.*, 'Hazelmere,' George-street, Burwood.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresque.
1875		Belisario, John, M.D., Lyons' Terrace, Hyde Park.
1876		Benbow, Clement A., 30 College-street.
1869	P 2	Bensusan, S. L., 14 O'Connell-street, Box 411 G.P.O.
1878		Berney, Agustus, 74 Alberto Terrace, Darlinghurst Road.
1889		Berney, George Augustus, 74 Alberto Terrace, Darlinghurst Road.
1884		Binstead, William Henry, 'Glenthorne,' Boulevard, Petersham.
1878		Black, Reginald James, M.L.A., Holt-street, Double Bay.
1877		Bladen, Thomas, c/o Mr. Frank Bladen, Government Printing Office, Sydney.
1883		Blaxland, Herbert, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Hospital for the Insane, Callan Park, Balmain.
1887		Blaxland, Ernest Gregory, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Burwood.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Broken Hill.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1886		Bowker, Robert S., L.R.C.P. *Edin.*, M.R.C.S. *Eng.*, 17 Clarence-street.
1886		Bowman, Arthur, 58 Elizabeth-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons' Terrace, Hyde Park.
1871	P 1	Brazier, John, F.L.S., C.M.Z.S., Corr. M.R.S., Tas., 'Curaçoa House,' 82 Windmill-street.
1889		Brett, Edward Edmund, J.P., 19 Macquarie Place, p.r. 'Sunnyside,' Whaling Road, East St. Leonards.
1879		Brindley, Thomas, Australian Joint Stock Bank, George and King-streets.
1878		‡Brooks, Joseph, F.R.G.S., 'Hope Bank,' Nelson-st. Woollahra
1886		Brown, David, 'Kallara,' Bourke.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1877		Bundock, W. C., 'Wyangarie,' Casino.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons' Terrace, Liverpool-st.
1877		Burnell, Arthur J., 'Clapton,' Upper Forbes-street.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street, N.
1880		Bush, Thomas James, Engineer's Office, Australian Gas-Light Company, 163 Kent-street.
1876		Cadell, Alfred, Union Club, Sydney.
1876		Cadell, Thomas, Australian Club, Sydney.
1880		Caird, George S., 'Lillingstone,' Ocean-street, Woollahra.
1876		Campbell, Allan, L.R.C.P. *Glas.*, Yass.
1876		Campbell, The Hon. Alex., M.L.C., 'Rosemont,' Woollahra.

Elected.		
1879		Campbell, Rev. Joseph, M.A., F.G.S., F.C.S., St. Jude's Vicarage, Randwick.
1889		Campbell, George S., 'Argyle,' Queen-street, Woollahra.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliff Road.
1886		Carey, John R., 'Caprera,' Milson's Point, St. Leonards.
1882		Carruthers, Charles Ulic, L.K. and Q.C.P., L.R.C.S., *Irel.*, 'Glenara,' Montague-street, Balmain.
1882		Chambers, Thomas, F.R.C.P., F.R.C.S. *Edin.*, 1 Lyons' Terrace, Hyde Park.
1879	P 1	‡Chard, J. S., Licensed Surveyor, Armidale.
1878		Chatfield, Captain William, Old Government House, Smith-street, Parramatta.
1884		Chesterman, Alfred Henry, L.S., Government Surveyor, Tintaldra, Upper Murray viâ Albury.
1878		Chisholm, Edwin, M.R.C.S. *Eng.*, L.S.A. *Lond.*, 'Abergeldie,' Victoria-street, Ashfield.
1885		Chisholm, William M.D., *Lond.*, 199 Macquarie-street North.
1888		Clubbe, C. P. B., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Catfoss,' Randwick.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*; Lic. R.C. Phys., *Lond.*; Lic. R.C. Phys. *Edin.*, Orange.
1878	P 1	Collie, Rev. Robert, F.L.S., 'The Manse,' Wellington-street, Newtown.
1886		Collingwood, David, M.D. *Lond.*, F.R.C.S. *Eng.*, 'Airedale,' Summer Hill.
1878		Colquhoun, George, c/o Messrs. Allen & Allen, Phillip-street.
1876		Colyer, J. U. C., Australian Gas-Light Co., 163 Kent-street.
1856		Comrie, James, 'Northfield,' Kurrajong Heights, viâ Richmond.
1882		Conlan, George Nugent. F.R.G.S., care of Mr. C. E. Riddell, Union Club.
1882		Cornwell, Samuel, Australian Brewery, Bourke-st., Waterloo.
1878		Cottee, W. Alfred, 2 Spring-street.
1859	P 1	Cox, James, M.D. *Edin.*, C.M.Z.S., F.L.S., Bligh-street.
1880		Cox, The Hon. George Henry, M.L.C., 'Winbourn,' Mulgoa, Penrith.
1884	P 2	Cox, S. Herbert, F.C.S., F.G.S., Norwich Chambers, Hunter-street.
1865	P 2	Cracknell, E. C., M. Inst. C.E., Electric Telegraph Department, Sydney.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 82 William-st.
1869		Creed, The Hon. J. Mildred, M.L.C., M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, 'Ravenscraig,' Wallis-street, Woollahra.
1870		Croudace, Thomas, Lambton.
1881		Crummer, Henry, 47 Rialto Terrace, Darlinghurst.
1875		Dangar, Fred. H., c/o Messrs. Dangar, Gedye, and Co., 11 Macquarie Place.
1890		Dare, Henry Harvey, B.C.E., 'Lugar Brae,' Waverley.
1876		Darley, Cecil West, Engineer-in-Chief, Harbours and Rivers Department, 'Erinagh,' Elizabeth Bay Road.
1877		Darley, The Hon. Sir Frederick, Knt., B.A., Chief Justice, Supreme Court.

Elected.		
1887		Davey, Thomas Garby, Mining Engineer &c., 'Harrietville,' Victoria.
1886	P 1	David, T. W. Edgeworth, B.A., F.G.S., Geological Surveyor, Department of Mines, Phillip-street.
1878		Dean, Alexander, J.P., 54 Castlereagh-street, Box 409 G.P.O.
1885		Deane, Henry, M.A., M. Inst.C.E., Acting Engineer-in-Chief for Railways, Woolwich.
1877		Deck, John Feild, M.D., Ashfield.
1856		Deffell, George H.
1881		Delarue, Leopold H., 378 George-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., 'Tharwa,' Queanbeyan.
1876		Dight, Arthur, 'Lansdowne,' Darling Point.
1875	P 11	Dixon, W. A., F.C.S., Fellow and Member Inst. of Chemistry of Great Britain and Ireland, Lecturer on Chemistry, The Technical College, Laboratory, Pitt-street, Sydney.
1882		Dixon, Fletcher, Manager, English, Scottish, and Australian Chartered Bank, 365 George-street.
1880		Dixson, Craig, M.D., *Syd.*, M.B., C.M., F.R.C.S. *Edin.*, M.R.C.S. *Eng.*, 291 Elizabeth-street, Hyde Park.
1880		Dixson, Thomas, M.B. *Edin.*, Mast. Surg. *Edin.*, 291 Elizabeth-street, Hyde Park.
1875		Docker, Ernest B., M.A. *Syd.*, District Court Judge, 'Carhullen,' Granville.
1879		Docker, Wilfred L., 'Nyrambla,' Darlinghurst Road.
1873		Du Faur, E., F.R.G.S., Exchange Buildings, Pitt-street.
1876		Eales, The Hon. John, M.L.C., Duckenfield Park, Morpeth.
1890		Eddy, E. M. G., M. Inst. C.E., Chief Commissioner of Railways, 'Colebrook,' Double Bay.
1886	P 1	Edmunds, Percy James, c/o Dr. Percy, Grafton-street, Dover-street, London.
1874		Eichler, Charles F., M.D., *Heidelberg*, M.R.C.S. *Eng.*, 56 Bridge-street.
1876		Eldred, W. H., Consul General for Chili, Blackstone Chambers, O'Connell-street.
1885		Ellis, Henry A., M.B., Ch.B. Univ. *Dub.*, 3 Bayswater Houses, Double Bay.
1879	P 3	Etheridge, Robert junr., Palæontologist and Librarian to the Geological Survey of N.S.W., and Palæontologist to the Australian Museum, Sydney, 233 Macquarie-street.
1876		Evans, George, 'Springfield,' Darlinghurst Road.
1881		Evans, Thomas, M.R.C.S. *Eng.*, 211 Macquarie-street North.
1877		‡Fairfax, Edward Ross, 145 Macquarie-street.
1868		Fairfax, James R., *Herald* Office, Hunter-street.
1887		Faithfull, R. L., L.R.C.P. *Lond.*, M.D., 5 Lyons Terrace.
1889		Farr, Joshua J., J.P., 'Cheltendale,' Marrickville.
1881		Fiaschi, Thos., M.D., M. Ch. Univ. *Pisa*, 39 Phillip-street.
1888		Fieldstad, Axel Hieronyunis, Physician and Surgeon, States Examen., *Norway*, 173 Liverpool-street, Hyde Park.

Elected.		
1874		Fischer, Carl F., M.D. Univ. *Wurzburg* and *Halle*, 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 Imperial Geographical Society, Vienna; c/o the Manager of the Bank of New Zealand, Pitt-street.
1888		Fitzhardinge, Grantly Hyde, M.A. *Syd.*, District Court Judge, 'Nunda,' Birch Grove, Balmain.
1856		Flavelle, John, 340 George-street.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, 215 Macquarie-street.
1881		Foster, The Hon. Mr. Justice (W. J.) Q.C., Judges' Chambers, Supreme Court.
1883	P 3	Fraser, John, B.A., LL.D., Délégué Général (pour l'Océanie) Alliance Scientifique de Paris; Associate of the Victorian (Philosophical) Institute of Great Britain; Randwick.
1890		Freehill, Francis B., M.A. *Syd.*, Solicitor, 'Carmena,' Wyalong-street, Burwood.
1881		Furber, T. F., Surveyor General's Office, 'Clifton,' Burwood.
1889		Gale, Walter Frederick. Member of Liverpool Astronomical Society, Savings' Bank of N.S.W., Barrack-street.
1877		Garnsey, Rev. C. F., Christ Church Parsonage, Sydney.
1868	P 1	Garran, The Hon. Andrew, M.L.C., M.A., LL.D. *Syd.*, 'Strathmore,' Glebe Point.
1883		Garrett, Henry Edward, M.R.C.S. *Eng.*, 157 Liverpool-street, Hyde Park.
1877		Garvan, J. P., M.L.A., 49 Castlereagh-street.
1878		Gedye, Charles Townsend, c/o Messrs. Dangar, Gedye & Co., 11 Macquarie Place.
1876		George, W. R., 318 George-street.
1879		Gerard, Francis, c/o Messrs. Du Faur & Gerard, Box 690 G.P.O.
1884		Gibbs, J. Burton, Hosking Place, 84A Pitt-street.
1876		Gilchrist, W. O., c/o Messrs. Gilchrist, Watt, & Co., Spring-street.
1884		Gill, Rev. William Wyatt, B.A. *Lond.*, LL.D. *St. Andrews*, 'Persica,' Illawarra Road, Marrickville.
1875		Gilliat, Henry A., Australian Club Sydney.
1876	P 4	Gipps, F. B., C.E., 35 Castlereagh-street.
1878		Goddard, William C., Norwich Chambers, Hunter & Bligh-sts
1883		Goode, W. H., M.A., M.D., Ch. M., Diplomate in State Medicine, *Dub.*, Surgeon Royal Navy, Corres. Mem. Royal Dublin Society, Mem. Brit. Med. Assoc., Lecturer on Medical Jurisprudence, University of Sydney, 159 Macquarie-street North.
1859		Goodlet, John H., 'Canterbury House,' Ashfield.
1887		Gordon, Charles Edward, H.M. Customs, 'Earlston,' East Crescent-street, Lavender Bay.
1886		Graham, James, M.A., M.D., C.M. *Edin.*, 4 Hyde Park Terrace, Liverpool-street.
1878		Griffiths, Fred. C., 10 O'Connell-street.
1877		Griffiths, G. Neville. 10 O'Connell-street.
1877		Gurney, T. T., M.A. *Cantab.*, Professor of Mathematics Sydney University, 149 Macquarie-street.

Elected.		
1880		Haege, Herman, 93 Pitt-street.
1878		Hall, Richard T., 'Hornsey,' Launceston, Tasmania.
1880		Halligan, Gerald H., C.E., 'Riversleigh,' Hunter's Hill.
1877	P 3	Hamlet, William M., F.C.S., F.I.C., Member of the Society of Public Analysts, Government Analyst, Government Laboratory, Treasury Buildings.
1882		Hankins, George Thomas, M.R.C.S. *Eng.*, College-street.
1890		Harris, Rev. Edward, M.A. *Oxon.* and *Syd.*, D.D. *Oxon.*, Head Master, Kings School, Parramatta.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo.
1877		‡Harrison, L. M., Macquarie Place.
1877	P 8	‡Hargrave, Lawrence, 'Ravensbourne,' 40 Roslyn Gardens.
1884		Haswell, William Aitcheson, M.A., D.Sc., F.L.S., Professor of Zoology and Comparative Anatomy, University, Sydney
1874		Hay, The Hon. Sir John, K.C.M.G., M.L.C., A.M. *Aber.*, Rose Bay, Woollahra.
1890		Haycroft, James Isaac, M.E. Queens Univ. *Irel.*, Assoc. M. Inst. C.E., L.S., 'Fontenoy,' Ocean-street, Woollahra.
1876		Heaton, J. Henniker, M.P., St. Stephen's Club Westminster, London.
1890		Henry, Arthur Geddes, M.B., Ch.M. *Syd.*, Resident Medical Officer, Callan Park Asylum, Balmain.
1877		Henry, James, corner of John and Frederic-sts., Petersham.
1884		Henson, Joshua B., C.E., Water and Sewerage Office, Pitt-st.
1879		Hills, Robert, 'Allington,' Elizabeth Bay.
1876	P 2	Hirst, George D., 379 George-street.
1879		Hitchins, Edward L., 9 Richmond Terrace, Domain.
1886		Holmes, Spencer Harrison, 'The Wilderness,' Allandale, Hunter River.
1879		Houison, Andrew, B.A., M.B., C.M. *Edin.*, 144 Phillip-street.
1888		Hull, Walter, M.D. *Lond.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Sydney Hospital.
1877		Hume, J. K., 'Beulah,' Campbelltown.
1878		Hunt, Robert, C.M.G., F.G.S., Assoc. Royal School of Mines *Lond.*, Deputy Master, Royal Mint, Sydney.
1882		Hurst, George, M.A. *Syd.*, M.B. Univ. *Lond.*, M.B., C.M. Univ. *Edin.*, Scott Chambers, 96 Pitt-street.
1886		Hutchinson, W. A., Bond-street, p.r. 'Alston,' Glebe Point.
1887		Huxtable, L. Ralston, M.B., C.M. *Edin.*, 177 Macquarie-st.
1879		Inglis, James, M.L.A., 8-10 Dean's Place, p.r. 'Craigo,' Boulevard, Strathfield.
1885		Jackson, Rev. H. L., M.A. *Cantab.*, St. James's Parsonage, Macquarie-street.
1876		Jackson, Henry Willan, M.R.C.S. *Eng.*, Lic. R.C. Phys. *Edin.*, 146 Phillip-street.
1879		Jefferis, Rev. James, LL.D., Vestry, Congregational Church, Pitt-street.
1884		Jenkins, Edward Johnstone, M.A., M.D. *Oxon.*, M.R.C.P., M.R.C.S., L.S.A. *Lond.*, 213 Macquarie-street North.
1888		Johnson, Alex. Mackey, M.D., Ch.M., K.U. *Irel.*, 78 Hunter-st.
1879		Johnson, James W., Norwich Chambers, Hunter-street.
1877		Jones, Edward Lloyd, 'Bickley,' Burwood.

Elected.		
1887		Jones, George Mander, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 'Hinckley,' Burlington Road, Homebush.
1874		Jones, James, 'Miltonia,' Randwick.
1879		Jones, John Trevor, C.E., 'Tremayne,' North Shore.
1884		Jones, Llewellyn Charles Russell, Solicitor, 7 Bent-street.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*. 16 College-st., Hyde Park, p.r. 'Llandilo,' Boulevard, Strathfield.
1876		Jones, Richard Theophilus, M.D. *Syd.*, L.R.C.P. *Edin.*, 'Caer Idris,' Ashfield.
1863		Josephson, Joshua Frey, F.G.S., 'St. Killians,' Bellevue Hill, Double Bay.
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C. E., George-street, Dulwich Hill.
1878		Joubert, Numa, Hunter's Hill.
1883		Kater, The Hon. H. E., M.L.C., 'Mount Broughton,' Moss Vale.
1873		Keele, Thomas William, M. Inst. C.E., District Engineer, Harbours and Rivers Depart., Ballina, Richmond River.
1877		Keep, John, 'Broughton Hall,' Leichhardt.
1884		Kendall, Theodore M., B.A., L.R.C.P., L.R.C.S. *Lond.*, L.M., 36 College-street, Hyde Park.
1887		Kent, Harry C., Bell's Chambers, 129 Pitt-street.
1874		King, The Hon. Philip G., M.L.C., 'Banksia,' William-street, Double Bay.
1878		Knaggs, Samuel T., M.D., *Aberdeen*, F.R.C.S. *Irel.*, 16 College-street, Hyde Park.
1881	P 2	Knibbs, G. H., 'Avoca House,' Denison Road, Petersham.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1875		Knox, The Hon. Edward, M.L.C., O'Connell-street.
1877		Kopsch, G., 8 Boulevard, Petersham.
1884		Kyngdon, Boughton, L.S.A., Medl. Assoc. King's Coll. *Lond.*, 'Olive Bank,' Strathfield.
1878		Kyngdon, F. B., F.R.M.S. *Lond.*, 'Waratah,' Woolley-street, Pyrmont Bridge Road, Glebe.
1878		Kyngdon, Frederick H., M.D., C.M. *Aberdeen*; L.S.A. *Lond.*; M.R.C.S. *Eng.*; 'Bon Accord,' North Shore.
1884		Lackey, The Hon. John, M.L.C., Warrigal Club, Macquarie-street, North.
1859	P 6	Leibius, Adolph, Ph. D. *Heidelberg*, M.A., F.C.S., Senior Assayer to the Sydney Branch of the Royal Mint.
1874		Lenehan, Henry Alfred, Sydney Observatory.
1883		Lingen, J. T., M.A. *Cantab.*, 101 Elizabeth-street.
1872	P 30	Liversidge, Archibald, M.A. *Cantab.*, F.R.S.; Assoc. Roy. Sch. Mines *Lond.*; F.C.S.; Fel. Inst. Chemistry of Gt. Brit. and Irel.; F.G.S.; F.L.S.; F.R.G.S.; Mem. Phy. Soc. *Lond.*; Member of Mineralogical Society, *Lond.*; Cor. Mem. Roy. Soc. *Tas.*; Cor. Mem. Roy. Soc. *Queensland*; Cor. Mem. Senckenberg Institute, *Frankfurt*; Cor. Mem. Soc. d'Acclimat. *Mauritius*; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. French Society of Mineralogy; Professor of Chemistry and Mineralogy in the University of Sydney, The University, Glebe.

Elected.		
1874		Lloyd, The Hon. George Alfred, M.L.C., F.R.G.S., 'Scottforth,' Elizabeth Bay.
1881		Lloyd, Lancelot T., 'Eurotah,' William-street East.
1890		Loir, Adrien, Director of the Pasteur Institute of Australia, Rodd Island, Box 1389 G.P.O.
1887		Long, Alfred Parry, Land Titles' Office, Elizabeth-street.
1876		Lord, The Hon. Francis, M.L.C., North Shore.
1881		Lowe, Edwin, Wilgar Downs Station, *viâ* Girilambone.
1880		Low, Andrew S., 'Sutherland House, Merrylands.
1878		Low, Hamilton, H. M. Customs, Sydney.
1887		Lyden, M. J., M.D., M. Ch., Q.U. *Irel.*, 44 College-street.
1887		MacAllister, John F., M.B., B.S. *Melb.*, Prince Alfred Hospital Camperdown.
1884		MacCormick, Alexander, M.D. M.B., C.M. *Edin.*, M.R.C.S. *Eng.*, Macquarie-street North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 376 Pitt-street.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1878		MacDonald, Ebenezer, 'Kamilaroi,' Darling Point.
1886		MacDonald, John Alexander, M. Inst. C.E., M. Inst. M.E., M. Am. Soc. C.E., Engineer for Bridges, Public Works Department, Sydney.
1868		MacDonnell, William J., F.R.A.S., Bank of New South Wales, Port Macquarie.
1877		MacDonnell, Samuel, Norwich Chambers, Hunter and Bligh-streets.
1886		MacFarlane, Edward, District Surveyor, Bourke.
1890		Macgeorge, W. J., (Manager, Bank of South Australia, Sydney) Union Club, Sydney.
1882		MacGillivray, P. H., M.A., M.R.C.S., F.L.S., Sandhurst, Victoria.
1876		McKay, Charles, M.D. Univ. *St. Andrews*, L.R.C.S. *Edin.*, 20 Carrington-street, Wynyard Square.
1876		Mackellar, The Hon. Charles Kinnard, M.L.C., M.B., C.M. *Glas.*, 183 Liverpool-street, Hyde Park.
1872		Mackenzie, John, F.G.S., Athenæum Club, Sydney.
1876		Mackenzie, Rev. P. F., 'Sydenham,' Reserve-street, North Annandale.
1887		Mackenzie, George Stephen, Ph. D. *Heidelberg*, F.I.C., 63 Pitt-street.
1880	P 3	M'Kinney, Hugh Giffin, M.E. Roy. Univ. *Irel.*, M. Inst. C.E., Athenæum Club, Castlereagh-street.
1876		MacLaurin, The Hon. Henry Norman, M.L.C., M.A., M.D., L.R.C.S. *Edin.*, LL.D., Univ. *St. Andrews*, 155 Macquarie-street.
1882	P 1	Madsen, Hans. F., 'Hesselmed House,' Queen-st., Newtown.
1885		Maher, W. Odillo, M.D., M. Ch. Queen's Univ. *Irel.*, M.R.C.S. *Eng.*, 20 College-street, Hyde Park.
1883	P 2	Maiden, Joseph H., F.L.S., F.C.S., F.R.G.S., Curator, Technological Museum, Sydney.
1878		Maitland, Duncan Mearns, 'Afreba,' Stanmore Road.
1873		Makin, G. E., Berrima.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.

Elected.		
1877		Mann, John F., 'Kerepunu,' Neutral Bay.
1876		Manning, Frederic Norton, M.D. Univ. *St. And.*, M.R.C.S. *Eng.*, L.S.A. *Lond.*, Hunter's Hill.
1881		Manning, The Hon. Sir William Montague, LL.D., M.L.C., 'Walleroy,' Edgecliff Road, Woollahra.
1869		Mansfield, G. A., 121 Pitt-street.
1880		Marano, G. V., M.D., Univ. *Naples*, Clarendon Terrace, Elizabeth-street.
1888		Marden, John, M.A., LL.D. *Melb.*, Principal, Presbyterian Ladies' College, Ashfield.
1885		Marks, James Surfleet, The City Bank, Carcoar.
1886		Marshall, George A., M.B. *Dub.*, 263 Elizabeth-street.
1890		Marshall, Hezlett Hamilton, L.R.C.P., L.R.C.S. *Edin.*, Lic. Fac. Phys. and Surg. *Glas.*, 2 Lyons' Terrace, Liverpool-st.
1886		Martin, Thomas M., L.R.C.P., L.R.C.S. *Edin.*, 32 College-street, Hyde Park.
1879		Matthews, Robert Chr., Sheridan-street, Gundagai.
1875		Mathews, R. H., J.P., L.S., Hassall-street, Parramatta.
1890		Mathias, William Lloyd, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 114 Darlinghurst Road, Sydney.
1888		Megginson, A. M., M.B., C.M. *Edin.*, 245 Elizabeth-street.
1889		Mestayer, R. L., M. Inst. C.E., F.R.M.S., Athenæum Club, Castlereagh-street.
1887		Miles, George E., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, Hospital for Insane, Callan Park.
1873		Milford, F., M.D. *Heidelberg*, M.R.C.S. *Eng.*, 3 Clarendon Terrace, 265 Elizabeth-street.
1882		Milson, Alfred G., 'Coreena,' East St. Leonards.
1882	P 1	Milson, James, 'Elamang,' North Shore.
1889		Mingaye, John C. H., F.C.S., Assayer and Analyst to the Department of Mines, Sydney.
1887	P 6	Mitchell, J. Sutherland, 'Etham,' Darling Point.
1856		Moore, Charles, F.L.S., Director of the Botanic Gardens, Sydney.
1879		Moore, Frederick H., 5 Bent-street.
1875		Moir, James, 58 Margaret-street.
1875	P 1	Montefiore, E. L., Pacific Insurance Co., 1 Bent-street.
1877		Morris, William, Lic. Fac. Phys. and Surg. *Glas.*, 27 Castlereagh-street.
1883		Morley, Frederick, 312 Victoria-street, Darlinghurst.
1880		Moses, David, J.P., 'Iolanthe,' Manly Beach.
1883		Moss, Sydney, c/o Mr. James Anderson, 97 Pitt-street.
1877		‡Mullens, Josiah, F.R.G.S., Eldon Chambers, Pitt.street.
1888		Mullins, George Lane, M.A., M.D., Trin. Coll. *Dub.*, F.R.M.S. T.C.D., 'Avenel,' Leichhardt-street, Waverley.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 97 Macleay-street, Potts' Point.
1885		Munro, Andrew Watson, M.B., C.M. *Edin.*, 183 Liverpool-street, Hyde Park.
1887		Munro, William John, M.B., C.M. *Edin.*, M.R.C.S. *Eng.*, 72 Glebe Road, Glebe.
1865		Murnin, M. E., 'Eisenfels,' Mittagong, Nattai.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.

Elected.

1890 Nardin, Ernest A., C.E., Roads and Bridges Branch, Public Works Depart., p.r. 'Cumnor,' Fitzroy-st., St. Leonards.

1874 Neill, A. L. P., City Bank, Pitt-street.

1873 Neill, William, City Bank, Pitt-street.

1886 Newmarch, Bernard James, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, Berry-street, St. Leonards.

1882 Norrie, Andrew, M.D., Mast. Surg. *Aberdeen*, 171 Liverpool-street, Hyde Park.

1873 Norton, The Hon. James, M.L.C., Solicitor, 2 O'Connell-st.

1878 Nowlan, John, 'Eelah,' West Maitland.

1879 O'Connor, Maurice J., L.R.C.S. *Irel.*, L.K.Q.C.P. *Irel.*, 26 College-street, Hyde Park.

1878 Ogilvy, James L., Commercial Bank of Australia, 122 Pitt-street, Sydney.

1890 Olliff, Arthur Sidney, Government Entomologist, Department of Agriculture, Macquarie-street.

1888 O'Neill, G. Lamb, M.B., C.M. *Edin.*, 175 Elizabeth-street.

1883 Oram, Arthur Murray, M.D., Univ. *Edin.*, 213 Macquarie-st. North.

1875 O'Reilly, W. W. J., M.D., M. Ch. Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street.

1883 Osborne, Ben. M., J.P., 'Hopewood,' Bowral.

1875 Palmer, J. H., 'Hinton,' Queen-street, Burwood.

1880 Palmer, Joseph, 133 Pitt-street, p.r. 'Longueville,' Lane Cove River.

1885 Park, Archibald John, Chairman Local Land Board, Hay.

1876 Parrott, Major Thos. S., C.E., c/o Messrs. Parrott & Beetham, Union Chambers, Pitt-street.

1878 Paterson, Alexander, M.D., M.A. *Edin.*, 157 Elizabeth-street, Hyde Park.

1878 Paterson, Hugh, 227 Macquarie-street.

1877 Paterson, James A., Union Bank, Pitt-street.

1877 Pedley, Percival R., 227 Macquarie-street.

1877 Perkins, Henry A., 'Barangah,' Coventry Road, Homebush.

1881 Phillip, Alex., L.K. Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 540 Park View Terrace, Crown-street, Surry Hills.

1876 Pickburn, Thomas, M.D., C.M. *Aberdeen*, M.R.C.S. *Eng.*, 22 College-street.

1879 Pittman, Edward F., L.S., Chief Mining Surveyor, Department of Mines, Phillip-street.

1881 Poate, Frederic, District Surveyor, Tamworth.

1890 Pockley, Francis Antill, M.B., M.C., Univ. *Edin.*, M.R.C.S. *Eng.*, 'St. Leonard's House,' St. Leonards.

1879 Pockley, Thomas F. G., Commercial Bank, Singleton.

1887 Pollock, James Arthur, B.E., Roy. Univ. *Irel.*, B.Sc. *Syd.*, 'The Towers,' Neutral Bay.

1882 P 3 Porter, Donald, Tamworth.

1878 Potts, F. H., 'Hydebrae,' Coventry Road, Homebush.

1886 Provis, John, 'Poldice,' Barton Terrace West, N. Adelaide.

Elected.		
1876		Quaife, Frederick H., M.A., M.D., Master of Surgery *Glas.*, 'Hughenden,' 12 Queen-street, Woollahra.
1886		Quaife, William Francis, B.A. *Syd.*, M.B., Ch.M. *Glas.*, 'Marathon,' 137 Queen-street, Woollahra.
1876		Quodling, W. H., 'Couranga,' Redmyre Boulevard, Strathfield.
1865	P 1	‡Ramsay, Edward P., LL.D. Univ. St. And. *Aberdeen*, F.R.S.E., F.L.S., Curator of the Australian Museum, College-st.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Elizabeth-street, Hyde Park, p.r. 'Penketh,' Oatley-street.
1888		Reading, Richard Fairfax, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.D.S. *Eng.*, Elizabeth-street, Hyde Park.
1886		Redfearn, William, Conder-street, Burwood.
1881		Reid, William, J.P., Australian Joint Stock Bank, Sydney.
1881	P 3	Rennie, Edward H., M.A. *Syd.*, D.Sc. *Lond.*, Professor of Chemistry, University, Adelaide.
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 46 College-street, Hyde Park.
1870		Renwick, The Hon. Arthur, M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 295 Elizabeth-street.
1880		Riddell, C. E., Union Club.
1886		Rigg, Thomas S. J., B.A. *Syd.*, Secretary's Branch, General Post Office, Sydney.
1868	P 4	Roberts, Sir Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. *Vienna*, 205 Macquarie-street North.
1871		Robertson, Thomas, Solicitor, Hay.
1885		Rolleston, John C., C.E., Harbours and Rivers Department, Works Office.
1887		Ross, Andrew, M.D., Mast. Surg. Univ. *Glas.*, M.L.A., Molong.
1884		Ross, Chisholm, M.B., C.M. *Edin.*, Hospital for the Insane, Gladesville.
1885		Ross, Elsey Fairfax, M.D. *Brux.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 145 Macquarie-street North.
1865		Ross, J. Grafton, O'Connell-street.
1885		Roth, Reuter Emerich, M.R.C.S. *Eng.*, 42 College-street, Hyde Park.
1882		Rothe, W. H., Union Club, p.r. 'Fiona,' Double Bay.
1864	P 42	Russell, Henry C., B.A. *Syd.*, C.M.G., F.R.S., F.R.A.S., F.R. Met. S., Hon. Mem. Roy. Soc. South Australia, Government Astronomer, Sydney Observatory.
1886		Sager, Edmund E., Secretary to the Board of Health, 127 Macquarie-street North.
1875		Sahl, Charles L., German Consulate, 42 Pitt-street.
1876		Saliniere, Rev. E. M., St. John's Road, Glebe.
1887		Schwarzbach, B., M.D. *Würzburg*, L.F.P. & S. *Glas.*, Phillip-street.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1886		Scott, Walter, M.A. *Oxon.*, Professor of Classics, Sydney University.
1880		Scrivener, Charles Robert, L.S., Survey Department, Muswellbrook.

Elected.		
1887	P 1	Seaver, Jonathan, C.E., F.G.S., M.L.A., Norwich Chambers, Hunter-street.
1876		Sedgwick, William Gillett, M.R.C.S. *Eng.*, 178 King-street, Newtown.
1877		Selfe, Norman, M. Inst. C.E., M. Inst. M.E., Victoria Chambers, 279 George-street.
1890		Sellors, R. P., B.A. *Syd.*, 2 Bligh-street, Newtown.
1876		Sharp, Henry, Green Hills, Adelong.
1878	P 1	Sharp, Rev. W. Hey, M.A. *Oxon.*, Warden of St. Paul's College, University.
1883	P 3	Shellshear, Walter, Assoc. M. Inst. C.E., 'Rosebury,' Gordon-street, Burwood.
1879		Shepard, A. D., Box 728 G.P.O. Sydney.
1875		Sheppard, Rev. G., B.A. *Syd.*, Berrima.
1882		Shewen, Alfred, M.D. Univ. *Lond.*, M.R.C.S. *Eng.*, 6 Lyons' Terrace, Hyde Park.
1882		Sinclair, Eric, M.D., C.M. Univ. *Glas.*, Hospital for Insane, Gladesville.
1883		Sinclair, Sutherland, Secretary Australian Museum, Sydney.
1884		Skirving, Robert Scot, M.B., C.M. *Edin.*, Elizabeth-street, Hyde Park.
1877		Slattery, Thomas, M.L.A., 85 Macleay-street, Potts Point.
1890		Sloane, Thomas G., 89 Pitt-street.
1877		Sloper, Frederick Evans, 360 Liverpool-street.
1888		Smeaton, William Henry Oliphant, Editor *Daily Northern Argus*, East-street, Rockhampton.
1888		Smith, Charles Atkinson, F.C.S., F.I.C., The Laboratory, Loftus-street, Sydney.
1874		‡Smith, John McGarvie, Denison-street, Woollahra.
1875		Smith, Robert, M.A. *Syd.*, 2 O'Connell-street.
1883		Smith, The Hon. Robert Burdett, M.L.C., C.M.G., 203 Macquarie-street North.
1879		Spry, James Monsell, Union Club.
1881		‡Starkey, John Thomas, 61½ Castlereagh-street.
1882		Steel, John, L.R.C.P., L.R.C.S. *Edin.*, Bachelor of Medicine and Bachelor of Surgery, Univ. *Melb.*, 3 Lyons' Terrace, Hyde Park.
1879		Stephen, Alfred F. H., Department of Audit, Bligh-street.
1889		Stephen, Arthur Winbourn, L.S., 28 Castlereagh-street.
1883		Stephen, Cecil B., M.A., 101 Elizabeth-street.
1879		‡Stephen, The Hon. Septimus A., M.L.C., 81 New Pitt-street, p.r. South Kingston.
1878		Street, John Rendell, M.L.A., 'Birtley,' Elizabeth Bay Road.
1876		Strong, William Edmund, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Government Medical Officer and Vaccinator for Sydney, Phillip-street.
1883		Stuart, T. P. Anderson, M.D., Univ. *Edin.*, Professor of Physiology, University of Sydney.
1883		Styles, Geo. Mildinhall, Commercial Bank, George-street.
1884		Syer, Frank Weston, 24 O'Connell-street.
1887		Sulman, John, F.R.I.B.A., 375 George-street.
1876		Suttor, The Hon. W. H., M.L.C., Darling Point.

Elected.		
1879		Tarrant, The Hon. Harman, M.L.C., M.R.C.S. *Eng.*, 207 Macquarie-street.
1862	P 14	Tebbutt, John, F.R.A.S., Private Observatory, Windsor, New South Wales.
1878		Thomas, F. J., Hunter River N.S.N. Co., Sussex-street.
1879		Thomson, Dugald, c/o R. Harper & Co., Empire Chambers, York-street.
1875		Thompson, Joseph, 'Trahlee,' Bellevue Hill, Double Bay.
1877		Thompson, Thomas James, Eldon Chambers, 92 Pitt-street.
1885	P 1	Thompson, John Ashburton, M.D. *Brux.*, Health Department 127 Macquarie-street.
1882		Thornton, The Hon. George, M.L.C., 377 George-street.
1886	P 1	Threlfall, Richard, M.A. *Cantab.*, Professor of Physics, University of Sydney.
1888		Thring, Edward T., F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, West-street, Petersham.
1876		Tibbits, Walter Hugh, M.R.C.S. *Eng.*, Liverpool Road, Enfield.
1876		Toohey, J. T., 'Moira,' Burwood.
1882		Traill, Mark W., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Coolabah,' Belmore-street, Burwood.
1873	P 1	Trebeck, Prosper N., 91 Pitt-street.
1879		Trebeck, P. C., 91 Pitt-street.
1883		Trebeck, T. B., M.A. *Syd.*, 'Hatfield,' Cooper-st., Double Bay.
1876		Trouton, F. H., 'Clifdale House,' Balmain.
1877		‡Tucker, G. A., Ph.D., c/o J. R. Street, Perpetual Trustee Company, 105 Pitt-street.
1875		Tulloh, W. H., 267 George-street, p.r. Ben Boyd Road, St. Leonards.
1883		Tuxen, Peter Wilhelm, L.S., Broken Hill.
1882		Twynam, George Edward, L.R.C.P., *Lond.*, M.R.C.S. *Eng.*, 38 Bayswater Road, Darlinghurst.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1884		Verde, Felice, 16 Prione, Spezia, Italy.
1890		Vicars, James, B.C.E., Palace-street, Ashfield.
1876		Voss, Houlton H., J.P., c/o J. R. Street, Perpetual Trustee Co., 105 Pitt-street.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-st.
1867		Walker, Philip B., Telegraph Office, George-street, p.r. 'Ellerslee,' Darlinghurst.
1867		Ward, R. D., M.R.C.S. *Eng.*, Blue-street, St. Leonards.
1883		Wardell, W. W., F.R.I.B.A., M. Inst. C.E., 'Upton Grange,' St. Leonards.
1877		Warren, William Edward, M.D., M.Ch., Queen's University *Irel.*, 265 Elizabeth-street, Sydney.
1883	P 3	Warren, W. H., Wh. Sc., M. Inst. C.E., Professor of Engineering, University of Sydney, p.r. 'Rosendale,' Stanmore Road, Petersham.
1876		Waterhouse, John, M.A. *Syd.*, 'Sauchie House,' Church-st., West Maitland.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, 18 Wentworth Court, Elizabeth-street.

Elected.		
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Morevale,' Erskinville Road, Newtown.
1877		Watt, Alfred Joseph, 528 George-street.
1859		Watt, Charles, Parramatta.
1876		Waugh, Isaac, M.B., M.C. *Dub.*, T.C.D., Parramatta.
1876		Webster, A. S., Gresham Chambers.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1881		‡Wesley, W. H.
1878		Westgarth, G. C., Maryborough Chambers, O'Connell-street.
1888		West, William Augustus, L.K.Q.C.P. *Irel.*, L.R.C.P. *Irel.*, 'Derby House,' 36 Glebe Road.
1883	P 1	Whitelegge, Thomas, F.R.M.S., Australian Museum, College-street.
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Sevington,' Stanmore Road, Petersham.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1874		White, Rev. James S., M.A., LL.D. *Syd.*, 'Gowrie,' Singleton.
1888		White, The Hon. Robert Hoddle Driberg, M.L.C., Union Club.
1884		Wiesener, T. F., 334 George-street.
1874	P 2	Wilkinson, C. S., F.G.S., F.L.S., Government Geologist, Department of Mines.
1878		Wilkinson, Rev. Samuel, 'Regent House,' Regent-street, Petersham.
1880		Wilkinson, Robert Bliss, M.L.A., 12 Spring-street.
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 130 Glebe Road, Glebe.
1876		Williams, Percy Edward, The Treasury, p.r. 'Ferndale,' Gladesville.
1884		Williamson, William Cotter, M.D., M.Ch. Queen's Univ. *Irel.*, Hospital for Insane, Newcastle.
1878		Wilshire, James Thompson, M.L.A., J.P., 'Havilah,' Emu-street, Burwood.
1879		Wilshire, F. R., P.M., Berrima.
1879		Wilson, F. A. A., Mercantile Bank, George-street.
1890		Wilson, James T., M.B., Mast. Surg. Univ. *Edin.*, Professor of Anatomy, University of Sydney.
1876		Windeyer, The Hon. Mr. Justice (W. C.), M.A. *Syd.*, LL.D. *Cantab.*, Judges Chambers, Supreme Court.
1878		Wise, Henry, Managing Trustee, Savings' Bank of N.S.W., Barrack-street.
1873		Wood, Harrie, J.P., Under Secretary for Mines, Department of Mines, Phillip-street.
1879		Woodhouse, E. B., 'Mount Gilead,' Campbelltown.
1876	P 1	Woolrych, F. B. W., 54 Watkin-street, Newtown.
1886		Worrall, Ralph, M.D., Ch.M. Queen's Univ. *Irel.*, 20 College-street, Hyde Park.
1881		Wright, Frederick, M.P.S., c/o Messrs. Elliott Bros. Limited, O'Connell-street, p.r. Harnett-street.
1872		Wright, Horatio G. A., M.R.C.S. *Eng.*, L.S.A. *Lond.*, 4 York-street, Wynyard Square.
1884		Yeomans, Allan, 'Gilgoin,' Brewarrina.
1879		Young, John, 'Kentville,' Johnston-street, Leichhardt.

Honorary Members.

Limited to Twenty.

M. recipients of the Clarke Medal.

Elected		
1875		Agnew, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart.
1884		Airy, Sir George Biddell, K.C.B., M.A., D.C.L. *Oxon.*, LL.D., *Cantab. et Edin.*, F.R.S., &c., 'The White House,' Croom's Hill. Greenwich Park, S.E.
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., Ealing, London.
1875	M	Ellery, Robert L. J., F.R.S., F.R.A.S., Government Astronomer, of Victoria, Melbourne.
1887		Foster, Michael, M.D., F.R.S., Professor of Physiology, University of Cambridge.
1875		Gregory, The Hon. Augustus Charles, C.M.G., M.L.C., F.R.G.S. Geological Surveyor, Brisbane.
1875	P 1 M	Hector, Sir James, K.C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., Director of the Royal Gardens, Kew.
1888	P 1 M	Hutton, Frederick Wollaston, F.G.S., Professor of Geology, Canterbury College, Christchurch, New Zealand.
1879	M	Huxley, Professor, F.R.S., LL.D., F.G.S., F.Z.S., F.L.S., &c., &c., Professor of Natural History in the Royal School of Mines, South Kensington, London.
1875	M	M'Coy, Frederick, C.M.G., D.Sc., F.R.S., F.G.S., Hon. M.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.
1875	P 6 M	Mueller, Baron Ferdinand von, K.C.M.G., M.D., Ph.D., F.R.S. F.L.S., Government Botanist, Melbourne.
1879	M	Owen, Professor Sir R., K.C.B., M.D., D.C.L., LL.D., F.L.S., F.G.S., V.P.Z.S., &c., &c., The British Museum, London, W.C.
1883		Pasteur, Louis, M.D., Paris.
1875		Schomburg, Dr., Director of the Botanic Gardens. Adelaide, South Australia.
1888	P 1	Tate, Ralph. F.G.S., F.L.S., Professor of Natural Science, University, Adelaide, South Australia.
1884		Tyndall, John, D.C.L. *Oxon.*, LL.D. *Cantab.*, F.R.S., F.G.S., &c., Professor of Natural Philosophy in the Royal Institution, Albemarle-street, London.
1875		Waterhouse, F. G., F.G.S., C.M.Z.S., Adelaide, S. Australia.

Corresponding Members.

Limited to Twenty-five.

1880	P 1	Clarke, Hyde, V.P. Anthropological Institute, 32 St. George's Square, London, S.W.
1883	P 1	Feistmantel, Ottokar, M.D., Bohemian Polytechnic High School, Prague, Austria.
1886		Marcou, Professor Jules, F.G.S., Cambridge, Mass., United States of America,

Elected.	
	OBITUARY.
	1888.
	Ordinary Members.
1872	Bolding, H. J., P.M.
1868	Campbell, The Hon. Charles, M.L.C.
1881	Ewan, John Frazer, M.B., Mast. Surg. *Edin.*
1877	Hawkins, H. S., M.A.
1878	Jackson, Arthur Levett.
1874	Knox, George, M.A., *Cantab.*
1876	Marshall, George, M.D., Univ. *Glas.*, L.R.C.S. *Edin.*
1865	Morrell, G. A., C.E.
1876	Murray, W. G.
1856	Rolleston, Christopher, C.M.G.
1868	Tucker, William.
	1889.
	Ordinary Members.
1880	Colyer, H. C., M.A.
1875	Nott, Thomas, M.D., *Aber.*, M.R.C.S.
1884	Sunderland, Rev. J. P.
	Honorary Member.
1875	Woods, Rev. J. E. Tenison-, F.G.S., F.L.S.
	1890.
	Ordinary Members.
1873	Atherton, Eben., M.R.C.S. *Eng.*
1878	Black, Morrice A., F.I.A.
1876	Conder, William J.
1876	Grahame, The Hon. William, M.L.C.
1876	Ratte, A. Felix.
1857	Stephens, Professor William John, M.A. *Oxon.*
1875	White, The Hon. James, M.L.C.
	1891.
	Ordinary Member.
1874	Latta, G. J.

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 Sir Richard Owen, K.C.B., F.R.S., Hampton Court.
1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.
1880 Professor Huxley, F.R.S., The Royal School of Mines, London, 4 Marlborough Place, Abbey Road, N.W.
1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne
1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph. D., F.R.S., F.L.S., Government Botanist, Melbourne.
1884 Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S., Director of the Geological and Natural History Survey of Canada, Ottawa.
1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., Director of the Royal Gardens, Kew.
1886 Professor L. G. De Koninck, M.D., University of Liége, Belgium.
1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.
1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.
1889 Robert Lewis John Ellery, F. R. S., F. R. A. S., Government Astronomer of Victoria, Melbourne.
1890 George Bennett, M.D., Univ. *Glas.*, F.R.C.S. *E.*, F.L.S., F.Z.S., William-street, Sydney.
1891 Professor Frederick Wollaston Hutton, F. G. S., Canterbury College, Christchurch, New Zealand.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

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

Money Prize of £25.

1882 John Frazer, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'
1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'
1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper on 'The Tin deposits of New South Wales.'
1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurence of gold-bearing veins and of the associated Minerals.'
1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'
1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.
1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.'

ERRATA.

Page 88, Line 24, read $a - p_1$ instead of $a - p_2$ ....(1)

Page 92, Line 26, read $\cdot 845 \dfrac{\Sigma v}{\sqrt{\{n (n-1)\}}}$ instead of $\cdot 845 \sqrt{\left\{ \dfrac{\Sigma v}{n (n-1)} \right\}}$ ....(19)

Page 103, Line 6, read 539″ instead of 559″.

ANNIVERSARY ADDRESS.

By A. LIVERSIDGE, M.A., F.R.S., Professor of Chemistry,
University of Sydney.

[*Delivered to the Royal Society of N.S.W., May 7, 1890.*]

THIS being the Sixty-ninth Anniversary Meeting of the Society, it again devolves upon me to address you upon the affairs of this institution and certain other matters, in which we are all probably more or less interested. I do not intend to give you any general review of the scientific progress made during the past year, since that, for many reasons, appears to me to be unnecessary. In the first instance this is a Society for all branches of science, and a review of all of them, even if I were capable of writing such, would necessarily be very fragmentary and incomplete; it would be of too one-sided a character if I were to confine myself to Chemistry alone, and would only appeal to a few of our members; moreover, we have at this time of the year the advantage of reading the annual summaries of scientific progress recently published in Europe and America, and which arrive shortly before our annual meeting. These addresses and scientific summaries are usually the work of the most eminent men, each a leader in his own department of science, and delivered to the members of societies who are also specialists; hence anything I could do in that way would naturally fall far short of what is already accessible to you. I shall therefore content myself by drawing attention to a few matters which may more particularly concern ourselves; the changes which have taken place during the past year, the work done by our own Society, some of the work it should do, and similar topics.

The number of members on the roll on April 30, 1889 was 471. Twelve new members have been elected during the past year; we have however lost by death three ordinary, one honorary, and one corresponding member; eight by resignations; and eleven have been struck off the roll for non-payment of subscription; leaving a total of 461 on April 30, 1890; this number however does no include our honorary and corresponding members. The losses by death were:—THOMAS NOTT, M.D., Aberdeen M.R.C.S., elected in 1875; The Rev. J. P. SUNDERLAND, elected in 1884; The Rev. J. E. TENISON-WOODS, F.G.S., F.L.S., Honorary Member, elected in 1875; Mr. FELIX RATTE, Assistant in Mineralogy at the Australian Museum; Major-General Sir EDWARD WARD, R.E., K.C.M.G., who first joined the Society in 1856.

The Society has sustained a great loss by the death of the Rev. J. E. Tenison-Woods, M.A., 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., &c., who died on the 7th October last. He was one of our first honorary members, elected in 1875, and he almost immediately acknowledged his connection with the Society by presenting contributions to it, the first being entitled, "On some Tertiary Australian Polyzoa," read before our meeting held on Oct. 4, 1876, followed by others at frequent intervals. The following account of the Rev. J. E. Tenison-Woods is founded upon various notices which appeared at the time of his death.

The Rev. Julian Edmund Tenison-Woods was born on Nov. 15, 1832, at West Square, London. He was the son of Mr. James Dominick Woods, Q.C., F.S.A., of the Middle Temple and Sydenham, Kent, who for forty years was a leading member of the literary staff of the "*Times*." His mother was daughter of the Rev. Joseph Tenison of Donoughmore Glebe, Country Wicklow, Ireland, a son of the Bishop of Ossory, and grand nephew of Archbishop Tenison of Canterbury. For a time he was educated under Mr. Thomas Hunt at Hammersmith and at the Grammar School, Newington, whence he proceeded to Balliol College, Oxford, and afterwards to France, where he became one of the instructors at the College for Naval Cadets at Toulon. During his four years stay in France he first developed his taste for Natural History and Geology. In

1855 he accompanied Dr. Willson, Roman Catholic Bishop of Tasmania, to that Colony for the purpose of establishing schools for the education of Roman Catholic children. In 1859 he went to South Australia where he was ordained and was occupied with mission work and the organisation of the Roman Catholic Schools of that colony. He also acted as sub-editor of the *Adelaide Times.* Later on he became a missionary priest in New South Wales and made Sydney his head quarters ; he now gave up most of his time to the study of Natural History and Geology, and worked with unflagging energy, as is shown by the bare list of the papers published by him. In 1883, on the invitation of Sir F. A. Weld K.C.M.G., Governor of the Straits Settlements, he proceeded to Singapore ; thence he made an exploratory trip through Malacca and reported upon its geology and mineral resources. He also visited Java, Borneo, Siam, the Phillipine Islands, Japan and other places, and was at Krakatoa during part of the volcanic eruption. After a lengthened cruise he returned to Hongkong. From that place he left to ascend the Hoang Ho, the Chinese "river of sorrows"; but fever compelled him to return to Hongkong and finding his health was seriously impaired he determined to make his way back to Sydney. He came in H.M.S. "Flying Fish," surveying vessel, as far as Port Darwin, visiting on his way some islands which had heretofore been unknown.

Mr. Parsons, the Government Resident in the Northern Territory, induced him to visit and report upon the mineral districts of that portion of the country which is under the rule of South Australia. His health by no means good at the time he undertook the task, was still further impaired by the fatigues and privations which were unavoidable on such a journey, and after an absence of about four years he returned to Sydney. A short visit to Queensland terminated his wanderings, and his return to New South Wales was a welcome rest to him. The hardships he had undergone began, however, to tell upon him seriously, and partial paralysis of his hands and legs slowly crept over him, and his health slowly but surely gave way. For nearly two years he was confined to his house, and was so debilitated that he was unable to see any but his intimate acquaintances. He suffered greatly, but he bore his afflictions with remarkable fortitude, and patience. Although an invalid he still continued to work at his scientific pursuits with a vigour that could hardly be expected from a person in his physical state, and published many essays on the natural history of the countries he had visited, one of his latest being "The Natural History of the Mollusca of Australia," for which he received our medal and a money grant of £25, offered for the best original communication upon that subject.

Mr. Woods was at one time President of the Linnean Society of New South Wales, and at the time of his decease was one of its Vice-presidents. He was the "Clarke Medallist" of the Royal Society of New South Wales in 1888. He also received the gold medal given by his Majesty William III., King of the Netherlands for a work upou "Fish and Fisheries of New South Wales," written by him at the request of the Government of New South Wales at the time of the Fisheries Exhibition held in London. He was an accomplished scholar and excellent linguist, a good musician and an artist of considerable ability; most of the drawings which illustrate his scientific works were the work of his own hand. He was characterised by great simplicity, courtesy and kindness of manner, a quiet, cheerful, pleasant voice and ready kindly smile, no small matters in these days of hurry and high pressure. Having been resident in several of the colonies, he was very widely known and laudatory biographical notices appeared in all the leading Australian papers. The full funeral honours of the Roman Catholic Church were paid to our late member (whose remains, previous to interment in the Waverley Cemetery, were on Oct. 9th last, taken to the Roman Catholic Cathedral) by the Cardinal and other church dignitaries; amongst those who attended his funeral as a tribute of respect were your President, the Senior Honorary Secretary and other members of the Council, together with members of the Council of the Linnean Society, many representative residents and personal friends of the deceased naturalist.

The following is a list of the papers and writings published by him, as far as I am able to ascertain, although there are doubtless others which have not come under my notice :—

I.—Before the Royal Society of New South Wales.

Oct. 4, 1876— 1. On some Tertiary Australian Polyzoa.
July 4, 1877— 2. On the Tertiary Deposits of Australia.
" " 3. On some New Australian Polyzoa.
Sept. 5, 1877— 4. The Palæontological Evidences of Australian Tertiary Formations.
Nov. 7, 1877— 5. On some Australian Tertiary Corals.
June 5, 1878— 6. Tasmanian Forests: their Botany and Economical Value.
Sept. 4, 1878— 7. The Molluscan Fauna of Tasmania.
" " 8. On some Australian Tertiary Fossil Corals and Polyzoa.
Aug. 6, 1879— 9. The Anatomy of Distichopora—with a Monograph of the Genus.
May 10, 1882—10. The Hawkesbury Sandstone.
Oct. 4, 1882—11. On some Carboniferous Marine Fossils.
" " 12. On some Mesozoic Fossils from the Palmer River, Queensland.
Dec. 6, 1882—13. A Fossil Plant Formation in Central Queensland.
July 4, 1883—14. On the Waianamatta Shale.
July 4, 1888—15. On the Anatomy and Life History of Mollusca peculiar to Australia (for which this Society's Clarke Memorial Medal was awarded to the author).
Nov. 7, 1888—16. The Desert Sandstone.

II.—Before the Linnean Society of New South Wales.

1. Observations on the Genus Risella.
2. On some Australian Species of Trochocochlea.
3. On a new Species of Neæra.
4. On a variety of Trigonia Lamarckii
5. On a Tertiary Formation at New Guinea.
6. { The Echini of Australia (including those of the "Chevert" Expedition.
Supplemental Note to the above Paper. }
7. On some Australian Shells described by Dr. A. Gould.
8. On some new Marine Shells.
9. On some Tertiary Fossils from New Guinea.
10. On the Extra-Tropical Corals of Australia.
11. On an Australian Variety of Neritina pulligera, Linn.
12. On a new Genus of Milleporidæ.
13. On a new Species of Psammoseris.

14. On a new Species of Desmophyllum (D. quinarium) in a young stage of Cycloseris sinensis.
15. On some Australian Littorinidæ.
16. On Bulimus Dufresnii.
17. On three new Genera and one new Species of Madreporaria Corals.
18. On two new Species of Land Shells.
19. On a new Genus of Polyzoa.
20. On some Corals from Darnley Island.
21. On some new Extra-Tropical Corals.
22. On some Fresh-Water Shells from New Zealand.
23. On some Tertiary Fossils from Muddy Creek, Western Victoria.
24. On some Tertiary Fossils.
25. On some new Marine Shells.
26. On some Fresh-Water Shells from New Guinea.
27. On some new Marine Shells from Moreton Bay.
28. On Arauga albens, Don.
29. On the Relations of the Brisbane Flora.
30. On some new Australian Echina.
31. On Heteropsammia Michelinii of Edwards and Haime.
32. On a new Species of Distichopora.
33. Note on Euktiminaria ducalis.
34. On some Fossils from Levuka, Viti.
35. On some Post-Tertiary Fossils from New Caledonia.
36. Presidential Address (January 28th, 1880).
37. On some of the Littoral Marine Fauna ot N.E. Australia.
38. On a Fossiliferous Bed at the mouth of the Endeavour River.
39. On the Habits of some Australian Echina.
40. Résumé of a Report on the Fossil Radiata of New Zealand.
41. On a new Species of Flabellum.
42. On a new Species of Diaseris.
43. On a young Specimen of a Temnopleurus.
44. Presidential Address (January 27th, 1881).
45. Botanical Notes on Queensland—No. I.
46. ,, ,, ,, No. II.
47. ,, ,, ,, No. III.
48. ,, ,, ,, No. IV.
49. ,, ,, ,, No. V.
50. On a new Species of Stomopneustes and a new Variety of Hipponoe variegata.
51. On various Deposits of Fossil Plants in Queensland.
52. On a new Species of Allopora.
53. On a Coal Plant from Queensland.
54. Remarks on Fossils from West Maitland and Ipswich; also of a Specimen of a Sertularian Hydroid.
55. Physical Structure and Geology of Australia.

56. On a large Mesozoic Mytilus from the Barcoo.
57. Remarks upon a Specimen of Coral from Port Jackson.
58. On a Species of Brachyphyllum from Mesozoic Coal-beds, Ipswich, Queensland.
59. On the Fossil Flora of the Coal Deposits of Australia.
60. Remarks on a Collection of Cretaceous Fossils exhibited by Mr. Gilliat.
61. On some Mesozoic Fossils from Central Australia.
62. Account of Travels in Perak (in letter to Hon. W. Macleay).
63. Report on the Geology and Physical Geography of the Stateof Perak.
64. On the Volcano of Taal.
65. Fisheries of the Oriental Region.
66. Geographical Notes in Malaysia and Asia.
67. Malaysian Land and Fresh-water Mollusca.
68. On the Vegetation of Malaysia.

By the Rev. J. E. Tenison-Woods and F. M. Bailey, F.L.S.

A Census of the Flora of Brisbane.

On some of the Fungi of New South Wales and Queensland.

III.—*Before the Philosophical Society of Adelaide and the Royal Society of South Australia.*

1865 and 1866 { 1. The Tertiary Rocks of South Australia.
2. The Geology of the South-East District of South Australia. }

Sept. 17, 1878—3. On some Fossil Corals from Aldinga.

,, 4. A List of Australian Starfishes.

Sept. 2, 1879—5. On some Recent and Fossil Species of Australian Seleniaridæ (Polyzoa).

July 6, 1830—6. On some New Corals from the Australian Tertiaries.

IV.—*Before the Royal Society of Tasmania.*

July 14, 1874— 1. Notes on the Physical and Zoological Relations between Australia and Tasmania.

March 9, 1875— 2. On some Tertiary Fossils from Table Cape.

April 13, 1875— 3. On some new Species of Tasmanian Marine Shells.

June 8, 1875— 4. On the Genus Fenestella.

Aug. 9, 1875— 5. On the Fresh-water Shells of Tasmania.

Nov. 8, 1875— 6. Description of new Tasmanian Shells.

,, 7. On a new Genus of Nudibranchiata

May 9, 1876— 8. On some Tasmanian Patellidæ.

July 11, 1876— 9. History of Australian Tertiary Geology.

,, 10. Notes on the Fossils referred to in the foregoing Paper.

11. Echinodermata (Fossils).

12. On a new Species of Ampullaria.

13. On some new Tasmanian Marine Shells. [Second Series].

Oct. 9, 1876—14. On a new Reversed Tasmanian Helix—Helix Weldii.
Mar. 13, 1877—15. Census, with brief descriptions, of the Marine Shells of Tasmania and the adjacent Islands.
Oct. 15, 1877—16. On Tasmanian Siphonaria, including a new Species.
Nov. 12, 1877—17. On some new Tasmanian Marine Shells.
18. On the absence of the Gault Formation in Australia.
April 9, 1878—19. On some new Tasmanian Marine Shells. [Third Series].
Oct. 7, 1878—10. On some Tasmanian Fresh-water Univalves.
Aug. 12, 1879—21. On some Tasmanian Trochidæ.
22. Notes on Bythinella.
Sept. 13, 1880—23. On some introduced Plants of Australia and Tasmania.

V.—*Before the Philosophical Institute of Victoria.*

Nov. 25, 1857— 1. Observations on some Metamorphic Rocks in South Australia.
Sept. 29, 1858— 2. Remarks on a Tertiary Deposit in South Australia.
Oct. 26, 1859— 3. On some Tertiary Rocks at Portland Bay.

Before the Royal Society of Victoria.

May 27, 1861— 4. On some Tertiary Fossils in South Australia.
5. On the Glacial Period in Australia.
Aug. 9, 1877— 6. On some new Marine Mollusca.
June 12, 1879— 7. On the Genus Amathea of Lamouroux, with descriptions of New Species.
April 15, 1880— 8. The Hodgkinson Goldfield, Northern Queensland.
Oct. 21, 1880— 9. On some new Marine Mollusca.
Aug. 10, 1882—10. A Physical Description of the Island of Tasmania.

VI.—*Read before the Queensland Philosophical Society.*

Dec. 20, 1880—Geology of Northern Queensland.

VII.—*Read before the Otago Institute, N.Z.*

Sept. 10, 1878—On a new Species of Millepora.

VIII.—*Read before the Wellington Philosophical Society, N.Z.*

July 24, 1880—On the Tertiary Corals and Bryozoa of New Zealand.

In Other Publications.

"On some Tertiary Rocks in the Colony of South Australia."—Geol. Soc. Jour., xvi., 1860, pp. 253-260.

"On some Tertiary Deposits in the Colony of Victoria."—Geol. Soc, Quar. Jour., xxi., 1865, pp. 389-394, and Phil. Mag., 1865, p. 404.

"On the Auroral Phenomena of the Northern Ocean."—"Electrician," iii., 1863, pp. 87-89.

"Corals and Bryozoa of the Neozoic Period in New Zealand."—[Colonial Museum and Geological Survey Dept.] 8vo. Wellington, 1880.

"Report on the Wild River and Great Western Tin Mines, near Herberton."—[Government Printer]. 8vo. Brisbane, 1881.

"Geological Observations in South Australia; principally in the District South-east of Adelaide."—pp. 404. 8vo. London, 1862.

"Fish and Fisheries of New South Wales."—p.p. 213. [Government Printer]. 8vo. Sydney, 1882.

"Tin: Stream Deposits of Perak."—Journal of the Straits Branch of the Royal Asiatic Society.

"Gunong Bubu: Journey to Summit of."

"Malayan Peninsula: Physical Geography of."—*Nature*, Vol. 31.

"Coalfields of Borneo."—*Nature*, Vol. 31.

"Malaysia, S. China: Geology of."—*Nature*, Vol. 33.

Reports, Pamphlets, &c.

"North Australia: Its Physical Geography and Natural History."—Adelaide, 1864.

"Portland: Geology of."—Two lectures, Portland, Victoria, 1865.

"S. Australia: Report on Geology and Mineralology of S.E. District of Adelaide, 1866.

"Tin Mine: Report on Wilde River and Great Western." Brisbane, 1881.

"Burrum Coalfield, Queensland."—Lectures on, with map. Maryborough, 1881.

"Natural History of New South Wales."—Sydney, 1882.

"Coal Resources of Queensland."—Brisbane, 1883.

"Northern Territory Report of Geology and Mineralology of."—Adelaide, 1887.

LETTERS TO NEWSPAPERS.

"Australia: Physical Geography of."—*The Australian*, 1866. Six letters.

"Wood's Point: a Trip to."—*The Australian*, 1867. Four letters.

"A Coral Reef: Trip to."—*The Australian*, 1879.

"Lichens: a few Words about."—*The Australian*, 1880.

"Coral Reefs: Australian."—*The Australasian*. Six letters.

"Nature: Wonders of in Australia."—*The Sydney Mail*, 1879. Ten letters.

"North Australia: Notes made in."—*The Sydney Mail*, 1880. Twelve letters.

"Wilde River: Visit to."—*The Sydney Mail*, 1882. Twelve letters.

"Coal Plants of Australia."—*The Sydney Mail*, 1883. Twelve letters.

"Queensland: Northern."—*South Australian Advertiser*, 1879-80. Twelve letters.

"Nature in the Far North."—*Sydney Morning Herald*, 1880. Eighteen letters.

"Myalls: a Day with the."—*Sydney Morning Herald*, 1882. Two letters.

"Sunda: Earthquake in Straits of."—*Sydney Morning Herald*, 1884. Three letters.

"Java: a Journey through."—*Sydney Morning Herald*, 1884. Twenty letters.

"Perak: Exploration in."—*Sydney Morning Herald*, 1884. Seven letters.

"North Australia: Explorations."—*Sydney Morning Herald*, 1887. Eight letters.

"Victoria River: Trip to."—*Sydney Morning Herald.* Two letters.

"Travel: Notes of."—*Sydney Morning Herald.* Seven letters.

"Coal Trade between Australia and the East."—*Sydney Morning Herald.* Six letters.

"Carboniferous Rocks of the Lower Burnett."—*Bundaberg and Mount Perry Mail,* 1881.

"Geological Observations in South Australia." 1862. 1 vol. London and Melbourne.

"Discovery and Exploration of Australia: History of." 1865. 2 vols. London.

"Fish and Fisheries of New South Wales." 1882. 1 vol. Sydney.

Major-General Sir Edward Wolstenholme Ward, R.E., K.C.M.G., of the family of Viscount Bangor, of Castle Ward, County Down, Ireland, the son of the Hon. John Petty Ward, of the Bengal Civil Service, and Eleanor Erskine, was born in 1823, and entered the Royal Engineers in 1841. He received instruction in practical chemistry under Dr. Lyon Playfair, and was one of the first students at the London School of Mines. He took part in the Great Exhibition of 1851, and was appointed Deputy Master of the Sydney Branch of the Royal Mint in 1853, and entrusted with its organization and establishment. He arrived in Sydney in 1854, and opened the Mint in 1855.

In 1857 he married a daughter of the late Hon. Robert Campbell, M.L.C., of Sydney. He remained in charge of the Mint until March, 1865, when he left the colony. Prior to his departure the thanks of Parliament were accorded him for his valuable services in the terms of the following resolution:—"The Council "further desire to place on record and to express to Colonel "Ward the high sense entertained by the Government of his "valuable services as Deputy Master of the Royal Mint Branch "in New South Wales, as well as for the important assistance "which on many occasions he has rendered in matters not "immediately connected with his own department of the Public "Service." He returned to military duty at Chatham. Afterwards he was re-appointed Deputy Master of the Mint, and charged with the formation and establishment of the Melbourne Branch, which he opened in 1872 and of which he held the

Mastership until 1877, when he retired on a well-earned pension, and was made Major-General. He then took up his residence at Cannes, in the South of France, where he remained until his death on February 5th last. During the years he resided in Sydney he took a leading part in the public and social life of the colony. He was fond of scientific research and a great lover of all manly games and sports, in which he excelled. He was one of our leading cricketers and took a prominent part in the formation of the Rifle Association, of which he was honorary secretary. He was an early and active member of our society, to which he contributed several papers, notably one on the strength of Australian timber. At the first meeting of the Philosophical Society of New South Wales, held May 9th, 1856, Captain Ward, R.E., was elected one of the hon. secretaries (in conjunction with Dr. H. G. Douglas and Professor Smith, M.D.), and held this office till the close of 1861. He was again elected hon. secretary in 1863, and thus filled this office for six years in all.

The following papers were read by him before the Philosophical Society of New South Wales, viz.:—May 12, 1858: "On the strength and elasticity of woods of New South Wales and New Zealand." August 10, 1859: "Analysis of certain colonial coals." December 7, 1864: "On the prospects of the Civil Service of New South Wales under the Superannuation Act of 1864."

He was a trustee of the Australian Museum from 1854 to 1865, and a member of the Legislative Council in 1854 and again in 1860, and Commissioner for Railways in 1865. For his services he was made a C.M.G. in 1864, Colonel of Royal Enginners in 1873, and a K.C.M.G. in 1879, being one of the very few in New South Wales who have been thus rewarded for non-political services. In recognition of his services to this society as one of the former hon. secretaries and a contributor to its journal, he was in 1880 elected a corresponding member.

I am glad to be able to state that the Society's financial affairs continue in a satisfactory condition. We are still able to afford a very fair sum annually towards our library, and to put by a small amount towards the building and investment fund. The publication of the volume for 1889 cost us £257, and there was an additional item this year for printing the first part of our library catalogue.

Improved Accommodation.—It has long been my desire to see the Society provided with better and more suitable accommodation, but until we were out of debt for our present building it was considered inadvisable to speak of incurring fresh obligations. Although the question has not been brought before the general meetings of the Society, it has been under discussion in the Council on many occasions, but deferred for lack of funds. When I last addressed you in 1886 we were £800 in debt for the house; but we are now in the fortunate position of having some funds in hand towards the acquisition of a new building or the enlargement of the old one. It may be thought by a few that we ought now to rest and be thankful; but we are not banded together for that purpose. The objects of the Society will not be advanced if we fold our hands. It is quite true that our present hall is quite large enough for our ordinary meetings, but it is altogether insufficient for lectures or our more popular meetings. Moreover, our library and reading-room accommodation is extremely limited; we require additional store-rooms for our books, and a separate reading-room, as well as other rooms for the meetings of the Council and Sections. With greater conveniences the members would be drawn more closely together and the objects of the Society promoted. It is very desirable that we should have a building specially designed for the work of the Society, and such a building might be arranged to provide accommodation for other societies and institutions at the same time. In fact what is wanted is a modest edition of Burlington House, Piccadilly, which was built by the Imperial Government, to lodge the Royal Society, the Astronomical, the Chemical, the

Geological and certain other societies together with the Royal Academy.

If such a building could be obtained it would not be necessary to provide meeting halls for each society, as was done by the English Government. Here in Sydney it would for the present be quite sufficient if two or three halls, or lecture rooms, were erected with the necessary separate offices, since several of the societies could use the same room for their general meetings, provided that they had a private room or two each for their offices, books, papers, &c. If more than one meeting-room be provided, one should be fitted up in such a way as to be suitable for the reading of papers and delivery of lectures upon Chemical, Physical and other experimental subjects. I believe that if the matter were carried out, even as a commercial undertaking, it would prove not only a very useful but also a fairly profitable investment.

Papers read in 1889.—During the past year the Society held eight meetings, at which the following 19 papers were read :—

1889.

May 1. 1—Annual Address. By Sir Alfred Roberts.

June 5. 2—Note on the Composition of two Sugar Plantation Soils. By W. A. Dixon, F.I.C., F.C.S.

„ 3—The Aborigines of Australia. By W. T. Wyndham.

„ 4—Note on the Recent Rain Storm. By H. C. Russell, B.A., F.R.S.

July 3. 5—On the High Tides of June 15 – 17, 1889. By John Tebbutt, F.R.A.S.

„ 6—List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and the neighbourhood. By T. Whitelegge, F.R.M.S.

Aug. 7. 7—The source of the underground water in the Western Districts. By H. C. Russell, B.A., F.R.S.

„ 8—The eruptive Rocks of New Zealand. By Prof. F. W. Hutton, F.G.S.

„ 9—On the application of Prismatic Lenses for making Normal-sight Magnifying Spectacles. By Percy J. Edmunds.

„ 10—Flying Machine Memoranda. By Lawrence Hargrave.

Sept. 4. 11—Irrigation in its relation to the Pastoral Industry of New South Wales. By H. G. McKinney, M.E., M.I.C.E.

Oct. 2. 12—The Analysis of Prickly Pear. By W. M. Hamlet, F.C.S., F.I.C.

„ 13—On the Occurrence of Arabin in Prickly Pear—*(Opuntia Braziliensis)*. By W. M. Hamlet, F.C.S., F.I.C.

„ 14—Personal Recollections of the Aboriginal Tribes once inhabiting the Adelaide Plains of South Australia. By Edward Stephens.

Nov. 6. 15—Aids to the Sanitation of unsewered districts—(Poudrette Factories). By J. Ashburton Thompson, M.D. *Brux.*

„ 16—Notes on Goulburn Lime. By E. C. Manfred.

„ 17—Notes on some New South Wales Minerals. By C. H. Mingaye, F.C.S.

Dec. 4. 18—Well and River Waters of New South Wales. By W. A. Dixon, F.I.C., F.C.S.

„ 19—The Australian Aborigines. By Rev. John Mathew, M.A.

A "reception" to the members of the Society was held in the Society's Hall on the 21st August, 1889, at which upwards of one hundred were present. The meeting was a successful one, and afforded a more satisfactory opportunity for the exhibition of objects of scientific interest, their examination and discussion, than the usual conversazione to which large numbers are invited.

Two lectures were also delivered to the members, viz. :—by Prof. Threlfall, M.A. "On the Present State of Applied Electrical Science," 24th June, 1889; and by Mr. M. Hamlet, F.I.C., F.C.S. on "The Evolution of the Kerosene Lamp," 16th October, 1889.

The Council had arranged for a course of three lectures on the "Geology of Australia," which Mr. C. S. Wilkinson, F.G.S., Government Geologist, had kindly offered to deliver, but on account of Mr. Wilkinson's absence from Sydney on Departmental business they had, much to the regret of the members, to be postponed. Now by Mr. Wilkinson's visit to England in charge of the Mineral Exhibits at the forthcoming Mining and Metallurgical Exhibition, it will be necessary to postpone the lectures for a still further period, but Mr. Wilkinson promises to deliver them on his return.

Clarke Medal.—On the 11th December, 1889, the Council awarded the "Clarke Medal" for 1890 to George Bennett, M.D., Univ. *Glas.*, F.R.C.S.,E., F.L.S., F.Z.S., of Sydney, in recognition of his meritorious scientific labours, and more particularly on account of his very valuable contributions to the Natural History of New South Wales.

Library.—During the past year 105 volumes have been purchased at a cost of £79 19s., this includes £40 devoted to medical works, also the back volumes necessary to complete the following sets, viz.: "Proceedings of the Royal Society of Edinburgh," "Biedermann's Technisch-Chemisches Jahrbuch," and the "Analyst." The donations to the Society's Library during the past year consisted of :—252 Volumes, 1,048 Parts, 231 Pamphlets, 4 Maps, 96 Charts, 1 Portfolio and 26 loose Diagrams and Plans, 3 Engravings, 3 Photographs, 5 Atlases.—Total publications, 1,669. At the present time many of the periodicals are laid out during the day in the room in which we now sit; unfortunately, on account of circumstances which we cannot control, these have to be gathered up and put away on certain days. I have no doubt many more members would make use of them if there were not the uncertainty that this room may be in use for some other purpose on the particular occasions when they would like to come.

Although a list of the publications taken by and presented to the Society is published annually in the volume, yet some of the members may not have fully realized that we subscribe to forty-five scientific and literary journals and publications, and receive annually in exchange for our own between two hundred and three hundred others; amongst them are the publications of all the principal scientific institutions in nearly every part of the world; some it is true are in languages not usually read, but the majority of the most valuable, are in English, French, and German.

The first part of the Catalogue of Books in the Society's Library, viz., the list under authors' names has been published, and the catalogue of bound volumes of serials, journals, &c., is nearly complete, the unbound books are still to be added, and it is expected that the second part of the Catalogue will be completed this year. It is hoped that the members will find these Catalogues useful, and enable them to make a more ready use of the books in the library.

Exchanges.—During the past year the Society presented its Journal of Proceedings, Vol. XXII., for 1888, to 342 Societies and Institutions, of which a list has been published in the volume as usual. Amongst the additional societies and institutions which have entered into an exchange of publications since last year are the following, viz.:—K.K. Oestereichische Gradmessungs Bureau Vienna; Laboratoire de Zoologie, Villefranche-sur-Mer. Gesellschaft Für Erdkunde zu Berlin. Oberhessische Gesellschaft für Natur und Heilkunde, Giessen. Sanitary Institute of Great Britain, London. Royal Asiatic Society, Ceylon Branch, Colombo. United Service Institution of N. S. Wales, Sydney. Highland and Agricultural Society of Scotland, Edinburgh. Trömso Museum, Norway. American Museum of Natural History, New York.

The Medical Section held seven General Meetings, which were well attended. Twelve papers were read, and numerous exhibits were shown at the different meetings. Special mention should be made of the excellent and valuable papers read by Dr. Newmarch, on "The Climate of New South Wales;" Dr. Hankins on "Wind Instruments, and their relation to certain Lung Diseases;" and Dr. Clubbe on "The After-treatment of Tracheotomy."

The Miscroscopical Section held six Meetings. No formal papers were read, but numerous exhibits were made at the meetings and many interesting matters discussed. Dr. H. G. A. Wright presented to the Society, through this Section, a one-twelfth oil immersion objective by Powell & Leland.

Increase in the Council.—As will be seen from the notice paper, it has been decided by the Council to recommend to the Society an increase in the number of the Council, as it is thought that the time has now come when this should be done. This is partly due to the increase in the number of members who are qualified for this position, and partly because it is felt that all branches of science taken cognisance of by the Society cannot be properly represented by a Council of the present limited size. It is felt that by obtaining the advice and assistance of more of our members on the Council, that the aims and objects of the Society will be greatly furthered; hence the proposal to elect six additional members, which has been brought before you this evening, two of whom it is proposed should be additional Vice-Presidents. It is also proposed that the term of office of President should not in future be limited to one year.

Biological Station.—In my last address I informed you that the Government had resumed the house and lands of the Biological Station at Watson's Bay, but I am glad to say that we now have the prospect of a new and more suitable site, and with the funds in hand the Trustees will be in a position to erect the necessary buildings. This Society should have a special interest in the work of the Biological Station, inasmuch as the Trustees are all members of our body, and, moreover, when the project was initiated the Society took great interest in its formation and was one of the first and most liberal contributors to the fund. When the Biological Station is again in working order it is to be hoped that many and valuable researches will issue from it.

Technological Museum.—Another institution in Sydney from which original scientific work has been issued and from which much more may be expected in the future, is the Technological Museum, which is under the energetic and zealous direction of our associate, Mr. Maiden, its curator. Unfortunately this institution is so poorly and inconveniently housed, that the collections are almost inaccessible, and at one time the committee almost decided to close the place in consequence. In December last the committee resigned their trust to the Government as they felt they could not be responsible for the care of the collections unless granted the necessary accommodation for their safe custody and proper exhibition to the public. Happily steps have now been taken to erect a suitable building for the Museum, in connection with the Technical College, so that the public will in due course have an opportunity of really judging of the extent and value of the collections which have been got together.

Original Researches.—As is well known to the members, this Society has now for several years (since 1881) published lists of subjects, peculiar to Australia, requiring investigation, in the hope that those, having the time and necessary qualifications, would be led to devote themselves to the work. The subjects offered for Prize Essays from 1881 to 1889 were the following:—1. On the Aborigines of New South Wales. 2. On the treatment of auriferous pyrites. 3. On the Forage Plants indigenous to New South Wales. 4. On the influence of the Australian climates and pastures upon the growth of wool. 5. On the chemistry of the Australian gums and resins. 6. On water supply in the Interior of New South Wales. 7. On the embryology and development of the Marsupials. 8. On the Infusoria peculiar to Australia. 9. Origin and mode of occurrence of gold-bearing veins and of the associated minerals. 10. Anatomy and life history of the Echidna and Platypus. 11. Anatomy and life history of Mollusca peculiar to Australia. 12. The chemical composition of the products from the so-called Kerosene Shale of New South Wales. 13. On the Tin-deposits of New South Wales. 14. On the Iron-ore deposits of New South Wales. 15. List of the Marine Fauna of Port Jackson with descriptive notes as to habits, distribution etc. 16. On the Silver ore deposits of New South Wales. 17. On the Aborigines ef Australia.

And the following awards have been made:—*Money Prize of £25*—1. Dec. 13, 1882, To John Fraser, B.A., West Maitland for paper on "The Aborigines of New South Wales." 2. Dec. 13, 1882 to Andrew Ross, M.D., Molong, for paper on "The Influence of the Australian climate and pastures upon the growth of wool." The Society's *Bronze Medal and £25*—3. Nov. 26, 1884, to W. E. Abbott, Wingen, for paper on "Water supply in the Interior of New South Wales." 4. June 30, 1886, to S. H. Cox, F.G.S., F.C.S., Sydney, for paper on "The Tin deposits of New South Wales." 5. July 27, 1887, to Jonathan Seaver, F.G.S., Sydney, for a paper on "Origin and mode of occurrence of gold-bearing veins and of the Associated Minerals." 6. May 30, 1888, to Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on "The Anatomy and Life-history of Mollusca peculiar to Australia." 7. May 29, 1889, to Thomas Whitelegge, F.R.M.S., Sydney, for paper on "List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood." 8. July 31, 1889, to Rev. John Mathew, M.A., Coburg, Victoria, for his paper on "The Australian Aborigines."

In the absence of communications of sufficient merit to warrant an award, some of the subjects have been offered for competition more than once. I referred rather at length to this matter in my previous address, but I feel justified in again doing so because it is only by constant re-iteration, that in the press of other matters we can hope to convey an idea of the necessity for, and value of such researches. The right elucidations of some of these questions might be of incalculable value and benefit to the Colony. Although we have not received essays of sufficient merit in all cases, we however need not lose heart in the matter for there is no doubt that we shall have the workers in due time, and although only eight awards have been made up to the present, it is to be hoped that with the increased population of the Colonies, and the increased facilities for scientific work, greater progress will be made and that we shall be able to make the full number of awards each year. It is very encouraging to find that last year, for the first time, there were two communications of sufficient merit to justify the Council in making the award. I wish to draw special attention to the very valuable list or census by Mr. Whitelegge, of the "Marine and Fresh-water Invertebrate Fauna of Port Jackson and its neighbourhood," as it is, I trust merely the forerunner of other papers dealing with similar matters. Although it is impossible to make catalogues of this character complete in the first instance, members should not thereby be dissuaded from making a commencement, for work of that kind "begun, is half done" since it is comparatively easy to correct and add to a census but much time and courage is required to initiate a laborious work of that kind.

At the present time the Council invites original contributions and offers its medal and a grant of £25 for the best original contributions upon the following subjects :—viz.,

Series IX.—To be sent in not later than 1st May, 1890.

No. 31—The Influence of the Australian Climate (general and local) in the Development and Modification of Disease.

No. 32—On the Silver Ore Deposits of New South Wales.

No. 33—On the Occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.

Series X.—To be sent in no later than 1st May, 1891.

No. 34—The Meteorology of Australia, New Zealand, and Tasmania.

No. 35—Anatomy and Life-history of the Echidna and Platypus.

No. 36—The Microscopic Structure of Australian Rocks.

Series XI.—To be sent in not later than 1st May, 1892.

No. 37—On the Iron Ore Deposits of New South Wales.

No. 38—On the effect which settlement in Australia has produced upon Indigenous Vegetation : especially the depasturing of sheep and cattle.

No. 39—On the Coals and Coal Measures of Australasia.

As you are aware the competition is in no way confined to members of the Society, nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication to be successful must be either wholly or in part the result of original observation or research on the part of the contributor. The successful papers are published in the Society's annual volume, and fifty reprint copies are furnished to the author free of expense.

Mineral and Medicinal Waters.—Amongst subjects which require investigation is that of the chemical composition of the mineral waters of the Colony, and of Australia generally, there are a few isolated analyses of such but no systematic chemical and physical examination has been made of them, nor have I seen any definite statements made as to their therapeutic effects.

Lightning.—Another question requiring investigation, is the effects of lightning, with especial reference to spots or buildings which have been struck more than once, and of instances in which the evidence points to an upward rather than a downward discharge. I mention this subject because I know of several instances where the same spot or object has been struck more than once, and it would appear that there must be some special cause for this, for in some of the cases the spot has not been by any means a prominent one—I also think that the upward stroke is very much more common than is usually supposed, but at present I am not in a position to go fully into the matter, nor is this perhaps a suitable occasion even to bring forward any material which I possess.

Febrifuge Properties of Gum Trees.—Still another matter that is well worthy of investigation is the alleged beneficial effect of the exhalations from our gum tree forests which are said not only to possess febrifuge properties but to be the cause of the blue haze seen amongst our mountains—several years ago, Mr. Russell and I, made an observation upon the latter with the spectroscope but with negative results, the only bands visible being the usual ones for water vapour or moisture, we however did not make any special preparations, and if the investigation were made in a more systematic way positive instead of negative results might perhaps be obtained, although I do not now much expect such would be the case ; when I first saw the haze on my arrival here, it certainly did give me the impression that it was due to something more than mere moisture in the air.

I venture to throw out these suggestions as to investigations, which require to be done, in the hope that by so doing it may lead to the work being taken up by some one having the necessary leisure and qualifications.

Australasian Anthropology.—It is very satisfactory to find that the two meetings of the Australasian Association have also (*i.e.*, in addition to the Society's effort to elicit papers) been the means of eliciting further papers upon Polynesian anthropology and languages ; papers which in all probability would not otherwise have seen the light for some time, or perhaps, even not at all. Doubtless others may be thereby induced to publish their observations and researches upon such matters, for many persons will follow when they will not lead or originate. There is much more to be done, but all honour however, is due to Messrs. Beveridge, Ella, Fyson, Fraser, Howitt, Pratt, Ridley and others who have led the way ; it is still an almost unploughed field, but not a barren one ; although much patient hard work would probably be required to penetrate through and remove the superficial deposits of half-known and imperfectly understood knowledge, but from deeper depths the true worker would be amply repaid by an abundant harvest. It is rather remarkable that so little is done in original researches upon the Australian and Polynesian languages, manners and customs, when it is borne in mind how many hundreds of people there are in the Colonies who have had a linguistic and literary training, which should have qualified them for such studies. Unfortunately, however, this kind of education does not seem to induce many of its possessors to make original inquiries nor to investigate the methods and science of language. Probably this is partly due to the method of teaching languages, which in too many cases appears to aim simply at teaching the student to translate and to do a little composition, in the style of certain selected models, instead of leading him to study the structure, development and relationship of languages to one another—*i.e.*, the art only of languages is too often taught instead of the science of languages. Every one will admit that even in Australia alone, there is much to be learnt respecting the various dialects or languages. In the course of a few years it will be too late, for the natives are becoming changed by contact with the white man, and are fast dying out, hence what is done should be done quickly.

Amongst other matters connected with the Australian aborigines there is still a large amount of interesting work to be done in describing and reproducing the rock and tree carvings which are to be found scattered about the Colony, and especially along the coasts ; there must still be a great many unrecorded ones even in the neighbourhood of Sydney ; only within the past three months a carving was exposed, by the heavy rains, on the rocks on the Burnt Bridge Creek, (about two miles from Manly) in a place where one would not have expected to find them.

Antarctic Exploration.—In addition to the objects already mentioned as worthy of investigation there are many others, some of which, however, are beyond the means of private individuals, and one of these is that of Antarctic Exploration ; this topic has been brought before the Australasian public many times during the past few years by members of the Australian Geographical Societies and others ; the British Association has had a Committee for this purpose since 1885, and three reports have been presented to the British Association by this committee ; the Baron von Mueller in 1886 strongly advocated the dispatch of an exploring Expedition and Mr. G. S. Griffiths, F.R.G.S., read a paper upon this subject in 1888 before the Sydney meeting of our local Association for the Advancement of Science. Such an Expedition would probably collect much information of commercial value as well as of scientific importance, especially with reference to the whaling and sealing pursuits.

One reason why I draw attention to this matter is that, when in England in 1887, Admiral Sir E. Ommanney urged the importance of this investigation upon me and requested me to lay the matter before you, and although it is more than two years ago, this is the first fitting opportunity I have had since the appearance of the Committee's last report and the conclusion, for the time being, of correspondence with the Imperial Government. I trust that when the time comes this Society will take the matter up and do all within its power to further the proposal, as it is a matter well worthy of its attention and one in which its assistance would be useful. An Antarctic Exploration committee was appointed by our own Science Association at its first meeting in Sydney in 1888, but no report was presented at the following meeting, the committee was, however, re-appointed, and it will doubtless have some report to lay before the New Zealand meeting. The subject is one of such great interest and importance that it should not be allowed to drop and be forgotten; unfortunately the cost of the proposed expedition must necessarily be much more than the £10,000 first suggested.

Reports to the British Association—The Committee of the British Association consisted of Sir Joseph D. Hooker, F.R.S., Sir George Nares, F.R.S., Mr. John Murray, F.R.S., General J. T. Walker, Admiral Sir Leopold McClintock, F.R.S., Mr. Clements Markham and Admiral Sir Erasmus Ommanney, F.R.S. (Secretary), and were appointed for the purpose of drawing attention to the desirability of further research in the Antarctic Regions. The Committee reported at the Birmingham meeting in 1886, that having given full consideration to the great importance of effecting a further exploration of the Antarctic Polar Sea, they desire in the first place, to express their opinion that it would be most essential, before approaching H.M. Government with the view of urging an expedition such as would be required for the carrying out an exploration of such magnitude, interest, and importance, that the requirements for its success and a plan of operations should be most carefully considered, and the results embodied in a written form for the approval of the Council of the Association and for the information of the Government. Furthermore in order to obtain the co-operation which the matter requires from eminent men in Science, the committee felt it necessary for their body to be enlarged by the addition of other bodies representing the various branches of Science interested in the investigation of this comparatively unknown region, and especially of the Royal Geographical Society. The committee pointed out that our knowledge of the South Polar region is chiefly confined to the grand discoveries effected by that celebrated expedition under the command of Captain Sir James C. Ross, conducted between the years 1839 and 1843 with sailing ships. Since that period the facilities for effecting a more complete research have been greatly augmented by the application of steam propulsion to vessels better adapted for ice navigation. This has been proved by continuous experience in the Arctic Seas during the last half century. For the above reasons the committee deemed it desirable to defer making their report, so that the objects of the expedition might be more clearly defined and further information obtained as to the best means of attaining them, also to expand the committee, in order to elicit to the fullest extent the opinions and to secure support from those conversant with the various branches of science which are to be investigated during an exploration which, from its very important and serious nature eminently merits the favourable consideration of this great and enterprising maritime nation.

The Second Report of the Committee presented at the Manchester meeting in 1887 was not published in the Association's Volume but a *Third Report* of the Committee, consisting of Sir Joseph D. Hooper, Sir John Lubbock, Sir George Nares, General J. T. Walker, Sir Leopold McClintock, Admiral Sir George H. Richards, Professor Flower, Professor Huxley, Dr. Sclater, Professor Moseley, Mr. John Murray, General Strachey, Sir William Thomson and Admiral Sir Erasmus Ommanney (Secretary), was presented at the Bath meeting and printed in the volume for 1888 as follows :—" Since the meeting held in Manchester last year, " the above committee have been in communication with the scien- " tific bodies in Australia, New Zealand, and Tasmania. These " colonies have manifested a very great desire for exploration of " the Antarctic Regions, which is strongly advocated by their " respective Governments. The result is that the Government of " Victoria has voted £5,000 towards an expedition provided that " the Imperial Government contributed a similar grant."

"The Colonial Office submitted the application to H.M. Treasury for favourable consideration, who sent it to the Royal Society for their report on the expediency of the expedition. A very influential committee was accordingly appointed by that learned body to consider the matter. The reply from the Royal Society together with a letter from the Colonial Office and the Treasury are annexed herewith which sufficiently explains the motives for declining the grant. It may be inferred from the tone expressed in the official letters that H.M. Government is favourably disposed towards Antarctic research. It is therefore to be hoped that the leading scientific societies and men of eminence in this country may combine in preparing a case to submit to H.M. Government that will justify an appeal to Parliament for an expedition being prepared on a scale equivalent to the one which met with such valuable results under Sir James Ross. It should be stated that the subject has been brought under the notice of the Admiralty, and your committee have met with the support of the Royal Geographical Society and other influential bodies besides eliciting encouragement from men of great eminence in the promotion of science. Your committee having thus given publicity to this desirable project, feel that their services are no longer required at present, but they trust the Council of the British Association may embrace any early opportunity for approaching H.M. Government to carry out this noble work of research into the Antarctic regions."

From the Colonial Office to the Treasury—

Downing Street, December 12th, 1887.

Sir,—I am directed by the Secretary of State for the Colonies to tranmit to you, to be laid before the Lords Commissioners of the Treasury, a copy of a letter from the Agent-General of Victoria, inquiring whether Her Majesty's Government will contribute the sum of £5,000 in the event of the Australian Colonies making a like contribution towards the cost of an Antarctic exploration. Copies of letters on the subject are also enclosed from the Admiralty, the Royal Colonial Institute, the Royal Geopraphical Society and the Royal Society, which their Lordship's will observe are all in favour of the co-operation of Her Majesty's Government in this work.

A reference was also made to the Board of Trade, and it may be seen from the accompanying copy of their reply that in their opinion it does not appear necessary in the interests of trade that Her Majesty's Government should contribute towards the expense. The Board of Trade do not however seem to have regarded the probability of a considerable trade in sperm oil and other products of whale fishery arising in the future, or the importance of the expedition for scientific purposes, which it is believed would constitute the principal object of the expedition and the value of which is strongly attested by the Royal Geographical Society and the Royal Society. Sir H. Holland trusts their Lordships will give their favourable consideration to this application on behalf of the Government of Victoria and consent to the contribution of the sum of £5,000 towards the scientific objects of the expedition. It would seem undesirable for Her Majesty's Government to take any direct share in the equipment or management of the expedition.

I am &c.,

JOHN BRAMSTON.

The Secretary to the Treasurer.

The Treasury to the Colonial Office—

Treasury Chambers, January 3rd, 1888.

The Lords Commissioners of Her Majesty's Treasury request you to inform Secretary Sir Henry Holland that they have had before them Mr. Bramston's letter of the 12th ultimo, submitting for their favourable consideration an inquiry made by the Agent-General for Victoria, whether Her Majesty's Government would contribute £5,000 towards the cost of an expedition to explore the Antarctic regions, if such an expedition were undertaken by the Australian Colonies. The objects of this expedition would be (1) the promotion of trade, and (2) scientific inquiry. But the department best able to judge of the first does not think the interests involved sufficient to justify the proposed imperial contribution; and the general result of the communications regarding the second object, received from scientific bodies, is to show that an expedition on the scale contemplated would do very little in the way of scientific investigation and would have to be regarded simply as a pioneer of future more complete and costly expeditions. In view of this testimony and of the many other pressing calls for imperial aid which they have felt it necessary to refuse, my Lords do not feel that they would be warranted in asking Parliament to provide the proposed contribution. They arrive at this conclusion, however, with sincere regret, and would have been glad to have co-operated with the Australian Colonies with an enterprise having something more than a merely commercial purpose. Perhaps however my Lords may be allowed to regard the present proposal as an indication that if any like expedition be undertaken hereafter by the Imperial Government, some of the British Colonies more closely interested in it might not be unwilling to contribute towards its cost.

(Signed) C. G. BARRINGTON.

The Under-Secretary of State, Colonial Office.

Report of the Committee of the Royal Society of London—The Committee appointed (October 27th) to consider and report upon the letter from the Colonial Office having reference to the question of an Antarctic expedition embodied their report in the following draft reply :—

Sir,—Your letter of August 27th with enclosures relative to a proposed Antarctic Expedition has been carefully considered by the President and Council with the assistance of a committee consisting of Fellows of the Society especially qualified to form a judgment on the matter and I am directed to reply as follows :—

Many observations of great scientific value might be made in the Antarctic Regions, and it would be very desirable in the interests of science to embrace an opportunity of making them.

(1) Hydrographical observations, especially with regard to the distribution of open sea.

(2) Meteorological observations especially with regard to the barometric pressure and the direction of the winds, to which may be added observations on the Aurora Australis.

(3) Magnetic observations, more particularly with a view to determine the changes which have taken place in the magnetic elements since the expedition of Sir J. Ross in 1839-43.

(4) Observations on the temperature of the ocean and on ocean currents.

(5) Soundings and dredgings and observations on the nature of the sea bottom.

(6) Collections and observations on the marine fauna and flora.

(7) Should land be anywhere discovered, geological and biological observations thereon would be of exceedingly great value.

It is obvious that an expedition adequately prepared and equipped to carry out all the above various observations would involve an expenditure far exceeding the £10,000 mentioned in your letter; but the President and Council are led to believe that this sum would suffice for a smaller pioneer expedition, which, while avowedly not designed to undertake an exhaustive inquiry, would be able under competent direction to make a careful survey of the northern boundary of the circumpolar ice region, to determine approximately the distribution of open water and the direction of oceanic currents, to take magnetical and meteorological observations and by means of the tow net and dredge, used at moderate depths, to collect pelagic animals and plants.

The results of such a general survey, even though not wholly complete would not only of themselves be of greater interest and value, but also be of paramount importance in guiding a decision as to the desirability or the contrary of sending out in the future expeditions more thoroughly equipped for special observations, and in preparing the way for such expeditions should the preliminary results render these desirable.

Should H.M. Government, therefore, decide to accept the proposal of the Government of Victoria and to place the sum in question on the estimates of the coming year, the President and Council will regard that decision with great satisfaction, and I am directed to say that such further assistance and advice as they can give is at the service of H.M. Government. In their deliberations on the matter the President and Council were much assisted by a memorandum drawn up by Admiral Sir G. F. Richards and another by Sir J. D. Hooker. These memoranda written by gentlemen having very special qualifications, derived from exceptional experience for offering important suggestions, contain so much that is interesting and valuable, that copies of them have been enclosed with this letter. Should you think it desirable that the Colonial Government should be acquainted with these memoranda, copies of them will be placed at your disposal.

I have the honour to be &c.

(Signed) M. FOSTER.

Since the Antarctic Expedition has lapsed for the present, something might be done towards the exploration of the Pacific Islands. The amount of £10,000 proposed for the Antarctic Exploration Expedition although quite inadequate for that purpose would, however, if judiciously expended, enable much to be done amongst the islands of the Pacific, in collecting information as to their Physical Geography, Meteorology, Geology, Botany, Zoology, Mineralogy, and last but not least in Ethnology and allied matters. An exploring party in a small but properly equipped steamer would be able for the above sum to make a very satisfactory examination of one or more of the less known groups of islands, and it is a work in which this Society might assist in many ways.

Coral Reefs.—One question in the Islands which would amply repay further investigation is the origin and growth of Coral Reefs; as you are aware, until Mr. John Murray, F.R.S., of the "Challenger" expedition put forth his theory, the explanation usually accepted by geologists was Darwin's subsidence theory, but of late years there has been some discussion upon the question, and as recently as 1888, Prof. J. Dwight Dana, of Yale College, who was on Wilkes' Exploring Expedition in 1839-1842, revisited the Sandwich Islands to verify his previous observations, and in the American Journal of Science, p. 103, XXXVII., 1889, he again supports Darwin's views. Dr. Guppy formerly of H.M.S. "Lark," supports Mr. Murray and he too has revisited the South Seas during the past year to confirm his previous observations. A very valuable and interesting discussion upon the theories propounded by Darwin and Murray will be found in the British Association Report for 1888, p. 718-723.

Dr. C. P. Sluiter, finds that "a coral reef in the Java Sea commences its growth on a muddy bottom in the form of a colony of corals growing on the stones and sunken pumice that there lie. As it increases in extent and height, it secures its own foundation by its weight, a large amount of coral materials sinking into the mud to a depth of even seven metres. In its upward growth it presents a level top, and displays no hollow or basin, a uniformity which it preserves until a foot from the surface, when it dies in the centre, and the agencies dwelt upon by Murray and Agassig then co-operate in forming an atoll or a barrier reef." (See H. B. Guppy "Nature," p. 303, 30. 1. 90.)

Chalk in the Pacific.—Another question, connected with the Pacific islands, in which I am personally much interested, is, as to the age of the chalk which occurs in New Ireland and other islands; in

1889, Mr. Woodford brought some chalk from Ulawa Island in the Solomon Group, this I submitted to Mr. H. B. Brady, F.R.S., the authority upon foraminifera, and he says, "it is a very interesting deposit, in some respects much more like cretaceous chalk than the New Ireland rock. It only contains, however, some thirteen species of foraminifera and the specimens are generally small. Of course I do not know what a larger supply of material might yield. I have more than doubled the number of New Ireland species by the examination of a good sized lump; I have an interesting soft grey deposit from the New Hebrides like Fiji soapstone, and I am now at work getting all together—Solomon Islands, New Hebrides, New Ireland, Fiji &c., and preparing a paper upon the general subject. The curious thing is, that out of a total list of two hundred and fifty species there are hardly more than a dozen that are not well known recent forms, and these are just such as one expects to find living some day. One of the deposits was taken from as much as 600 feet above sea level."

As I have pointed out elsewhere (Melbourne Meeting Association for the Advancement of Science) the chalk from the Solomons contains flints which can not be distinguished from those of the English chalk, and, although, even the presence of these flints does not prove the chalk to be of cretaceous age, it proves, to my mind, that the rock is not recently consolidated coral ooze as some contend.

Australasian Association for the Advancement of Science.—When I addressed you in 1886, a proposal was made that we should start an Association here on the lines of the British Association, this as you are already aware has been done and two very satisfactory meetings have been held; the first in Sydney in 1888 and the second in Melbourne in January last; the success of the young association has, so far exceeded the expectations of even the most sanguine of its proposers; at the first meeting there were in all 857 members and 110 papers were read, and at the Melbourne meeting there were 1,080 members and some 140 papers and reports were read.

The members belonging to the various Colonies were as follows:

	N.S.W.	Vict.	S.A.	W.A.	Q'land.	N. Ter.	Tas.	N.Z.	Total
1888. Sydney ...	550	130	59	3	46	1	18	50	857
1890. Melbourne	323	580	73	2	33	*	30	37	1080

The number of members living in New Zealand is noteworthy when we consider the small population and the great distance of New Zealand, and the comparatively infrequent communication that there is between it and Sydney as compared with that of the other colonies.

A feature in connection with the Melbourne meeting—the first meeting at which it was possible—is that reports were received at it from the Committees appointed at the first meeting, and although only a few of the Committees reported, it is a source of great satisfaction to find that the work is being taken up by them, for after all the work done by the Committees should be the backbone of the Association, we cannot always hope to obtain good papers from individual members, for they of course would usually prefer and rightly so, to read them before special Societies, and that too without having to wait until the annual meeting of the Association comes round, hence we must look to the Committees for the best work of the Association, as is the case with the British Association. We must not, however, forget the fact that a vast amount of good work is done which does not appear in print at all, for we must not overlook the benefit which accrues from the discussions and from the opportunity given to workers, ordinarily living at great distances apart, to meet and compare their views by word of mouth, instead of by printed papers only.

Some think that there is no longer any necessity for the British Association but a glance at its annual volume of reports from Committees shows that this idea is quite erroneous. The meeting of such Associations infuses much vitality and enthusiasm amongst not only the working members, but induces others to try to do something towards the Advancement of Science, even if only in the way of providing entertainment to the members; the peripatetic nature of these meetings also affords facilities for seeing new districts and objects of interest.

* One each from Fiji and Canada.

The general public have an opportunity of learning that there is no great mystery either about scientific workers or their methods of work; of course, in some cases long and laborious training is necessary for certain investigations, but a very great deal of a very useful kind can be done by those who have had no special training whatever, provided that they are of ordinary intelligence and use and cultivate their powers of observation, and work diligently upon some selected and definite question, the results usually depend more upon the willingness to take pains, than what is termed genius or brilliancy of intellect.

At the meetings themselves, there is no doubt that some of the members try to do too much and rush from one lecture room to another, it is not the intention of the Association to provide for such; the hours of meeting for the various sections are made so that members may be able to attend all the meetings relating to a certain group of subjects, but not the others also; if the meetings of the sections, were arranged so that everyone could attend all the sections, or if all the papers were read before general meetings of the Association instead of before the Sections, the time occupied by the meeting would extend over almost as many weeks as there are sections instead of for one week as at present.

The next meeting will be held in Christchurch, New Zealand, under the presidency of Sir James Hector, K.C.M.G., F.R.S., commencing on January 15th, 1891; Professor Hutton of Canterbury College, Christchurch, is the Hon. Secretary for New Zealand, and he has already nearly all the arrangements complete. The Union Steam Ship Company have agreed to give members "all round" tickets, together with other privileges as to priority of berths for the return trip— a matter of no small importance—at greatly reduced fares; the steamers from Melbourne will call in at Milford and other Sounds; the railway authorities in New Zealand, as well as those in the Australian Colonies, have agreed to give return tickets to members at single fares.

With the much larger number of committees for investigations and the experience gained by their members at the previous meetings, the Christchurch meeting should excel its predecessors in real work, although it is feared by some that the actual number of members may perchance be smaller, personally I am inclined to think that the meeting will eclipse the former meetings, if not in numbers, certainly in its final results.

Committees were appointed at the Sydney meeting to inquire into certain matters, and reports were received and ordered to be printed upon the following subjects :—1. A Census of the Minerals of Australasia, this paper contains much valuable information and will be found to be useful by all who are interested in Mineralogy. 2. Upon the Sanitation of towns. 3. Upon Australasian and Polynesian Bibliography. 4. Upon Gold and Silver Saving Appliances.

The following additional Committees were appointed at the Melbourne meeting, and it is expected that most of them will be in a position to present reports at the Christchurch Session :—1. To inquire into and report upon the occurrence of Rust in Wheat. 2. Upon the Location and laying out of Towns. 3. Upon the Improvement of Museums as a means of Popular Education. 4. Upon the fertilization of the Fig in Australasia. 5. The Unification of Signs and Colours in Geological Maps. 6. Upon the present state of knowledge of Australasian Palæontology. 7. Upon the Tides of Australasia. 8. To formulate a scheme whereby the assistance of the Government of the various Colonies may be enlisted in procuring material for special investigations.

The New Zealand Committee has decided to send invitations to prominent men of Science in England and elsewhere, so that we may expect to have a few visitors present at our next meeting.

Sir Henry Roscoe in 1887, the then President, and many other prominent members of the British Association spoke to me about the proposed visit of the B.A. to Sydney in 1887, and expressed their regret that the invitation of this Colony was afterwards withdrawn, for a very large number of the members, including many of the most eminent men of science in the United Kingdom, expressed their intention of attending the Australian meeting.

American Association.—While speaking of our own Association it may not, perhaps, be amiss to refer briefly to the American Association for the Advancement of Science, a body founded upon the lines of the British Association and similar in its aims and constitution, which was originated in 1844, by a few geologists, including James Hall, who, in the rooms of the Academy at Philadelphia formed an Association of geologists and naturalists.

Three years later in Boston it was decided to enlarge the Association, hence at the Philadelphia meeting in 1848 a new constitution was adopted of the present comprehensive character upon the lines of the British Association, and its aims were set forth in terms almost identical with those of the British Association.

The object of the American Association was stated to be "by periodical and migratory meetings to promote intercourse between those who are cultivating Science in different parts of the United States, to give a stronger and more systematic direction to Scientific research in our Country; and to procure for the labours of scientific men increased facilities and a wider usefulness." Afterwards the name United States was replaced by America and the scope of the Association extended, as shown by Article 1 of the modified constitution.

The young Association apparently experienced great difficulties, in its earlier years, from lack of funds and the great distances that its members had to travel. With the increase of the cultured and leisured classes, it is now fast growing into a large and influential body. The American Association for the Advancement of Science was incorporated by act (1874) of the Senate and House of Representatives, for the pupose of holding real property not exceeding 100,000 dollars in value, and personal property to the value of 250,000 dollars.

Article 1. of the Constitution sets forth the aims and objects as follows:—"The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating Science in different parts of America, to give a stronger and more general impulse and more systematic direction to Scientific research and to procure for the labours of scientific men increased facilities and a wider usefulness;" although the terms are so similar to those of the British Association, it is curious to note that nothing is said with respect to foreign men of Science or Non-Americans.

Articles 2 and 3. provide that the Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

Article 4. States that Fellows shall be elected by the Council from such of the members as are professionally engaged in Science or have by their labours aided in advancing science. The election of Fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

In democratic America it is also remarkable to see that there is class distinction in Science, viz.:—Patron, Fellow, and ordinary member, distinctions which it is true are of a mild form but which do not exist in the British Association in spite of the aristocratic institutions and feelings supposed to be predominant in England.

Article 5. states that any person paying the Association 1,000 dollars shall be classed as a Patron and entitled to all the privileges of a member &c.

Article 6. provides for the election or three Honorary Fellows in each Section.

Articles 7. to 19. regulate the conduct of officers. The President and Vice Presidents (the latter are Chairmen of the Sections) are required to give addresses; the former at the meeting following his year of presidency. I do not cite the other clauses since they refer to minor matters of administration.

At the Buffalo and New York meetings the numbers on the roll were :—

roll were :—	Buffalo, 1886.	New York, 1887.
Patrons	3	3
Members	1253	1285
Carried forward ...	1256	1288

	Buffalo, 1886.	New York, 1887.
Brought forward...	1256	1288
Honorary Fellows ...	1	1
Fellows	629	667
	1886	1956

I regret that I cannot give similar details with respect to the Swiss, French, German, Russian, and other associations, but the idea of speaking of the associations, other than our own, did not occur to me until too late to procure full information relating to any except the American. Closely connected with the meetings of the Associations on general Science are the various congresses or associations for special purposes, and it may probably interest some of the members to know that there is to be a Congress of Geologists at the American International Exhibition to be held in Chicago in 1892. The Geological Congress was originated at the Philadelphia Exhibition in 1876, and has since held meetings at the Paris Exhibition in 1878; at Bologna in 1881; at Berlin in 1885; and in London 1888, and is doing much valuable work in a quiet way.

In my remarks this evening I have purposely gone over some ground covered by my last address, since I know by experience that in order to get things properly understood, initiated, and brought to a successful issue, it is often necessary to bring them forward more than once, hence I trust I shall receive your forgiveness if it appears that I have been unnecessarily referring to matters which have already been considered.

The Presidency.—It is very gratifying to me personally and doubtless also to all the members to find that Dr. Leibius has at last consented to allow himself to be nominated for the office of President. Dr. Leibius has been a member of the Society for the past 31 years, and was one of the honorary secretaries from 1875 to 1886, and I have very much pleasure in testifying to the eminent services which he rendered during that period and I feel great satisfaction in vacating the chair to one so worthy of this, the highest honour which the Society can confer upon one of its members.

It now only remains for me to express the wish that the Society may progress in the future, as it has done in the past, and eventually acquire that usefulness and prestige here, which is possessed by its great prototype in the mother country.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, MAY 7, 1890.

ANNUAL GENERAL MEETING.

Prof. LIVERSIDGE, M.A., F.R.S., President, in the Chair.

About thirty members were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st March, 1890, was presented by the Hon. Treasurer and adopted:—

GENERAL ACCOUNT.

RECEIPTS.	£	s.	d.	£	s.	d.
Subscriptions — One Guinea	227	17	0			
Subscriptions — Two Guineas	327	10	0	584	15	0
Subscriptions — Arrears	27	6	0			
Subscriptions — Advances	2	2	0			
Entrance Fees				18	18	0
Parliamentary Grant on Subscriptions received during 1889				500	0	0
Rent of Hall				92	10	6
Carried forward...				£1196	3	6

Receipts—*continued.*	£ s. d.		£ s. d.
Brought forward			1196 3 6
Repayment of Advances—			
For Books, Freight, Charges, &c., ...			24 11 11
Total Receipts			£1220 15 5
Balance on 1st April, 1889...			5 8 3
			£1226 3 8

Payments.	£ s. d.	£ s. d.
Advertisements...	35 5 9	
Assistant Secretary...	250 0 0	
Books and Periodicals	183 2 0	
Bookbinding	38 13 6	
Freight, Charges, Packing, &c.	19 17 1	
Furniture and Effects...	17 7 6	
Gas	23 13 7	
Housekeeper	10 0 0	
Insurance ...	8 8 5	
Petty Cash Expenses	17 19 0	
Postage and Duty Stamps	41 15 0	
Printing	46 12 6	
Printing Library Catalogue, Part I.	33 10 0	
Printing and Publishing Journal...	257 4 6	
Prize Essay Awards...	50 0 0	
Rates ...	25 0 0	
Refreshments &c., at Meetings & Lectures	18 14 3	
Repairs	46 7 1	
Stationery ...	38 8 10	
Sundries	19 13 3	
Total Payments		1,181 12 3
Balance on 31st March, 1890...		44 11 5
		£1,226 3 8

BUILDING AND INVESTMENT FUND.

Receipts.	£ s. d.
Interest on Fixed Deposit	25 14 0
Balance on 1st April, 1889	514 3 1
	£539 17 1

	£ s. d.
Fixed Deposit in Union Bank	539 17 1
	£539 17 1

CLARKE MEMORIAL FUND.

Receipts.	£ s. d.	£. s. d.
Fixed Deposit on 1st April, 1889		246 6 7
Final Instalment from Liquidator of the Oriental Bank Corporation—		
Amount Due ...	30 4 9	
Net Loss ...	4 1 11	26 2 10
Interest Accrued to 31st March, 1890		13 6 3
		£285 15 8

	£	s.	d.
Fixed Deposit in Union Bank	285	15	8
	£285	15	8

AUDITED, P. N. TREBECK. ROBERT HUNT, *Honorary Treasurer.*
H. O. WALKER. W. H. WEBB, *Assistant Secretary.*
SYDNEY, 16th April, 1890.

Messrs. P. N. Trebeck and J. B. Henson 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 CARRINGTON, G.C.M.G.

President:
A. LEIBIUS, Ph. D., M.A., F.C.S.

Vice-Presidents:
PROF. LIVERSIDGE, M.A., F.R.S. | W. A. DIXON, F.C.S., F.I.C.

Hon. Treasurer:
ROBERT HUNT, C.M.G., F.G.S.

Hon. Secretaries:
F. B. KYNGDON. | PROF. WARREN, M.I.C.E.

Members of Council:
HENRY DEANE, M.A., M.I.C.E.
ROBERT ETHERIDGE, JUNR.
CHARLES MOORE, F.L.S.
H. C. RUSSELL, B.A., F.R.S.
PROF. ANDERSON STUART, M.D.
H. G. A. WRIGHT, M.R.C.S.E., &c.

The following gentleman was duly elected an ordinary member of the Society :—

Haycroft, James Isaac, M.E. Queen's Univ. *Irel.*, Woollahra.

The Certificate of one new candidate was read for the second time, and of five for the first time.

The names of the Committee-men of the different Sections were announced, viz. :—

MEDICAL SECTION.
Chairman ... Prof. T. P. Anderson-Stuart, M.D.
Secretaries... Dr. Hull and Dr. McAllister.
Committee ... Dr. Sydney Jones, Dr. Knaggs. Dr. Shewen, Dr. Crago, Dr. W. H. Goode, Dr. Huxtable.

Meetings held on the Third Friday in each month, at 8·15 p.m.

MICROSCOPICAL SECTION.
Chairman ... S. MacDonnell.
Secretary ... H. O. Walker.
Committee ... Dr. Wright, F. B. Kyngdon, G. D. Hirst, P. R. Pedley.

Meetings held on the Second Monday in each month at 8 p m.

The Chairman announced that the Council had decided to hold a Conversazione at the University in September next.

The following letter was read from George Bennett, M.D., Univ. *Glas.*, F.R.C.S.E., F.L.S., F.Z.S.—

Sydney, December 20th, 1889.

Gentlemen,—I have the honour of acknowledging the receipt of a letter from the Council of the Royal Society of New South Wales, dated Decr. 12th presenting me with the "Clarke Memorial Medal," I return them my very best thanks for the same and feel highly gratified that they should consider me worthy of such a gift and associating my name with so many distinguished men.

I have the honour to remain yours truly,

GEORGE BENNETT, M.D.

To the Hon. Secretaries.

Professor Liversidge moved the following amendment to Rule 3, viz., that after the words 'one year' it read "*four* Vice-Presidents, a Treasurer, and one or more Secretaries, who with *ten* other members shall constitute a Council for the management of the affairs of the Society."

The motion was seconded by Prof. Anderson Stuart M.D., and carried unanimously.

Sir Alfred Roberts moved the following amendment to the same rule " that the other officers of the Society shall consist of a President, who shall not hold office for more than *two* years in succession &c., &c."

The motion was seconded by Mr. J. A. Pollock, B.E., and carried unanimously.

Prof. Liversidge, M.A., F.R.S., then read his address.

A vote of thanks was passed to the retiring President, and Dr. Leibius, M.A., F.C.S., was installed as President for the ensuing year.

The following donations received since the last meeting were laid upon the table :—

List of Donations Received since December 4th, 1889.

(The Names of the Donors are in *Italics.*)

TRANSACTIONS, JOURNALS, REPORTS, &c.

ADELAIDE—Forest Flora of South Australia, Part ix. *Government Printer, S.A.*

Royal Society of South Australia. Transactions and Proceedings and Report, Vol. XII., 1888-89. *The Society.*

South Australian School of Mines and Industries and Technological Museum. Annual Report &c., 1889. *The Director.*

University. The Adelaide University Calendar for the Academical years 1889 and 1890. *The University.*

Albany—New York State Library. Annual Report (42nd) of the Trustees of the State Museum of Natural History for the year 1888. *The Trustees.*

Amsterdam—Koninklijke Akademie van Wetenschappen. Verslagen en Medeelingen. Afd. Letterkunde, Derde Reeks, Deel v., 1888; Afd. Natuurkunde Derde Reeks, Deel v., 1889. *The Academy.*

Auckland—Auckland Institute and Museum. Report for 1889-90. *The Institute.*

Ballaarat—School of Mines, Industries and Science. Annual Reports for 1888 and 1889. *The Director.*

Baltimore—Johns Hopkins University. University Circulars, Vol. ix., Nos. 76, 77 and 78, 1889. *The University.*

Bergen—Museum. Aarsberetning for 1888. *The Museum.*

Berlin—Gesellschaft für Erdkunde. Verhandlungen, Band xvi., Nos. 1 - 10, Jan.-Dec., 1889; Band xvii., No. 1 Jan. 1890. Zeitschrift, Band xxiv., Heft 1 - 5, Nos. 139 - 143, 1889; Band xxv., Heft. 1, No. 145, 1890. *The Society.*

K. Preuss. Akademie der Wissenschaften. Sitzungsberichte, Nos. 22 - 38, 25 April - 25 July, 1889. *The Academy.*

Birmingham—Philosophical Society. Proceedings, Vol. vi., Part ii., Session 1888-89. *The Society.*

Bologne—R. Accademia delle Scienze dell'Istituto di Bologna. Memorie, Serie iv., Tome viii., 1887, ix., 1888. Note sur les derniers progrès de la Question de l'Unification du Calendrier dans ses rapports avec l'heure universelle, 1888. Nouveaux progrès de la question du Calendrier et du Méridien Universel. Rapport de la Commission de l'Unification du Calendrier, 1889. *The Academy.*

Boston, Mass.—Boston Society of Natural History. Proceedings, Vol. xxiv., Parts i. and ii., 1888-89. *The Society.*

Brisbane—Colonial Secretary. Annual Report on British New Guinea from 4 Sept., 1888 to 30 June, 1889, with map and appendices by Sir William Macgregor. *The Hon. the Colonial Secretary of Queensland.*

Chief Weather Bureau. Meteorological Instructions by Clement L. Wragge, F.R.G.S., F.R.M.S., 1889. Meteorological Report for 1887, with diagrams and maps. Meteorological Record—Climatological Tables, Sept. 1889. Meteorological Synopsis, Dec. 1889, Jan. 1890. Table of Rainfall during the months of Oct., Nov., Dec., 1889. Weather Charts of Australasia at 9 a.m., 1890, Jan. 9 - 11, 13 - 15, 17, 18, 20 - 25, 28 - 31; Feb. 1, 3 - 8, 10 - 15, 17 - 22, 24 - 28; Mar. 3 - 8, 10, 18 - 22, 24 - 29, 31; April 1 - 3, 8 - 12, 14 - 17. *Government Meteorologist.*

Department of Agriculture. Report on Insect and Fungus Pests, No. 1., by Henry Tryon. *The Under Secretary for Agriculture.*

Royal Geographical Society of Australasia. Proceedings and Transactions of the Queensland Branch, Vol. v., Part i., 5th Session 1889-90. *The Society.*

BRUSSELS—Observatoire Royal de Bruxelles. Annales Astronomiques, Nouvelle Série, Tome v., Fasc 3, 1885; Tome VI., 1887. Annales Météorologiques, Deuxième Série, Tome II., 1885. Annuaire, par F. Folie, 52e-55e Année, 1885-88. Bibliographie Générale de l'Astronomie, par J. C. Houzeau et A. Lancaster, Tome I., Partie i., 1887. Ouvrages Imprimés and Manuscrits. *The Observatory.*

Société Royale Malacologique de Belgique. Annales, Tome XXIII., (Quatrième Série, Tome III.) Année, 1888. Procès-Verbaux des Séances, Tome XVII., Année 1888, pp. 73-124; Tome XVIII., Année 1889, pp. 1-132. *The Society.*

BUCHAREST—Institut Météorologique de Roumanie. Annales, Tome III., 1887. *The Director.*

BUENOS AIRES—Instituto Geografico Argentino. Boletin, Tomo x., Cuaderno viii., ix. and x., 1889. *The Institute.*

CALCUTTA—Asiatic Society of Bengal. Journal. Vol. LVII., Part i., 1888. Special Number (The Modern Vernacular Literature of Hindustan, by George A. Grierson, B.A., B.C.S.) Vol. LVIII., Part i., No. 1, N.S. No. 287, Part ii., Nos. 1, 2, N.S. Nos. 289, 290, 1889. Proceedings, Nos. 1-6, 1889. *The Society.*

Geological Survey of India. Records, Vol. XXII., Part iv., 1889; Vol. XXIII., Part i., 1890. *The Director.*

CAMBRIDGE—Philosophical Society. Proceedings, Vol. VI., Part vi.; Vol. VII., Part i., 1889. Transactions, Vol. XIV., Part iv., 1889. *The Society.*

CAMBRIDGE (Mass.)—Cambridge Entomological Club. *Psyche*, Vol. v., Nos. 160-166, Aug. 1889 to Feb. 1890. *The Club.*

Museum of Comparative Zoology at Harvard College. Annual Report of the Curator for 1888-89; Bulletin, Vol. XVI., (Geological Series, Vol. II.) No. 6 1889; Vol. XVII., Nos. 5 and 6, 1889. *The Trustees.*

CARLSRUHE—Grossherzogliches Polytecknikum zu Karlsruhe. Der Stein der Weisen von Dr. C. Engler, 1889; Die Forschungsaufgaben im Walde von Forstrat K. Schuberg, 1889. *The Director.*

CHRISTIANIA—Royal University of Norway. Die Silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker. Von W. C. Brogger, 1882. Jahrbuch des Norwegischen Meteorologischen Instituts für 1885, 1886. *The University.*

Videnskabs-Selskabet i Christiania. Forhandlinger, Aar 1888, Nos. 1-13. Oversigt over Videnskabs-Selskabet Moder i 1888. *The Society.*

COLOMBO—Royal Asiatic Society. Journal of the Ceylon Branch, Vol. x., Nos. 34 and 35, 1887. Contents of Journal and Proceedings, 1845-1886. ,,

CRACOW—Académie des Sciences de Cracovie. Bulletin International, Nos. 8-10, 1889; No. 1, 1890. *The Academy.*

DENVER—Colorado Scientific Society. Proceedings, Vol. II. Part i., 1885. *The Society.*

DRESDEN—K. Säch. Statistische Bureau. Zeitschrift, Jahrgang XXXIV., Heft 3, 4, and Supplement 1888. *The Bureau.*

EDINBURGH—Botanical Society. Transactions and Proceedings, Vol. XVII., Part iii., 1889. *The Society.*

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ON A COMPRESSED-AIR FLYING-MACHINE.

By Lawrence Hargrave.

[With Three Diagrams.]

[*Read before the Royal Society, N.S.W., June 4, 1890.*]

Considerable satisfaction is felt in recording a material advance since August 1889, in the development of the detail of flying-machines, and in the direct proof by experiment that yet another form of apparatus flies with ease. The principle embodied in this experiment is that of Borelli, published in 1680, and it doubtless has had many staunch advocates in later times; but the writer maintains that this is the first practical demonstration that a machine can, and does fly by the simple flapping of wings; the feathering, tilting, twisting, trochoiding, or whatever it be called, being solely effected by torsional stress on the wing arm.

The combination of Borelli's views with the results of work recorded in your proceedings has swept away such a mass of tackle from the machine that its construction becomes a ridiculously simple matter. The engine of the model of course retains its position as the most important part, and by continuous effort the number of pieces and the difficulties of construction have been so reduced that it is possible to make them by the gross at a cost that cannot exceed five shillings each. For instance the cylinder, usually the most expensive portion of an engine can be produced with the ease and celerity of a jam-tin. The importance of this cheapness of manufacture may be realized when we consider that there must be many young mechanics who would willingly work at this branch of engineering, but for the difficulty of procuring or making a light and powerful motor; such objection cannot now be made as herewith you have drawings showing the relative dimensions of a proved successful machine, and it surely will not be a laborious job to make others of greater range and power.

As to the efficiency or rather the absence of it in this engine, let us take the centre of effort of the wings at two feet from the fulcrum; their total area is 1·5 square feet, and supposing from the indicator diagram that as many as forty double vibrations were made in twenty seconds, it is clear that a little over 300 foot-pounds is all the flapping power used to drive a machine weighing 2·53 pounds a distance of 368 feet horizontally in a dead calm. Regarding the theoretical foot-pounds of work in the 144·6 cubic inches of air at 230lbs pressure. Mr. Arthur Pollock of the Physical Laboratory at the University has ascertained for the writer that the work done by the 145 cubic inches of air at 230lbs. initial pressure above the atmosphere in 40 double vibrations of the engine, on the assumption that it expands *approximately*, adiabatically into the cylinder and at the end of each stroke escapes into the air, is 2,500 foot-pounds. If the adiabatic relation was fully realized the pressure in the receiver after the forty-third double vibration would be 32lbs. above the atmosphere. As the final pressure by the diagram is really 50lbs. at the end of the forty-third double vibration a correction has been applied to the above calculation.

Mr. Pollock has also no doubt that the calculation of 300 foot-pounds for the work required to flap the wings is quite unreliable as it takes no account of the disturbances set up in the air, and he feels confident that very nearly 2,500 foot-pounds is spent in driving the machine. On the other hand the writer thinks that if the wings flapped up and down in the same place at every stroke the eddies created would be a waste of a further portion of the 300 foot-pounds; and if the 2,500 foot-pounds was really a applied to the air through the piston and rod, 5·7 double vibrations per second would be the result instead of 2 as there are actually. We now begin to grasp the idea of how imperfect the motor is still, and what a trifle of thrust makes the machine fly.

On the supposition that 7·32 ounces is the force resisting the motion of each wing, a similar wing was held rigidly by the butt and a weight of 7·5 ounces put on the membrane 24 inches from the fixed point and $1\frac{5}{8}$ inches abaft the wing arm; the deflection produced due to torsional stress was $3\frac{1}{2}$ degrees; and even by moving the weight from $1\frac{5}{8}$ inches to $3\frac{1}{4}$ inches, that is half way across the wing, it was only twisted $8\frac{1}{4}$ degrees. So that only $\frac{1}{7}$ of the 300 foot-pounds is actually used in pushing the machine forward, the rest being lost work. This suggests a wide field for experimenting with slow-burning rocket compounds and well proportioned direct-acting jets.

The valve gear is thought to be a truly original invention, but surprise will not be felt if it comes into general use to see others claim and prove too, that it is quite common and has been known for years. The problem to be solved in its construction was to make the valve reciprocate when the piston was in two positions, at all other parts of the stroke the valve was to be stationary; the force that moved the valve was to be uniform and independent of the pressure in the cylinder, as from the nature of the case the cylinder pressure was decreasing. A slight variation makes this gear suitable for using the air expansively; the model shows it in its first form, from which it will be seen that three additional moving pieces are required for cutting off at half stroke, and two more enable us to do so instantaneously at any earlier point.

This is not thought to be an extravagant number compared with the generality of expansion gears.

The drawing shows the arrangement of parts clearly and the valve has only failed on one occasion when it was choked with a scrap of dirt or sand. The engine works if the valve is not held by either catch, but then the piston has not the full stroke. The catch that holds the valve in its lower position is too high up in the drawing, the steel plate into which the valve is screwed would knock against the catch instead of against the head of the guide bolt that regulates the travel of the valve. It will be seen that one catch is fast to the valve and the other to the valve cylinder; in the model exhibited both are on the valve cylinder, this does not alter the principle of the valve gear, it is an adaptation to suit this particular case. That thing like a string of beads in the drawing is a spring $\frac{1}{8}$ inch diameter, made of steel music wire No. 8 ; it is soldered by the middle to the valve plate. Some of the failures of these vibrating engines have been due to the ports being too small, this is an error that might have been avoided by a little more elementary knowledge of engineering.

The receiver ends and cylinder covers are pressed, but do not think for a moment that a fly-press is one of the writer's laboratory tools, neither are the dies steel nor hardened. Any scrap of brass or iron is used for the dies if the size is suitable, and the disc for the proposed cover is cut out with the tin shears, a grip in the vice completes the operation unless a ragged edge has to be turned off in the lathe. The test pressure with water gives the required amount of dish to the receiver ends. The piston and junk ring are made of vulcanite, and the cup leather packing does away with the necessity for the cylinder being either round or parallel.

The air-pump has proved itself a serviceable tool, it has a bent lever handle and long links on the principle of the Stanhope press so that the most powerful leverage acts on the cylinder full of air when it is reduced to its smallest volume. The valves are made very small and great pains were taken to reduce the clearances to a minimum. The ram is $1\frac{3}{8}$ inches diameter, and the stroke about $4\frac{1}{2}$ inches. The suction valve is in the bottom of the ram, through which the air is drawn. The delivery valve seat is $\frac{1}{8}$ inch diameter and there is no water jacket to the cylinder. The receiver in Plates I. and II., is charged in six minutes to 230 pounds, the pump is then warm. When the pump leather is in good condition a pressure of 400 pounds can be shown on the gauge. Should more high pressure air-compressing gear be required, a water pump will be used to force water into a large receiver to compress the air therein, thus avoiding the loss of power by the expansion of the air left in the cylinder and passages between the valves at the end of the stroke. It may be pointed out that even the air-pump is not a necessity for this class of investigation as the engine of the machine is an air-pump itself if its action is reversed and the wing levers are used as pump handles. This is a distinct advantage in using compressed air as a motive power which is not to be lightly ignored, as it is obvious that instances could be cited where coal mines, gas-works and water would not be available for restoring the power to the machine.

Attention is called to the starting gear as being very simple and effective, it has a spring to the cock handle which opens it the desired amount when the toggle that keeps it shut is withdrawn; the left wrist is passed through the becket of the toggle. This arrangement has never failed to produce a perfect start.

It is thought that much useful work has been lost to us by experimenters loading their apparatus with devices to save them from damage, and artistic conceits to show where the passengers are to be seated in ornamental cars with flags &c. It should be remembered that flying machines are only to battle with the air, and not for knocking down fences or ploughing up the ground. It is not usual to proportion the scantling and plating of ships so that they will stand beating on rocks and sand, but only to safely resist the strains produced by the winds and waves. Perhaps much of the writer's success has been due to the avoidance of this fault, although it is somewhat of a trial to see a month's work knocked out of all shape in a moment.

This last machine is the first departure from previous practice in this respect, as it has a stick lashed under the receiver and projecting about sixteen inches before the engine, so that when the machine comes to earth the stick is broken and the engine and receiver are less injured than they would be otherwise. There has been no material damage done although seven wrecks are recorded; on the eighth flight as is usual in a successful trial, the machine escaped with hardly a scratch. Some of the wrecks are believed to have been due to the centre of gravity being too high, so the sides of the body plane have been made to slope upwards; this has the advantage of checking any tendency to slue by opposing some considerable lateral resistance.

In spite of past experiences the percentage of area in advance of the centre of gravity has been made as much as 30% of the whole area, but continued disaster caused its reduction to 23·3%: it is so difficult to force the mind to believe what seems unreasonable. In fact to show that a large part of the tail area is absolutely useless, a crossbow model of this machine, as it was at the seventh trial, seemed perfectly balanced, and yet when the paper surface A B C D, Plate I., was cut out it was still in equilibrium although 41·8% of the area was in advance of the centre of gravity. There is much to be learnt here, it seems as if the centre part of the body is best removed as it only serves to conduct the air, the inertia of which has been overcome by the weight of the forward part of the machine, to the tail. Whereas if the middle of the body plane has been cut out the used air escapes upwards and the tail has a better chance of getting comparatively solid air to float on. The neglect of previous knowledge gained partly arose from reasoning that in calculating the area in advance of the centre of gravity the dividing line should be taken through the centre of gravity of the machine when wound up ready to fly, instead of through the mean centre of gravity; as in the india rubber driven machines it is moving forward as the bands contract.

Another experiment was made that bears on this point of the continuity of surface. A stick and paper model for the cross bow had two surfaces, 10 inch by 10 inch, in the same plane, separated by a distance of 15 inches, with the centre of gravity in the middle, that is 7·5 inches from either plane. This showed a slight inclination to rise forward, but equilibrium was established by moving the centre of gravity only ·72 inch from the geometrical centre.

Every effort has been made to render this matter intelligible, and no pains have been spared in making the drawings perfect; but some apology is due to the members for their inferior reproductions in the last paper "Flying-machine Memoranda," which were not submitted to the author for approval.

It is well known that publishing the results of experiments as they progress is not a course that most inventors would pursue, but the whole subject is thought to be so far-reaching in its effect, and the varieties of practicable flying-machines so numerous, that any attempt to secure a monopoly of the profits accruing from their construction would be a mean and selfish proceeding, and totally unworthy of consideration. The writer feels assured that if he should ever make flying-machines for sale his productions will be as well appreciated as any others; and that the endeavour to strangle the work of others by patenting would only result in real progress being hampered by conflicting monetary interests and much ill feeling.*

The use of paper as a material for the required surfaces is still recommended, damages are then so easily repaired; there is no need to take much trouble in stretching it at first as after the

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* The writer thinks the act of invention to be a sort of inspiration, and a pleasure that the individual does not seek to be rewarded for undergoing; it is followed by a greedy sensation or wish to obtain money from others without giving an equivalent. This results in the development of the invention by the ordinary work of drawing-board drudges and laboratory experimenters who are not generally permitted to share in the profits of a patent. Inventors will always invent, they cannot help it, and you cannot stop them; and a patentee is nothing but a legal robber.

gum is dry, if a light spray of water is blown over the paper a few minutes suffices to make it as tight as a drum.

It might be said that this flying-machine is not on the principle enunciated by Borelli, because the wings are not continuous from the tip to the body. But this is only a device to enable the wing tips to act on the required quantity of air with less spread; it may possibly be one of those variations that make all the difference between success and failure. These wings are also distinctly double acting, and it is not quite clear that bird's wings thrust during the up stroke; but, as previously stated the question as to the exact movement of a bird's wing is merely straw-splitting when we have a mechanism that actually flies and is manifestly imperfect in mechanical detail.

In the transactions of the Institution of Naval Architects, Vol. xxx., 1889, there is a paper by Beauchamp Tower, "On an apparatus for providing a steady platform for guns &c. at sea." The wheel revolving on a cup-bearing by tangential jets, and the vertical axial jet nozzle playing on to the passages to the rams (Tower has four rams, three would be better) is the germ of an automatic apparatus for steering flying-machines level.

As an instance of the unreliable nature of thrust diagrams taken from the stationary machine, it may be mentioned that another screw-driven one has been tried, Plate III. is the engine of it. When the blades are set at 20° pitch angle a high thrust is got on the indicator, but the machine flies a very short distance; when the blades are set at 45° a low thrust is shown by the indicator card, but the machine flies 50% further. Coupling this with the result obtained with the vibrating wings, it is reasonable to suppose that screw machines should have the blades set parallel to the screw-shaft, and allow the pitch to be automatically adjusted by torsion. The blade surfaces of course being altogether abaft the screw arms. This is a matter for the consideration of those who prefer the screw to the flapping wings.

Some may ask what is the use of experimenting in calm air when such a state of the atmosphere is exceptional. But the answer is that by patiently waiting for still air reliable data can alone be obtained; and when we have the correct proportions of the machines none of the parts can be more strained by a gale of wind than by the lightest zephyr. The speed through the air does not vary, it is only the distance over the ground that is affected.

It has long been thought that there would be a spice of danger in trying large flying-machines, but now it is known that if experiments are conducted over water a ducking is the only risk involved, besides which the machine would be very slightly damaged.

Discussion.

Mr. Russell—I am one of those who admire the ingenuity and perseverance displayed by Mr. Hargrave in his attempts to produce a perfect flying-machine. I congratulate him upon the production of those ingenious models intended to copy the methods followed by nature to produce motion in various animal organizations. I think it is greatly to his credit that he now willingly admits he finds after experiment that he can attain far better results with a simple form of mechanism than with that of a complex nature. He has introduced several important inventions in connection with his scheme, which in the case of most men would have been taken to the Patents Office without delay, but which he from pure love of science freely gives to the world as part of his flying-machine. I have much pleasure in proposing a vote of thanks to Mr. Hargrave for his interesting paper.

The President—Mr. Hargrave has my best wishes for the success of his experiments. It would be a very gratifying thing if a really practical flying-machine were invented by an Australian. They say the proof of the pudding is in the eating, and the success of this invention will be proved when we see him fly across to North Shore (Laughter). I wish him every success.

ON THE TREATMENT OF SLIPS ON THE ILLAWARRA RAILWAY AT STANWELL PARK.

By Walter Shellshear, Assoc. M. Inst., C.E.

[With One Diagram.]

[*Read before the Royal Society of N.S.W., June 4, 1890.*]

In locating a railway the engineer often finds himself forced to carry his line through country of a more or less treacherous and rotten nature, where the difficulties of maintaining the earthworks become a very formidable problem, and perhaps few illustrations of this could be found where the difficulties have been more serious than on the Illawarra Line, between Otford and Bulli. In this case there was no choice between carrying the line through almost a continuous tunnel or facing the difficulty of carrying it over ground of the most treacherous nature. At Stanwell Park the line passes through a succession of spurs of rotten shales and drift composed of sandstone boulders mixed with decomposed shale and pipe-clay, the shale is cut up in all directions with pipe-clay veins. During the construction of the line the contractors experienced considerable trouble with slips in the cuttings, and the completion of the line was delayed in consequence. After the line was opened the year 1888 being a tolerably dry year no very serious trouble was experienced ; but when the great rain storm of May the 25th, 26th, and 27th, 1889 set in, during which over 20 inches of rain fell, the results were most serious. On Monday the 27th of May the cutting under Mr. Hargrave's house came in and completely blocked the line, several feet of earth and mud being forced over the rails, and the embankment at 33 miles slipped out bodily from the bed rock, leaving the ends of the sleepers over-hanging about 4 feet. Every effort was made to clear the road and the traffic was resumed on Friday 31st May, but it was found that the bank at 33 miles which had been temporarily repaired with ashes &c., was still travelling seaward at a serious rate. It was necessary to bring a constant supply of ashes to lift the road to keep the traffic going, large quantities of the soil were continually going over the cliff as the ground settled down, the whole space between the foot of the railway embankment and the edge of the cliff being broken up into large fissures.

The problem that then had to be considered was how to stop the outward motion of the ground since it was evident that unless this was stopped there was every probability of the hill above the line following, as it is composed of drift, and from its appearance was nothing but an old natural slip. If this had taken place the line would have been blocked for months, and a deviation in the shape of a tunnel would have been necessary to get out of the broken ground.

After carefully examining the ground the author came to the conclusion that the only chance of saving the embankment was by an extensive system of drainage, and thus if possible to consolidate the ground above the bed rock, the great depth of the soil, and the enormous mass of material to be kept back making it almost impossible to do any good with retaining walls. Before describing the system adopted in connection with the drainage works, it may be well to describe the nature of the ground so that the difficulties of the work may be better understood. The cliff which at this place is about 150 feet above sea level, is of sandstone with beds of shale. The surface soil which varied from about 1 to 30 feet in thickness rested on a bed of chocolate coloured shale with numerous veins of pipe clay, the dip of the strata being slightly inclined inwards, thus giving a slight recess at every break of the strata to hold the water, and keep the surface soil in a sodden state, which in conjunction with the large amount of pipe clay in the soil gave it every opportunity to slide out under the superincumbent weight. In many places it was found that the shale had been broken up for a considerable depth by the action of the slip, the water having found its way into the pipe clay veins. One point of importance may be noticed in connection with the soil immediately above the shale and it is this, that when charged with water it had the consistency of porridge and would not carry its own weight, but when dry it set very hard and required a pick to shift it. From the above it was evident that for the drains to be successful it was necessary to lead the water off from the strata immediately above the shale and to get rid of it as quickly as possible so as to prevent it eroding the shale, and at the same time a filter was necessary to prevent the drains getting choked with slurry.

The drainage works were carried out as follows :—An open cut was made starting from the edge of the cliff, the cut being 4 feet 6 inches wide. The shale was cut into a succession of steps to give a good footing for the rubble stone with which the drains were eventually filled, a channel sufficiently wide to let in a 12 inch earthenware pipe being cut in the centre so that no lodgment of water could take place at the different steps, and earthenware pipes were carefully laid in this channel but the joints were left open to freely admit the water, the use of the pipes being to prevent the soft shale from being eroded by the action of the water. The difficulty of opening out these cuts can be well imagined, when it is remembered that in some of them there was something like 20 feet of moving soil upon the top of the rock. When a length of about 30 feet had been opened out and securely timbered, the pipes were laid and rubble stone carefully hand-packed round them, the cut was then filled up with hand packed stone to within 3 feet of the surface, small fascines of brush wood being packed in between the soil and the stone to prevent silting up, and fascines were laid upon the top of the stone, selected soil then being filled up over the drains to surface level; this completed, another length was taken out and treated in the same way until the foot of the enbankment was reached, after which the drains were continued as drives under the enbankment, the whole being filled with stone and fascines as above described. To drain off the water from the drives a series of holes were drilled through the roof until the water was reached. There are eight cuts in all, (See fig. 2) four were taken through the bank and ended in shafts at the high side which were filled up within 3 feet of the surface with rubble stone and finished off with fascines and a layer of about 2 feet of puddle to keep out the surface water. (Fig. 3.) Two were taken nearly to the centre of the embankment and finished with a dead end, and the other two were carried only to the foot of the embankment.

The effect of these drains was very marked, at the commencement of the work the ground was so soft that there was considerable risk of getting bogged when attempting to walk upon it, and it was found that when the first set of timbers were being fixed, that the ground was slipping past at the rate of fully four inches per day, but as the cuts advanced this motion gradually ceased, and the ground near the drains became hard and the fissures gradually closed up. Large quantities of water were struck as the cuts advanced, but it soon ran out of the ground and at the time of the completion of the works there was only a very small stream running from each of the pipes over the cliff, and by the end of 1889 a good crop of couch grass had grown over the work and nothing could be seen to indicate that any extensive works had been carried out. All the timber except that in the drives was drawn.

The author little thought that the efficiency of these drains would have been so soon put to so serious a test as has been the case since the beginning of the present year. In Sydney the rainfall from the 1st of January to 9th May amounted to 48·556 inches, and at Stanwell Park although no record has been taken, there is every reason to believe that this large amount has been exceeded. It is satisfactory to note that not the slightest movement has taken place in this embankment, although in many places that stood the great storm of May 1889 serious slips have taken place, the only damage done at the 33 mile bank was that a very slight slip has taken place between No. 5 and 6 drives at the edge of the cliff, but not sufficient to in any way endanger the stability of the line.

In connection with the carrying out of these works the author was very fortunate in having the services of a very experienced miner, Thomas Smith, and it is is very gratifying to record that not the slightest mishap occurred during the carrying out of this difficult work. Several serious slips have taken place in the township of Clifton during the recent rains, and these the author is treating in a somewhat similar way to that successfully carried out at the 33 mile bank.

In conclusion the author would remark that the treatment of slips is by no means an easy problem as every case has to be carefully studied, thus in many descriptions of clays, burning has been found a most effectual cure, in other places retaining walls have succeeded, and many other systems have been carried out with more or less success, but in every case it is sbsolutely necessary for the engineer to make himself familiar with the nature of the soil before starting work unless he wishes to be disappointed with the result. It has been said by some people that slips are things that should have been foreseen and guarded against by the engineers constructing the lines, but the nature of country cannot be judged at sight by the best of men, and the fact of slips taking place by no means proves that anything has been neglected by those who originally carried out the work of constructing the lines.

DISCUSSION.

Mr. MOORE—To those who have had any experience in earthwork the steps taken for curing the slips referred to in the paper appear to be the very best. Ditch drains have been found of great importance because underground drainage will only catch water found in the soil. I have had experience with them myself. Centennial Park had not been put down more than two or three weeks before a tremendous storm came on, and I found ditch drains of great use on that occasion.

Mr. H. DEANE—Having had some experience of earthwork in the colony I should like to say a few words. I think Mr. Shellshear is to be congratulated upon the effective manner in which he tackled these slips, and also for the manner in which he is dealing with another place further along the line. When this line was constructed the difficulty and the danger of these slips was fully recognised ; and since the line was opened the weather has been of an exceptional character. The rainfall of last year, which Mr. Shellshear mentions, was of a character unprecedented in the neighbourhood of Sydney, and since then we have had most remarkable rains. This part was looked upon as specially deserving attention, and some deep drains were cut and filled with rubble stone. It is quite evident they were not sufficient, for in spite of that when the heavy rain came of May last year the line began to slip as he has described. I have been over that place and had the benefit of Mr. Shellshear's company, and he has shewn me what he has done, and it seems to me to be most satisfactory; and I think the steps he is taking to get rid of the further slips on the other side—Coalcliff—will also meet with success. This particular method of dealing with slips is not of course a new one. I remember a good many years ago several slips in the railway line in Eastern Hungary and Pennsylvania. They came under my notice and were on a very large scale indeed, and steps had to be taken to obviate them. It was found that the whole hillside was moving, and the bed on which the slip took place had to be drained. There is a description of the method adopted in a paper read before the Society of Austrian Engineers, and there are some abstracts of this paper in the Proceedings of the Institute of Engineers of 1874 or 1875.

Mr. SHELLSHEAR—in reply said that the surface drainage had been attended to—that every provision had been made to get rid of the surface water.

NATIVE NAMES OF SOME OF THE RUNS &c. IN THE LACHLAN DISTRICT.

By F. B. W. Woolrych, L.S.
Communicated by John F. Mann, L.S.

[*Read before the Royal Society of N.S.W., June 4, 1890.*]

The following notes were made by me in or about the year 1863 after some conversations with Regan of the Coora Burrima run, who was managing it for old "Jim White" of Burrangong. He had been twenty years or more resident in the Level Country* and could converse freely with the Levels tribe in their own language. He told me that although the Burrowa tribe were entirely separated from the Levels tribe their dialect was the same; but the tribes of the Lachlan and Murrumbidgee Rivers had dialects of their own. He could not converse with them although he understood many of the words spoken by them. The pronunciation of the same word sometimes differed among the different tribes, for example boolla or bulla, the word for two would rhyme with our word 'cooler,' comparative of cool, if pronounced by a 'Levels' blackfellow; but with 'duller' the comparative of dull by a Murrumbidgee black, hence probably the different spelling and pronunciation of the town of Burrowa or Booroowa, said to mean a very small kind of kangaroo, &c.

The present names of many of the sheep and cattle stations or runs in the pastoral district of the Lachlan have been derived from the original names of the 'camping places' of the blacks. These NAMES were always *significant* they recalled to mind some scene, some simple occurrence or event, or characterized the peculiarity of some leading landmark and therefore indicated the exact locality. When the white settlers overran the country they appropriated all the finest waterholes for their head stations, consequently these occupy what were at that time the chief camping grounds of the blackfellow and therefore possessed of native names.

Burrangong—The head station on the Burrangong Creek, from Booroon-gong—'Booroon' a small animal like a rabbit-rat spotted like a native cat, and 'gong,' going. The whole word suggests a scene in which a 'booroon' running was the chief object.

Merri-merri-gal—Name of a head station of a run on the Lachlan River, from 'Merri' a dog, and 'gal' bold, (or impudent). Picture some unusually bold native dog approaching the camp.

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* See appended sketch.

[The repetition of the word 'Merri' is plural and means many dogs. The name therefore signifies a place where the dogs were numerous and bold.—J. F. M.]

Birran-birran—A head station on a tributary of the Bland Creek, from 'birran' a kind of wood like colonial hickory. Birran-birran or the camp where the 'birran' wood abounds.

[Possibly this word may be identical with Yarran, a tree of the Hickory species, hence Yarra. The repetition indicates that it grows in clumps or clusters, sometimes of great extent.—J. F. M.]

Moonbooka or Moonbukka—A head station on the Bland Creek, from Moeen booka—Mooeen, a spider and 'booka,' any good-for-nothing thing, or a thing decayed away. Probably in this case the name refers to a venomous spider found in the locality.

[A venomous 'no good' spider found in decayed timber. —J. F. M.]

Kurra-wamby or Kaura-wamby—A head station on the Bland Creek, from 'kurra,' a pine tree and 'wamby' carrying anything. The locality was associated with some scene or event in which a blackfellow carrying a pine log was the chief object.

Coorroo Boorrima—A head station on the Bland Creek, from 'Coorroo' a kind of red kangaroo-rat and 'burrima' got him or catch him. Here the name recalls to mind in association with the camp some remarkable chase after this kangaroo-rat.

Note—The white fellow's gun came to be called 'burrima' also because the sight of it became associated with the idea of 'catching' or 'getting.'

Cáboot—A long reed spear.

The Yarra-yarra Plain—A small plain near the Koorowatha Creek and Bumbaldry, from 'Yarra' a gum tree. Probably gum trees were either very numerous or large there formerly.

[See note 3.—J. F. M.]

Billár—Pronounced Bil-lár (accent on last syllable) is a kind of *Casuarina* growing straight and tall, forming a close forest.

Woo-róngalong—(accent on rōn) a Box tree.

Jillōōng—Jil-lōōng, a very small hole of water.

Arrámagong—A head station on a tributary of the 'Tyagong' creek. It should have been spelled and pronounced Narrám-agong—signifying Wombats running into their holes—'gong' for going.

Ty'-agong—A kind of wombat—a pig-like animal living in burrows along the banks of the Tyagong Creek, which takes its name from the great number of these animals found along its course.

Moóyung-bógal—A place on the Bland run, the name signifies an owl coming out of a hole.

Nar′roo-burrima—from Narroó, honey and 'burrima' got it or got him.

Wid′-din—The Widdin Mountain is partly on the Arram′agong run (properly Narram′agong lately leased by P. Maley or O'Maley). 'Widdin' signifies to stop, and it was upon this mountain that the young blackfellow had to remain for a certain time during the ceremony of his initiation into manhood. The mountain is the highest in this part of the country and a conspicuous landmark for many miles round.

Bri′-bera (called also Bob-berâ by the residents)—A hill near the Moon-booka run, Bland Creek, the name is a corruption of 'Boorri-boolla' from 'boórri' a boy and 'boolla' two. There are two rocks on the top of the hill which bear a fanciful resemblance to a couple of children, hence the name.

[Boōlla—This word also means two in the Hunter River and Hawkesbury dialects.—J. F. M.]

Belábala Creek—A tributary of the Bland Creek, from 'boolla' two. *Boolla-boolla* referring to the junction of two creeks.

Morán-gareél—A head station on the Bland Creek, from 'Morang' a cockatoo and 'gareél' a little reed spear. Picture a cockatoo killed by a little reed spear.

Búrra-múnda Troy—A head station on a branch of the Tyagong Creek. 'Troy' appears to be a spurious addition to the native name. 'Búrra is a stinging nettle, and 'Múnda' a piece of bark.

Thóoree—means born.

Nar-rár-then—A small kind of bat.

Bumbaldry—A head station near the source of the Tyagong Creek. A water hole and great bathing place of the blacks. 'Bumbáld' indicates the jumping in of the gins or women, and darée (noise)—the noise made by their plunging into the water together.

We′-ogo—A head station and name of a high hill near it. The word signifies a mountain standing by itself. An isolated mountain.

Cow′al—is a large water, a lake, or swamp at the end of a creek. Thus the Bland Creek empties during floods into a basin or 'Cow′al' from 20 to 30 miles long, and from 10 to 15 miles wide, its depth being from 6 to 15 feet deep, its banks are for the most part well defined. During ordinary seasons this Cowal has in the summer time the appearance of an extensive plain, dry and sun-cracked with much polygonum growing over it, as also excellent pasturage for cattle, so that it forms a valuable run. After unusually wet seasons the Cowal is filled and overflows by a narrow outlet which conducts the water to a fine sheet of permanent water called the "Manna lagoon" the overflow from this is led off by an insignificant looking outlet, but soon spreads over another plain or 'Cowal' of smaller dimensions known as the Naráng or little Cowal —('Naráng,' *little*). This when full forms a broad but shallow sheet of water which has also its outlet, though scarcely perceptible to an inexperienced bushman; this is the head of a creek, gradually deepening and having a course of several miles when it terminates in another fine lagoon four or five miles long, of permanent water, which bears the name of Bogandillan. 'Búggin' means a large sheet of water, and 'díl-lan' signifies can't get out, or dammed back.

[The word Cowal is an adjective, signifies large, extensive, etc., 'Cowal cowal' the largest; 'Bugon' or 'Buggin' signifies a lagoon or swamp. This lagoon, in question, would be called by the blacks, "*Cowal Cowal Bugon*" the largest lake, shortened to "Cowal." It will be readily seen how this word became adopted by both whites and blacks as a proper name. This word has a similar signification in the language of the Hunter River and Hawkesbury Tribes. "Narang or Nerang," means small, inferior, it is used with that meaning by the Wellington blacks as well as by the above named tribes.—J. F. M.]

Bogandillan Lagoon, as it is called by the whites, has an outlet and the surplus waters after continued rain again spread out into polygonum flats, until eventually it finds its way to the Lachlan River; but there may be long intervals between seasons when water flows throughout the whole of the course described to the Lachlan River.

Manna Mountain—This is the highest hill and finest landmark in this part of the district, the Manna lagoon is at its base on the east. The native name is Mún-ya* signifying manna, which is plentiful there.

Jin'-da-lee—The native name of "Morris's Hill" in the county of Harden, it is bare on the top (or bald) while the neighbouring hills are thickly timbered, hence its name 'Jin'-da-lee' meaning 'got no skin on your bones.' The 'a' in 'da' is sounded as in the word fāther.

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* This word appears to me remarkably like the Hebrew for manna—*i.e.* Man hu) as given in the Imperial Dictionary.

Bullan Bullan—The name of a Station. 'Bullan' is a black duck, and it is to be presumed that black ducks were unusually plentiful at this camp.

Thooroong'-galee—A station near the Bland Creek from thoōroón and galée—this was the name of a fine permanent spring. 'Thooróon' means snake, and the blackfellow's tradition related that a monstrous snake came out of the ground here and the water immediately gushed from the hole made by it.

[Gâlee means pleasant, convenient, thus Minmurra Gâlee is the name of the flat upon which the village of Cassillis now stands; a convenient camping place on the Minmurra River. Snakes, especially black, travel long distances for water, and possibly this spring was as frequently visited by snakes as by the blacks, who no doubt found it a convenient camping place.—J. F. M.]

Warr'-billy—This word means a wrestling of blackfellows. In pronouncing it the rr should be well trilled.

Mirrool Creek—Mē-rool means pipe clay, either red or white, used by the blacks to paint themselves with, or plaster themselves over.

Koo'ruggin—A station on the Bland Creek. This was probably the first place where they saw a bullock feeding, as the word means 'a bullock feeding.'

Yeo-Yeo—This is the original name of a waterhole on the Bland Creek, which has also been called the Yeo Yeo Creek. 'Yeo Yeo' means Devil-devil.

Terra-galonga—The name of a station on the Great Cowal at the junction of two creeks. From 'ter'ra' like two arms, and 'ga'long' where they meet.

Na'riah—The name of a hill. The word means a bare place on a hill. The hill so named terminates in a high rocky bluff which is bare, the rest of the hill being scrubby.

Muringo—The name of a head station and now of a township on a tributary of the Lachlan River. The name was probably formed from 'Murring' a bark canoe, and 'go' going, or going after anything.

NOTE—The owner of the station arbitrarily changed its name to *Marengo* by which it is now known at the General Post Office.

Burrung-gombidya—The name of a high and remarkable point on a range near a tributary of the Murrumbidgee River; probably means flying away, 'burrung' flying, 'gombidya' signifying the sound as of anything flying.

Wil'lawang—This word signifies the junction of two creeks in the dialect of the Lachlan tribe.

Bim'bel—This is the name of a tree resembling the native apple tree, it is distinguished by its shining leaf. It is found in the country to the west of Bland Creek. There is a run called Bimbelingel.

Go'goburra—A bird known as the laughing jackass. Is the name of the range of hills from the Mirrool Creek to the Lachlan River. 'Go'goburra' has been changed by the whites to Cocoparra.

Cabood-boolla—This was the original name of a high hill on which two native apple trees grew—this was a sufficiently remarkable circumstance to suggest a name, as apple trees are not generally found on the tops of hills. 'Cabood' is an apple tree, and 'boolla' two. The name was turned into Coppabella and given to the station.

Canna-mum-boolla—This is the large hill at Burrowa. It has two tops and hence the name 'Can'na' a hill, and 'boolla' two.

Murrimboolla—According to the blacks about Bennelong the name is derived from two remarkable canoe-shaped water holes in the creek at this place. 'Mur'rim' water, and 'boolla' two. The name was changed to Murrumburrah as there was a place on the coast called Merimbula, to which letters were often sent in mistake for Murrimboolla.

Narrandera—A station. 'Nurrung' is a Jew-lizard and the whole name should be Nurrung-derry, means a place where jew and other kinds of lizards abound.

Bulgarn Goolarmie—Is the proper name for Mr. White's station on the Yuglo Creek. 'Goolarmie' is another name for 'Wummera' or boomerang and bulgarn goolarmie (miscalled by Messrs. White Bros., Boligamy gulman) signifies the place where a blackfellow lost a boomerang.

Bennelong—Township was named after a native chief belonging to another part of the country, the native name for the principal waterhole there was 'Bangalal.' Binalong was thought more euphonious than Bennelong by the gentry of the district who finally succeeded in converting the postal authorities to their opinion, and the name was changed after an obstinate resistance on the part of the Bennelongites.

Waddy-man-dow—An out station on the south side of the Lachlan River not far from Forbes, is also given by Mr. Woolrych as an example of the way the blacks sometimes introduced English into their compound words. The hut-keeper in charge of the place had a wooden leg. Waddy signifies a stick. 'Waddy-man or mŭn-dow' "man with a wooden leg."

[A small party of blacks were, many years ago, encamped in one of the beautiful valleys of the upper M'Leay, the men were away hunting, the camp being in charge of a few women who were attending upon a young mother and her newly born babe; the infant was exposed to the sun upon an opossum cloak, when an eagle swooped down and carried the helpless child away to the summit of some neighbouring cliffs. Some of the men soon returning, at once scaled the precipice, they discovered the remains of the infant, and the eagle, satiated, drinking from a pool of water in the rocks. The remains were collected and buried amidst great lamentation especially on the part of the women. The name given to this water hole on the cliff in consequence of this event was "*Kau-oola-patamba*, the place where the eagle drank." I believe the above to be as genuine a list as can now be obtained, but must caution any one who may wish to follow up the subject, to be careful in securing good authority in the investigation. The "man with the wooden leg," is an instance as to how a native name can be formed, and I am aware that another name in the same locality is the combination of parts of the names of three men attached to a survey party.—JOHN F. MANN.]

Remarks on notes by Mr. Mann.

Birran birran, Yarra yarra (Notes 2 and 4.)—I think it improbable that the words Birran birran, Yarra yarra are, as suggested by Mr. Mann's notes (2) and (4) identical with 'Yarran.' The *Scrub* called 'Yarran,' 'Yurreen,' or 'Yarrin' is well known by that name in the 'Level' country, where it is common. This name, as I have been told, was given by the blacks to any kind of useless scrub. The word 'Yarra' on the contrary, survives in the 'Level' country only as the name of an out station at some waterholes in the Bulabla Creek, two miles east of Morangareel, where it might be expected that 'Gum' trees would be found. The Yarra yarra plain is at least fifty miles distant from the 'Yarra' above mentioned, and is situated in a part of the country where I have never seen 'Yarreen' scrub. It is perhaps worthy of note that not only 'Yarra,' but 'Coolac,' 'Mooney mooney' and probably other native names in the old 'Pastoral district of the Lachlan' are identical with those of well known places near Melbourne. Bri'bera—The hill called Bobbera is one of the most conspicuous landmarks in the County of Harden; but the name properly belongs to another hill—(Mr. Mann's pencil note against 'Bribera' would suggest *that* hill as being the Bobbera of the blacks). The early settlers in fact applied the name to the wrong hill, so that the true native names for the 'Bobbara' and Little Bobbara of the Government Maps viz. 'Jindabmeer (or Jindabmeung) and 'Jindabmeer (or Jindabmeung) Narang' have been lost.—F. B. W. W.

Sketch of that portion of the Old 'Pastoral District of the Lachlan' in the colony of New South Wales to which the accompanying notes on aboriginal names refer.

REMARKS ON A NEW PLANT RICH IN TANNIN.

By CHARLES MOORE, F.L.S., &c.

[*Read before the Royal Society of N.S.W., June 4, 1890.*]

IN a letter lately addressed by me to the newspapers, I gave a few details regarding an American plant which possesses to a large degree, tanning properties. There seems, however, from what has since appeared in the press and from private communications, that more information relative to this plant is required. It is therefore with that object that I now venture very briefly to address you on the subject. The plant in question, *Rumex hymenosepalus* (Torrey), belongs to the natural family Polygonaceæ many members of which are rich in furnishing large supplies of oxalic acid, while some yield strong purgative properties, but in addition to these qualities, the prevailing characteristic of the genus Rumex is that of astringency. We might therefore naturally expect to find in some of the species the tanning principle more or less developed. It was not, however, so far as I have been able to learn, till 1868 that this principle was known to reside in the root stock to any great extent. In that year a package of the roots was sent from Texas to the Agricultural Department at Washington, accompanied by a letter stating that by analysis they were found to yield 32 per cent. of tannin. Curiously enough this letter was lost sight of till 1878, when fresh roots were reported on by the Commissioner of Agriculture.

In the American Journal of Pharmacy of 1876, p. 42, this plant is referred to as having been sent from St. Antonia as Indian roots or Yerba del Indio or Raiz del Indio. The root is described as consisting of heavy globular or fusiform pieces, about 6 inches long, and from 1 to 3 inches in diameter. When fresh it is externally of a reddish-brown colour, and internally varies from a bright to a yellowish-brown. The roots are said to be produced in clusters in a manner similar to small potatoes, and grow near the surface of the ground. The plant seems to have a wide range in a natural state. It has been found in many parts of Mexico, where it is said to have been used for tanning purposes for over two centuries. It is abundant in Texas and in South Western America. The stem and leaves are acid, due to the presence of oxalic acid, and are in consequence occasionally used in California and Utah for culinary purposes. Several analyses of this plant have been furnished, and these vary very much, but under favourable conditions the roots are said to yield 37 per cent. of tannin; but in none of the analyses has any substance been found that would prove injurious to leather.

Some go so far as to think that this Rumex will supersede the use of Valonia and Gambier. It is however quite possible in this country the tanning properties of this "dock" may not be so great as it is represented they are in other lands. In giving these details I have not drawn on my own imagination, but have simply stated the asserted facts as furnished by the Kew authorities. The names by which this species of Rumex is generally known are: Gouagra in Mexico, Canaigre in Texas, and Wild Pie plant in Utah and California; and in these quarters will probably be found the sources from whence supplies of seeds may be most readily procured. I would add that in this country no species of the genus Rumex or "Dock," either indigenous or introduced, possesses any known tanning material.

Discussion.

Mr. Moore—I have been inundated with letters since I wrote that letter to the press. In that it was made plain that docks and sorrels were only mentioned as examples of the genus Rumex, but I never intended to convey the idea that all the docks possessed tannic principles. That this plant will I think likely become of some importance is almost certain. Our climate suits it admirably, and it can therefore be easily grown. I would cultivate it in the same way as I would cabbage. I have taken measures to get the seeds, but hope that no one will rely upon me entirely for seeds. Anyone having correspondents in Mexico can obtain them from there. It is a plant of most easy cultivation, and I shall do all I can to get the seeds and give it a fair trial. It is very singular however that no tannic principles should have been found in any of the other species.

Mr. H. C. L. Anderson—I have been very much interested in the paper, particularly as I received some specimens two weeks ago from Victoria, where it has been grown for the last three years. I am having it analysed by Dr. Helms, for the purpose of determining the amount of tannic acid in it. We know it averages from 26 to 40 per cent. It may, however, like some docks, become a curse more than a blessing. I hear though, that in Victoria ground becomes worth £10 an acre by the cultivation of this weed. When the analysis is made I will send it to Mr. Moore that he may see whether under the influence of our climate and soil we can compare it to the English and American analyses. Very probably it will become a commercial product of some value.

Mr. F. B. Kyngdon—Mentioned that the publications of the Department of Agriculture of the United States contained two papers on the same subject. Such publications were in the Library of the Society.

The PRESIDENT—In thanking Mr. Moore for his paper, said it had also provoked remarks of an interesting nature. What Mr. Anderson had said would prove of interest to many people at present, and he hoped when that gentleman had had his analyses made he would bring them under the notice of the Society.

RECORD OF HITHERTO UNDESCRIBED PLANTS FROM ARNHEIM'S LAND;

By BARON FERDINAND VON MUELLER, K.C.M.G., M.D., PH.D., F.R.S., &c

[*Read before the Royal Society of N.S.W., July 2, 1890.*]

THE plants of Arnheim's Land became gradually known to a now large extent in the course of this century through successive observers. The earliest investigations were by the celebrated Robert Brown, during Flinders' memorable exploratory voyage, when from December 1802 till the commencement of March 1803 the east coast of Arnheim's Land was surveyed. During Admiral P. P. King's four geographic voyages from 1818 to 1821 it fell to the share of Allan Cunningham, to reveal much of the vegetation along the north and the west coast of the territory mentioned. Though other navigators touched subsequently at the same region, no special phytologist was attached to their expeditions; some of these voyages however enriched other branches of the natural sciences; and valuable gatherings of plants were secured by Dr. Bynoe, while Admiral Stokes visited Arnheim's Land in 1839, for the great Kew establishment.

Leaving minor other kindred efforts out of consideration, it was only in 1855 and 1856, that further large access to our knowledge of the plants of Arnheim's Land could be obtained, the interior regions then for the first time coming largly within reach, through Aug. Gregory's expedition, though Leichhardt had crossed in 1845 from the Roper River to Port Essington, and had not been unobservant of the flora. About a dozen years ago Mr. Schultz, a special and successful emissary of the Adelaide Botanic Garden, traversed for botanical collecting purposes the vicinity of Port

Darwin, where subsequently Professor Tate of the Adelaide University professionally explored,—this distinguished scientist carrying on geologic and phytologic researches simultaneously. Some time previously Mr. B. Gulliver was sent from the Botanic Gardens of Melbourne, by the writer of these pages, on a collecting errand with Captain Cadell's expedition, and much earlier Mr. Armstrong had formed an herbarium at and near Port Essington for the Royal Garden of Kew. During the last few years the director of the Botanic Garden at Port Darwin, Mr. Maurice Holtze, has with a most praiseworthy zeal been engaged whenever any opportunities did occur, to add still further to our knowledge of the native plants of Arnheim's Land, he being occasionally aided by Mr. Paul Foelsche, and latterly also by a young enthusiastic son. The Holtzean collections comprise now nearly one thousand species, and it is my object, to submit to the Royal Society of New South Wales from time to time, records of novelties from his gatherings, some of his discoveries having obtained publicity already. It is further hoped, that in a few years a full list of the plants, indigenous to the extremest part of North Australia, may become elaborated.

Dunbaria singuliflora.

Weak, procumbent or somewhat twining, densely beset with very short hairlets; stems and branches thinly filiform; leaves quite small, on very short petioles; stipules extremely narrow, pointed; leaflets from lanceolar-elliptical to oblique-ovate, of rather firm consistence, granular-dotted beneath, recurved at the margin, the two lateral leaflets on extremely short stalklets; stipelles none; flowers axillary, always solitary, their stalk of about the same length or shorter; lobes of the calyx pointed, the lateral two shortest, deltoid-semilanceolar, the upper two connate to a bidenticular apex, the lowest hardly longer than these; petals glabrous, the lowest conspicuously incurved; fruit comparatively large, very much compressed, elongatedly and obliquely elliptic-lanceolar, without transverse impressions, but almost septate; seeds several, somewhat compressed, roundish, but at the base truncate, outside black-brown; strophiole conspicuous, almost colourless, bisected.

A delicate plant, with the aspect somewhat of *Rhynchosia glandulosa*, probably quite herbaceous. Vestiture grey. Leaflets $\frac{1}{3}-\frac{1}{2}$ inch long, paler beneath, the dots copious, pale, hardly shining and much concealed. Calyx scarcely $\frac{1}{4}$ inch long, granular dotted. Petals of about double calyx-length, deciduous, probably yellow, the lower two sometimes twisted. Style capillulary, glabrous. Fruit $1\frac{1}{2}-2$ inches long, about $\frac{1}{3}$ inch broad, with very thin vestiture, without any basal stalk-like attenuation. Funicles very short, but dilated downward. Cotyledons pale; radicle very short, slightly curved, partly enclosed. Strophiola ellipsoid in outline, turgid. Nearest allied to *D. debilis.*

Some difficulty has arisen in assigning to this plant its generic position; it accords in every respect with *Dunbaria*, except development of a large and turgescent strophiole, which is quite that of *Atylosia* and so the septation, but the fruit has not the traverse impressions of that genus and of *Cajanus*. From the normal species of *Rhynchosia* our plant recedes merely in having a fruit containing more than two seeds with cellular somewhat membranous disepiments between them, although the strophiole is often very minute; but as in many other genera of Papilionaceæ, for instance *Indigofera* and *Tephrosia*, fruits occur with one and with several seeds, it might "pari passu" be advisable, to reduce *Cajanus*, *Atylosia* and *Dunbaria* as sections of *Rhynchosia* also. The inflorescence is that of *Rhynchosia uniflora* and *Dunbaria debilis*, as hardly needs to be noted.

Clerodendron Holtzei.

Pendant or prostrate or diffuse, much beset with short spreading hairlets; leaves comparatively small, almost sessile, from cordate- to rhomboid-orbicular, above nearly glabrous; peduncles terminal and from the axils of the upper leaves, bearing cymousely from three to several flowers; bracteoles narrow, very short; flowers rather small; calyx cleft to near the middle, finally somewhat enlarging, but without succulence, its lobes acute; corolla pure white, outside beset with minute hairlets, its tube nearly doubly as long as the calyx, at the orifice bearing soft hairlets, its lobes from ovate to orbicular, about half as long as the tube; stamens hardly extending beyond the corolla-lobes; anthers ellipsoid-sagittate; style glabrus, almost totally enclosed; fruit shorter than the calyx; pericarp thin, somewhat succulent; endocarp thinly osseous, often only one of the nutlets perfect. In clefts of rocks, the comparatively long carnulent root deeply penetrating. Stems seemingly but slightly woody, often only a foot long even when flowering, slender. Leaves mostly measuring $1 - 1\frac{1}{2}$ inches, exceptionally somewhat indented, never pointed. Calyx occasionally 6 cleft. Corolla measuring $\frac{1}{2} - \frac{2}{3}$ inch in length. Nutlets $\frac{1}{4} - \frac{1}{3}$ inch long, when solitary verging into a globular form. Testa pale. Cotyledons white, turgid; radicle very short.

This species is as regards its flowers not unlike *C. tomentosum*, but the stamens are shorter, and the leaves as well as the stature and the fruit are widely different; in size of the leaves it comes near *C. phlomoides.*

Utricularia Wallichiana;

Wight, icon. pl. Ind. orient. 1572, fig. 1. Oliver in the Journal of the L. S. III., 182. Clarke in J. Hook. fl. of Brit. Ind. 332.

Tall, annual, weak and often twining; root rather short, its fibres capillulary, much branched, scantily or hardly pitcher-bearing; leaves very small, from linear- to ovate-lanceolar, all radical, never numerous, early perishing; stems thinly filiform; racemes mostly elongated and flexuous, with generally distant flowers; bracts very short, ovate-lanceolar, without any basal protraction; pedicels spreading, about as long as the flowers or even longer, finally towards the end dilated; upper sepal rhomboid-orbicular, lower sepal orbicular-ovate; corolla yellow, its upper portion laterally recurved, roundish, slightly bilobed, its lower portion somewhat longer, orbicular-rhomboid, undivided, towards the centre bulging and more intensely coloured; posterior protrusion subulate-conical, about as long as the upper segment; style very short; fruit much shorter than the pedicel, ovate-roundish, compressed, nearly as long as the calyx; seeds almost ovate, papillular-rough.

Attaining, when twining, a height of 2 feet, and then quite of the habit of *U. volubilis*; when straight erect of less height. This plant, for which I intended the name *U. tortilis*, does not seem to require specific separation from the Indian plant, to which it is now referred, but as it is new for Australia, a description is furnished from Mr. Holtze's specimens.

Among Australian congeners it differs from *U. chrysantha*, which is not known ever to be conspicuously twining, already in much longer pedicels, larger flowers, uncleft lower division of the corolla, form of fruit and considerably larger seeds. From *U. fulva* it is chiefly distinguished in seemingly always greater height, again in elongated pedicels, in undotted lower division of the corolla, in usually less slender and more acute posterior protraction of the latter, and not globular fruit; it is still more distant from the Asiatic *U. reticulata*, although that species is likewise of twisting growth, the colour of the corolla being yellow, never blue.

Utricularia Singeriana.

Annual, never tall, always glabrous; root capillulary fibrous, short, bearing rather conspicuous pitchers; leaves very small, all radical, from broad- to narrow-elliptic, but gradually passing into the petiole, early perishing; stem devoid of bracts, one-flowered; pedicel about as long as the calyx; bracteoles minute, lanceolar-deltoid, without any basal protraction; upper sepal roundish- or cordate-rhomboid, lower almost orbicular, occasionally somewhat bilobed; corolla large, on the surface throughout lilac-coloured, below reddish-brown, its upper portion obovate-cuneate, truncate or slightly bilobed; its lower portion hardly longer, from rhomboid- to renate-semiorbicular, posterior protraction nearly or fully as long as the other portions of the corolla, but paler, broadish-conical, blunt, its orifice ciliolated; filaments about as long as the anthers; pollen-grains pale; style very short; ovulary roundish; ovules very numerous.

Stem solitary, usually 4 to 6 inches high, unbranched, not very thin. Corolla dark-coloured when dried, larger than that of any other Australian species, somewhat exceeding even that of the large-flowered state of *U. dichotoma*, but far from rivalling with that of *U. montana* (of Jacquin, the *U. alpina* of Linnæus, which however seems to be nowhere truly alpine).

A well marked species, which in the systematic series would find its place best near *U. dichotoma.* This rare and beautiful plant has been dedicated to Professor Dr. J. Singer, the Director of the Royal Botanic Society of Ratisbon, at a time when that eldest of all Botanic Societies celebrated its centenary jubilee, he having for nearly twenty years been the leading administrator of the affairs of this celebrated union and thus also the editor of the Ratisbon "Botanische Zeitung," he having furnished already in 1865 a "Flora Ratisbonensis," It may not be out of place, to remember here, that forty-two years ago the writer of these lines had dedicated the *Phyllanthus Fuernrohrii* to the distinguished predecessor of Prof. Singer. The "Botanisches Taschenbuch," a periodical initiated actually by Prof. Hoppe, the predecessor of Furnrohr, commenced precisely one hundred years ago.

This new species differs from its nearest ally, the *U. dichotoma*, in bracts not turgid at the base, in greater size or the corolla, with a different colouration and a very much larger upper segment; the fruit when known will likely also prove very different.

Incidentally it may here be observed, that Mr. Holtze from fresh specimens notes the corolla of *U. leptoplectra* as mauve-coloured on the surface and as salmon-coloured below; the nearly bisected lower portion of the corolla with its almost dimidiate-ovate segments is quite remarkable; the fruit, now obtained, is globular, extends considerably beyond the calyx, and measures nearly $\frac{1}{4}$ inch; fully matured seeds are not yet known. *U. chrysantha* has extremely minute seeds, almost truncate-ellipsoid, subtle-streaked, shining and yellowish. *U. fulva* has been sent from near waterfalls of the Elizabeth and Edith Rivers by Mr. Foelsche. Several of our *Utricularias* occur exceptionally with white corollas, for instance, *U. dichotoma* and *U. cyanea.*

Aneilema vaginatum;

R. Brown, prodr. fl. Nov. Holl. 127 (Annotation); Kunth, enum. IV., 67; Wight, icon. plant, Ind. or. VI., t. 2076; Hasskarl, Commelin. Indic. 34; Clarke, Commelinac, Bengal. 35, t. 23; Clarke in De Cand. monogr. phanerog. III., 216. *A. pauciflorum*, Dalzell in Hook. Kew Miscell. III., 136.

Slender; leaves broad-linear, nearly flat, gradually pointed; flowers small, three or two together or singly terminating the stem or the branches, conspicuously stalked; bracts rather elongated but narrow, longitudinally incurved; sepals as well as stalklets beset with very short spreading hairlets; petals blue; two of the stamens fertile; filaments bearing crisped hairlets; style glabrous; cells of the ovulary uniovulate; fruit trigonous-globular, shining; seeds plano-convex, ovate-roundish, nearly black outside and rugular, without any lustre.

Not previously found in Australia, one plant so far as hitherto observed being the dwarf unbranched form.

Sida Holtzei.

Copiously beset with spreading bristlets; leaves rather large, paler green beneath, the upper forming from near their base usually five lobes, these from lanceolar- to broad-linear, bluntly serrated, the middle lobe longest, the next two also elongated, the lowest variously abbreviated, not revergent; stipules comparatively long, linear-filiform; flowers almost or quite sessile, singly axillary, but some crowded at the end of the branches between diminutive leaves; calyx very small, somewhat beyond the middle five-cleft, partly whitish, its lobes equal, semilanceolar, thinly carinulated and margined, imperfectly ciliolated; petals thrice as long as the calyx, white, bearing outside minute hairlets; anthers pale, on extremely short filaments at the staminal column; styles slightly exserted; stigmas labellate; ovularies 5, glabrous; fruit quite small, depressed-globular; fruitlets 5, separate, blunt, reticular-venulated, towards the base attenuated; seed brownish, narrowed downward.

The aspect of this remarkable plant is more that of some species of *Hibiscus* (particularly from the sections *Lagunea*, *Furcaria* and *Abelmoschus)*, than that of a *Sida*. Vestiture pale-yellowish. Stipules attaining a length of $\frac{2}{3}$ inch. Lower leaves not obtained; upper to five inches long, their denticulation short. Calyx at flowering time about $\frac{1}{6}$ inch long, terminated by elongated hairlets. Length of corolla hardly above $\frac{1}{2}$ inch. Lower portion of staminal column devoid of anthers. Fruit $\frac{1}{5}-\frac{1}{4}$ inch broad; pericarp of fruitlets membranous, seemingly indehiscent. Seed at the hilum beset with minute hairlets.

Tylophora Leibiana.

Quite upright, unbranched, glabrous in all its parts except the corolla; root fascicularly fibrillous; leaves narrow-linear, revolute at the margin; umbels axillary, containing several or only few flowers; peduncles thin, about as long as the pedicels or even shorter; calyx small, its divisions almost semilanceolar; corolla dull-coloured, its segments much elongated, from a semi-lanceolar base filiform-linear, very much exceeding the calyx, at the inner side particularly downward beset with white papillular hairlets; coronular lobes dark-coloured, erect, rounded-blunt, slightly turgid; pollinia purplish-black; ovularies slender, glabrous.

Root to 2 inches long. Stem to 3 feet long. Leaves towards the middle of the stem often about 2 inches long, but less than $\frac{1}{8}$ inch broad. Pedicels $\frac{1}{4}$ – $\frac{1}{2}$ inch long. Corolla when fully developed measuring nearly 1 inch in length. Stamens about $\frac{1}{10}$ inch long; terminating membranule of the anthers very short. Fruit not obtained.

This plant is singularly different from all its congeners in the extreme narrowness of the leaves and in the length and slenderness of the corolla-segments, the latter reminding of those of *Calostigma insigne.*

The dedication is to Dr. A. Leibius, F.C.S., who through many years was one of the Hon. Secretaries of the Royal Society of N.S.W., and who at present occupies the distinguished presidential position of that eldest of Australian Science-unions.

Hoya Australis.

R. Brown according to Traill in the Transact. of the Horticultural Society VII., 28.

Creeping over rocks near the sea-shore. Not previously traced to N.-W. Australia.

As stated in the report on the Burdekin-Expedition, this species is often beset with minute hairlets. Mr. Holtze has succeeded in finding also the fruit; its characteristics are the following: Pericarp about 6 inches long, when flattened out nearly $\frac{3}{4}$ inch broad at the middle, gradually acuminated, inside and outside glabrous. Placentary less than $\frac{1}{4}$ inch broad. Seeds numerous, glabrous, pale-brownish, hardly more than $\frac{1}{6}$ inch long, narrow-elliptical, but attenuated upwards and truncate at the summit. Tuft of hairlets attaining a length of one inch, white.

(To be Continued.)

WEDNESDAY, JUNE 4, 1890.

Dr. Leibius, M.A., F.C.S., President, in the Chair.

Forty-five members were present.

The minutes of the last meeting were read and confirmed.

The Certificate of one new candidate was read for the third time, of five for the second time, and of seven for the first time.

The following gentleman was duly elected an ordinary member of the Society :—

Mathias, William Lloyd, M.R.C.S.E., L.R.C.P.L., Sydney.

The following amendments to Rule 3, proposed at the General Monthly Meeting held May 7th were agreed to, being carried unanimously viz. :—

1. Moved by Prof. Liversidge, that after the words 'one year' it read "four Vice-Presidents, a Treasurer, and one or more Secretaries, who with ten other members shall constitute a Council for the management of the affairs of the Society."

2. Moved by Sir Alfred Roberts, "that the other officers of the Society shall consist of a President, who shall not hold office for more than two years, &c."

Mr. Lawrence Hargrave read a paper on "A compressed-air Flying-machine."

Remarks were made by Mr. H. C. Russell, and the Chairman.

Mr. Walter Shellshear, A.M.I.C.E., read a paper "On the treatment of slips on the Illawarra Railway at Stanwell Park."

A discussion followed in which Messrs. C. Moore, H. Deane, and the author took part.

In the absence of the author, Mr. J. F. Mann read a paper by Mr. F. B. W. Woolrych on "Native names of some of the Runs &c. in the Lachlan district."

Mr. Charles Moore, F.L.S., read a paper "Remarks on a new plant rich in tannin."

A discussion followed in which Messrs. H. C. L. Anderson, W. M. Hamlet, F. B. Kyngdon, the Chairman and the author took part.

The thanks of the Society were accorded to the various authors for their valuable papers.

Two new filmy ferns were exhibited and described by Mr. Charles Moore, F.L.S.

Description of two Filmy Ferns exhibited by C. Moore, F.L.S., Director of the Botanic Gardens, Sydney, June 4, 1890.—The genus Hymenophyllum is one of the most interesting of ferns, from the extreme delicacy of texture, and the minute size of several species, in the latter case these might readily be passed over by those unacquainted with their forms although looking for them. Both of the species which I have now to bring under your notice, are of the smallest kinds, and appear in their natural habitat more resembling a moss than that of a plant of a higher organization, and both are I believe new to these colonies, and undescribed species. One of these was first brought to my notice by my friend W. H. Catlett Esq., who discovered it about ten years ago growing on wet ledges of earth near the top of the Broker's Nose, in the Illawarra Range, but not in fruitification, and could not then be determined. Since that time I have discovered it in fruit, on wet rocks near the top of the pass leading from Kiama to Moss Vale, and have therefore been enabled to describe it under the name of *H. Catletti*, in honour of its discoverer, a most enthusiastic lover of botany and horticulture. In its wild state it grows in dense caespitose masses, of a very dark green colour. The other plant was found by me in company with the former which it is unlike both as regards colour and form, near the top of Kiama Pass, growing on the sides of very wet rocks. The fronds or leaves of this plant are of a pale green colour and quite lucid, in this last respect it appears very similar to an allied species described in Brown's Prodromus under the name of *Hymenophyllum nitans*, from which it is to be distinguished by its smaller size, more regular and fragile form; this I have ventured to describe under the name of *Hymenophyllum lucidum*. The botanic definitions of these two plants are as follows :—

Hymenophyllum Catletti, Moore.—Fronds distinctly flabellate in form, scarcely more than half an inch in length or breadth, segments radiating from a filiform or hair-like stipes about an inch long bifurcating into obtuse lobes. Sori slightly within the apex of the lobe. Involucre widening from the base upwards, crenated at the margin, receptacle slightly protruding. The lobes and stipes often margined with scattered brown hairs.

Hymenophyllum lucidum, Moore.—Fronds from one to three inches long on a slightly shorter filiform stipes, very pale shining green, linear lanceolate in form pinnate or deeply pinnatifid, segments quite entire unequal linear and obtuse. Sori terminal. Involucre cup-shaped immersed in the substance of the lobe at its apex. Habitat on wet rocks in shady places on the side of the pass above Kiama.

Mr. H. C. Russell, B.A., F.R.S., exhibited the Narraburra Meteor and described it as follows :—The Narraburra Meteor was found in the year 1855 by Mr. O'Brien in Latitude 34° 10′ S; Longitude 147° 43′ East, which is a point on the Narraburra Creek about twelve miles east of Temora. When found it was on a hard and stony surface, but I have been unable to obtain any other particulars, as the finder has long since passed away to the majority. Mr. O'Brien gave the meteor to Mr. Patrick Harrold of Mount Hope, near Cootamundra, and it has been in his keeping ever since, until the 30 March 1890 when he was induced by Mr. William R. Eury, Inspector under the State Children's Relief Branch, to send it to me. Mr. Eury as soon as he saw the meteor pointed out to Mr. Harrold the great scientific interest attaching to it, and that undoubtedly the proper place for it was in the Observatory where a collection of these so called shooting stars is being made, and upon this Mr. Harrold sent it to me. I am very much indebted to both of these gentlemen for enriching the Observatory collection by this most interesting specimen of a metallic meteor. In appearance this meteor is like rusty iron, and it has a very irregular outline, which seems to have resulted from the oxidation or solution of rounded masses, which had solidified with the iron and formed cavities in it. Two of these are so placed that they look like the orbits in an ox's skull, a suggestion borne out by the general outline, which is not unlike the bone in question. In one place a hole nearly an inch in diameter, and 1½ in. deep, has been made straight into the solid iron; and there seems to be little doubt that when the iron originally cooled down from its gaseous state it did so in the presence of these rounded and cylindrical masses, which impressed their form on the plastic iron as it solidified. These, as I have already suggested, have no doubt been removed since they reached the earth's atmosphere. A meteor which fell in New England in November last was seen to have a spiral motion, emitting steam or smoke in jets. Looking at the holes in this meteor one can see at once that if, when it reached the atmosphere, they were charged with some substance that would burn freely in the oxygen of the air. It requires no great stretch of the imagination to see how this solid mass of iron would have twisted about under the influence of the many gas jets from the burning masses in its sides. I find its specific gravity is 7·57 and its weight is 70 lbs. 14 oz.. Meteoric iron is, I think, never quite pure, and masses of it vary considerably in specific gravity. Taking five at random which fell on different parts of the earth, it varies in them from 7·38 to 7·82, and the mean happens to be 7·62, almost exactly the same as the one before us.

Prof. Anderson Stuart, M.D., demonstrated the working of the valves of the heart through circular plate glass windows tied into openings in the walls of the right auricle and ventricle.

The thanks of the Society were accorded to the various exhibitors.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF MAY, 1890.

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THE THEORY OF THE REPETITION OF ANGULAR MEASURES WITH THEODOLITES.

By G. H. KNIBBS, L.S., Lecturer in Surveying, Sydney University.

[*Read before the Royal Society, N.S.W., August 6, 1890.*]

THE system, in using a theodolite, of *repeating* the measure of an angle, that is of continuously adding it on the graduated circle, may be advantageously employed whenever the errors of reading that circle, or the errors of its graduation, are large as compared with those due to imperfect direction of the telescope on the objects between which the angle is included. In discussing the theory of this system, it is proposed to exhibit its intrinsic character, to investigate the errors peculiar to it, to supply a criterion of its precision, and to indicate the manner in which it may be made to contribute the most accurate results.

Method of Repeating.

Repetitional measures may be thus described:—Setting the verniers or microscopes to read zero,* the telescope is directed by

* The commencement of the process is expressed in this way for the sake of simplifying the discussion. The necessary modifications, when the verniers are not primarily at zero, are too obvious to require explicit statement.

the movement of the azimuth circle, (the revolution of the outer axis) until the cross wires appear to be exactly coincident with the object viewed. Releasing then the inner axis, to which the verniers and the telescope are invariably fixed, and revolving it; the latter is now similarly directed and adjusted on the second object, clamped in position, and the arc, registered by this movement upon the graduated circle, read off. The outer axis is again released and adjusted as before on the first object, the verniers remaining at the same readings, as when on the second. After clamping in position the release of the inner axis and re-direction of the telescope upon this last, scores the angle between the objects a second time on the circle. This operation is repeated as often as deemed advisable, and consequently if the directions and readings were perfect, and if the mechanical construction of the instrument were absolutely faultless, the readings would be 0, a, $2a$, $3a, \ldots\ldots\ldots na$, a denoting the angle between the objects.*

Errors of Pointing.

The adjustment of the cross wires in the reticule of the instrument on the image of the object is always, it is hardly necessary to say, but an approximation, and if the error of the attempt, technically called an *error of pointing*, be denoted by p, instead of the telescope having been turned through the arc a each time, it is really turned through the arcs :—

$$a - p_2 + p_2, \; a - p_3 + p_4, \ldots\ldots\ldots \; a - p_{2n-1} + p_{2n} : \ldots\ldots\ldots (1)$$

in which expression p^1 denotes the error made in pointing to the first object, p_2 to the second, p_3 to the first object the second time, p_4 to the second object the second time, and so on; p being either positive or negative. The true readings on the arc are therefore :—0 ; $a - p_1 + p_2$; $2a - (p_1 + p_3) + (p_2 + p_4)$;......$na - (p_1 + p_3 + \ldots + p_{2n-1}) + (p_2 + p_4 + \ldots + p_{2n})$:.........(2) so that if there were no graduation errors, and if the graduation could be read perfectly, the *error* of the measure of a as obtained by the usual method of dividing the final reading as above, by the number, n, of repetitions, would be $+\dfrac{\Sigma p'' - \Sigma p'}{n}$........ (3), in which the first term in the numerator denotes the final term (in brackets) in (2); and the second, the one preceding that. That is to say, the numerator in (3) represents the algebraical sum of the whole of the errors of pointing.

Errors of Phase Irrelevant.

Now, although the probability of the actual errors of pointing at either object may not in certain instances be that of their being

* By making therefore n large enough the effect of any error in the graduation of the circle may be diminished to within any desired limit.

negative, as when their unequal illumination produces a *phase* or *constant error* which tends toward the illuminated side, and although these constant errors for each object, so, or otherwise produced, may not be mutually eliminative, no inaccuracy will be introduced by neglecting to recognise their existence when discussing *accidental errors*. For all *constant errors* must be treated independently by appropriate investigations, determined, and then eliminated by corrections; and it is not proposed in this article to examine any errors except such as are either peculiar to the system under consideration, necessarily coëxistent with them, or such as must perforce be argued in this connexion.

Probable error of Pointing.

If errors of pointing be determined or expressed by their angular value measured at right angles to the line of sight, which in fact is the most legitimate way of estimating their magnitudes, that part of the error which influences angles of azimuth is the horizontal component only, or to express it otherwise, the distance of the intersection of the wires in the reticule of the instrument from the vertical line through the image of the object, measured at right angles to that line. As the effect of this component varies with the altitudes of the objects, (1) and (2) require modification to make them generally true, being in view of the preceding qualification restricted in their present form to the case where the altitudes are zero. In this we may substitute for (3), $+\frac{\Sigma p}{n}$......(4) for the errors p'' and p' will, generally, each be subject to the ordinary laws of frequency of accidental error, and have the same measure of precision, or modulus. Being in their nature compensating or mutually eliminative (equally likely to assume equal positive and negative values) they may be discussed by the ordinary theory of errors. Putting therefore, $p_\circ$ for the *probable error* of a single pointing, the probable value of (4) by that theory is $\pm\frac{p_\circ\sqrt{2n}}{n} = \pm p_\circ\frac{\sqrt{2}}{n}$ or $\pm 1{\cdot}414\frac{p_\circ}{\sqrt{n}}$............(5), so that if $p_\circ$ can be evaluated, the probable error due to errors of pointing may be ascertained for any number of measures. For example if $p_\circ$ be $1''$, nine repetitions would be subject to a probable error of $0.''47$, viz. $\frac{1{\cdot}''414}{\sqrt{9}}$ or $\frac{1''\times\sqrt{(2\times 9)}}{9}$.

The effect of errors of pointing varying in their influence upon azimuthal measures with the altitudes of the objects viewed, if the latter be denoted by β_1 and β_2, and $p_\circ$ signify as before the probable horizontal error of pointing, its azimuthal values will be $p_\circ \sec \beta_1$, $p_\circ \sec \beta_2$............(6); (4) cannot therefore be rigorously substituted for (3) in the general case, for the moduli of the errors are not identical, and thus (3) becomes $+\frac{\sec\beta_2\ \Sigma p'' - \sec\beta_1\ \Sigma p'}{n}$...... (7),

the final reading, see (2), being :—
$na - \sec\beta_1(p_1 + p_3 + \ldots\text{etc}) + \sec\beta_2\ (p_2 + p_4 + \ldots\ldots\text{etc}), \ldots\ldots\ldots(8).$
Evaluating the probable errors of the terms after na in (8), that of the former term is $\pm \sec\beta_1\, p_\circ\, \sqrt{n}$............(9) and of the latter similarly $\pm \sec\beta_2\, p_\circ \sqrt{n}$......(10); the probable error of the sum of which is the square root of the sum of their squares, viz.:— $\pm\sqrt{(\sec^2\beta_1\, p_\circ^2\, n + \sec^2\beta_2\, p_\circ^2\, n)} = \pm\, p_\circ \sqrt{n}\sqrt{(\sec^2\beta_1 + \sec^2\beta_2)}$... (11), and this divided by n, the number of measures gives the probable error of the mean result :—$\pm \frac{p_\circ}{\sqrt{n}}\sqrt{(\sec^2\beta_1 + \sec^2\beta_2)}$...(12), becoming identical with (5) when β_1 and β_2 are each zero.

The practical significance of the result given is this :—When applying an evaluation of the average probable errors of pointing for some particular instrument and observer, to the discussion of specific cases, the element of altitude, *if considerable*, should not be ignored.

Errors which may be classed as errors of pointing.

The errors which may legitimately be included as errors of pointing, in addition to that arising from visual incapacity to appreciate when the cross-wires are exactly upon the image of the object, (an incapacity that varies with the delicacy of those wires, with the keenness of the observer's sight, with the state of the atmosphere, with the quality of the definition, and, to a large extent, with the magnifying power of the telescope,) are errors occasioned by irregular refractions of the rays from them. These operate by leading to the adoption of a false direction through temporary apparent displacement, and by making it difficult to decide the mean position of the (sometimes) apparently rapidly vibrating object. All these errors, intrinsically identical in their consequences, are in general inseparable, and can be differentiated for the purpose of estimating their relative magnitudes, only by discussing a very large number of measures, in which they severally exist, with a similar number in which they are severally absent.

Errors of Reading and Graduation.

The terms in (2) assume perfect circle graduation and reading, a purely hypothetical condition. Entering now upon the consideration of errors in these elements, it may be remarked that accidental errors of reading, and accidental errors of graduation may indifferently be classed together as errors of reading or of graduation.* Periodic errors either in the verniers or reading

* For the purpose of this discussion. The former element probably varies with each observer, more particularly when verniers are used. After therefore a combined error of this character is investigated, and its magnitude ascertained, it should be remembered that that magnitude is true only for a particular observer and instrument. With reading microscopes the graduation element is probably the greatest, next to this

microscopes, or in the dividing of the graduated circle, or arising from mechanical imperfections in the construction of the instrument such as want of parallelism between the axis of the graduated circle and that carrying the verniers, or constant errors, such for example as that of collimation, must be examined, measured, and eliminated by corrections, and for the purpose of the following investigation these corrections are supposed to have been applied and the several results to be, therefore, free from such errors.

Denoting the errors under consideration by the letter g and remembering that not only was the first setting at zero subject to an error of this character, but also every subsequent reading, the terms in (2) properly varied to represent the *actual* instead of the true readings, will be as follows:—$0°$, $a - p_1 + p_2 - g_1 + g_2$, $2a - p_1 + p_2 - p_3 + p_4 - g_1 + g_3$,........., $na - p_1 + p_2 - \ldots\ldots + p_{2n} - g_1 + g_{n+1}$..................(13).

With regard to the final quantity in (13), the terms following na constitute the total *actual* error, the first part of which has already been symbolically ascertained. When the value of a is found by dividing this final reading by the number of repeats, the only errors of reading that enter into the result are the primal and final; the probable error due to these is therefore that of $\frac{-g_1 + g_{n+1}}{n}$; which, putting $g_\circ$ for the probable value of g_1 or g_{n+1}, is $\pm \frac{g_\circ \sqrt{2}}{n}$ or $\pm 1{\cdot}414 \frac{g_\circ}{n}$..............(14).

Combining (12) and (14), the probable error of the mean of n repeats is:—

$$\pm \sqrt{\left\{\frac{2g_\circ^2}{n^2} + \frac{p_\circ^2}{n}(\sec^2\beta_1 + \sec^2\beta_2)\right\}} = \pm \frac{1}{n} \sqrt{\left\{2g_\circ^2 + np_\circ^2(\sec^2\beta_1 + \sec^2\beta_2)\right\}}$$

.........(15) and this, when β_1 and β_2 are each zero, becomes:—

$$\pm \frac{1{\cdot}414}{n} \sqrt{(g_\circ^2 + np_\circ^2)} \ldots\ldots\ldots\ldots\ldots\ldots(16)^*$$

From (15) and (16) it is evident that to find the probable error of the result of repeating measures, the probable errors of pointing and of reading must each be ascertained; but if the number be very large the result may, in some instances without serious error, be assumed to be affected by errors of pointing only. In determining the number requisite to warrant such an assumption the relative magnitudes of g and p furnish the necessary criterion. Thus for example if $np^2 = 5g^2$, the probable error will be varied about one tenth, if $10g^2$, one twentieth, from the correct value.

A better result will, however, always be obtained by (even roughly) estimating the value of g and including it. For example

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the error due to imperfect construction of the microscope, and that of the observer's reading is doubtless the least.

* See Table IV.

if $g = 7''$ and $p = 1''$ twenty repetitions will give a result with a probable error of $\pm 0''59$; if g were wrongly estimated and included as $5''$, it would appear as $0.''48$, but if it were neglected entirely only $0.''32$, little more than half its proper value.

Algorithm of the process of evaluating errors of pointing and of reading.

If in (13) each quantity be subtracted from the next following, the result is the following succession of values for the angle measured, and hence this process exhibits symbolically the errors of the several measures, *regarded* as independent observations of the angle. Each measure is affected by two errors of pointing and two of reading, as the following series shews :—

$a - p_1 + p_2 - g_1 + g_2,\ a - p_3 + p_4 - g_2 + g_3 \ldots\ldots a - p_{2n-1} + p_{2n} - g_n + g_{n+1}, \ldots\ldots\ldots (17).$

When the arithmetic mean is subtracted from each of these quantities, which represent the several measures of an angle as shewn in I. hereafter, the residuals, (remainders, or differences) are individually affected by errors resulting from the combination of the two errors of reading and two of pointing, and the estimation of the probable error of a single measure in the ordinary way gives (approximately) the probable error of one measure of an angle *subject to the errors defined.*

Using v as the symbol to denote a residual Σv and Σv^2 for their sum and the sum of their squares, the probable bi-elemental error of one measure is, somewhat approximately, $\cdot 675 \sqrt{\dfrac{\Sigma v^2}{n-1}} \ldots (18)$ or $\cdot 845 \sqrt{\left\{\dfrac{\Sigma v}{n(n-1)}\right\}} \ldots\ldots\ldots (19)$, the latter formula being applicable rather when the number of observations is large, than generally. It is not legitimate however to determine the probable error of the mean of n such measures by dividing (18) or (12) by $\sqrt{n}$, as in the case of independent and collateral measures, and for this reason, viz, that although each measure *per se* is subject to two errors of pointing and two of reading, the peculiarity of the method of repeating is that, while leaving the errors of pointing unaffected, it eliminates every error of reading (as the terms in (13) clearly exhibit) except the primal and final. As a consequence neither the probable error, nor the weight of the mean result, varies (respectively) reciprocally or directly as the number, or as the square root of the number of measures, nor does either admit of any antecedent general evaluation.*

Reverting to (18) and (19) the error of the arithmetic mean of the measures in (17) is evidently $+\dfrac{\Sigma p - g_1 + g_{n+1}}{n} \ldots\ldots\ldots\ldots (20)$,

* Except in the restricted form exhibited in Table (III.) hereafter.

that formula assumes it to be $+\frac{\Sigma p + \Sigma q}{n}$ ....(21), or rather it is on the assumption that the probable error of a residual is determined by the probable value of (21), that $n-1$ appears as a denominator (instead of n) in the formulæ. Hence it is evident that if these denominators were determinable in strict accordance with the probability of the cases to which the formulæ are applied they would appear as some quantity greater than n but less than $n-1$, and in some instances it will be desirable, as contributing more approximate results, to employ $\cdot 675 \sqrt{\frac{\Sigma v^2}{n}}$ ...(22), or $\cdot 845 \frac{\Sigma v}{n}$ ......(23), rather than (18) or (19). This desirability may often be decided *à priori.*

As indicating the illegitimacy of finding the probable error of the final result by dividing that of a single measure by the square root of the number, and exhibiting at the same time the algorithm of a truer process, an example of nineteen repetition measures of an angle is given, taken advisedly from the records of observations with small theodolites, in order to display the extraordinary precision of results obtained by the "repeating" method.

In I., Column 1 shews the number of "repeats"; 2 the successive values of the mean of the readings of verniers A and B; 3 the separate measures of the angle as obtained by subtracting each reading from that next following; 4 the residuals v obtained by subtracting the arithmetic mean (or what is the same thing the final reading divided by 19, the number of repeats) from each measure of the angle; 5 the squares of these residuals v^2; 6 the several readings, in column 2, divided by the number of repeats. Column 7 after the double line shews the residuals v' formed by subtracting the more probable value of the angle as found by the method exhibited in II.; and 8 their squares v'^2.

In II., Column 1 shews the readings taken to form the series of ten repetition measures; 2 the total angle found by subtracting 0 from 10, 1 from 11, etc.; 3 the value of the angle obtained by dividing the total angle by the number of repetitions, 10; 4 the residuals formed by subtracting the arithmetic mean of these different values from them individually; and 5 the squares of the residuals.

By (22) $\cdot 675 \sqrt{(\frac{1666\cdot 51}{19})} = \pm 6\cdot 3''$. By (23) $\cdot 845 \frac{135\cdot 7}{19} = \pm 6\cdot 0''$. $\pm \frac{6\cdot 3''}{\sqrt{19}} = \pm 1\cdot 40''$.* (See I. on following page.)

* This would be the probable error of the mean of nineteen such measures if they were independent and collateral, which however they are not. In regard to the expression of results to so (in this instance) excessive a degree of precision, see a note later on concerning this in particular. (See I. on following page.)

I.

No.	Mean Reading.	Angle.	v	v^2	Reading. ÷ n	v'	v'^2
	° ′ ″	° ′	″		° ′	″	
		89 59			89·59		
		″			″		
0	0 0 0						
1	89 59 45	45	−7·9	62·41	45·0	−7·7	59·29
2	179 59 52	67	+14·1	198·81	56·2	+14·3	204·49
3	269 59 45	53	+0·1	·01	55·0	+0·3	·09
4	359 59 30	45	−7·9	62·41	52·5	−7·7	59·29
5	89 59 20	50	−2·9	8·41	52·0	−2 7	7·29
6	179 59 12	52	−0·9	·81	52·1	−0·7	·49
7	269 59 20	68	+15·1	228·01	54·3	+15·3	234·09
8	359 59 12	52	−0·9	·81	54·1	−0·7	·49
9	89 59 15	63	+10·1	102·01	55·0	+10·3	106·09
10	179 58 50	35	−17·9	320·41	53·0	−17·7	313·29
11	269 58 30	40	−12·9	166·41	51·8	−12·7	161·29
12	359 58 40	70	+17·1	292·41	53·3	+17·3	299·29
13	89 58 30	50	−2·9	8·41	53·1	−2 7	7·29
14	179 58 22	53	+0·1	·01	53·4	+0·3	·09
15	269 58 25	62	+9·1	82·81	53·7	+9·3	86·49
16	359 58 07	42	−10·9	118·81	53·0	−10·7	114·49
17	89 58 00	53	+0·1	·01	52·9	+0·3	·09
18	179 57 50	50	−2·9	8·41	52·8	−2·7	7·29
19	269 57 45	55	+2·1	4·41	52·9	+2·3	5·29
19	Sums.	1005″	135·9	1665·79		135·7	1666·51
	° ′ ″						
n	86 59 52·9	Mean	Σv	Σv^2		$\Sigma v'$	$\Sigma v'^2$

II.

From	Angle.	Angle / n	u	u^2
	° ′	° ′		
	899 58	89 59		
*	″	″	″	
0 to 10	50	53·0	+0·3	·09
1 11	45	52·5	−0·2	·04
2 12	48	52·8	+0·1	·01
3 13	45	52·5	−0·2	·04
4 14	52	53·2	+0·5	·25
5 15	65	54·5	+1·8	3·24
6 16	55	53·5	+0·8	·64
7 17	40	52·0	−0·7	·42
8 18	38	51·8	−0 9	·81
9 19	30	51·0	−1·7	2·89
n'=10	Σ468	Σ526·8	7·2	8·50
	″	″		
Mean.	46·8	52·68	Σu	Σu^2

By (18) $\cdot 675 \sqrt{\frac{8\cdot 50}{9}} = \pm 0\cdot 66''$. By (19) $\cdot 845 \frac{7\cdot 2}{\sqrt{(10 \times 9)}} = \pm 0\cdot 64''$.
$\pm \frac{0\cdot 66''}{\sqrt{10}} = \pm 0\cdot 21''$.†

* 0 here represents the first reading (zero), and thus the 10th is the (m+1)th as by the rule given hereafter.

† This would be the probable error of the mean of the results of ten independent and collateral series of measures giving the results in Column 3.

Each angle in the third column in I. is affected by two errors of reading and two of pointing, see (17), but in the summation they are all excepting the first and last, cancelled out of the result, see (20), or (13). Thus although the angles are symmetrical in respect of their errors, to find the arithmetical mean of n measures is *exactly* equivalent to dividing the $(n+1)$th reading by n, and the intermediate readings have no influence on the result, a result liable to any abnormity in the two readings on which it depends, and yet having a higher probability than n *independent* measures liable to the same errors.

Forming in I. the residuals, (and their squares) in the usual way, by subtracting the mean 89° 59′ 52·9″ from each measure, see v and v^2, or preferably by subtracting 99° 59′ 52·7″, which will hereafter be shewn to be a more probable value of the angle, see v' and v'^2, the probable error of a single measure subject to two errors of reading and two of pointing may be found. This, employing (22) instead of (18), the desirability of which a general knowledge of the magnitudinal relation of the errors of reading and pointing suggested, and the final results sufficiently confirm, is $\pm$ 6·3″, *vide* I.

Proceeding similarly in II. but employing (18), the mean of ten measures affected with twenty errors of pointing and two of reading is found to have a probable error of $\pm$ 0·66″.

In the example taken, the altitudes of the objects were both zero, but in view of the deductions expressed in (6) to (12) it will be desirable, in order to exhibit the form of the general solution, to put $q =$ probable value of each *pair of errors* of pointing. Thus:

$$q = \sqrt{(p'^2 + p''^2)} = p_{\circ} \sqrt{(\sec^2 \beta_1 + \sec^2 \beta_2)} \ldots\ldots\ldots\ldots (24).$$

Using the general notation of this article, the probable error of a single measure in I. is $\pm q$ as regards pointing, and $\pm g_{\circ} \sqrt{2}$ in respect of reading, the probable error of the sum of the two being $\pm \sqrt{(q^2 + 2g_{\circ}^2)} = \pm 6{\cdot}3''$, and similarly the probable error of the mean of ten "repeats" in II. is $\pm \frac{\sqrt{(10q^2 + 2g_{\circ}^2)}}{10} = \pm 0{\cdot}66''$. Whence, by multiplying both sides of the latter equation by 10, and then squaring both equations, those hereunder are obtained, viz.:— $q^2 + 2g_{\circ}^2 = 39{\cdot}69''$ and $10q^2 + 2g_{\circ}^2 = 43{\cdot}56''$; from the solution of which q^2 is found to be 0·43″, q to be 0·66″, $g_{\circ}^2$ to be 19.6″, and $g_{\circ}$ to be 4·43″.*

Having found q and $g_{\circ}$, the probable error of the mean results of either I. or II. may be ascertained in the manner sketched hereinafter. Thus the probable error of the latter is shown to be

* The quantities are expressed to a high degree of precision not as indicating their reliability to within such limits or that these limits ought in general to be regarded as significant, but in order to more clearly exhibit the processes.

$\pm$ 0·26″ and this error may be employed to proceed to a higher approximation of the above, q and $g_\circ$, in the following way* :— $\pm$ 0·26″ × 1·483 = $\pm$ 0·386″ the "*mean error*" or "*error of mean square*" of result, the multiplier being that number which expresses the value of the "mean error" in terms of the "probable error." Denoting this corrective quantity by the letter e, to the sum of the squares of the residuals (Σv^2, and Σu^2) the quantity ne^2 and ne'^2 should be added, and formula (22) used in both instances for discovering the probable errors, which are, seeing 19 × (0·386)² = 2·83, and 10 × (0·386)² = 1·49, $\cdot 675 \sqrt{\{(1666{\cdot}51+2{\cdot}83)\div 19\}} = \pm\, 6{\cdot}33''$ and $\cdot 675 \sqrt{\{(8{\cdot}50+1{\cdot}49)\div 10\}} = \pm\, 0{\cdot}675''$. Introducing these new values in the above equations, 39·69″ and 43·56″ become respectively 40·07″ and 45·56″, and resolving with these, q^2 is 0·61″ q is 0·78″, $g_\circ^2$ 19·73″ and $g_\circ$ 4·44″.†

By (24) $$p_\circ = \frac{q}{\sqrt{(\sec^2\beta_1 + \sec^2\beta_2)}} \quad \text{...........(25);}$$ so that in the present example, where β_1 and β_2 are each zero, it is $\frac{q}{\sqrt{2}}$, and this numerically determined from the value of q last found, is $\pm$ 0·55″. The former value gives $\pm$ 0·46″. The evaluation of such errors, by a discussion of so few a number of measures as nineteen, can of course be expected to lead to results by no means of a highly approximate character ; yet a number of examinations of the performances of the same instrument, of a varied as well as of a similar character to the preceding, sufficiently confirmed the accuracy of the values discovered by it.‡

System of deducing most probable result.

The liability of a result given, as in I., by dividing the $(n+1)$th reading by n to the prejudicial effect of any abnormity in the two reading errors, on which it depends, has already been adverted to. In the method shewn in II., each quantity is affected by twenty

* The 'mean errors' of residuals will be the 'mean errors' of the mean results employed (or of 82° 59′ 52·7″ in the example) and therefore if they be denoted by ϵ_v and ϵ_u the probable errors of a single measure and of a single ten-measure mean are $\pm\, \cdot 675 \sqrt{\frac{\Sigma v^2 + n\epsilon_v{}^2}{n}}$ and $\pm\, \cdot 675 \sqrt{\frac{\Sigma u^2 + n'\epsilon_u{}^2}{n'}}$, ϵ_v and ϵ_u being equal in this particular instance. $\epsilon_u = 1{\cdot}483\, r_u$ if r_u be the probable error of a residual, or $\frac{r_u}{\cdot 675}$.

† The preceding note applies here also. The whole must be viewed simply as an illustration of method, and as hereinafter the same principle will be followed, the same qualification should be understood.

‡ The values when obtained will not be general, but true only for a particular observer, as the pointing error, and the reading element of the reading and graduation error will vary with the observer, and with the observer's physical condition. This is conspicuously the case with unpractised observers.

errors of pointing and two of reading, but the errors of reading are different in each instance, and two errors of pointing are included, not included in that preceding; two likewise being excluded. Thus the measures are perfectly symmetrical as regards their errors, and are varied so as to secure whatever advantage the utilization of every reading taken affords ; an advantage counterbalanced only by the repeated inclusion of some only of the errors of pointing. But when those errors, as compared with the former, are small, it is *à priori* evident that the advantage is considerable. The *limits* of advantage will form the subject of inquiry later on.

In this method, a rule for which is now given, each reading has, as evidently it should, precisely the same influence on the result. *Taking an odd number* (2m − 1) *of measures* of the angle the value of which is required, *subtract the first or initial reading from the* (m+1)*th, the second from the* (m+2)*th, and similarly to the* m*th from the* 2m*th, or final reading, adding to each difference the proper multiple of* 360° : *the sum of the differences divided by* m^2 *will be the mean value sought.**

If the number of *measures* be even, 2m, subtract the first reading from the (m+1)th, and so on, adding as before the proper multiple of 360°, the final subtraction being the (m+1)th from the (2m+1)th, and divide the sum of the differences by m(m+1). In the latter case the (m+1)th reading has no influence whatever upon the result, upon which fact the dictum, that an *odd* number of measures should be taken, is based.

Evaluation of probable errors of results.

The probable values of the errors of pointing and reading having been disclosed by the preceding investigation, the application of formula (16) immediately gives the probable error of the result presented by the method of I. Thus, $(1{\cdot}414 \div 19) \times \sqrt{\{19{\cdot}73'' + (19 \times 0{\cdot}55^2)\}} = \pm\ 0{\cdot}38''$, (the first approximate values for $g_\circ$ and $p_\circ$ give + 0·36″); and the result may therefore be expressed, 82° 59′ 52·9″ ± 0·4″, a result evidently agreeable to the indications given in column 6.†

In ascertaining the probable error of the value found in II., it is to be remarked that it is influenced by thirty-eight (2 × 19, or $2n$) errors of pointing and twenty (19+1, or $n+1$) of reading. It is necessary to have regard however, not only to the number of errors but also to the way in which they enter into the result. The following series will represent the actual quantities (the multiple

* The elimination of collimation and of focussing error by this rule is adverted to later on.

† A Table (III.) is given hereafter by means of which the probable error may be readily formed by inspection.

of the *true* angle and the *real* errors) of the multiple measures defined in column 1 of II., viz. :—

$$10a + (-p_1 + p_2 - \ldots\ldots + p_{20}) - g_1 + g_{11},$$
$$10a + (-p_3 + p_4 - \ldots\ldots + p_{22}) - g_2 + g_{12},$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots,$$
$$10a + (-p_{19} + p_{20} - \ldots\ldots + p_{38}) - g_{10} + g_{20}.$$

and the addition of these is,—

$100a + \{1(-p_1+p_2)+2(-p_3+p_4)+3(-p_5+p_6)+\ldots\ldots 10(-p_{19}+p_{20}) +\ldots\ldots 3(-p_{33}+p_{34})+2(-p_{35}+p_{36})+1(-p_{37}+p_{38})\} + (-g_1 - g_2 - \ldots\ldots - g_{10}+g_{11}+\ldots\ldots+g_{19}+g_{20})$. ....(26), the error of the mean result being one hundredth of the terms following $100a$, inasmuch as it is the one hundredth part of the whole quantity. Putting q as before for the probable value of $(-p'+p'')$, the probable value of the p term is that of :—$q\ (1+2+3+\ldots+10+\ldots.+3+2+1)$ and this is, by the theory of errors, $q\sqrt{(1^2+2^2+3^2+\ldots.10^2+\ldots.3^2+2^2+1^2)}$......(28). Proceeding to numerical evaluation, $q^2 = 0{\cdot}61''$, the sum of the series $= 670$, therefore $\sqrt{(670 \times 0{\cdot}61'')} = \sqrt{408{\cdot}7''} = \pm 20{\cdot}22''$ the probable error of the p term. That of the g term is $\sqrt{(20g_0^{\ 2})} = \sqrt{(20 \times 19{\cdot}73'')} = \sqrt{(394{\cdot}6)} = \pm 19{\cdot}86''$. The value of the whole error is consequently $\pm \sqrt{(408{\cdot}7 + 394{\cdot}6)} = \pm 28{\cdot}34''$. This is to be divided by 100, thus the result by II. may be expressed 89° 59′ 52·7″ ± 0·3″.

It is seen by these determinations that the value of *repetitional* is very much greater than that of *independent* measures. The probable error of the mean of nineteen independent measures such as shewn in I. would be 1·40″, as contrasted with 0·38″ the actual probable error. Further that the probable error of the method in II. is greater than if the ten series were independent, the errors being in the example 0·28″ as contrasted with 0·21″.

Tabulated probable errors, and empirical combinations of measures made with different instruments.

The reading of the graduated circle after each measure, although affording the means, generally, of obtaining a better value for the angle, and a check upon any erroneous use of the instrument (as say the movement of the wrong tangent screws) involves so much time, that it has become a common practice to note the first measure, and the final reading only, dividing the latter by the number of measures. The result should approximately agree with the recorded first measure, which serves therefore as a safeguard against error in respect of that number. It has been usual to assume that the probable error of the result is reciprocally proportional to the number of measures, to which ratio indeed it closely approximates when the probable graduation (or reading) error is very large as compared with that of pointing. How far this assumption is justifiable is exhibited in the following table

III., which also serves for readily finding the probable error of any result by the method of I., when p and g are known, and for deciding for any given variations in the values for these last quantities, what number of measures will produce an equivalence of probable error, or afford results of equal reliability.

In regard to the practical application of the Table, if the probable errors of pointing and reading are ascertained (for each particular instrument used) by a large number of observations made under the atmospheric and other conditions generally obtaining, the probable error of the result of any number of repetitions, in which only the initial and final readings are noted (or employed), may be very fairly defined on the basis of these ascertained errors. Thus the mean of nine measures with a probable pointing error of 0·4″, and graduation of 2·0″ (or five times the former) would be 0·37″, viz. 0·4 × 0·92, this last quantity being taken out in table under 9 and opposite 500.

As another example of its use, suppose that (being necessary to employ in the measures of the angles of a geodetic survey two theodolites, in one of which a number of investigations indicated that p and g were respectively 0·2″ and 1·6″, and in the other 0·3″ and 3·0″) it was desired for the purposes of ready reduction, to "repeat," when observing, that number of times which would make the work of each instrument equally reliable. To elicit the required numbers from the table, it will be necessary to select in line 800, (100 × 1·6 ÷ 0·2) one or more values which when multiplied by 0·2 will equal values in line 1000, (100 × 3·0 ÷ 0·3) multiplied by 0·3. Multiplying out the lines mentioned (by 0·2 and 0·3) and comparing, it will be seen that the result given by eight repetition measures with the former instrument has the same probable error as that of fifteen with the latter, viz. 0·30″. If this were considered an excessive number, four and eight (0·58″ and 0·55″), or five and nine (0·47″ and 0·50″) might be employed, or *vice versa* fifteen and thirty (0·17″ and 0·16″).

If the original evaluation of p and g (as of course it should) be founded upon observations reduced as in I. and II., the determination of the relation of the measures with the two theodolites will then be a legitimate empiricism, and a reasonable estimate of the probable error of the measures can, at least approximately, be made.

The Table exhibits the magnitudes of the probable errors for different numbers of repetitions, the probable error of pointing p being regarded as 100 and constant, for errors of reading and graduation g, from 200 to 2000. Thus if p represent 1″ the quantities will represent hundredth seconds. To find the probable error of a result of n measures, multiply the quantity under n and opposite the line representing the relative value of g to p, by the absolute value of p divided by 100.

III.

Table of values $\frac{1}{n}\sqrt{(2g^2 + 2np^2)}$ Formula (16).

p=100	Number of Repetitions. n												
g	2	3	4	5	6	7	8	9	10	15	20	25	30	100
200	173	125	100	085	075	067	061	057	053	041	035	030	027	014
250	203	143	113	095	082	074	067	061	057	043	036	032	028	015
300	235	163	125	106	091	081	073	067	062	046	038	033	029	015
350	267	184	143	115	101	089	080	073	067	049	040	035	031	015
400	300	205	158	130	111	097	087	079	072	052	042	036	032	015
450	334	227	174	142	121	105	094	085	078	056	045	038	034	016
500	367	249	190	155	131	114	102	092	084	060	047	040	035	016
550	402	272	207	168	142	123	109	098	090	063	050	042	037	016
600	436	294	224	181	153	131	116	105	096	067	053	044	038	016
650	470	317	240	194	164	142	125	112	102	071	056	046	040	017
700	505	340	257	208	175	151	133	119	109	075	059	049	042	017
750	540	363	274	221	186	161	142	127	115	080	062	051	044	018
800	574	386	292	235	197	170	150	134	122	084	065	053	046	018
850	609	409	309	248	208	180	159	142	128	088	068	055	048	019
900	644	432	326	262	220	190	167	149	135	093	071	058	050	019
950	679	455	343	276	231	199	175	157	142	097	074	060	052	020
1000	714	478	361	290	243	209	184	164	148	101	077	063	054	020
1500	1065	712	535	429	358	308	270	240	217	147	111	089	075	025
2000	1418	946	711	569	475	407	357	318	286	192	145	117	098	032

Limit of advantage of the reduction system of II.

The repeated unequal inclusion of some of the errors of pointing, in order to utilize each reading in finding the best value for the angle measured, cannot be deemed *theoretically* satisfactory; and the extent to which this is advantageous is consequently a proper subject of inquiry.

Putting $2m - 1$, as in the Rule, for the number of observations, it may be shewn that the general expression for (28) is $q\sqrt{\frac{m(2m^2+1)}{3}}$ ...(29), the quantity under the radical sign being the sum of the squares of the series of numbers 1 to m to 1) and as this is to be divided by m^2, the probable error of the p terms in (26) will be found on reduction to be $\pm\, q\sqrt{\frac{2m^2+1}{3m^3}}$......(30). That of the same terms in the sum of the repeats, as shewn in I., is $p_\circ\sqrt{\{2(2m-1)\}}$, and $p_\circ\sqrt{2}$ being equal to q, this term becomes when divided by $2m-1$ the number of measures, $q\sqrt{\frac{1}{2m-1}}$.........(31). (30) and (31) are an equality when $m = 1$; but when m is more than 1, (30) is the greater. There may therefore be a limit to the advantage of employing the rule exhibited in II., viz., that determined by the balancing of the increase of probable error through the excess of (30) over (31) with the decrease of the same arising from the inclusion of all the readings in the mean result. Such a limit, if it exists, is clearly dependent upon the relative magnitudes of g and p. The necessary criterion is thus established:—

The probable error in (26) due to errors of reading being $\pm g_\circ \sqrt{(2m)}$, which divided by m^2 expresses that of the mean result by II., viz:—$\pm g_\circ \sqrt{\frac{2}{m^3}}$......(32), the combination of this with (30) gives, $\sqrt{\frac{q^2(2m^2+1)+6g_\circ^2}{3m^3}}$.........(33)* that is the probable error of that result. That of the method of I. is, remembering $n = 2m - 1$, $\sqrt{\frac{q^2(2m-1)+2g_\circ^2}{(2m-1)^2}}$.........(34). To find the limit, (33) and (34) must be taken as equivalents. Squaring and removing the fractional form gives the equation :—$(2m-1)^2\{q^2(2m^2+1)+6g_\circ^2\} = 3m^3\{q^2(2m-1)+2g_\circ^2\}$......(35) and this reduced is, $\frac{6g_\circ^2}{q^2} = \frac{2m^4-5m^3+6m^2-4m+1}{m^3-4m^2+4m-1}$.....(36).

If any numerical or rational values be assigned to $g_\circ$ and q,(36) may be solved for m, or for $2m - 1$, that is for the number of observations producing equality of probable error, and beyond which the system II. is inapplicable or disadvantageous.

In the following table, IV., the argument is $\frac{g}{p}$, the probable error of reading divided by that of pointing, p being $\frac{q}{\sqrt{2}}$. Solving algebraically, one of the roots, it will be observed, is 1 ; a result true for any value of the left hand member of (36), and the physical interpretation of which is obvious. As only integral values are required for $2m - 1$, the solution is simple after $\frac{g}{p} = 3$, when $\frac{6g^2}{q^2}$ will be 27, and the right hand member of (36) may be written $2m + 3 + \frac{10}{m}$, the last term serving for a second approximation : and after $\frac{g}{p} = 4$, (36) may be still further simplified ; for putting c for that quantity, and remembering that $\frac{6g^2}{q^2} = 3c^2$, and that results are required but to the nearest unit, $m = \frac{3c^2-3}{2}$......(37) or $n = 2m - 1 = 3c^2 - 4$.........(38).

If then n be greater than $3c^2 - 4$ the process exhibited in II. should not be followed, and this is the required criterion, tabulated in IV.

IV.

Limits of 2m – 1 Rule.

$\frac{g}{p}$	n	$\frac{g}{p}$	n	$\frac{g}{p}$	n	$\frac{g}{p}$	n	$\frac{g}{p}$	n
2·2	5	3·1	24	3·6	35	4·5	57	7	143
2·4	9	3·2	26	3·7	37	5·0	71	8	188
2·5	13	3·3	29	3·8	39	5·5	87	9	239
2·8	18	3·4	31	3·9	41	6·0	104	10	296
3·0	22	3·5	33	4·0	44	6·5	123	11	359

* A table similar to III., might be constructed with the same arguments using formula (33) instead of (16) for use with this method.

Constant and periodic errors and their effects.

The successive readings of the circle entered in column 2 of I., being the means of verniers 180° apart,* any error of eccentricity as between the centre of the vernier-axis, and that of the graduated circle, is entirely eliminated. To rigorously determine the magnitudes of the accidental errors of reading and pointing, however it is further requisite that corrections be applied for any other periodic errors entering into the results. Of these some are peculiar to the *repeating method* and others though not so, require to be noticed. A general investigation for the discovery of periodic errors of graduation might with advantage, in some instances, be made in the usual way,† but the graduation of modern instruments is frequently so excellent that, especially when resorting to repeating measures, this may be held superfluous.

Of the strictly constant errors that demand notice, that of variation of the line of collimation by changing of focus, and that of collimation are perhaps among the most important.

The former is generally very slight except for great differences of focus. It may be measured by observing an angle with the face of the instrument in reversed positions. Denoting it by f, the number of measures with the face in one position by m, those in the other by m', and the total difference between the multiple measures by d, its value will be :— $f = \frac{d}{m+m'}$............(39). This assumes the measure to be made with the altitudes of the objects zero, when f is to be regarded as its horizontal value. If the face of the instrument be reversed for each successive measure in actual practice, this error will be eliminated from the result, as also will the collimation error, (c, treated of hereafter) provided $2m-1$ measures are taken and reduced as in II.‡ If the value of the angle is obtained, however, by dividing the final reading by the number of measures, that number should be even, to eliminate both f and c.

The error due to focussing is strictly, though it is not convenient so to consider it, a collimation error, for the latter differs in this : it has no effect upon angles when the altitudes of the objects between which they are included are equal. When they are not, putting m for the real error of collimation and c for the error it introduces into the measure of an angle, $c = m\ (\sec\beta_1 - \sec\beta_2)$... ......(40).§ As c and f enter as combined constants into the

* It may be observed, *en passant*, that the probable reading error 4·44″ is consequently that of the mean of the two verniers.

† By the application of the theorems relating to periodic functions.

‡ Refer back to note respecting the $2m-1$ rule.

§ The mode of measuring the various errors of instruments has been treated in an article on the Rigorous Examination of Theodolites, by the writer, published in "The Surveyor," the Journal of the New South Wales Association of Surveyors, Vol. I., No. 10.

results, their sum may be denoted by k, the sign of which will be reversed with a reversal of the face of the instrument. In I. therefore, since the readings marked 1, 3, 5 etc. contain k, and those marked 0, 2, 4 do not, the addition of the seconds in the third column of the respective readings shewing seconds only indicates that $a - k = 466'' \div 9$ and $a + k = 559'' \div 10$, k therefore being $+ 1{\cdot}05''$. The result is simply illustrative of a method legitimate only with a *very large* number of such measures and in this example has no intrinsic value. It may more accurately be found, by the process to which (39) applies, substituting k for f, thus similarly $k = \frac{d}{m+m'}$.........(41) the general formula, (39) being merely a particular instance where β is 0°. c and f may be differentiated out of this result by means of (40) when m is known.*

If the pivot axis of the telescope be not perfectly adjusted so as to make the plane of revolution of the latter vertical, a constant error, also changing its sign with change in the face of the instrument, will enter into the results. This too is included in the general formula (41).

Turning now to periodic errors, one of these, essentially peculiar to the system of theodolite repeating-measures, is that due to want of parallelism between the azimuthal axes, the outer and inner. This error operates in the following way:—as the relative positions of the two axes change, the plane of revolution of the telescope departs from the vertical, an amount determined by the inclination of the axes, and the sine of the angle through which the axis is turned.† If therefore β_1 and β_2 be not zero, each reading will be subject to a correction, without which the result will be more or less in error (except in a particular instance hereinafter mentioned) and the investigation of the probable value of the reading and pointing errors, and of the absolute amount of the focussing and collimation errors, is impossible. If l denote the elevation of the right hand side of the pivot axis of the telescope (looking along the telescope), and z the error of azimuth caused by this defect, $z = l\ (\tan\beta_1 - \tan\beta_2)$......(42) or if this inclination vary as it does in repeating, $z = l_1 \tan\beta_1 - l_2 \tan\beta_2$...........(43). The angles l may be read for variations caused by the differential revolution of the axes, by means of the level upon the vernier plate, or with the striding level; or may be computed when the inclination i of the axes, and the direction of the plane passing through the the two is known (γ). If then in repetitional measures the outer

* It is convenient to regard the error of collimation at the principal focus (or when the instrument is focussed for infinite distances), as the true collimation error; and to denote the variations from this value at different focal distances, errors due to focussing.

† The method of measuring this error is described in an article previously quoted.

axis, as it is desirable it should, be made vertical, the series of errors in the measures of the angles will be as follows :—$l_1 \tan \beta_1 - l_2 \tan \beta_2$; $l_2 \tan \beta_1 - l_3 \tan \beta_2$;......$l_n \beta_1 - l_{n+1} \beta_2$.........(44). But l_1 etc., are functions of i, γ and a, thus ;—$l_1 = i \sin \gamma$, $l_2 = i \sin (\gamma + a)$, $l_3 = i \sin (\gamma + 2a)$ etc.......(45).* If a happen to be a submultiple of 360° ; say $\frac{360^\circ}{n}$, the last terms in (45) become $i \sin \{\gamma + (n-1)a\}$ and $i \sin \gamma$,......(46): and since (44) may be written in this case,— $(l_1 + l_2 + l_3 + \ldots + l_n)(\tan \beta_1 - \tan \beta_2)$.........(47), inasmuch as $l_{n+1} = l_1$, and as the sum of the series $i \sin \gamma, \ldots\ldots\ldots i \sin \{\gamma + (n-1)a\} = 0$ when $a = \frac{360^\circ}{n}$, it, (44) becomes zero: in other words the errors are eliminated. If the telescope be reversed after each measure, the desirability of which has been previously indicated, (47) will take the form :— $(l_1 - l_2 + l_3 - \ldots + l_n)(\tan \beta_1 + \tan \beta_2)$............(48), so that if n be an even number the last term will be $- l$, and the series may be written :—$i \sin \gamma + i \sin \{\gamma + (a + \pi)\} + \ldots\ldots + i \sin \{\gamma + (n-1)(a + \pi)\}$......(49), the sum of which (to n terms, a being $\frac{360^\circ}{n}$) is zero, a result obvious also from the fact that the + terms in the first factor, and also the − terms, differ when expressed as in (45) by $\frac{360^\circ}{2n}$, each taken separately being therefore zero.

The result of this investigation may be thus expressed :—If the pivot axis of the telescope be adjusted so as to be at right angles to the inner azimuthal axis, and in taking a series of repeating measures, the outer azimuthal axis be made vertical, the effect of inclination between the latter is eliminated in the final reading, if the angle measured be a submultiple of 360°, whether the number of the series be even or odd, provided the face of the instrument be not reversed, and if the reversions be successive without this qualification should the number be even.† The maximum error will occur when na is 180°. It is evident that if na approximate to 360° the error will be correspondingly small.

This result is very useful in observations for determining the true meridian by azimuths of the pole star, or of circumpolar stars, owing to whose altitudes the errors last considered enter into the measures with large factors. Fortunately for the general precision of geodetic observations, this remark does not hold good in reference to the measurement of the angles of geodetic triangles.

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* γ denotes the angle measured from the plane passing through both axes to the initial reading.

† The $(2m - 1)$ rule is open to objection in view of this result, as, if reversion of face take place at each successive reading to eliminate collimation and focussing errors, a small error will be introduced through imperfect elimination of axial error. It is easy to decide in specific cases which course to adopt.

Instability of Instrument.

Of all sources of error in angular measurement that arising from instability of the instrument is perhaps the most irregular, and the most difficult precisely to ascertain. All results from single series of repeating-measures should be regarded as subject to correction by some undetermined quantity to be ascribed to this cause, which in general will tend to reduce the value of the arc through which the telescope is turned. Hence this element of instability (which appears to be independent of the magnitude of the arc measured and to due what may be called play in the parts of the instrument) may be at least partially eliminated by measuring also the complementary arc, to make up 360°, and the half difference of the sum of the measures subtracted from 360° may be taken as the value of the constant for instability. Other causes of movement can only be guarded against by delicate handling, and by protection from the effects of variations of temperature, wind, sun, etc. But for this injurious element, small and easily portable theodolites, properly fitted with large telescopes, might be made to serve every purpose required in geodetic operations of a first class character.

In conclusion it may be remarked that a rigorous examination of the errors, and an incisive inquiry into the performances of instruments used in surveys of precision, would no doubt lead to more exact opinions as to the possibilities of this branch of the science of physical measurement, than at present exist; and if this article, which discusses the repeating system so far as the writer is aware on new lines, has aided in any degree the realization of this end, or contributed any suggestions tending thereto, it has achieved its object.

Discussion.

Mr. J. F. Mann—I think this paper is a most valuable one. In the early days of surveying these transit theodolites were not known, but with the transit and with tape measures the most wonderful results have been obtained. I beg to move a vote of thanks to Mr. Knibbs for his paper.

Mr. D. M. Maitland—The information conveyed in Mr. Knibbs' paper is of a most valuable and instructive character, especially to those surveyors who have had any experience in the higher branches of the profession. I am tolerably well acquainted with most works on the subject and have had a fair experience, but he has certainly treated the subject in a manner entirely new to me. I think therefore the paper is all the more valuable. From what I know of Mr. Knibbs I feel sure that any theory he has advanced is certainly based upon his own practical experience, and the observations he has made. For that reason I regard his paper of more value than many of the so-called books on surveying that are issued apparently by theorists who form their theories and then attempt to get evidence in favour of them. I shall be delighted to see the paper in print, and most heartily support the vote of thanks.

THE PRESIDENT—I thoroughly endorse the opinions which have been expressed. This paper will be highly esteemed by professional gentlemen. It will be published immediately. We have now made arrangements with our printers to have papers in print a week or two after they are read.

ON SOME PHOTOGRAPHS OF THE MILKY-WAY, RECENTLY TAKEN AT SYDNEY OBSERVATORY.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[*Read before the Royal Society of N.S.W., August 6, 1890.*]

THE mounting of our photo-telescope being so far complete and waiting only for the object-glass, it became a question whether it could not be turned to some good use, and acting upon a suggestion made by some experiments at the Lick Observatory, I obtained one of Dallmeyer's largest portrait-lenses with a clear aperture of 6 inches and focus of 32.6 inches, and determined to take photos with it which should serve to delineate the southern part of the Milky-Way and show the general character, number and grouping of the stars in it.

Some time was unavoidably lost at the start; it was found that the visual was outside the actinic focus, and it took a number of experiments to determine where the desired focus was, when determined it was found to be confined to a small space about 5 inches in diameter and there is still a doubt in my mind whether any part of the field can be got into sharp focus for stars. It is stated in standard works on photography that in portrait-lenses other considerations are sacrificed to the purpose of getting a good picture of an object 20 or 30 feet distant, and that one of the means used to this end is to separate the lenses more than they should be for distant objects; this may be so, but after getting an adjustable mounting which permitted various distances between the lenses, I took pictures, gradually reducing the distance at each setting, until the lenses were $2\frac{1}{2}$ inches nearer together than when in their own mounting, with the result, that there was no better position than that in which they were originally placed by the maker. I mention this because it may save some one else the trouble of doing it. The next step was to ascertain what exposure was necessary to get in stars down to the 15th magnitude, and I found that three hours was required on a fine night. The telescope mounting works most satisfactorily and there is no trouble whatever in following the stars perfectly, and the difficulty has been the weather, and that has been bad enough to try one's patience ; the time already spent would have sufficed to take all the photos, had the weather been good, but when the clouds have been absent the moon or a haze has generally taken their place. The moon-light reflected from the atmosphere in S.W. when the moon is in N.E. will fog and spoil a plate in ten minutes, and since the stars require three hours it is useless to attempt taking a photo of them when the moon is shining, and a haze hardly visible is found to double the time of exposure. These are some of the difficulties in the way of taking star photos, and viewed in the light of actual experience they are rather serious, and only to be met by the exercise of a large amount of patience. The work is however intensely interesting, it is throwing an entirely new light on the configuration of the stars in the galactic region, and as will appear presently, some of the features which strike the eye of the observer and have been considered characteristic and definite enough to give rise to the most celebrated speculations of the form and arrangement of the universe in which we move must I fear be classed as optical illusions.

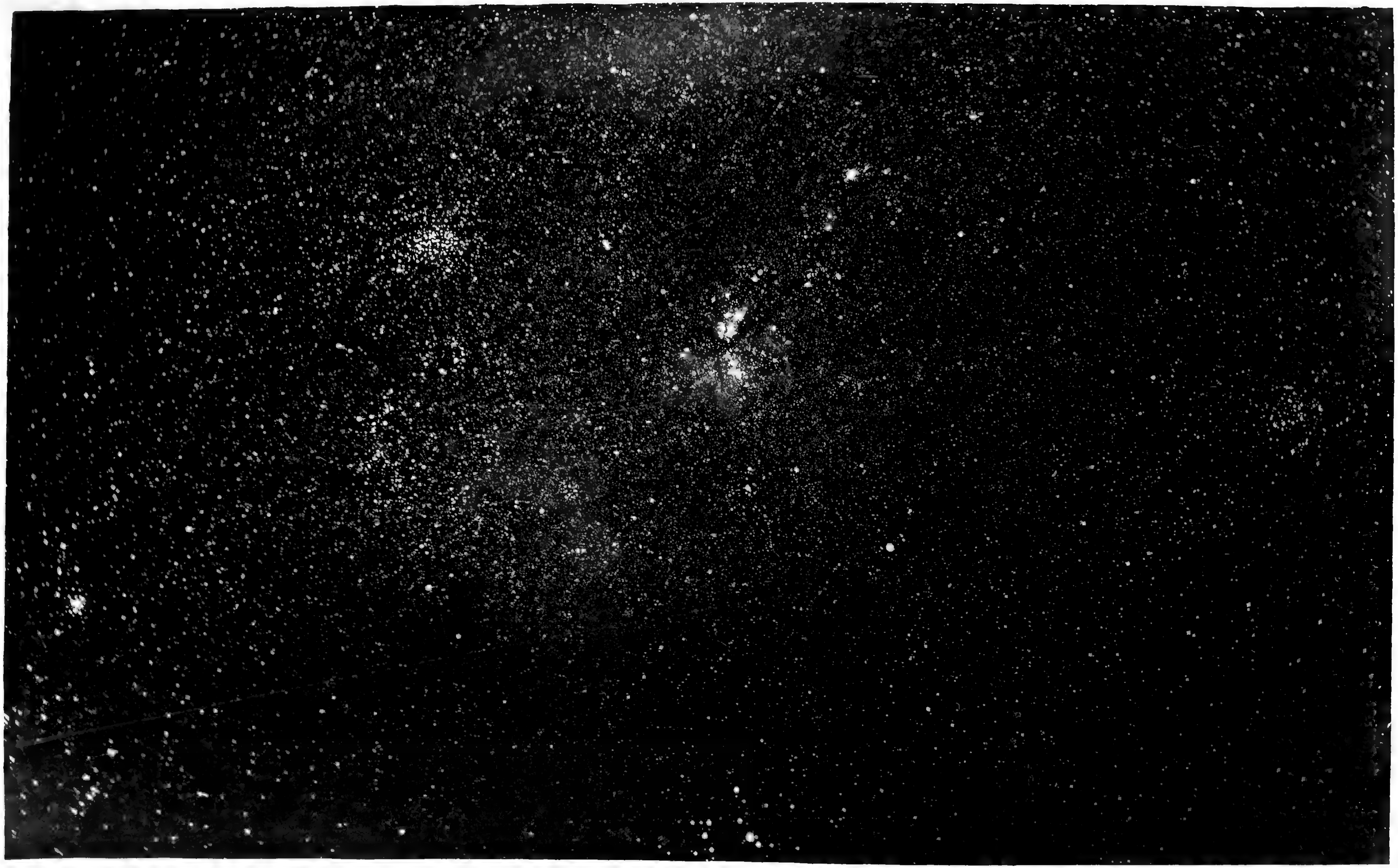
I have mentioned that the lens I am using only gives a sharp focus over a circle of 5 inches diameter, but by adjustment it may be made passible over a circle of 6 inches, provided one does not examine the star images with too great a magnifying power. Outside of that limit the images gradually pass from circles into crosses, and this distribution of the light over a large surface prevents the smaller stars from recording themselves. I mention this for reasons which will appear presently. Another condition has to be borne in mind, and this is, that the photographic plate is so sensitive, and the lens so quick, that a 1st magnitude star records itself in a small fraction of a second, and a 15th magnitude takes nearly three hours; the bright stars must therefore be terribly over-exposed and clusters of stars are apt to be run together from the enlargement of the discs of the brighter stars from over-exposure. Still this is not a very serious drawback to my purpose, which is as stated above to picture the great mass of the stars forming the Milky-Way.

A negative of the Milky-Way is not a very beautiful picture, the plate looks just as if it had been dusted over with black sand,

and it is so unlike a picture of stars that I have only brought one, just to show you what it is like; the best way I have so far found of showing the stars is to make a glass positive from the negative, and this with a bright light behind gives a good idea of a field of stars, and it is very striking to see how the fainter stars shew out in this process, provided the photo manipulation is carefully done. To what extent it would be possible to carry the exposure is doubtful; pictures of interiors of buildings have, I believe, been taken which required ten days' continuous exposure so faint was the light, and there seems to be no reason why plates should not be exposed on the same object night after night until even the faintest objects recorded themselves, if due care was exercised in covering the plate during the day and in other necessary precautions. I have experimented in this direction, that is as to the best time for my purpose to expose the plates, and have come to the conclusion that three hours on a fine night is enough for a first series.

Subsequently another set may be taken with six hours' exposure in order to bring out still fainter stars, but the present series will show stars to the 15th magnitude. Owing to weather difficulties and the short time the lens has been available I have only got good pictures of the Milky-Way about Eta Argus, Alpha Centauri, the Southern Cross, and a point near Alpha Centauri to shew you. Each of these cover a considerable surface, one hour in R.A. and fourteen degrees in declination. If you look at the map you will see that five such pictures would take in all the sky over which the Milky Way is supposed to extend, from the great break near Eta Argus to the constellation Lupus, or nearly all of it that is near the South Pole. In many respects the most striking of the photos I have to show you to-night was one taken on the 24th of July last with the star Alpha Centauri in the centre. The night was fine but not first-class, and the plate was exposed for two hours fifty-five minutes and it seems literally covered with stars.

In the densest part near the centre I have counted in one square degree 1,108 stars, taking next the part which seemed to have fewest stars I found 663 to a square degree; I have counted a number of other portions and get an average of 862 stars to a square degree. As I have already explained, it is only the central part of the plate, a portion containing nine degrees on each side or eighty-one degrees where the definition is good, and over this space then we have 862 stars in each square degree or 70,000 stars; from counting other portions outside this limit of good definition I estimate that there are another 30,000 stars, or a total of 100,000. Sir John Herschel's star gauges of this part of the sky give 936 stars to the square degree, and his telescope was



From a Photograph taken at Sydney Observatory, July 25, 1890

NEBULA AND MILKY WAY.

About Eta Argus.

$18\frac{1}{2}$ inches in diameter. In the experiments in photographing the Milky-Way at Lick Observatory, it was estimated by Mr. Barnard that on one of their plates measuring 10×8 (mine are 6×8) there were 64,000 stars; if we may compare the plates it would appear that in the same area I have about 160,000 stars where Mr. Barnard has 64,000, which indicates that the stars are more numerous in the part of the sky about Alpha Centauri than in the northern part of the Milky-Way. I feel sure that so far we have not had a single photo taken under the best conditions, that is a clear bright night with little wind, and when we do get such weather I shall not be surprised if the regions now photographed yield 50 or 100 per cent. more stars, for such hazy bad weather as we have had for months past is most unfavourable for this work.

I have brought one photograph of the region in which the Southern Cross is situated to show you what the coal sack is like. You will see that there are hundreds of stars strewn over it, and a curious zig-zag line of stars extends from Alpha Crucis to the solitary 7th magnitude star in the coal sack, and that there are two small and striking clusters of stars, but this picture was taken on a very bad night and does not show as many stars here as it ought to. It will be observed that a ring of stars incloses the dark space, but it is more remarkable for the greater brightness of the stars than for their numbers. The photograph of the region round Eta Argus shews a condensation of stars as close, or nearly so as that round Alpha Centauri, and is perhaps still more striking owing to the numbers of clusters of comparatively bright stars on it, and I think that the curious grouping, curved and straight lines, circles, ellipses, etc., which may be traced here are more remarkable than in the other plate. You will observe that there are two negatives of this region, one taken with the longer dimensions of the plate in R.A., the other one with it in declination, but the point to which I wish to call your attention is that the better one of the two was exposed for two hours and forty minutes and the other one for three hours and five minutes. The difference between them is striking. The longer exposure was on a fine night, but it had a slight and almost invisible haze to contend with, and this apparently slight drawback was sufficient to reduce the number of stars it contains by fully one-half, although it had a longer exposure by fully twenty-five minutes. The positive from the better of these two plates is most successful; the photographer has caught just that exposure and density of the image giving the best and most pleasing picture conditions, which are not easy to attain. In this case it serves to bring out with great clearness the marvellous beauty of this portion of the heavens. I will not try to picture it for you in words because the task is a hopeless one, the only way for you to get an idea of its beauty is to examine the picture which I have brought for that purpose and then you will understand the overpowering effect which such a vast multitude of stars, their variations in size and arrangement have upon the mind.

I began this work, as I have already stated, with the object of delineating the southern portion of the Milky-Way and showing where its limits may fairly be placed, but a host of other questions present themselves as one examines these plates with all the stars of wide sky space brought directly under the eye, in a way that it is otherwise quite impossible to see them : for with a telescope large enough to show these minute stars one is fortunate to get a field of view equal to one-quarter of a square degree, and to carry on such views in the mind's eye, remembering the features of several to compare them as if all seen at once, is impossible. But here we have 140 square degrees at once in view, and we can see how the curve of stars in one telescopic field is but part of an oval, a circle, or some other figure in its full development here; but I am not going to detain you upon this question. I have not yet had time to examine the plates in detail and read their story, and I must leave these points to a more convenient season. After showing what a large sky space these plates cover ($14° \times 10°$) I shall perhaps be asked why it is necessary to have all the elaborate machinery and large telescopes agreed to at the Paris Conference, and the ten years of work, while with this instrument one man with good weather might do the whole sky in a year. The answer is a simple one: here the object is to get as much into one plate as possible; there the object is to make the stars as far as possible apart, so that they may be measured accurately, and double stars divided which with this camera are not seen to be doubles at all, and lastly to have all the stars sharply defined.

One of the most striking features of these star photographs is that some of the well-known dark spaces in the Milky-Way seem to be absent, and one looks in vain for the great rift in the Milky-Way at the head of which stands Alpha Centauri. To the naked eye it is a great dark space dividing the Milky-Way into two streams, and its presence there led to Herschel's speculations of the form of the universe of stars in which we live, and in all other schemes to account for the arrangement of stars in our universe this rift has been an important factor; and yet as we look at the photograph it cannot be seen, stars as numerous as in other parts round Alpha seem to fill up the void; and we are driven to accept the conclusion that the theories based upon what the eye sees, are resting upon very faulty data. It is quite evident that the stars extend all over this region as thickly or nearly so as in other parts; and in future pictures of the Milky-Way, a very different figure of this and probably of other parts must be given. As we saw just now even the coal sack is full of diamonds, so here we find no rift in the stars of the Milky-Way, but the same distribution of stars as in other parts. It has always seemed to me that the theories put forward to account for the visible Milky-Way were most fantastic and improbable, and that something must be wrong about the facts which required such views to account for them, because they are so unlike the arrangements which we can see amongst distant nebulous bodies.

Of course the question at once arises, if these stars have no effect on the eye why are they so conspicuous with the photographic eye. In looking at the stars in these spaces with the large telescope, I have always had the impression that I was looking at stars through a mist, and accounted for their faintness by supposing that cosmical clouds intervened, a view that has been held by many, but their presence here may mean that speaking generally, the stars in these regions are more powerful in photographing themselves than those in other parts. There might, for instance, be a preponderance of blue or of white stars, while other parts conspicuous to the eye might have a large number of yellow and red stars, and every one who has examined the bright parts of the galaxy knows how these colours congregate in the brighter parts of it; such stars of course have very little power in recording themselves by photography. If such be the case it would account at once for the difference between the visual and photographic picture. But I am disposed to think that this is not the main cause, although it may have something to do with it; what seems to be the real cause is a fault in the photographic method, which will have to be carefully remembered in using it, for it tends to exaggerate the small stars and show them out of their true relation to the larger ones. Suppose for instance a photo is taken of a group of stars of various sizes, the light from the brighter stars continues to shine on one part of the plate, and when it has produced all the effect that can be produced on that part of the film it can do no more, no matter how long the exposure is carried on; during the same time that the larger star took to produce its full effect, the smaller one with its feeble beams produces but a very slight effect on the sensitive plate, but by continuing the exposure the feeble star goes on accumulating its effect upon the film until ultimately it will have done as much as the brighter one. Or to put it another way, this process may be carried on until the true relation of the stars is destroyed; and in order to make the camera show us what the eye sees, a series of pictures is necessary, shewing first the brighter stars, then those of the next magnitude, and so on. But the fact remains that in some of the great dark spaces of the Milky-Way we have probably as many stars, fainter though they be, as we have in the other parts.

AUSTRALIAN ABORIGINES: VARIETIES OF FOOD AND METHODS OF OBTAINING IT.

By W. T. WYNDHAM, Boyne Island, Queensland.

[*Read before the Royal Society of N.S.W., August 6, 1890.*]

NOTES on "Sugar Bag"[5a*] and the different ways the aborigines have of finding honey.—The little black native bee the Ucumble call cobbi[1], alone, I think, inhabits the Western Waters. There is another bee[2] that is found in the Eastern Falls as well as the cobbi, called by the blacks in other dialects worell, which makes an acid honey, and is common in the district where I am now located. The large bumble bee[3] probiccullo, bores in the dead wood, particularly in the old stems of the grass tree. The cobbi is found in the winter season chiefly through the habits of a large sort of weasel[4] and a squirrel[5] that gnaw a hole in the bough where the sugar bag is, so that the aborigines often detect it by the marks made by these animals.

The cobbi towards the fall of the year collects rosin[6] off the cyprus pine tree, gathering it on their hind legs in little round pellets that they have manipulated with their forceps, and as they crawl over the bark on the way to their hole, they leave slight tracks of this rosin and pollen. The aborigines minutely look at the bark of a likely tree and trace them by these indications. There is also another way of tracing the bees in the winter time by the excreta of the squirrels and weasels from under the trees and this the green headed ant[7] is particularly industrious in collecting in their nests. Aborigines go down on their knees and blow the dust from the ant's nest with their mouth, picking up on the end of a small straw, which they wet with their mouth, any likely looking little pellet which they carefully squeeze between their thumbnails, and often smell. The next thing is to go up the nearest tree, and trace the hive by means of the various indications before described. In the summer time the hive is found by looking at likely boughs towards the sun, when you can see the bee between the eye of the observer and the light. The dogs of the aborigines frequently find the honey in blown down timber.

The next plan which affords by far the best sport is running the bee home from a tree where it is collecting rosin. Frequently three or four old men may be seen sitting down under one or more trees with bags of the down of the eagle-hawk[8] and lumps of pipe clay,[9] and each with a little flattened stick. One of the natives

* The small numerals refer to list under index at the end of paper.

will draw out some of the down between his finger and thumb, working it on his thigh with finely powdered pipe clay and making two minute shaped balloons[10] of down. These he places lengthways on the little flat stick, and then takes the two little down balloons between the thumb and second finger and watches the bee closely while it is collecting rosin. As soon as he sees that the insect has nearly loaded, he adjusts the two balloons with great slight of hand, and thereupon some of the young men and gins, but not the whole party, immediately give chase to the bee which goes in a straight line to its hive, often times situated at some distance. There are generally three or four relays of aborigines waiting at the feathering, so that there may be several hunting parties going in different directions at the same time. It is possible however that a large dragon fly may pounce on the bee and spoil the run. The introduced European bee is very easily found, since in dry weather by sitting by a waterhole from whence you can observe in which direction the bees fly, and by using a pocket compass it is possible to walk straight to the hive. The bumble bee[3] carries a round pellet of pollen and honey about the size of a small marble found in separate partitions about two inches long inside the grass tree or dead stick in which the young grub exists. This is also found by the aborigines by eyesight.

With regard to fishing, it will be necessary to mention the name of the fish that principally inhabit the Western Water commencing with the Murray cod[11], and then for instance yellow-bellied perch[12], jew or cat fish[13], bream[14], small speckled perch[15]. A hand net is most in use[16], another variety is a net about two or three yards long, oblong in shape[16], but this latter one is frequently used as a drag-net, as well as in another fashion. I enjoyed a month's fishing some thirty years ago, wandering down one of the Western rivers that fall into the Murray, living as an aboriginal, as was my wont when out of my country or beat[17] of my tribe, when I suddenly came on a large camp of aborigines. They unfortunately did not understand my dialect, so that I found myself in rather disagreeable quarters; though I knew they were a mixture of Wallerii, Cumilii, and Wirragarii, as soon as I heard them speak. My first proceeding was to sit down in the approved style and hold my peace. On looking round I saw they were camped by a fall in the river, and that they had heaps of fish roasted round their fire. By and by when we began to converse by signs and other means, they produced a gin that could speak Ucumble indifferently, so I had to tell them all the news such as where I had come from. I noticed that some of the gins and all the black fellows were very busy twisting up Korygong bark and making nets. Being myself exceeding fond of fishing, and from my childhood an excellent netter I at once let them see I could net, thinking it the safest thing to do. After having a good feed of roast fish, I thought to continue my journey, but the blacks did not see the force of it, and I submitted with patience. I was kept netting for a month or more. (I saw one of these blacks years afterwards on the Peel River, and he recognised me). The water was rushing over the fall in half flood, and the fish were obstructed by the fall. Four or five blacks entered this turbid water at the same time. Although an excellent swimmer I did not care at first to look into a boiling cauldron, in that there seemed a fear lest all would be dashed to pieces. Those in the water held one of the oblong nets on high between their hands, and all dived in beneath the rushing flood. I found afterwards, when I picked up courage to go in with them, that they pressed the net flat down on the backs of the fish, and then all seizing the fish in their hand from under the net rose to the surface, and struggled to the shore with their booty. I went in frequently afterwards with them, and it was something extraordinary to feel the fish all round you, and to find them lying in heaps as it were, in every hole and cranny of the rocky bottom. It certainly was to one who has been fishing and hunting a life time a most exciting method of fishing.

There are three sorts of fresh water turtles or tortoise[19] that come out to lay their eggs about September, particularly if there should chance to be rains. The aborigines knowing the time were accustomed to go along the banks of the rivers and track the turtles to their nests, which generally contained twelve eggs. The nest is usually concealed with a cake of mud, and so nicely hid, that it is somewhat difficult to find. The turtle was caught frequently on the nest, and I have often seen the aborigines dive in the water and catch them with their hands.

Of cray-fish[20] the aborigines eat quantities. A large sort they dig out of, or catch in the swamps of New England, a smaller sort (that inhabits I think all the small fresh-water creeks of Australia) they catch under stones among roots and in banks. This reminds me that the name I went by among the Ucumble tribe, was Cray-fish, or Goonool, and I got it when I was a "New Chum" under the following circumstances: there was a great drought, and I used to turn over the stones in the bed of the rivers, whereupon the aborigines spotted me, and gave a name that clung to me for ever after. They also eat the fresh-water mussel[21] procured by means of their toes, from the muddy banks of the rivers. Shrimps or prawns[22] are also consumed.

The aborigines used to walk along the river banks with a spear and throw in little pieces of peeled white wood into the clear holes amongst the weeds; the cod fish would rush up thinking it was something good to eat, and get speared. Often when the water was low in a drought, I have seen the aborigines spear five or six cod, whilst the rest of the fish would take no notice until however one by and by, would get away wounded, and strike the bottom making a bumping noise, when every other fish in sight would disappear and hide. The blacks used to say, he sounded or struck his heliman.[23] There are two flat bones in the cod's head which the blacks used to point out to me, and say they were the fishes shields, and they sounded them. In some parts they poisoned the water when nearly dried up, with certain leaves and weeds. In Central Queensland where I now reside, they have many other ways of fishing on the coast, but it is scarcely worth my while mentioning them, as it would take up some space, and others resident here are no doubt better informed than myself. On Keppel Island the blacks used to collect the small blue crabs that travel about in hundreds at low water on the sands, and at night take a torch of ti-tree bark. On the shore under the cliffs there were quantities of large crevices amongst the rocks that the water rushed up and boiled over in on the flood tide; in these they would go with their torches and throw in handfuls of the blue crabs as "berley." As soon as they saw the fish come to the bait they would plunge into the lower end of the crevice and catch them. By daylight quantities of large fish, dugong, turtle, and others were speared.[24] The spear head was fitted into a socket and a line attached to the head, so they frequently if a very large fish was struck you would see the black fellow, his gins, and piccaninnies, all lay hold of the line and so get towed to sea, when it used to be a fair fight which should be the winner, the fish or fishers.

The emu and bustard I have often seen hunted in the following manner:—the birds would be feeding on the open, whereupon a number of the men would start off with their spears and making a large détour would get well down to windward of them, when they would climb the trees and wait in ambush, the rest of the tribe would now let the birds see and wind them at a great distance, whereupon the poor birds would walk away, and fall an easy prey to the men in ambush. Another common way of spearing the emu was to find out any place the bird was in the habit of feeding, being fond of fruit and berries, when a black fellow would place himself in a tree over the shrubs that bore the fruit, and wait with the greatest patience day after day, until at last he generally succeeded in killing the emu.

A common way of hunting all the species of kangaroo[26] was by making a large détour and forming a circle which would gradually lessen until the natives forced the animals into a cul-de-sac.

Moths, grubs, cockchafers, and their larvæ are consumed in great variety by the aborigines. There is a grub that lives in the oak tree which the Ucumble blacks call Billarngun. The name is derived from Billar a swamp oak tree. The beetle or cockchafer that is the mature form of the grub, lays its eggs in the tree. This grub is good bait for fishing. The blacks eat both the cockchafer and grub, roasted and raw. Another grub called Yarungun derives its name from inhabiting yarrar gum tree. The perfect insect is a very large handsome moth. The method of a grub hunt is as follows: at the bottom of the gum trees on the ground the grub's excreta is to be seen like saw-dust, and from the size of the pellets, the size of the grub that drops them can be judged. If considered worthy of trouble, the native examines the trunk and boughs of the tree, and possibly finds a minute hole about the size of a pea. If the grub is large, the bark most probably will be slightly puffed up. Where upon the tomahawk is used to chip the tree where the hole seems to be, and then with a little hook, called in Ucumble Nilla, [of which this is a diagram]

the grub's hole is forced till the grub's head comes into view and by giving a slight twist with the finger and thumb, (it needs some practice) the native will hook the grub by the head and pull him out neatly and whole, if not sufficiently expert most likely he will be broken and the hunter will have to lick up the gravey. These grubs are most delicious, particularly when roasted. A similar moth is very fond of laying its eggs in the roots of the wattle tree. The aborigines find it both by the saw-dust and by seeing where the bandicoots, and kangaroo-rats[26] have been scratching in endeavouring to get at the grub. All these larvæ are known by the name of Beeu, though the different species have a name of their own. There is one in the ground that turns into the Cicada, (commonly known as the locust) the blacks collect the larva as they come out of the ground on a damp night in order to crawl up the trees, throwing off their chrysalis state and turning into locusts. They carry a torch for the purpose.

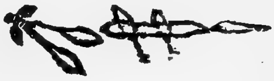
It is a long while since I lived with the Ucumble tribe, and I have consequently lost much of their language; only a few of them are still alive, and if I had time, I should much like to stay with them and freshen my memory.

Index.

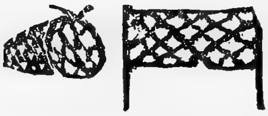
No.		Ucumble	Various Native Languages.
1	Small native Bee	Cobbi	
2	Larger sized, Eastern Waters	Worell, acid honey.	
3	Bumble Bee	Probiccullo.	
4	Large sort of Weasel	Murroe.	
5	Squirrel	Bunga	
5a	Honey or Sugarbag	Narrow	Gooney.
6	Cyprus Pine	Toolgil.	
7	Green Head Ant	Goonan.	

No. Ucumble — Various Native Languages.

8 Down of Eagle—Goora.
9 Pipeclay—Goongun.
10 Diagram—Balloons



11 Murray Cod—Correll. — Coodo.
Very large size—Mundre.
12 Yellow-bellied Perch—Gidarl. — Tucci.
13 Jew or Cat-fish—Wargerber, — Tucore.
14 Bream—Coopre. — Cumbarl.
15 Small speckled Perch—Pubbe. — Bobbe.
16 Hand-nets—Bundamull. — Oöloö.
Longer net I have lost the name of.
Diagrams—



17 Country or land—Thary.
18 Korygong—Yappre.
19 Green Turtle—Toure. Seldom leaves the water except to lay its eggs. A stinking sort Boolagre emits a nasty stench if you handle him and is marked rather prettily on his belly. There is another larger sort with very long neck, I forget the name. The two last you will find on land, indeed sometimes up a mountain, where you never would expect to see them.
20 Cray-fish—Goonool. Ginnon. Inga. Another sort of Cray-fish burrows on the swamps of the table-land of New England, I have lost the name.
21 Mussels, two sorts—Uere.
Larger sort—Undan.
22 Prawns—Geendarnger.
23 Shield—Tungi.
24 Diagram of spear—

25 Emu—Noorun.
Bustard—Ombilgo — Buraower.
26 Big Forest Kangaroo—Bundar.
Red Jacket—Kooroman.
Walaroo—Tandor. Yulama.
Rock Walaby—Weegul.
Scrub Walaby—Waugoey. — Mye.
Kangaroo Rat—By.
Feather-tailed Rat—Gemma.
27 Bandicoot—Ooni. — Cooroo.

List of Drawings in water-colours executed by Miss Wyndham, in illustration of the above paper.

1. Tow Tar, a creeper common on alluvial flats from the Hunter River to the Fitzroy. Root baked or steamed, very good eating; large quantities eaten by aborigines.

2. Marar a flaggy grass used for making Dilly bags, Nullo, Nindore. First allowed to get dry, then damped and used as wanted.

3. Goonerang a vetch-like creeper. Root first roasted then pounded between stones, chewed and the fibre spat out, large quantities used. Has a liquorice flavour.

4. Coolo, the grass mentioned by Sir T. Mitchell, known by the aborigines from Liverpool plains to Central Queensland, and most probably much further; the seed is very minute, but notwithstanding it was greatly used ground with water into a paste between flat stones, then baked in ashes. Yappoola Central Queensland.

5. I have forgotten aboriginal name, but the seed-pods were roasted before ripe and the husks only eaten on the Mackintyre and New England.

6. Native Pomegranate, Bumbul, here Nunky. Fruit when ripe smells very good and has a nice flavour. There are several varieties of this fruit in Central Queensland, I think they are called capers.

7. Koomine, a bean root largely used and decidedly not bad.

Remarks on the Drawings by Rev. Dr. Woolls, F.L.S.

1. *Boerhaavia diffusa*, Linn. (Nyctagineæ). According to Mr. Bentham (" Flora Australiensis, Vol. v. p. 278), this is a common weed in the warmer regions of Asia and Africa, and is widely diffused through the Australian Colonies, especially on alluvial flats. It is highly esteemed in the Western Districts as a fodder plant; and Mr. E. Palmer, M.P. of Queensland, states, in his " Notes on some Australian Tribes; London, 1884," that the tap-root has a pleasant mealy taste, is very nourishing, and is eaten by the blacks on the banks of the Mitchell and Cloncurry." The same plant is mentioned as an article of food amongst the blacks of Western Australia (Grey's Expeditions, Vol. II., p. 292).

2. *Xerotes multiflora*, R. Br., (Juncaceæ) is common to N.E. and S. Australia, as well as to Victoria, and with other species of the genus, it may be utilised for its strong fibre. Baron F. von Mueller, in referring to *X. longifolia*, R. Br., remarks: "This plant is dispersed throughout S.E. Australia and Tasmania, and it can be employed both for printing and writing paper. It has the recommendation of great tenacity. Several allied species will yield similar material. The aborigines make baskets (Dilly bags ?) of it. (" Report for Intercolonial Exhibition, 1867 ").

3. *Glycine tabacina*, Benth., (Leguminosæ) (so called according to Mr. F. M. Bailey, F.L.S., because it is used as tobacco) is a slender twining plant common to the Australian Colonies and Tasmania. The root is said to have the flavour of liquorice, and

is chewed and relished by the blacks. An allied plant (*Kennedya monophylla,* Vent.) Mr. Bailey states, is called by bushmen 'Native Sarsaparilla,' and its roots are used in decoction as a beverage. It is scarcely necessary to remark that the real native Sarsaparilla is *Smilax glycyphylla,* Sm., known as 'Sweet Tea.'

4. *Panicum decompositum,* R. Br., or *P. lævinode,* Lindl., a semi-aquatic grass, called 'Blue Polly' or 'Umbrella Grass,' is one of the most valuable native grasses. Sir Thomas Mitchell was the first to notice how it was utilised by the blacks ("Expeditions, Vol. I., p. 238), and Mr. E. Palmer ("Notes on some Australian Tribes, p. 42") states that "they gather and grind the seeds between two stones with water, and bake the substance as a cake in the ashes . . . . . It is found nourishing and satisfying."

5. *Eustrephus angustifolius,* R. Br., a liliaceous plant common to Queensland, N. S. Wales and Victoria, having weak and flexuous stems, and a climbing habit. The flowers are of a pale colour, and the fruit nearly globular and of an orange colour. Mr. O'Shannesy, F.L.S., says that it has sweet tubers an inch long. The allied plant (*Geitonoplesium cymosum,* A. Cunn.) is called by the blacks "Garran," and the roots are compared to asparagus, ("Frag. Phytographiæ Australiæ, Vol. VII., p. 74").

6. *Capparis Mitchellii,* Lindl., (Capparideæ) called sometimes "Native Pomegranate" is a small tree, and it was regarded by Dr. Lindley as one of the most interesting plants discovered by Sir Thomas Mitchell. M. Thozet, in his "Notes on Roots etc. eaten by the Blacks," says that the natives of the North called it "Mondo," and that its fruit is two or three inches in diameter. Several species of *Capparis* have edible fruits.

7. *Phaseolus Truxillensis,* H. B. & K., (Leguminosæ) is a twining or trailing plant of Queensland and North Australia with pinnately trifoliate leaves. M. Thozet says that the blacks of the Cleveland Tribe called it "Kadolo," and those of Rockhampton, "Komin." He describes the pods as cylindrical, two to four inches long, and the roots shaped like carrots.

Discussion.

Mr. T. W. Edgworth David, F.G.S.—Apropos of the food of the aborigines it may be of interest to some of the members to know that the aborigines in Maitland District at all events were particularly fond of the fruit of the Macrozamia. Mr. Elliott who used to reside there, told me that the gins used to gather it when ripe and would put it to soak in nets made of the fur of opossums. After allowing it to soak for three or four days in rain water, they would bruise it and bake it into cakes fifteen inches in diameter and eat it when hungry. As regards animal food there is no doubt that a tribe who lived at Maitland were cannibals at times when their ordinary food supply was scarce. They generally subsisted on kangaroos, wallaby, native bear, opossums and any fish they could spear, and also a good deal on snakes. Mr. Elliott told me there was a black who lived at his selection, and did not migrate like the others, because he said the whole of Mr. Elliott's selection was on a bit of land the King of the tribe gave to him, and he always resided permanently upon it. This black knew the life history of nearly every living creature on this piece of land, and he particularly studied the snakes. One day Mr. Elliott saw a large black snake near his hut, and killed it. Presently this black-fellow came up in a terrible state of indignation, "What you done?" Why do that? Why you kill that fellow? Me watch that fellow this long time. That fellow not fat enough yet. Me wanted by and by to kill and eat him when get fat enough." It shows what kind of observation they take of the different classes of food on which they set special value, especially snake preserves.

WEDNESDAY, JULY 2, 1890.

Dr. Leibius, M.A., F.C.S., President, in the Chair.

Forty-two members were present.

The minutes of the last meeting were read and confirmed.

The Certificates of five candidates were read for the third time, and seven for the second time.

The following gentlemen were duly elected ordinary members of the Society :—

Allan, Percy, C.E., Sydney.
Burne, Dr. A., Sydney.
Nardin, E. A., C.E., Sydney.
Vicars, James, B.C.E., Ashfield.
Wilson, James T., M.B. Univ. *Edin.*, Sydney University.

In the absence of the author, the Hon. Secretary (Mr. Kyngdon) read a paper by Baron Ferd. von Mueller, K.C.M.G., M. and Ph.D., F.R.S., &c., "Record of hitherto undescribed plants from Arnheim's Land.

Prof. Anderson Stuart, M.D., exhibited a new mode of demonstrating the manner in which the mind judges of the position of objects in the outer world; also working models demonstrating the value of the spinal curves in diminishing the evil effects of mechanical violence.

The Rev. Robert Harley, M.A. *(Oxon.)*, F.R.S., exhibited Charles third Earl Stanhope's Arithmetical machine bearing date 1780, also his 'Demonstrator' an instrument for the performance of logical operations which he described as follows:—

"On the Stanhope Logical and Arithmetical Machines."

Abstract.

Charles third Earl Stanhope* is known to science by his mechanical inventions. The works to which he owes his celebrity are chiefly the following:—A printing press and a microscopic lens, both of which bear his name, a method of securing buildings from fire, an arithmetical machine, a monochord for tuning musical instruments, certain improvements in the process of stereotype printing and in the construction of locks for canals, and a steam-boat, or, as it was described by its inventor, a vessel to sail "without the aid of either wind or tide or oars." But until within recent years it does not seem to have been generally known that the Earl devoted a large portion of his life to the study of logic and that he invented an instrument for the mechanical performance of logical operations. None of the accounts which appeared of his intellectual labours contained any allusion to his researches on the subject, or to the curious contrivance which he called

The Demonstrator.

His logical speculations which employed his thoughts more or less during a period of thirty years, remained absolutely unpublished and unnoticed down to the time when the present Earl found among the relics of his scientific ancestor the logical instrument which I have now the honour to exhibit to the Society. At the suggestion of the late Mr. William Spottiswoode, then President of the Royal Society, this instrument was placed in my hands for examination, and I soon discovered that it was constructed with a view to the mechanical solution of logical problems. The discovery led to a search being made in the archives of the Stanhope family for letters and other manuscripts relating to the Earl's logical inquiries. Such remains as could be found were entrusted to me for a time, and I studied them with care, embodying some of the results of my studies in a paper entitled "The Stanhope Demonstrator: an instrument for performing logical operations," which was communicated to the British Association at the meeting in Dublin, 1878. This paper with some additions

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* Born 3rd of August, 1753, died 15th December, 1816.

was afterwards printed in *Mind*, Vol. IV., pp. 192–210. The materials in my possession did not enable me to give a complete or systematic account of Stanhope's views on logic, nor was that the object of my paper. What I endeavoured to do, was to bring out, so far as I had been able to collect them from scattered and fragmentary hints, those points in his system which serve to illustrate and explain the working of his Demonstrator.

For a full description of the instrument and the manner of working it, the members are referred to the paper above cited.*

THE STANHOPE ARITHMOMETER.

I am not aware that any account of this instrument has hitherto been published, though its existence has long been known, in fact there are no fewer than four in existence; one is in the hands of the present Earl, (the great grandson of the inventor), two others of like construction, have come into the possession of General Babbage, who found them among the relics of his celebrated father Charles Babbage, and the fourth, a much smaller and less effective instrument, here exhibited, has become by deed of gift, my own property. It was probably one of the earliest that Stanhope devised and caused to be executed.

On the face of the instrument are twelve moveable discs of which nine are for pounds, namely units, tens, hundreds, &c., up to hundreds of millions, and the other three are for shillings, pence and farthings, respectively, namely twenty shillings, twelve pence and eight farthings, the last mentioned being constructed for eight instead of four farthings, in order, no doubt, that the spindle carrying the disc might not be inconveniently small. The instrument is nine inches long, three inches wide, and nearly an inch deep. It is of excellent workmanship and bears the inscription. "Visct. Mahon Inv. 17/80 Jas. Bullock Fecit."

The following description applies chiefly to the pound or decimal discs, but much of it applies also to the others. The discs lie level with the face or upper plate, in openings made to receive them. Round each disc there is engraved a circle containing the ten digits, 0, 1, 2 ... 9, the alternate discs having these figures arranged in the reverse order. On each disc, near to its circumference, there is a series of equidistant holes, each hole being situated opposite one of the figures in the surrounding circle. A hand or pointer on the disc coincides with the centre and one of the holes.

The process of addition is performed by inserting the point of a style in the hole opposite the figure 0 in the circle surrounding the disc, and moving the disc in the direction 0, 1, 2, 3, &c., until

* Mr. Harley has presented to the Society a separate copy of his paper and also a photograph of the instrument taken by Mr. Hurwood of Liverpool-street, Sydney.

the style is opposite the figure to be added, and then the hand on the disc will point to the result. When the hand passes over the space between 9 and 0, a unit is carried to the next higher disc. In like manner the addition of each succeeding digit is effected on its own disc, the units on the unit disc, the tens on the tens, and so on.

To effect subtraction, the point of the style is placed in the hole opposite the figure to be subtracted, and the disk is moved in the direction 3, 2, 1, 0 until the style is opposite 0. The hand then indicates the result. If in the process the hand passes the space between 0 and 9, a unit will be deducted from the superior disc.

The instrument enables us also to perform multiplication and division, but not so readily as the larger machines constructed by the Earl.

Each disc is placed on a tubular spindle carrying—

1. A flange which lying immediately under the face or lid of the box, keeps the mechanism in its place. The flange is somewhat larger than the disc.

2. A wheel having ten teeth, and

3. A "carrying-tooth," to effect the carriages, that is to say, to move the next higher disc one figure forward or backward when passing from 9 to 0 in addition, or from 0 to 9 in subtraction. This "carrying-tooth" is of rather more than twice the radius of the toothed wheel. When therefore it gears and moves the wheel on the next superior disc, it does so at a correspondingly greater speed, and therefore with a proportionate loss of power. This is of no consequence so long as the carrying affects only one or two of the higher discs, but when they all indicate 9, and the carrying has therefore to run through the whole series, a practical difficulty arises. Thus, let the disc indicate 999,999,999, and let 1 be added; then each disc will have to advance one figure, and since the whole movement forward has to be effected by the movement of the units disc, the force required will be enormously greater than would be sufficient to move the units disc by itself. Each carrying tooth is necessarily in the same plane with the toothed wheel into which it gears; but in order that the carrying teeth may not interfere with each other, they are arranged in three different planes. Each tubular spindle fits into a pin of the same length fixed in the bottom of the brass box containing the machine. On this pin it revolves freely as required. Each disc is steadied by a grasshopper spring, one end of which is fixed to the box, the other or free end being V-shaped and falling between two teeth of the above-named toothed wheel. Besides steadying the disc in each of its ten positions, this spring completes the work of carrying, for each carrying tooth leaves the wheel into which it gears before it has moved the latter through a full tenth of its circum-

ference. When carrying simultaneously through the whole series of discs, the great force required is more than these springs can exert; and consequently the operation is not completed; the toothed wheels become in fact locked together.

It has been pointed out to me by Mr. Joseph Edmondson of Halifax, (England), who is himself the inventor of an excellent calculating machine, that the process employed by Stanhope is precisely that performed mechanically in Babbage's celebrated Difference Engine as well as in that of Scheutz which was founded on Babbage's. He also remarks that in Babbage's Analytical Engine, which was never completed, the carriages are effected simultaneously and "before the additions from which they result."

Mr. H. C. Russell, F.R.S., one of your Vice-Presidents, who has carefully examined the internal mechanism of Stanhope's Arithmometer, remarks:—"It is very interesting as indicating the method so painfully slow, by which inventions progress. Mentally of course we add up the shillings until 20 is reached, and then we carry one, so following this process the Earl arranged his counter to push the next disc on one suddenly. Now it is obvious that there is no necessity for pushing on the second disc in this sudden way. The same purpose would be served by putting on the axis of the shillings wheel a pinion of ten teeth; and on the second disc a wheel of two hundred teeth, one turn of the shilling wheel would slowly turn the next wheel one-twentieth; and there would be no need for a stop spring; and if this method were carried through the whole series of discs there would be no more force necessary to carry one all through than at any other step in the process. But Earl Stanhope was making a machine to do what was before done mentally, and in that way it is more convenient to carry one by a jerk, than to look at it as gradually accruing, and therefore the machine had to carry one by a jerk motion. I want some inventor to go another step and produce a machine which will admit of units, tens or hundreds being added at pleasure. The hundreds by moving the first handle, the tens by the second, and the units by the third. So that the computer reading 765 would turn the first handle 7, the second 6, and the third 5, and know that the machine had counted 765, It would be invaluable in meteorological work. I have a design for one, but it has so far gone no farther than the design."

The following donations were laid upon the table and acknowledged:—

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RECORD OF HITHERTO UNDESCRIBED PLANTS FROM ARNHEIM'S LAND;

By BARON FERDINAND VON MUELLER, K.C.M.G., M.D., PH.D., F.R.S. &c.

[*Read before the Royal Society, N.S.W., September 3, 1890.*]

HABENARIA HOLTZEI.

Glabrous ; lower leaves narrowly elongate-lanceolar, the next gradually smaller, the upper more bractlike ; spike densely small-flowered ; bracts linear towards the base, gradually narrowed upwards, much pointed, about as long as the flowers or surpassing them in length ; calyx-lobes white, broadly lanceolar, the lower oblique ; paired petals also white, narrower than the calyx-lobes, but nearly as long, broadish towards the base ; labellar petal slightly longer than the others, its middle lobe upwards filiform-linear, the lateral lobes several times shorter, deltoid-semilanceolar, the descending appendage clavate-filiform, about as long as the calyx-tube; fruit ellipsoid, much attenuated at the very summit. Height about 2 feet. Root not obtained. Larger leaves extending well up on the stem, to 6 inches long, to ½ inch broad. Spike measuring about 3 inches in length. Fowers numerous, but crowded. Lowest bracts to ¾ inch long. Lobes of the calyx hardly exceeding ¼ inch in length. Ripe fruit nearly ½ inch long.

Seeds brownish, almost cylindric, at the nucleus slightly turgid, somewhat twisted and streaked; the testule membranously protracted at both extremities, truncate at the one, accuminate at the other; whole length about ½ mm.

The aspect is quite different from that of any other Australian species. In some respects it approaches however *H. elongata*, but the labellum is more than that of *H. xanthantha*.

As regards extra-Australian species our new one merges towards the group containing *H. linguella*, *H. acuifera* and *H. densa*. *H. elongata* according to Mr. O'Shannesy, has green flowers; Mr. Holtze found them greenish-yellow, and mentions that the flowers of *H. graminea* are flesh-coloured and fragrant; the variety *Arnhemica* he notes as having greenish-yellow flowers.

SOME APPLICATIONS OF THE RESULTS OF TESTING AUSTRALIAN TIMBERS TO THE DESIGN AND CONSTRUCTION OF TIMBER STRUCTURES.

By W. H. WARREN, M. Inst. C.E., M.Am. Soc. C.E., Wh. Sc., Challis Professor of Civil and Mechanical Engineering at the University of Sydney.

[With Nine Diagrams.]

[*Read before the Royal Society of N.S.W., September 3, 1890.*]

THE strength and elasticity of all the important Australian timbers having been determined by the author, it is proposed to illustrate the methods of applying the results of testing to the design and construction of timber structures.

In the experiments on beams of Australian timber failure occurred generally from the crushing of the fibres on the concave side of the beam, followed immediately by the tearing of the fibres on the convex side of the beam, in some few cases owing to the presence of gum veins, failures occurred by shearing longitudinally near the neutral axis. The reason of these peculiarities may be seen by inspecting the tables of the results of testing in tension, compression and shearing, which show that the tensile strength is about double the compressive, while the modulus of rupture is slightly less than the tensile strength. For instance, the compressive strength of the best iron-bark timber is about 10,000 pounds per square inch, the tensile strength 22,000, and the modulus of rupture 18,000 pounds per square inch. The resistance to shearing along the fibre is much greater in Australian timber than in pine timber or oak, and frequently reaches 2,000 pounds per square inch, it is not proportional to the tensile compressive transverse strengths.

The shearing resistance of red gum timber is not much below that of good iron bark, but the compressive, transverse and tensile strengths are not much greater than one half those of iron-bark. Blackwood timber is inferior to ironbark in compressive, transverse and tensile strength but superior in its resistance to longitudinal shearing along the fibres. Former experimenters on Australian timber have confined their attention to the determination of the constants for transverse strength and elasticity, leaving the tensile, compressive and shearing strengths and elasticities untouched, excepting Mr. Laslett whose results as pointed out by the author in a paper read before the Society in 1886, are inaccurate so far as tension is concerned. A few experiments have been made by Mr. Campbell, C.E., Melbourne, on the tensile strength of timber which agree, as far as they go, with those made by the author.

In deciding as to the value of timber for a special purpose the following considerations may be necessary. Its durability under the conditions to which it will be subjected in practice, its weight per cubic foot, seasoned and unseasoned, its loss of weight and decrease in volume during seasoning, its transverse, tensile, compressive and shearing strengths and elasticities. For floor beams and simple beam bridges the durability, transverse strength, modulus of transverse elasticity are the most important data. For compound beams consisting of ordinary beams connected together by means of wedges and bolts, in addition to the considerations necessary with plain beams already referred to, the shearing resistance of the wedges and the shrinkage of the timber must be considered. In timber roof principals and timber bridge trusses we have to consider in addition to the foregoing the compressive resistance of the timber when used as long and short columns, the force which will cause failure by buckling. The tensile stresses which will be developed in the main tie beams and bracing of the roof and bridge truss need not concern us, as the tensile strength of Australian timber is greater than can possibly be developed at the joints, and failure is more likely to take place by shearing of the timber along the grain, or from the unequal distribution of stress over a given cross-section due to tension and crossbreaking combined.

The main difficulty in designing timber structures is due to the joints and connections, and these should be so arranged that they will not loose their efficiency through the shrinkage of the material. In selecting timber for the manufacture of railway rolling stock it is necessary to obtain the lightest and most durable timber, it should not decrease appreciably in volume during seasoning, and should possess considerable resistance to the various stresses which are developed in the truck or carriage when in use. Blackwood appears to the author to fulfil these conditions at least as well as any of the Australian timbers, and it is probably as useful for the purpose as that of any other timber in the world.

Australian timber differs considerably in its resistance to stresses as well as in various other qualities from that grown in other countries. For instance the results obtained in testing red and yellow pine, and spruce timber, in the very valuable and elaborate experiments made at the Watertown Arsenal, Massachussets, and recorded in the reports of the United States Government, as well as those made with equal skill and care by Prof. Bauschinger of Munich, differ considerably from those obtained by the author for Australian timbers, thus :—In the experiments on spruce beams and red and yellow pine timber referred to, failure took place as often by longitudinal shearing along the fibres, as by tearing of the fibres on the convex side of the beam. Direct experiments on the shearing resistance proved that the beams were just as likely to fail by longitudinal shearing as by tearing of the fibres on the tension side of the neutral axis.

The resistance of many of our Australian timbers to shearing along the fibres is about five times as great as that of the pine timbers, so that beams of Australian timber will never shear along the fibre unless there is some defect in the specimen tested such as the presence of gum veins near the neutral axis.

In applying the results of testing Australian timbers to the design of simple beam bridges and viaducts, such as those illustrated in Plate 5 and Plate 6, it is necessary to make use of the following equations. The bending moment must be calculated and equated with the moment of resistance. For rectangular beams loaded with an uniform distributed load we have—

$$\frac{W\,l}{8} = \frac{b\,d^2 f}{6}$$

$$\therefore \quad W = \frac{4\,b\,d^2 f}{3\,l} \qquad (1)$$

$$V = \frac{5\,W\,l^3}{32\,b\,d^3\,E}$$

Where W = total load uniformly distributed in pounds or tons.
f = modulus of rupture per square inch in pounds or tons.
l = length, b = breadth, d = depth of beams.
V = the deflection at the centre.
E = modulus of Elasticity in pounds or tons per square inch.
F = Shearing stress.

It is necessary to state that the same units should be used throughout, viz. inches, square inches, and pounds or tons.

If the load is not uniformly distributed the maximum bending moment must be found and equated with the moment of resistance. Plate 1 shows an ordinary timber viaduct designed to carry a single line of railway, consisting of two beams each 10 feet long by 12 inches by 12 inches. The deck is formed with cross sleepers each 10 feet long by 8 inches by 8 inches, spaced 16 inches centre to centre, bolted to the main beams with bolts $\frac{3}{4}$ inch in diameter. There is a timber guard rail on each side. The piers consist of three piles, with two horizontal walings at the top, and diagonal bracing. As this deck appears to the author to be very suitable for timber railway viaducts, and as it has been very largely used in America, and in a few cases in this colony it is thought desirable to investigate its strength and to consider its advantages somewhat in detail. The maximum weight on the driving wheels of the locomotives on the New South Wales Railways does not exceed 16 tons for a pair of wheels, therefore the weight on each rail is say 8 tons, but since this may be increased from a variety of causes such as the oscillation and plunging of the engine, defects in the balancing of the rotating parts, it is assumed that the total maximum effect will not exceed 10 tons on each rail. At least three sleepers will take part in carrying the weight brought on any one of them from the driving wheels, therefore the maximum weight on a sleeper is taken at 5 tons for each rail, so that W= 5 tons in the sketch fig. 1.

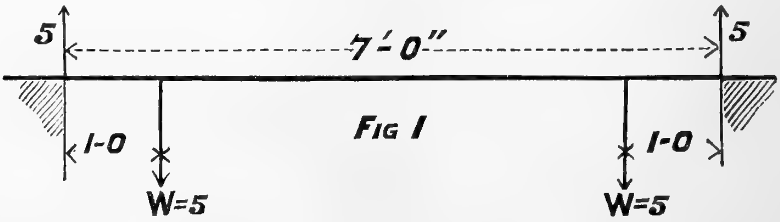


FIG I

$$\text{Max. Bending moment} = 5 \text{ foot tons} = 60 \text{ inch tons.}$$

$$\text{Moment of Resistance} = \frac{b\ d^2 f}{6} = \frac{8 \times 8 \times 8 \times 14000}{6}$$

$$= 1194600 \text{ inch pounds.}$$

$$= 533 \text{ inch tons.}$$

$$\text{Therefore the factor of safety} = \frac{533}{60} = 8{\cdot}8.$$

The author is indebted to Mr. W. Shellshear, A.M.Inst.,C.E., District Engineer, for particulars of this deck as applied in the

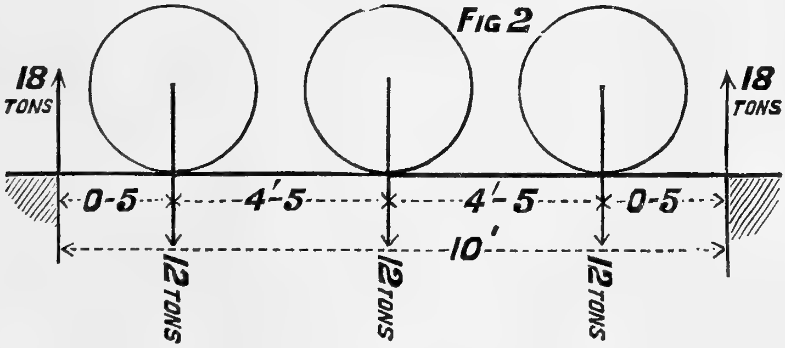
Petersham Viaduct, the plate web girder bridge at Strathfield, and the Penrith Bridge which are similar to those shown on Plates 5 and 7. This deck is also used in the Hawkesbury Bridge, but for some reason or other soft wood timber has been used instead of Australian timber. This very obvious mistake is generally acknowledged, and when the present deck is renewed it is to be hoped that good iron bark or other approved Australian timber will be substituted.

The advantages of this deck over the ordinary close timber deck are as follows:—The sleepers are spaced sufficiently close to allow the wheels of a carriage to run without sticking in the case of derailment, and they are exposed on four sides to the air and therefore dry uniformly and last a much longer time, moreover any defective sleeper can be readily seen and replaced.

The timber guard rail is a precaution against the effect of derailment and serves also in assisting to destribute the weight of the driving wheels over at least three sleepers. The spacing is large enough to allow hot material from the engine to fall between the sleepers and helps to make the deck fireproof, as was proved a few years ago when a train was on fire upon the Petersham Viaduct. The number and strength of the sleepers gives considerable lateral strength and stiffness to the structure, enabling it to resist wind pressure and oscillations. The 7 feet spacing of the main beams ensures an elastic road, and easy running.

The strength of the main beams in the 10 feet spans will now be considered. The greatest bending moment which can be produced on these spans will be from the Consolidation engines the driving wheels of which are shown in sketch fig. 2.

FIG 2



The bending moment at the centre is :—$18 \times \cdot 5 + 6 \times 4 \cdot 5 = 36$ foot tons = 432 inch tons. $\therefore \frac{w\,l^2}{8} = 36 = \frac{w \times 10 \times 10}{8}$ where w equals the equivalent distributed load. $\therefore w = 2 \cdot 88$ tons per foot.

The moment of resistance of two beams each $12'' \times 12''$ on a span of 10 feet is :—$\frac{2 \times 12 \times 12 \times 12 \times 13000}{6} = 7488000$ inch pounds.
$= 3342 \cdot 8$ inch tons.

The modulus of rupture is taken at 13000 pounds per square inch in consequence of the larger section of the main beam.

Hence the factor of safety is $\frac{3342 \cdot 8}{432} = 7 \cdot 7$.

In the design for timber viaducts which has been used extensively in Victoria for spans of 15 feet, the superstructure consists of 4 main beams arranged so that there are two under each of the rails with a space of 7 inches. Upon the beams is laid a close timber deck from 3 inches to 4 inches thick, and there is a kerb 12 inches deep by 4 inches wide for retaining the ballast. The rails, sleepers and ballast are laid in the ordinary way upon the timber deck, and are maintained as on other parts of the line. The piers are somewhat similar to those illustrated on Plate 5. The main beams are made 18 inches deep by 7 inches wide when red gum timber is used. The strength may be calculated as follows :—The dead weight of the structure including the permanent way is half a ton per foot run, and produces a bending moment in the centre thus: $\frac{w\, l^2}{8} = \frac{15 \times 15}{2 \times 8} = 14$ foot tons.

For the live load assume one of the heaviest of the Victorian engines with a pair of driving wheels carrying 14 tons load exactly at mid span, the leading and trailing wheels would be off the span and would not affect the bending moment which is :—$\frac{W\, l}{4} = \frac{14 \times 15}{4} =$ 53 foot tons. Total bending moment is therefore 67 foot tons.

The moment of resistance of the four beams each 7 inches wide by 18 inches deep is taking the modulus of rupture of red gum as 7,000 pounds per square inch :—$\frac{7000 \times 4 \times 7 \times 18 \times 18}{6} = 10584000$ inch pounds. $= 393 \cdot 75$ foot tons.

Hence the factor of safety is $\frac{393 \cdot 75}{67} = 6\frac{1}{2}$.

These viaducts are very economical in timber and are much appreciated in Victoria, they are clearly not too strong, but experience has shown that they are strong enough. They would not carry our Consolidation engines with the same factor of safety as may be seen from the following calculations :—The equivalent distributed load produced on a span of 15 feet, see fig. 2, is 2·8 tons producing a bending moment of 78·7 foot tons. The total bending moment would therefore be $78 \cdot 7 + 14 = 92$ foot tons, and the factor of safety $= \frac{393 \cdot 75}{92} = 4\frac{1}{4}$, which is not sufficient for railway practice. If however iron bark timber was substituted for the red gum the factor of safety would be about 8 which is ample, hence the design adopted in Victoria might be advantageously used in New South Wales for spans of 15 feet, with iron bark, and a few of our strongest timbers.

Plate 6, illustrates completely the practice of the Roads and Bridges Department, New South Wales for ordinary beam bridges.

The strength may be calculated from the equations given after the manner already sufficiently explained.

Plate 7, shows a timber viaduct for 24 feet spans designed to carry a single line of railway. As the design of this class of structure has not been investigated and does not appear to the author to be generally understood, it has been thought desirable to work out an example in detail. In the first place the stresses in the wedges and bolts will be considered. Fig. 3 represents a portion of a beam subjected to transverse stress. It is required to find the intensity and distribution of the horizontal shearing stress at any section of the beam.

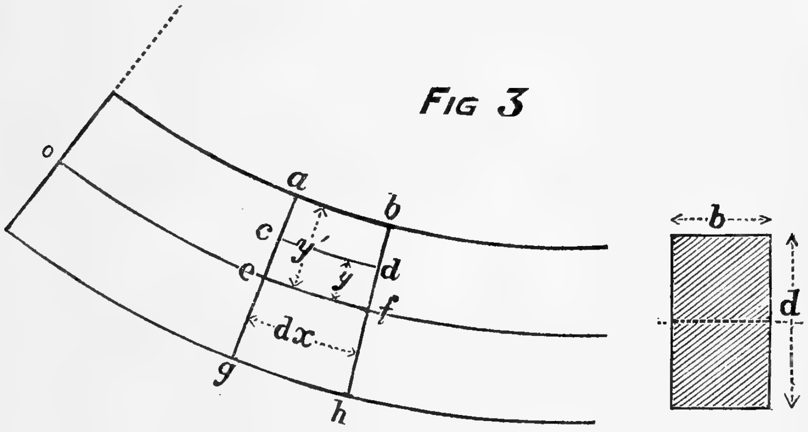


FIG 3

Let M denote the bending moment at a section $a\ c\ e\ g$ at a distance x from the origin.

Let $M + \Delta M$ denote the bending moment at a section $b\ d\ f\ h$, at a distance $x + dx$ from the origin.

Let f denote the intensity of direct horizontal stress at c.

Then $M = \frac{f\,I}{y}$ and $f = \frac{M}{I}\,y$ where I denotes the moment of inertia of the section with reference to an axis passing through its centre of gravity.

The total stress on the plane $a\ c\ e\ g$ between a and c is : $\frac{M}{I}\int_{y}^{y_1} y\ b\ d\ y$

The total stress on the plane $b\ d\ f\ h$ between the same limits is :

$$\frac{M + d\ M}{I}\int_{y}^{y_1} y\ b\ d\ y$$

The difference between these stresses equals the force with which the portion of the beam $b\ d$ of the section $b\ d\ f\ h$ is pushed towards the section $a\ c\ e\ g$— $= \frac{d\ M}{I}\int_{y}^{y_1} y\ b\ d\ y$

This stress is distributed over an area $b \times d\ x$, hence the intensity of horizontal shearing stress is :— $H = \frac{d\ M}{I\ b\ d\ x}\int_{y}^{y} y\ b\ d\ y$

and since the beam is rectangular in section b is constant

$$\therefore H = \frac{\frac{dM}{dx}}{I}\int_{y}^{y_{1}} y\,dy \text{ but the shearing stress } F = \frac{dM}{dx} \therefore H = \frac{F}{I}\int_{y}^{y_{1}} y\,dy$$

The shearing stress at the neutral axis will be found by integrating between the limits $y^1 = \frac{d}{2}$, and $y = o$. $\therefore H = \frac{F}{I}\frac{d^2}{8} = \frac{3F}{2bd}$

It therefore follows that the intensity of horizontal shearing stress at any point in the cross section of a beam can be determined. For example take the case of a compound beam formed with two plain beams each 12 inches by 12 inches.

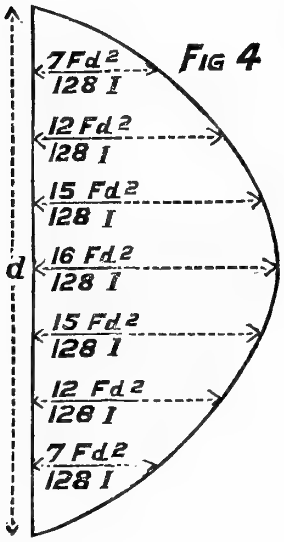


FIG 4

The intensity of shearing stress 3 inches from the neutral axis is—

$$\frac{F}{I}\int_{\frac{d}{8}}^{\frac{d}{2}} y\,dy = \frac{F}{I}\left\{\frac{d^2}{8} - \frac{d^2}{128}\right\} = \frac{F}{I} \times \frac{15}{128}d^2$$

At 6″ from the neutral axis it is—

$$\frac{F}{I}\int_{\frac{d}{4}}^{\frac{d}{2}} y\,dy = \frac{F}{I}\left\{\frac{d^2}{8} - \frac{d^2}{32}\right\} = \frac{F}{I} \times \frac{12}{128}d^2$$

At 9″ from the neutral axis it is—

$$\frac{F}{I}\int_{\frac{3}{8}d}^{\frac{d}{2}} y\,dy = \frac{F}{I}\left\{\frac{d^2}{8} - \frac{9}{128}d^2\right\} = \frac{F}{I} \times \frac{7}{128}d^2$$

At 12″ from the neutral axis the horizontal shearing stress is zero.

These stresses are represented graphically in the diagram fig. 4, but they may also be determined by setting out the central ordin- of a parabola $= \frac{3\,F}{2\,b\,d}$ with a base equal to the depth of the beam d and drawing the curve in the usual way.

In order that the compound beam referred to formed with two plain beams each 12 inches by 12 inches should be equal in strength to that of a beam 24 inches deep, it is necessary that means should be provided for resisting the horizontal shearing stresses which have been investigated, and also the vertical shearing stresses which are of equal intensity. The method of doing this is illustrated in Plate 7, which shows a design proposed by the author for a timber viaduct carrying a single line of railway. The function of the bolts and wedges is to resist the shearing stresses referred to, and it is clear that the bolts can be screwed up and the wedges driven in further from time to time as the timber shrinks. Again the timbers are separated so that they may season in position under favourable conditions, and any defect which may be developed can be easily seen and dealt with. From an inspection of the tables of results of testing the shearing strength of timbers, it will be seen that blackwood, ironbark, spotted gum, red gum, flooded gum, grey gum, slaty gum, mahogany, stringy-bark, white box, rose wood, coach-wood, black bean, red bean, and beech may be advantagously used for this purpose. Since the bending moment increases as the square of the span, and the moment of resistance of the beam as the square of the depth, it follows that a span of 20 feet would give the same factor of safety as that found for the 10 feet span, provided the equivalent distributed load remained the same. The equivalent distributed load on a 24 feet span with the heaviest engines does not exceed 2·4 tons per foot run, hence the span may be increased from 20 to $20 \times \frac{288}{240} = 24$ feet. The total depth of the compound beam is 26 inches, but it will be taken as 24 inches. The area is reduced in the centre by the bolt hole, and to a slight extent by the wedges. The corbels over piers will certainly more than compensate for these reductions, and the former may be taken to balance the latter with perfect safety.

The shearing stress over piers is—$\frac{2 \cdot 4 \times 24}{2} = 28 \cdot 8$ tons or 14·4 tons for each beam which is distributed over the depth of 24 inches by 12 inches in the manner referred to. The maximum shearing stress horizontally and vertically is therefore :— $F = \frac{3 \times 14 \cdot 4}{2 \times 24} = 0 \cdot 9$ tons per lineal inch. The wedges immediately over the corbels are spaced 15 inches centre to centre and will have to resist a horizontal shearing stress of $15 \times 0 \cdot 9 = 14 \cdot 5$ tons, and the corresponding bolts a vertical shearing stress of the same amount.

Let x = the width of the wedges measured along the beam, the area exposed to shearing along the fibre (neglecting the portion of the wedge which projects beyond the beam for driving) is $12x$. The safe intensity of shearing stress may be taken as 250 pounds per square inch in the timbers which are the most suitable for this purpose, therefore the resistance of the wedge is—$12 \times 250 \times x = 3000x$ $\therefore$ $3000x = 14 \cdot 5 \times 2240$

$$x = 10 \cdot 8 \text{ inches}$$

The wedges should consequently be made 11 inches wide by 6 inches deep. The area required in the bolts is—$\frac{14 \cdot 5}{6} = 2 \cdot 4$ square inches or $1\frac{3}{4}$ inches in diameter.

The shearing force at any other point may be calculated from the following formula :— $F_1 = \frac{w(c+x)^2}{4c}$

Where F_1 = the shearing stress

w = live load per foot run on each beam

Where c = half span

x = distance from centre of beam

$$\therefore F_1 = \frac{1\cdot2\ (12+x)^2}{4\times12}$$

If $x = o$; $F_1 = 3\cdot6$ tons

$x = 6$; $F_1 = 8\cdot1$ tons

And these stresses are distributed over the section of the beam as before. The maximum shearing stress per lineal inch in the centre of the beam is therefore :— $F = \frac{3\times3\cdot6}{2\times24} = 0\cdot225$ tons.

The bolts and wedges are spaced 18 inches from centre to centre, therefore the central bolt will be called upon to resist a stress of— $18 \times 0\cdot225 = 3\cdot38$ tons. The area required is consequently $\frac{3\cdot38}{6} = 0\cdot56$ square inches, or say 1 inch diameter.

The bolts at 6 feet from the centre will be required to resist a stress :— $F = \frac{3\times8\cdot1}{2\times24} = 0\cdot5$ tons per lineal inch, or a total force of $18\times0\cdot5 = 9$ tons, the area required is therefore—$\frac{9}{6} = 1\cdot5$ square inches or say $1\frac{1}{2}$ inches in diameter.

The width of the corresponding wedges 6 feet from the centre of the beam is found thus :—$3000\ x = 9\times2240$

$\therefore\ x = 6\cdot7$ inches

hence the wedges may be made 7 inches by 4 inches.

The sizes of the remaining bolts and wedges may be determined in a similar manner.

In order to test the foregoing theory, the author had made several scale models which were tested and gave results in close agreement with the calculations. Compound beam bridges have been constructed by the Roads and Bridges Department up to a span of 42 feet, the main beams being formed with 3 beams each 12 inches by 12 inches.

Plate 8 shows an example of a composite structure designed by Mr. J. A. McDonald M.Inst. C.E., Engineer for Bridges, for a bridge over the Lachlan River at Cowra. Only one of the large spans will be considered in this paper. The trusses are 160 feet from centre to centre of the bearing on piers, and are 27 feet deep between centres of triangulations. The top chord principals and diagonal bracings are of ironbark timber, the bottom chord is of steel formed of stringer-plates and angle iron bars top and bottom. The suspension bolts are of wrought iron, placed in groups of four, and connected with wrought iron washer plates.

All the timber members are adjustable by means of wedges, so that any shrinkage that occurs may be taken up.

The cross girders are of steel spaced 20 feet from centre to centre, and constructed with flange plates and angles connecting the flanges to the web, they are fish-bellied and project on either side of the main trusses forming cantilevers for carrying the foot-ways. The minimum carriage way is 20 feet in the clear and the two foot-ways have each a width of 5 feet. The longitudinal girders resting upon the cross girders are of sawn timber, and the deck is formed with tallow wood boards laid diagonally on the carriage way, and transversely on the foot-ways. The two trusses are braced together in a horizontal plane between the top and bottom booms with timber transverse struts and wrought iron diagonal tie rods.

The piers are composed of wrought iron cylinders 6 feet in diameter, stiffened with wrought iron diaphragm bracing, and founded on cast iron cylinders filled with cement concrete. The pressure on the rock foundations is 14·6 tons per square foot, and on the clay foundations 6 tons per square foot. The bridge has been designed to carry a live load of 84 pounds per square foot of carriage and foot-way. The cross girders and longitudinal girders have been designed to carry a traction engine weighing 16½ tons.

Plate 9 shows the method adopted for determining the stresses in the various members of the truss. The dead load concentrated at each of the apices of the triangulation due to the weight of the the structure itself is 14 tons on each truss. The live load at each of the apices is 11·25 tons on each truss. The four reciprocal diagrams of stress have been drawn for the dead load of 14 tons concentrated at each of the four apices in the half truss separately. The length of the lines in the four diagrams represent the stresses in the various members of the truss to scale, they are measured and tabulated in the manner fully illustrated on Plate 9, so that the maxima stresses for the dead load may be written down for each bar. The stresses ascertained in this manner have also been found independently by the method of sections (which will be more fully explained) and the mean of the two methods written down in the column Mean Maxima Stresses. Since the live load diagrams would be simply a repetition of the dead load diagrams referred to, the stresses due to the live load are found by multiplying the maxima dead load stress by the ratio of live to dead load thus— $\frac{11 \cdot 25}{14} = 0 \cdot 8$, and each of the stresses in column "Mean Maxima Stresses" is multiplied by 0·8 and the result written down in column "Distributed Live Load Maxima Stresses," The sum of the two gives the greatest stress than can be developed in the members of the truss. The column "Concentrated Rolling Load" contains the stresses developed when a traction engine of 16½ tons passes over the bridge. It will be seen that they are considerably smaller than those due to the distributed live load.

Summary of Stresses.

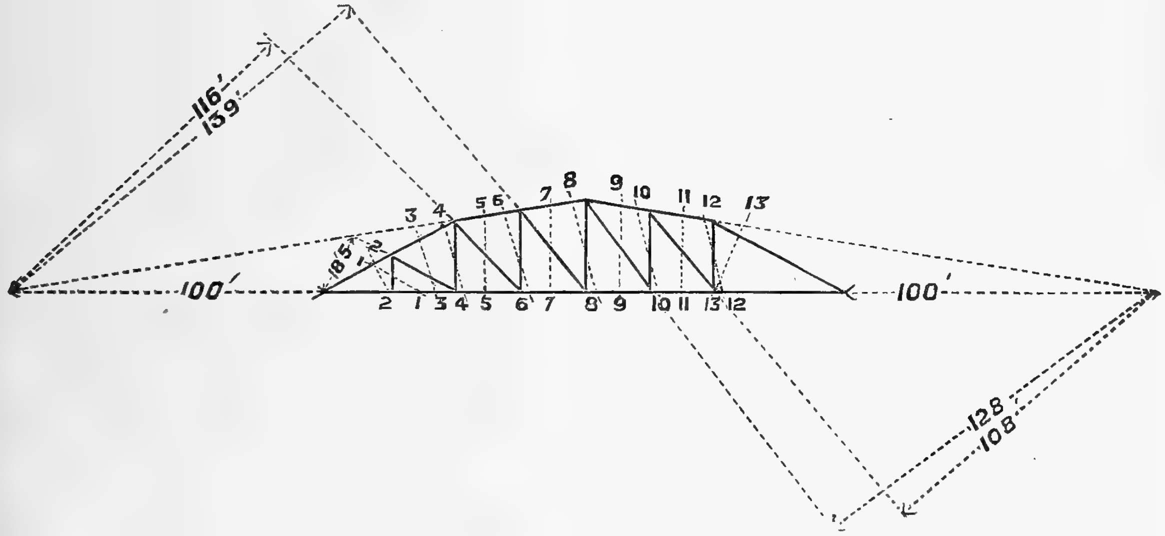
Bar.	Dead Load. Stresses obtained by Graphic Method. Stress due to Load at 1	2	3	4	5	6	7	Maxima Stresses	Max. Stresses obtained by Meth. of Sec.	Mean Max ima Stresses.	Distributed Live Load—Maxima Stresses.	Concentrated Rolling Load—Maxima Stresses.	Maxima Stresses due to any manner of Loading.
X1	23·45	20·03	16·73	13·39	10·05	6·70	3·39	93·74	93·33	93·53	74·82	18·48	168·35
2	23·45	20·03	16·73	13·39	10·05	6·70	3·39	93·74	93·33	93·53	74·82	18·48	168·35
3	10·11	20·03	21·96	17·60	13·16	8·79	4·47	96·12	95·63	95·88	76·70	19·18	172·58
4	7·40	14·63	21·96	20·85	15·60	10·41	5·26	96·11	95·60	95·85	76·68	18·67	172·53
5	5·26	10·41	15·60	20·85	21·96	14·63	7·40	96·11	95·60	95·85	76·68	18·67	172·53
6	4·47	8·79	13·16	17·60	21·96	20·03	10·11	96·12	95·63	95·88	76·70	19·18	172·58
7	3·39	6·70	10·05	13·39	16·73	20·03	23·45	93·74	93·33	93·53	74·82	18·48	168·35
8	3·39	6·70	10·05	13·39	16·73	20·03	23·45	93·74	93·33	93·53	74·82	18·48	168·35
Z1	26·45	22·61	18·89	15·10	11·33	7·57	3·82	105·77	106·38	106·08	84·86	20·86	190·94
2	11·40	22·61	18·89	15·10	11·33	7·57	3·82	90·72	90·81	90·77	72·62	18·00	163·35
3	7·48	14·80	16·93	13·55	10·14	6·77	3·45	73·12	73·31	73·22	58·58	14·66	131·80
4	5·31	10·55	15·77	17·80	13·31	8·89	4·55	76·18	76·38	76·28	61·02	15·46	137·30
5	4·55	8·89	13·31	17·80	15·77	10·55	5·31	76·18	76·38	76·28	61·02	15·46	137·30
6	3·45	6·77	10·14	13·55	16·93	14·80	7·48	73·12	73·31	73·22	58·58	14·66	131·80
7	3·82	7·57	11·33	15·10	18·89	22·61	11·40	90·72	90·81	90·77	72·62	18·00	163·35
8	3·82	7·57	11·33	15·10	18·89	22·61	26·45	105·77	106·38	106·08	84·86	20·86	190·94
V1	14·00	...	...	...	...	...	...	14·00	14·00	14·00	11·25	9·86	25·25
2	7·05	14·00	6·21	5·00	3·76	2·50	1·28	39·80	39·75	39·77	31·82	11·20	71·59
3	2·88	5·67	14·00	4·37	3·30	2·20	1·10	33·52	33·47	33·49	26·79	10·94	60·28
4	2·57	5·06	7·62	14·00	7·62	5·06	2·57	44·50	44·17	44·33	35·46	11·31	79·79
5	1·10	2·20	3·30	4·37	14·00	5·67	2·88	33·52	33·47	33·49	26·79	10·94	60·28
6	1·28	2·50	3·76	5·00	6·21	14·00	7·05	39·80	39·75	39·77	31·82	11·20	71·59
7	...	...	...	...	...	...	14·00	14·00	14·00	14·00	11·25	9·86	25·25
Y2	15·09	...	...	...	...	...	...	15·09	15·14	15·12	12·10	10·56	27·22
3	3·95	7·82	...	...	...	...	...	11·77	11·77	11·77	9·42	6·12	21·19
4	3·33	6·58	9·92	...	...	...	...	19·83	19·64	19·74	15·79	8·18	35·53
5	1·35	2·66	4·10	5·45	...	...	...	13·56	13·67	13·62	10·90	4·62	24·52
6	1·65	3·26	4·90	6·55	8·10	...	...	24·46	24·31	24·38	19·50	6·13	43·88
7	...	...	...	...	...	...	15·09	15·09	15·14	15·12	12·10	10·56	27·22
8	...	...	...	...	...	7·82	3·95	11·77	11·77	11·77	9·42	6·12	21·19
9	...	...	...	...	9·92	6·58	3·33	19·83	19·64	19·74	15·79	8·18	35·53
10	...	...	...	5·45	4·10	2·66	1·35	13·56	13·67	13·67	10·90	4·62	24·52
11	...	...	8·10	6·55	4·90	3·26	1·65	24 46	24·31	24·38	19·50	6·13	43·88

The stresses in structures (such as those designed by engineers which are non-deformable) depend upon their form and dimensions and are independent of the material of which they are composed so that the foregoing example might have been given for an iron bridge, only that the diagonals in an iron bridge are fixed while those in the Cowra bridge are incapable of withstanding tension as they merely rest in pockets and are wedged up to enable them to withstand compression.

In proportioning the areas of the various parts of the structure to resist the stresses developed in them it is necessary to know exactly the manner in which the material (which it is intended to use) will behave under the stresses referred to, *i.e.*, its strength and elasticity, and in order that the various joints and connections thould not cease to fulfil their functions efficiently, it is necessary so allow for the shrinkage of the material.

METHOD OF SECTIONS.

The method of sections which has been mentioned may be briefly described as follows. If we consider an ideal section cutting any three bars of the truss illustrated in Plate 9, and separating it into two portions, and if we apply stresses to the three bars equal to those developed in the structure, we may consider the portion cut off to be removed as the stresses balance the external forces. In order to obtain the stress in one of the three bars it is convenient to take moments about the point where the other two meet and forming the equations with the unknown stress and the known reaction at abutment and loads at apices of triangulation, we readily determine the unknown force. It is generally very convenient to draw the truss to a sufficiently large scale, and measure off the lengths of the lever arms to the same scale. The details of the method are fully illustrated in the following equations in which the letters *X V Z* &c. correspond with the letters on Plate 5.



STRESSES DUE TO DEAD LOAD.

Section.		Tons.
1	$-X_1 \times 10{\cdot}5 + 14.\ \frac{7}{8} \times 20 = 0$	$X_1 = +\ 23{\cdot}33$
2		$V_1 = +\ 14{\cdot}00$
	$+Z_1 \times 9{\cdot}1 + 14.\ \frac{7}{8} \times 20 = 0$	$Z_1 = -\ 26{\cdot}92$
3	$-X_2 \times 10{\cdot}5 + 14.\ \frac{7}{8} \times 20 = 0$	$X_2 = +\ 23{\cdot}33$
	$+Z_2 \times 18{\cdot}5 + 14\ (\frac{7}{8}.\ 40 - 20 = 0$	$Z_2 = -\ 11{\cdot}35$
	$+Y_2 \times 18{\cdot}5 + 14 \times 20 = 0$	$Y_2 = -\ 15{\cdot}14$
4	$-V_2 \times 40 + 14 \times 20 = 0$	$V_2 = +\ 7$
5	$-X_3 \times 21 + 14\ (\frac{7}{8} \times 40 - 20) + 14.\ \frac{6}{8} \times 40 = 0$	$X_3 = +\ 30$
	$+Z_3 \times 23{\cdot}5 + 14\{(\frac{7}{8} + \frac{6}{8})\ 60 - (20 + 40)\} = 0$	$Z_3 = -\ 22{\cdot}34$
	$+Y_3 \times 116 - 14\{\frac{1}{8}\ (6 + 7)\ 100 - (120+140)\} = 0$	$Y_3 = -\ 11{\cdot}77$

Section.		Tons.
6	$-V_3 \times 160 - 14\{\frac{1}{8}(7+6)\,100 - (120+140)\} = 0$	$V_3 = +8{\cdot}53$
7	$-X_4 \times 24 + 14\{(\frac{7}{8}.60 - 40) + (\frac{6}{8}.60 - 20) + (\frac{5}{8}.60)\} = 0$	$X_4 = +43{\cdot}75$
	$+Z_4 \times 26{\cdot}5 + 14\{(\frac{7}{8}.80 - 60) + (\frac{6}{8}.80 - 40) + (\frac{5}{8}.80 - 20)\} = 0$	$Z_4 = -31{\cdot}70$
	$+Y_4 \times 139 - 14\{\frac{1}{8}(7+6+5)\,100 - (120+140+160)\} = 0$	$Y_4 = -19{\cdot}64$
8	$-V_4 \times 180 - 14\{\frac{1}{8}(7+6+5)\,100 - (120+140+160)\} = 0$	$V_4 = +15{\cdot}17$
9	$-X_5 \times 27 + 14\{(\frac{7}{8}.80 - 60) + (\frac{6}{8}.80 - 40) + (\frac{5}{8}.80 - 20) + \frac{4}{8}.80\} = 0$	$X_5 = +51{\cdot}85$
	$+Z_5 \times 23{\cdot}5 + 14\{(\frac{7}{8}.100 - 80) + (\frac{6}{8}.100 - 60) + (\frac{5}{8}.100 - 40) + (\frac{4}{8}.100 - 20)\} = 0$	$Z_5 = -44{\cdot}68$
	$+Y_5 \times 128 + 14.\frac{1}{8}(1+2+3+4) \times 100 = 0$	$Y_5 = -13{\cdot}67$
10	$-V_5 \times 160 + 14.\frac{1}{8}(1+2+3+4)\,100 = 0$	$V_5 = +10{\cdot}94$
11	$-X_6 \times 24 + 14\{(\frac{7}{8}.100 - 80) + (\frac{6}{8}.100 - 60) + (\frac{5}{8}.100 - 40) + (\frac{4}{8}.100 - 20) + \frac{3}{8}.100\} = 0$	$X_6 = +65{\cdot}63$
	$+Z_6 \times 20{\cdot}6 + 14\{(\frac{7}{8}.120 - 100) + (\frac{6}{8}.120 - 80) + (\frac{5}{8}.120 - 60) + (\frac{4}{8}.120 - 40) + (\frac{3}{8}.120 - 20)\} = 0$	$Z_6 = -50{\cdot}97$
	$+Y_6 \times 108 + 14.\frac{1}{8}(1+2+3+4+5) \times 100 = 0$	$Y_6 = -24{\cdot}31$
12	$-V_6 \times 140 + 14.\frac{1}{8}(1+2+3+4+5) \times 100 = 0$	$V_6 = +18{\cdot}75$
	$-X_7 \times 21 - 14.\frac{1}{8}(1+2+3+4+5+6) \times 40 = 0$	$X_7 = +70{\cdot}00$
13	$-Z_7 \times 18{\cdot}5 - 14.\frac{1}{8}(1+2+3+4+5+6) \times 40 = 0$	$Z_7 = -79{\cdot}46$

Plate 6 shows the total stresses developed in the various portions of the structure, and the areas and sections provided to resist them. There are several matters in connection with the design of this bridge which will now be considered.

1. The shrinkage of timber in length is provided for by double wedges at the end of each strut.

2. The shrinkage in the length of the upper chord would produce sag in the whole truss, but this can be neutralized by screwing up the suspension bolts.

3. It is found in truss-bridges that the bottom chord or tension member is the first to decay, consequent on the number of joints and keys required to give the necessary tensile strength, and the chance thereby given for water to find its way in. Where any part of this chord decays it is most difficult to renew it, without expensive staging under the whole truss, and again, on the completion of the life of the truss, scaffolding has to be erected, the whole of the old truss removed and the new truss erected completely in its place. This work causes considerable and lengthened interruption to the traffic. To overcome this difficulty to a great extent a steel chord has been provided which may be regarded as permanent. When any part of the truss requires renewal it can be done with only a very slight interruption to the traffic. And when the removal of all the timber in the truss is necessary only a very slight staging will be required to support the chord during re-erection, the traffic going on all the time.

4. The timbers in the top chord are made double with a space between them, so that if it is desired to replace a defective piece of timber, there is sufficient room to insert a temporary piece while the defective piece is removed without stopping traffic.

5. Each of the struts in the bracing can be removed and replaced in a similar manner wnenever it is necessary to do so.

6. This bridge is an exceedingly economical one, and reflects the greatest credit on its designer, and the author submits it as an example of the many advantages to be derived by preparing designs within the colony to suit the materials obtainable.

The author has considered it desirable to give every detail in connection with the design of this important structure, because it may be taken as a model for similar works in the future, and because the strength and elasticity of the timber under the various stresses developed, have been arranged in strict accordance with the experimental data supplied by the author.

Plate 11 shows a timber truss bridge of 90 feet span, and Plate 12 an arched bridge in timber with three hinges, one at centre and one on each abutment.

Plate 13 shows a skeleton diagram for the truss and for the arch with the stresses developed in the various members which have been derived in the same manner as in the case of the Cowra Bridge which has been fully considered.

The author desires to acknowledge the kindness of Mr. R. Hickson, M. Inst. C.E., Commission and Engineer-in-Chief for Roads and Bridges in supplying him with the particulars of the designs illustrated in Plates 6, 8, 9, 10, 11, 12, 13, and also that of Mr. J. A. McDonald, M. Inst. C.E., Engineer for Bridges, for his help on a variety of matters referred to in the paper.

Discussion.

J. Trevor Jones—While this evening's meeting is called ostensibly to discuss Prof. Warren's paper, the Professor has left very little to discuss in his statements, and it seems only open to us to comment upon and apply his valuable contribution. In the immediate future it is to be hoped, a Local Government bill will be an accomplished fact, and under it, it is expected, an impetus will be given to municipal works all over the colony,—these works entail the use of timber in large quantities, because small rivers and creeks will be bridged in numbers, and for new communities native timbers are found to be a very excellent substitute for stone, brick, and iron, until the traffic shall justify the use of the latter materials. It is a matter for congratulation that the State has inaugurated a Forestry Department, and not a day too soon, as the good timber was rapidly disappearing, and very little was being put in to take its place. A further matter for congratulation is that our native timbers give such excellent results under tests as is shown by the Professor's former paper, and also possess such exceptional durability. The results obtained by Professor Warren from actual tests of ironbark timber are such as to lead to the hope that the Forestry Department will devote large areas to the cultivation of these valuable trees; they require little care and are found growing in the most sterile soil, yet in transverse strength, in resisting crushing forces as well as shearing and tensile strains, they are more like the metal from which they derive their name than perhaps any other timber. "The main difficulty (says the Professor) in designing timber structures is due to the joints and connections, these should be so arranged that they will not lose their efficiency through the shrinkage of the material." These words should always be borne in mind by designers of framed wood structures; a design for a timber bridge is easily conceived if one could procure timber that will not shrink. The ordinary double beam timber viaducts of the Railway Department give by calculation a resistance equal to that of four beams laid side by side, if the cross ties would not shrink; but practically they will shrink in dry weather, and cease to fill the notch in which they are lodged, to an extent that almost entirely deprives them of the power of giving additional resistance to bending moments. In the branch of the Victorian Railways where I was for many years, this shrinking of timber in trusses and in all manner of framed work, entailed constant care by the maintenance men in wedging up trusses, or screwing up bolts in order to make the timbers take up their proper share of the stresses. The Engineer for Bridges, by making some of the tension members of iron, in his "type" road bridges, has afforded easy means of correcting this defect. Colonial timber gives excellent resistance to tension, but its efficiency as ties is greatly discounted by the difficulty and cost of making joints and connections to take up tensile strength, a proportion of the value of wrought iron is lost in this way but a much greater loss is made on wood. An example is given in the paper of the most common form of small span railway viaducts used in New South Wales, where the span is ten feet between the piers, crossed by two beams each, for single line, 12″ × 12″ on which are laid ties or sleepers 8″ × 8″, the distance between the beams is 7 ft. and between the centre of rails 5 feet; thus the weight is not brought directly over the beams but on a point 1 foot inside thereof. This induces a bending moment of 60 inch-tons, but the resistance of the tie is shown to be 533 inch-tons, therefore there is a factor of safety of 8·8. In Victoria the beams are placed directly under the rail, therefore no bending moment at all is produced on the cross ties, and an ordinary 9″ × 4″ sleeper spaced 3 feet apart answers the purpose. This was the first type of light lines made in 1872-3-4, at about £2,000 per mile; a case of derailment with such a type would be fatal, therefore later on the ties were planked with 4″ hardwood decking and ballasted, still the rails were placed over the beams, without cause for complaint that I have heard of; such a plan makes for economy in the cross timbers, though probably the New South Wales method gives a more elastic road. The paper gives formulæ for transverse resistance of beams as well as for determining deflection in their simplest forms and of great value to students, the former viz:— $\frac{W\,l}{8} = \frac{b\,d^2 f}{9}$ is recognizable as identical with Prof. Rankine's $M^\circ = \frac{W\,l}{8} = N f b\, h^2$ where $N = \frac{1}{6}$ and f the co-efficient representing the strength of any given timber. As there are round beams in some of the structures illustrated by the plates it may be desirable to supplement the above formula, which is for rectangular beams with the following modification to adapt it for round beams, as given by Rankine $\frac{W\,l}{8} = \frac{b\,d^2 f}{10}$ for a distributed load, or $\frac{W\,l}{4} = \frac{b\,d^2 f}{10}$ for a central load. The paper not only furnishes the formulæ but gives practical examples worked out so as to render the information accessible to aspirants for knowledge on timber bridge building. Indeed this paper with copious examples of cases and illustrated by the drawings so liberally allowed to be published by the Commissioner for Roads and Bridges and the Engineer for Bridges, places before young engineers (and old engineers for that matter) a means of fitting themselves as municipal engineers, such as would have been most acceptable to me and my contemporaries when studying for the profession, and Professor Warren is entitled to the hearty thanks of this Society and the community generally for placing within reach of students the means of learning to design public structures, as well also as a most valuable table of co-efficients for local timbers as well as foreign.

J. I. Haycroft, M.E., Q.U.I., Assoc. M. Inst., C.E.—Very little matter of a debatable nature, with one special exception, which I will refer to later on, occurs in the paper. The several designs for timber viaducts, though not admitting of much scope for variety, seem to be well thought out, and the rejection of close decking and ballast on such structures, is to be commended for many reasons, the principal ones being saving in materials and consequently cost, reduction in dead weight, increased facility for inspection and reduced liability of timber to decay. Notwithstanding these apparent advantages, however, the Railway Construction Department do not seem to recognise them, as I notice several of the bridges on the recently constructed St. Leonards line are close decked and ballasted. The remarks in the paper on the use of soft wood decking, on the Hawkesbury Bridge, are, I consider, but just. The explanation of the use of such materials, given at your last meeting, viz ; saving in dead weight, could not I think be an item of great importance, and would entirely disappear if the direct advantages due to the use of suitable colonial hardwood were weighed against it. The mistake however I consider should have been rectified before acceptance of tender, as I surmise, the intended use of this class of material was shewn on drawings and specified. The special exception referred to is the composite truss over the Lachlan River, at Cowra ; the stresses in the several members of which will, I think, on investigation be found incorrect. I have from the data furnished in the paper, developed by the method of graphic statics, as shewn on the drawing, the true maxima stresses in the several parts of the truss, and find them differ considerably from those given in the paper. A complete comparative list is appended and a few extracted from it are as follows ; the stress in tension boom at centre is given as $172\frac{1}{2}$ tons should be 159 tons. The stress in compression boom at centre is given as 137 tons and should be 153 tons. The stress in centre tie V_4 is given as $79\frac{3}{4}$ tons and should be 45 tons. In the braces the maximum stress in Y_6 is given as $43\frac{3}{4}$ tons, should be $31\frac{1}{2}$ tons whilst in Y_3 and Y_8 the stress is given as 21 tons, although I think it will be found no stress can exist in these members from the class of loading under consideration. These braces however should not I think be omitted, as they preserve uniformity in appearance, and, if properly utilized, are a source of strength to braces Y_{11} and Y_6. Without occupying too much of your time in demonstrating what I consider the reasons for these errors, it will I think be manifest to anyone conversant with the subject. that the principle of determining the maxima stresses for live and dead load, in the several parts of the truss, by multiplying the stresses due to dead load, even if arrived at correctly, by the proportion between the two classes of loading is certainly incorrect as regards the bracing and verticals, though correct as regards the booms. I cannot, without further data, give a decided opinion as to the accuracy of the maxima stresses due to rolling load, such as the traction engine mentioned, but if my surmise is correct, that they have been calculated on the supposition that its weight can be concentrated at each apex separately, they are inaccurate. An item in the design, which I do not consider good practice, is the fact that even supposing the stresses in the verticals to be correct as given in the paper, viz: varying from 25 to 80 tons, these members are made identical in section throughout the truss, being four $2\frac{1}{4}$ inch diameter rods. I am an advocate of uniformity in section of groups of truss members within certain limits, though the stresses in those members vary in amount, still I consider the limits exceeded in this instance. The four rods, under a working stress of 5 tons, will support 80 tons with a factor of safety of 4; this factor would be unduly increased to more than 12 in the case of the verticals, with 25 ton stress, which is not economy in design. Appended will be found a check calculation by the method of sections, of maxima stresses in the booms.

Maximum Stresses in Booms by Method of Sections.

$$X_1\ (10\tfrac{1}{2}) = 88{\cdot}375 \times 20 \qquad \therefore X_1 = 167{\cdot}95 = X_2$$

$$X_3\ (24) = 88{\cdot}375 \times 60 - 25\tfrac{1}{4}\,(40 + 20) \qquad \therefore X_3 = 158{\cdot}23 = X_4$$

From symmetry $X_5 = X_6 = 158{\cdot}23$

" " $X_7 = X_8 = 167{\cdot}95$

$$Z_1\ \left(10\tfrac{1}{2}\,\frac{20}{(20^2+10{\cdot}5^2)^{\frac{1}{2}}}\right) = 88{\cdot}375 \times 20 \qquad \therefore Z_1 = 190{\cdot}04 = Z_8$$

$$Z_2 \times 18{\cdot}5 = 88{\cdot}375 \times 40 - 25\tfrac{1}{4} \times 20 \qquad \therefore Z_2 = 163{\cdot}78 = Z_7$$

$$Z_3 \times 20{\cdot}7 = 88{\cdot}375 \times 40 - 25\tfrac{1}{4} \times 20 \qquad \therefore Z_3 = 146{\cdot}37 = Z_6$$

$$Z_4 \times 26{\cdot}5 = 88{\cdot}375 \times 80 - 25\tfrac{1}{4}\,(60+40+20) \qquad \therefore Z_4 = 152{\cdot}45 = Z_5$$

Comparative table of Maxima Stresses in semi-truss:

Member.		Stress as given.		Stress as proposed.
Z_1	...	190·94	...	190·0
Z_2	...	163·35	...	164·4
Z_3	...	131·80	...	147·0
Z_4	...	137·30	...	153·0
X_1	...	168·35	...	168·0
X_2	...	168·35	...	168·0
X_3	...	172·58	...	159·0
X_4	...	172·53	...	159·0
V_1	...	25·25	...	25·25
V_2	...	71·59	...	55·0
V_3	...	60·28	...	25·25
V_4	...	79·79	...	45·0
Y_2	...	27·22	...	25·25

Member.		Stress as given.		Stress as proposed.
Y_{11}	...	43·88	...	31·5
Y_{10}	...	24·52	...	3·0
Y_4	...	35·53	...	13·0
Y_3	...	21·19	...	Nil

James Vicars, B.C.E.—In discussing the valuable paper read before this Society by Professor Warren I am the more interested in the subject, as for several years past I have given close attention and research into the various applications of timber for constructive purposes, and especially into its use in bridge building. My remarks will be chiefly directed to the Cowra bridge section of the paper, especially so from the criticisms and deductions brought out in Mr. Haycroft's remarks. The design of the Cowra bridge as illustrated in Plate 8 will be found to contain details of a novel and well thought-out character, forming perhaps the most important feature in the design; and when the stresses on the various members of the structure are being determined, these important details must be taken into account. The wedges at the feet of the diagonal braces, for instance, are so arranged as to enable any shrinkage in the latter to be taken up in the line of direct stress, thus maintaining the points of intersection, and by them also is counteracted any tendency to produce tension in the diagonals. Under these conditions the stresses determined graphically in Plate 9, and checked by Rankine's method of sections, are correct. When computing the stress on any particular diagonal, all loads, whether dead or alive, which would tend to produce tension in that brace, must be ignored for reasons already given. For example, take load (1) nearest the left support, part of it is transmitted to the right support through the system of diagonals running from left downwards to right, *i.e.*, through Y_2, Y_3, Y_4, Y_5, Y_6 and the end inclined post, but no other diagonals can be affected by this load as they are not connected up; part of load (2) is transmitted to the right support through the same system omitting, of course, Y_2; also part of load (3) goes to the right support through the same system, omitting Y_2 and Y_3, the remainder of load (3) gets to the left support through diagonal Y_{11} and the end inclined post, but does not affect diagonals Y_2 or Y_3. By similar reasoning no other loads than (1) and (2) can affect diagonal Y_3, which must therefore always be in compression. The stress in diagonal Y_4 is obtained by considering only loads (1), (2) and (3) as acting and loads (4), (5), (6) and (7), which can have no affect on this brace, as non-existent; and the stresses in the other braces are similarly obtained. I cannot, therefore, agree with that portion of Mr. Haycroft's remarks wherein the stresses as tabulated in the "Summary" and the methods of obtaining them were described by him as erroneous and faulty. From an inspection of the stresses and graphic stress diagrams prepared by Mr. Haycroft it is apparent that he has ignored the important action of the wedges altogether; and were brace Y_3 omitted, as he advocated, the design would be so materially altered that the stresses then obtained by him, even if correct for his design, could not possibly be correct for the original design. Although Professor Warren has given us much useful and practical information with regard to timber and its application to bridgework, I consider that had the paper contained more information on the strength of long columns of the timber referred to, and also the determination of "f" and "a" in Gordon's Formula, its value would have been greatly enhanced.

H. H. Dare, B.C.E.—Mr. Vicars has demonstrated very clearly the peculiarity of the stresses in the truss under discussion; and taken in conjunction with Professor Warren's paper his remarks should prove of great interest, since, so far as I am aware, there is little or no previous literature on this subject. Mr. Haycroft has apparently gone astray in neglecting the fact that no arrangement of loads can affect the diagonals so far as tensile stress is concerned, and that for that reason, only the loads producing the maximum compression in each bar need be considered. Take Y_4 for example. The only loads which can affect it are those at (1), (2) and (3), and it is immaterial whether the other loads be on the truss or not, since they cause no direct or counteracting stress in the bar. As given on page 140, the maximum stress is the summary of the effects of these three loads. The principle of determining the maxima stresses for live and dead loads by multiplying the stresses obtained for the dead load by the proportion between the two classes of loading, has been condemned by Mr. Haycroft as "certainly incorrect for the bracing and verticals"; but without doubt this is by far the simplest and most correct method of calculation under existing conditions. The action of the wedges and the necessity for the bars Y_3 and Y_8 have already been explained by Mr. Vicars and there is no necessity for further reference to those features in the design, but I should like to bring before the meeting the following simple investigation into the relation of stresses in a rectangular ironbark beam. Assuming modulus of rupture at 18000 lbs. per sq. in., and ultimate shearing stress at 2000 lbs. per sq. in., in order that the beam may be equally as strong for shearing as for direct stresses, the following should obtain:—Supposing the beam to be loaded with a uniformly distributed load,

$$\text{Maximum B. Mt.} = \frac{W\,l}{8}; \ \text{Mt. R.} = \tfrac{1}{6} f\,b\,d^2$$

$$\therefore \frac{W\,l}{8} = \tfrac{1}{6} f\,b\,d^2;\ W = \frac{f\,b\,d^2 \times 8}{6 \times l} = \tfrac{4}{3}\frac{f\,b\,d^2}{l} \quad \text{(i).}$$

Now maximum shear per sq. in. = 2000 lbs. = $\frac{W}{2} \times \frac{3}{2} \times \frac{1}{b\,d}$ (ii).
$\therefore$ substituting for W in (ii).

Maximum shear per sq. in. = $\frac{4}{3} \times \frac{f\,b\,d^2}{l} \times \frac{1}{2} \times \frac{3}{2} \times \frac{1}{b\,d} = \frac{f\,d}{l}$
= 2000 lbs. per sq. in.; and $\frac{f\,d}{l} = \frac{18000\,d}{l}$

$\therefore \frac{d}{l} = \frac{1}{9}$.

Therefore, in a rectangular beam of ironbark with an evenly distributed load, the resistance to shearing will be equal to the resistance to direct stresses when the ratio of depth to span is one-ninth. If the ratio be less than this the resistance to direct stresses will be greater than the resistance to shearing, and vice versa.

WALTER SHELLSHEAR, Assoc. M. Inst. C.E.—The thanks not only of this Society but of the public of the whole of the Australian Colonies are due to Professor Warren for his instructive and interesting papers on Australian Timbers and their uses, and in this special line of investigation his labours may be considered unique for by a study of his works on this subject the physical properties of these valuable natural products are most clearly set forth. Having had some little experience in timber structures of various ages it may be of interest to point out a few things that are necessary to be observed if this material is to be used to the best advantage. In this colony we have two great enemies to the life of timber structures, the first is white ant, and the second dry rot, and in tracing the working of these damaging agents some light may be brought out as to the best means of guarding against them. White ants as a rule, attack bridge work at the abutment end where the timber is in contact with the more or less moist earth, and gradually work through the heart of the timber making large pipes in the girders, thus weakening the girders and eventually completing their destruction. They also attack the piles at about ground level, finding access through sun cracks, and once inside the pile, usually confine their action to the heart of the timber, extending their workings only a few feet below ground level but rising upwards to the top of the pile and if left to themselves will gradually eat the pile away until there is nothing but a mere shell. They are also very liable to attack the deck of a bridge when ballasted, the ballast protecting them from the light and affording the necessary moisture for their existance. The white ants are rarely found in timber that is isolated from moist earth, and good ventilation is one of the greatest safeguards against them, consequently for railway bridges what is known as the open topped bridge has very great advantages over the close topped bridge and ballasted road, and at the abutment end it would be advisable to use small brick piers with the earth tipped round them instead of the ordinary timber abutment. For protecting the piles it would be advisable to slightly char them and give them a good coat of tar before driving. The best safeguard against dry rot is ventilation and the open topped bridge may be considered nearly proof against this trouble. As to the question of preserving the timber by paint, tar or other agents: from observation it appears advisable to slightly char and tar the piles below ground level and for a foot or two above, but on any part of the timber work exposed to the action of the sun, tar has proved very detrimental to the life of timber as it has the effect of destroying the nature of the wood or opening out the fibre. The exposed ends of all timber should be well painted with white lead as it prevents the timber opening out; and it might be advantageous to give the timber a good coat of paint after the bridge had been erected about twelve months, but the advantages of painting are not very great as it is not the surface of the timber which deteriorates but the heart. As to the life of Australian timber in bridges, it is difficult to say how long the best classes of timber would last under favourable circumstances. The original timber bridges on the Western line between Parramatta and Penrith which were opened for traffic in 1860-62, were renewed in iron in 1886. When the old structures were removed more than half the timber (which was mostly iron bark) was found to be in a very good state of preservation. The original bridges between Campbelltown and Menangle which were opened for traffic in 1862 are still in use and are in a fairly good state of preservation, the only repairs and renewals to these structures have been a few new girders, a few deck timbers and piles, the total renewals not amounting to more than about 10 per cent. of the total amount of timber in the structures up to date. From the above facts it may be safely calculated that the life of a timber railway bridge built of the best Australian timber is at least 25 years. A question of very great importance in connection with railway construction in these colonies is the commercial and economical advantages of timber bridges of small spans as compared with structures of brick and iron. On almost all lines it is necessary to cross a large number of small creeks which in a dry season have little or no water in them, but in wet weather may extend to a width of many yards, necessitating the construction of a large number of long shallow waterways; the soil upon which these waterways have to be constructed being often many feet in depth before anything like good foundation ground is reached. To illustrate this matter, the attached plan shows designs for an arched bridge for double and single line, also a timber bridge for double and single line over the same creek. In the case of the arches the design is that in common use in the elevated portions of the London Metropolitan Railways and the foundations are taken at an average depth of 7′ 0″ from ground level. The timber viaduct is of 12 feet spans similar to that proposed by Professor Warren in his paper, but with a small brick pier at the abutment end in place of a timber abutment, the assumed depth of the piles below ground level is 15 feet. The water way in the case of the brick viaduct is about 2,750 square feet, and in the case of the timber viaduct 3,750 square feet, giving an advantage of 1,000 feet extra water way for the same height of rail. The following table gives the relative first cost of these structures taking the prices at recent contract rates:—

	Double Line.	Single Line.
Brick viaduct	£6,800 ...	£4,750
Timber viaduct	£2,225 ...	£1,150

For every additional foot in depth of foundations the cost of the brick viaduct for double line will increase by about 10/-. per foot run, and for a single line about 6/6 per foot run, and in the case of the timber viaduct the cost for each additional foot of depth for the piles will be 1/4 per foot run for a double line bridge, and 8d. per foot run for a single line bridge. Therefore in the case of it being necessary for the foundations to be taken down to a considerable depth the difference in cost between the brick and timber structures will be still more marked than in the above table. The proportional first cost of the structures may be taken approximately as follows:—For a double line, timber 1, brick 3; for a single line, timber 1, brick 4. Therefore considering this case in the light of an investment at compound interest in the same way as explained by Mr. J. A. McDonald M.I.C.E., &c., in his evidence on the Cowra Bridge before the Public Works Committee we get the following result:—Taking life of timber bridge at 25 years, and brick bridge at infinity. Interest at 4 per cent. sinking fund for timber bridge 2·4 per cent. For every £100 invested in double line timber bridge we have £300 invested in double line brick bridge, and for every £100 invested in single line timber bridge we have £400 invested in single line brick bridge. Therefore the annual charges are as follows:—double line timber bridge per £100 invested, charges £6 8s., corresponding brick bridge £300 invested, charges £12; annual saving for timber bridge £5 12. Taking at end of 25 years at compound interest for timber bridge per £100 invested £218 16s. Single line timber bridge per £100 invested £6 8s., corresponding brick bridge £400 invested, £16; annual saving for timber bridge £9 12. Saving at end of 25 years at compound interest for timber bridge per £100 invested £375 4s. Or in the case of the bridges above referred to by the adoption of timber a saving of no less than £4,868 6s. for the double line bridge, and £4,314 16s. for the single line bridge would be effected at the end of 25 years. For the class of viaduct under consideration the cost of iron and brick are about the same, but for a given height of rail the water way is considerably greater in the case of iron superstructures, and the same care is not required with the foundations as is the case with brick arches. From the above example I do not think there can be any question as to the great commercial and economical advantages of timber for this particular class of viaduct. Professor Kernot of the Melbourne University informed me in a letter dated 18th February 1889, that in Gippsland Victoria, timber viaducts of 15 feet spans and a height of from 8 to 10 feet above ground had been erected at an average cost of less than £2 per foot of length for single line. With reference to the American deck constructed of Australian hard wood, a considerable number of bridges have been fitted with this class of deck on the New South Wales Railways, and from my observations I am of opinion that for most classes of bridges it possesses advantages over all other descriptions of decks that have been brought forward, for the following reasons :—Firstly—It makes a very easy road to run over and in the case of iron bridges greatly reduces the impact and jar on the iron work. Secondly—In case of a derailment there is no possibility of a train going through the deck, and the guard timbers would most probably prevent the vehicle going over the side. Thirdly—It is practically fire-proof. Fourth—As the sleepers are only 16 inch centres there is practically a continuous bearing for the rail, and there is therefore no risk of the rails breaking on the bridge, and if a breakage should occur the rail would not be easily misplaced. I notice in Professor Warren's paper that planks are shewn down the centre of the deck of his proposed bridges, I think this must have been an oversight, as they are not required, and would be liable to cause fire. In conclusion it is to be hoped that considering the great value of our timbers, the question of the conservation and planting may be energetically taken in hand by the Department of Forests, so that our children may not be able to say that we came into a heritage of the finest timber for engineering works known, and after using a small portion of it ring-barked and wasted the rest, and were too short sighted and selfish to take the necessary steps for the conservation of this most valuable production of the soil

J. F. Mann—The points under discussion refer to the durability and inflammability of ironbark timber for bridge flooring in comparison with pine timber. It has been shown that the advantage of the former over the latter as to durability is as twenty-five years to eight, and I desire to point out that this period could be extended by using split slabs, whereby the grain or fibre of the wood would be retained intact throughout the whole length of the piece, in preference to sawn stuff; and I further wish to point out that, when dry, ironbark timber is most inflammable, certainly not to the extent of pine, but still liable to catch fire, as when once alight the fire will smoulder throughout the whole log, however large. Before slates or iron for roofing came into use it was a question of some of the Insurance Companies as to whether the shingles in use were of ironbark or of oak.

P. N. Trebeck —I take a little exception to that last remark about the pastoral interest. The country ringbarked contains inferior timber. Except in the Silver-leaved Ironbark country of Queensland, land that grows ironbark would not grow good grass. The pastoral interest did not destroy the valuable ironbark timber. That country is not adapted for pasture at all. They only ringbark box timber. It is better to utilise the land for growing grass than inferior timber.

J. F. Mann—I beg to differ in opinion, having travelled hundreds, perhaps thousands of miles over this country and noticed with regret the reckless destruction of fine timber by ringbarking. The introduction of galvanized iron has done much to prevent the bark from being stripped from the straightest and finest trees for roofing purposes. To such an extent was this carried in the early days of gold digging, that builders and others had great difficulty in obtaining sufficient timber for permanent buildings. I recently visited an extensive tract of ironbark country where, by the judicious process of burning off all undergrowth and rubbish, the large trees had been preserved and the otherwise poor soil was covered with good grass.

D. M. Maitland—I have a very few remarks to make with regard to what was said by a gentleman at the last meeting in connection with the reason for decking the Hawkesbury Bridge with soft timber instead of hardwood. The reason given for using soft wood instead of hardwood was the difference in the weight, but I think it would appear to most people that the difference in weight of a few tons between soft and hard wood is of very little moment in a structure of the size of the Hawkesbury Bridge. It would lead one to suppose if that was a consideration that the margin of safety must be run very fine. I hope that in his reply Prof. Warren will touch upon that subject.

Professor Warren—I will endeavour, as far as possible, to reply to the various remarks which have been made in the discussion. First, with regard to the relative advantages and disadvantages of pine timber and Australian timber in the decks of bridges, Mr. C. O. Burge, M. Inst. C.E., Government Engineer in charge of the erection of the Hawkesbury Bridge, stated "that the reason ironbark timber was not used for the deck was that the extra weight of the ironbark timber would necessitate a greater weight of steel in the bridge, the cost of which would more than compensate for any advantages due to the ironbark deck." The dimensions of the present oregon sleepers in the bridge are 24 feet long by 9 inches wide by 8 inches deep, and in order that ironbark sleepers should have the same strength they would require to be 8 inches wide by 6 inches deep, since the modulus of rupture of ironbark is at least twice as great as oregon timber. The weight of the present oregon deck is about 60 tons, and the iron-bark deck would weigh 80 tons, as the weight of ironbark is about twice that of oregon. The total load on one span of the bridge is :—

Steel ...	...	=	960
Timber	...	=	60
Live Load	...	=	944
Total	...		1964 tons.

Therefore one ton of steel carries about two tons of load, hence in order to carry the extra 20 tons due to the ironbark deck, the total weight of steel in main trusses, cross girders, and longitudinals would not require to be increased by more than 10 tons. Taking the cost of this steel erected at £35 per ton, the extra cost of steel in one span of the bridge is £350. The life of a steel bridge is usually taken at 150 years, and the iron-bark deck at 25 years, while the oregon deck would not exceed 7 years. Hence, in order to cover interest at 4 % on prime cost and depreciation, we have the following annual charges :—

Steel	would require	4·01 %	per annum.
Ironbark	,,	6·40 ,,	,,
Oregon	,,	16·66 ,,	,,

The price of oregon timber is 2s. per cubic foot, and of ironbark timber 2s. 3d. per cubic foot, hence the cost of the oregon deck would be £376, and the cost of the ironbark deck £282. The capital values for the extra steel, the ironbark, and the oregon are as follows :—

$$\text{Steel} = \frac{350 \times 4{\cdot}01}{4} = £351$$

$$\text{Oregon} = \frac{376 \times 16{\cdot}66}{4} = £1566$$

$$\text{Ironbark} = \frac{282 \times 6{\cdot}40}{4} = £451$$

The difference in favour of the ironbark deck is therefore £764 per span. If the life of the oregon deck were 10 years instead of 7 the saving would have been £232 per span. The saving due to the less frequent renewal of the ironbark deck, and the interruption to the traffic every 25 years instead of every 7 years, would represent something more, hence I conclude that Mr. Burge is incorrect if he supposes (which I really doubt) that there is any real advantage in the oregon deck.

Mr. Burge—I did not intend to convey that impression. Professor Warren, in his paper the other evening, said he did not know for what reason the oregon deck was adopted. I accordingly suggested the idea, without going into a calculation such as the Professor has gone into now. I am by no means a defender of it. I agree with him it ought to be ironbark.

Professor WARREN—I am glad Mr. Burge has explained the statement made by him at the last meeting. The Union Bridge Company, who designed and constructed the bridge, told me that if they had known the value of our ironbark timber, they certainly would have used it in preference to oregon timber. The remarks made by Mr. Trevor Jones imply that the shrinkage of the wedges in a compound beam would reduce its strength and stiffness, but the design illustrated in Plate 7 clearly anticipates this shrinkage, and provides for the wedges being driven in to fit tightly in the notches cut in the main beams to receive them. It is only necessary for these wedges to fit tightly in the direction of the length of the beams, as they have to resist the horizontal shearing stresses only; the vertical shearing stresses, which are of equal intensity, will be resisted by the bolts. In consequence of the shrinkage of the timber, there is always considerable maintenance in timber bridges, more especially when unseasoned timber has been used in their construction. This maintenance is greater during the first 12 months than afterwards, but there is obviously no more difficulty in driving in the wedges from time to time than in screwing up the bolts, consequently the design illustrated in Plate 7 would not be less efficient from the shrinkage referred to. With regard to Mr. Jones' remarks on the strength of circular beams, I explained fully how the strength of a beam of any section might be determined, but the beams used in Plate 2 are prepared from round logs of timber by adzing at top and bottom, and may be calculated from the formulæ given in the paper by merely substituting the mean breadth for b. Mr. Haycroft appears (as far as I can judge from his diagrams and calculations) to have considered the stresses in the Cowra Bridge just as if the diagonal members were rigidly connected to the booms and were consequently capable of transmitting tensile as well as compressive stresses. Of course it is not possible, in listening to a description such as that given, to say precisely how Mr. Haycroft has considered the question, but I understand that he has dealt with the stresses just as he would have done in an iron bridge with the diagonals rigidly attached by means of rivets, and thus capable of transmitting tensile as well as compressive stresses. Thus the diagonal marked Y_3 in Plate 13 is in compression if the joints to the left are loaded, while it is in tension if the joints to the right are loaded, and if the diagonals were attached by means of rivets as in an iron bridge the resultant stress on it would be tensile, as the tension produced by loads to right would more than balance the compression produced from loads to the left. But, in the case of the Cowra Bridge, it is clear from the details shown on Plate 8 that the diagonals fit into pockets and are wedged up to take compression but are incapable of resisting or transmitting tension, consequently Y_3 will be always in compression, and the tensile stresses in the the web will be resisted entirely by means of the verticals. I consider that Mr. Vicars has clearly shown the difference between the Cowra Bridge and that calculated by Mr. Haycroft.

Mr. HAYCROFT—I did not consider what the bridge was made of.

Professor WARREN—Mr. Haycroft's calculations appear to be correct for an iron bridge, but are incorrect as applied to the Cowra Bridge. Mr. Dare in his remarks agrees with Mr. Vicars in the calculations given in the paper for the Cowra Bridge, and he differs consequently from Mr. Haycroft. Mr. Dare has also shown clearly the proportion of depth to span in ironbark timber beams in order that they may not fail by horizontal shearing along the neutral axis, his method is correct, and may be applied generally to Australian timbers. I would merely remark that the resistance to shearing along the grain frequently exceeds 2,000 pounds per square inch, and that consequently the depth need not always be as great as one-ninth of the span even for a distributed load. In the case of a compound beam these considerations do not apply for reasons already given. The remarks made by Mr. Shellshear are very valuable, and will be appreciated by all those who have had experience of timber structures. Mr. Shellshear has clearly shown the advantages of Australian timbers in railway construction over iron and brickwork, his objections to the planking shown on Plates 5 and 8, I fully admit. Mr. Vicars also pointed out that I had not shown in my paper how long compression members should be designed in such a structure as the Cowra Bridge, and in thinking over the question since reading the paper, I decided to prepare the following table which covers every case likely to arise in practice :—

Comparative Strength of Long and Short Columns of Australian Timbers per square inch of sectional area.

Local Name.	Number and Letter.	Ratio of Length to Smallest Dimensions.		Modulus of Transverse Elasticity.
		4 to 1	36 to 1	
NEW SOUTH	WALES	TIMB	ERS.	
Red Ironbark	P, 4 ...	12,013	8,338	3,084,333
Red Ironbark	B, 16 ...	12,308	6,250	2,658,433
Grey Ironbark	B, 17 ...	10,288	6,250	2,806,975
White Ironbark	P, 5 ...	11,239	6,625	3,037,400
Tallow-wood	P, 2 ...	9,511	5,169	2,745,333

Local Name.	Number and Letter.	Ratio of Length to Smallest Dimensions.		Modulus of Transverse Elasticity.
		4 to 1	36 to 1	
Blackbutt	B, 22 ...	9,250	6,140	2,424,666
Blackbutt	P, 1 ...	10,204	5,875	2,514,100
Spotted Gum	B, 14 ...	8,406	5,250	2,386,833
Red Gum	B, 11 ...	9,842	5,000	2,197,076
Flooded Gum	P, 8 ...	9,618	6,259	2,196,696
Grey Gum	P, 7 ...	9,822	5,125	2,547,300
Ribbon Gum	K... ...	5,572	2,790	1,400,566
Mountain Gum...	B, 19 ...	7,940	4,531	1,766,233
Mountain Gum or Grey Gum	J.... ...	6,576	3,219	1,389,450
Woollybutt	B, 15 ...	7,355	4,975	2,070,833
Forest Mahogany	P, 11 ...	9,953	5,641	2,524,466
Swamp Mahogany	B, 10 ...	6,992	4,569	1,715,453
Swamp Mahogany	P, 12 ...	5,768	3,656	1,996,300
Mountain Ash	B, 18 ...	8,485	5,656	2,159,866
Stringy-bark	B, 12 ...	8,844	4,547	1,953,033
Smooth-topped Stringy-bark	I.	5,699	3,219	1,616,866
Victorian Messmate	S.... ...	4,624	3,635	1,768,066
Messmate	P, 6 ...	8,605	5,606	2,233,600
Messmate	B, 20 ...	9,470	4,922	2,040,833
Brush or White Box	{ P, 10 ...	7,083	3,513	1,990,600
	{ B, 9 ...	9,521	5,172	3,114,936
Bloodwood	P, 9 ...	11,116	6,438	2,185,533
Bloodwood	B, 13 ...	9,215	3,906	1,782,312
Blackwood	B, 21 ...	7,534	3,975	1,661,126
Forest Oak	P, 13 ...	10,227	5,062	2,577,713
Turpentine	B, 23 ...	9,885	5,031	2,001,166
Turpentine	P, 3 ...	9,236	4,531	1,963,233
Hoop, or Moreton Bay Pine ...	P, 17 ...	5,284	3,419	1,341,633
Rosewood	P, 16 ...	7,587	4,125	1,705,033
Coach-wood	P, 14 ...	6,206	3,638	1,717,833
Coach-wood	B, 24 ...	5,484	3,281	1,438,400
White Beech	P, 15 ...	5,195	3,550	1,430,900
Beech, or Negro Head ...	P, 18 ...	5,427	4,516	1,645,633
Red Cedar	P, 19 ...	2,915	969	693,315
VICTORIAN TIMBERS.				
Blue Gum	M, 1 ...	8,993	5,210	1,747,783
Mountain Ash	M, 2 ...	7,575	4,388	2,026,046
Red Gum	M, 3 ...	7,579	3,325	1,373,542
Blackwood	B. V. ...	6,370	3,625	1,253,448
Mahogany	M. V. ...	8,098	5,263	1,507,366
WESTERN AUSTRALIAN TIMBERS.				
Jarrah	M.C.D. 1.	5,960	3,516	1,300,775
Jarrah	M.C.D. 4.	7,720	4,456	1,941,766
Red Gum	M.C.D. 2.	5,927	3,438	1,712,546
Karri	M.C.D. 3.	7,132	4,013	1,707,326
QUEENSLAND TIMBERS.				
Ironbark...	A... ...	8,604	4,328	2,304,500
Spotted Gum	C.... ...	10,866	5,325	2,515,666
Grey Gum	H... ...	10,190	5,688	2,258,833
Blackbutt	B... ...	7,377	3,750	2,438,633
Tallow-wood	D... ...	7,473	4.069	1,597,966
Swamp Mahogany	E... ...	9,161	4,313	2,372,316
Turpentine	G... ...	9,865	5,422	2,800,500
Penda	I.... ...	9,916	3,938	2,273,466

The table shows the relative strength of timber columns subjected to direct compression, as would be the case in a column 12 inches long and 3 inches by 3 inches in section, compared with a column 6 feet long and 2 inches by 2 inches in section, or with a ratio of length to smallest dimensions of 4 to 1 compared with 36 to 1. The short columns failed by direct crushing of the fibres, while the long columns failed by buckling transversely, and the tables give at once the compression per square inch at which failure occurs without any calculation. The behaviour of long and short timber columns have been investigated by Professor Rankine, Gordon and Shaler Smith, but their formulæ are mathematically incorrect, although they are approximately correct, for those cases in which the constants f and a have been determined under similar conditions to those existing in the case under consideration, and from the data contained in the foregoing table it would be an easy matter to calculate the values of the constants f and a for Australian timbers, but the experimental results given in the table render the formula unnecessary for Australian timbers. The most complete investigation of the strength of long columns is that given by Professor R. W. Smith, of the Mason College, Birmingham, published in the *Engineer* for October, 1887, pages 303, 345, and 425, and I recommend it to all those who are interested in the subject. In conclusion, I am glad that the paper has called forth such a good discussion, and my thanks are due to those gentlemen who have taken part in it.

The PRESIDENT—I am sure we are all pleased not only at having had the opportunity of hearing Professor Warren's paper read at the last meeting, but of listening to the valuable discussion upon it. It is to be hoped that the question of our Australian timber will come to the front now it has been shown to be so superior to that hitherto used here in the construction of bridges and so forth.

CORRESPONDENCE.

JOHN A. MCDONALD, M.I.C.E.—I did not intend taking any part in the discussion on this paper, but on reading over the remarks made by the different members, it appears to me that some points might be brought out more clearly. Mr. Haycroft states, in speaking of the Cowra bridge, "the stresses in the several members of which will, I think, on investigation be found incorrect." I may state that the stresses *have been* thoroughly investigated, as might have been judged by the paper, and Mr. Haycroft's statement that he only "thinks" they will be found incorrect, seems rather to admit a doubt of his own calculations.

Later on Mr. Haycroft states that he has developed "the true maxima stresses in the several parts of the truss, and finds them differ considerably from those given in the paper." This appears at first sight as if Mr. Haycroft considered the stresses in the paper were incorrect, but must be taken in conjunction with the above "I think" and his statement later on that—"In Y_3 and Y_8 the stress is given as 21 tons, although I think it will be found no stress can exist in these members from the class of loading under consideration. These braces, however, should not, I think, be omitted, as they preserve uniformity in appearance, and, if properly utilised, are a source of strength to braces Y_{11} and Y_6." It appears to me strange for an engineer to come forward at a meeting like the present and make vague charges of error in a calculation which he does not prove; and to recommend the putting in of struts which he states carry no stress so that they may be "a source of strength to braces Y_{11} and Y_6." The calculation of stresses in redundant structures is so well understood that it is needless for me to say much further than has already been given in the paper, but I would point out that the live and dead loads combined at apices 1 and 2 produce a certain reaction on the right abutment, that this reaction is taken by the chord horizontally and by an imaginary diagonal from right abutment to the intersection of Z_3 and V_2. The amount of the stress on this diagonal can then be resolved along Z_3 and Y_3, and if this simple principle of a triangle of forces be adopted, it will be seen at once that there is a stress of 21·19 tons on bar Y_3. In a similar manner the dead loads on apices 3, 4, 5, 6 and 7 produce a stress of 24·38 tons on Y_{11}. The two systems of diagonals in this case are entirely independent, and the strut Y_3 can in no way relieve the stress on Y_{11}. Mr. Haycroft's *surmise* in reference to the concentrated rolling load is, to say the least, strange; however, as he may mean it seriously, I will explain how this load has been taken. The traction engine is assumed to weigh in steam 16 tons, of which $9\frac{1}{2}$ tons are on the driving wheels, and $6\frac{1}{2}$ tons on the trailing wheels. The wheels are 1′ 4″ wide, and 5′ 0″ centres, the distance between centres of driving and trailing wheels being 10′ 4″. The maximum stress in one truss occurs when the traction engine is close up to the kerb, and the driving wheels are over a cross girder. The total load at this apex is then 9.86 tons due to both driving and trailing wheels. (The detail calculation being so simple is omitted). Mr. Haycroft states that he does not consider it good practice to design all the suspension bolts the same size. Of course this is a mere statement of opinion on his part, and as the additional cost for surplus material is only £15 per truss, the advantage of uniformity more than compensates for this waste.

JAMES VICARS, B.C.E.—Since the discussion on Professor Warren's Paper, I have prepared the diagram given on Plate 16, to show more clearly the manner in which the loads are transmitted through the various members of the truss to the points of support. The forces acting at each apex, due to the dead load, are resolved in the directions of the several members meeting at these points, in accordance with the principles of the parallelogram, or rather triangle of forces. The diagram shows a portion of load (1) transmitted to the right support, B, through Z_2 and Y_2, the direction of their resultant stress being a line from their apex to B; a portion of load (2) together with the vertical component of Y_2 transmitted to B through Z_3 and Y_3, the line from their apex to B being the direction of their resultant stress; and similarly that all loads transmitted to B pass through members of the system Y_2, Y_3, Y_4, Y_5 and Y_6, while all loads transmitted to A use members of the other system Y_7, Y_8, Y_9, Y_{10} and Y_{11}; but since the diagonals are not connected up, the stresses in members of the one system cannot affect the stresses in members of the other system. The maximum stress on Y_3 obtained by this method, with live loads at V_1 and V_2 is (3·1 + 6·3) due to dead load and (4 + 7·8) due to live load, or a total of 21·2 tons against 21·19 tons given in the paper. The stresses on the various members obtained are given in the table appended, which agrees generally to the first place of decimals with those given in the paper.

TABLE OF STRESSES FOR DEAD LOADS.

Bar.	Stresses obtained by triangle of forces.		Stresses given in paper.
	Stresses.	Total.	
X_1, X_2, X_7, X_8	93·4	93·4	93·53
X_3, X_6	93·4 + (15·7 − 13·4)	95·7	95·88
X_4, X_5	95·7 + (8·1 − 8·1)	95·7	95·85
Z_1, Z_8	22·5 + 56·7 + 26·5	105·7	106·08
Z_2, Z_7	22·5 + 56·7 + 11·4	90·6	90·77
Z_3, Z_6	17 + 34 + 14·7 + 7·4	73·1	73·22
Z_4, Z_5	17·6 + 26·6 + 15·7 + 15·9	75·8	76·28

TABLE OF STRESSES FOR DEAD LOADS—*Continued.*

Bar.	Stresses obtained by triangle of forces.		Stresses given in paper.
	Stresses.	Total.	
V_1 V_7	14·0	14·0	14·0
V_2 V_6	14 + 7 + 18·7	39·7	39·77
V_3 V_5	14 + 8·5 + 11	33·5	33·49
V_4	14 + 15·2 + 15·2	44·4	44·33
Y_2 Y_7	15·0	15·0	15·12
Y_3 Y_{11}	7·8 + 4·0	11·8	11·77
Y_4 Y_{10}	9·8 + 10	19·8	19·74
Y_5 Y_9	8·2 + 5·5	13·7	13·62
Y_6 Y_8	8·1 + 16·3	24·4	24·38

Professor Warren—In reply to the correspondence I agree with the remark made by Mr. Vicars and Mr. Macdonald, and consider that the stresses given in the paper are those for which the bridge should be designed to resist.

WEDNESDAY, AUGUST 6, 1890.

Dr. LEIBIUS, M.A., F.C.S., President, in the Chair.

Thirty members were present.

The minutes of last meeting were read and confirmed.

The certificates of seven candidates were read for the third time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Dare, Henry Harvey, B.C.E., Waverley.
Eddy, E. M. G., Assoc. Inst., C.E., Double Bay.
Freehill, Francis B., M.A., Sydney.
Henry, Arthur Geddes, M.B., Callan Park Asylum.
Pockley, Francis Antill, M.B., St. Leonards.
Rutledge, David Dunlop, M.A., M.B., Ch.M., Sydney.
Sloane, Thomas G., Sydney.

The Chairman announced that the Journal and Proceedings for 1889, Vol. XXIII., had been received from the binder and would be distributed in the course of a few days to all the members entitled to it.

A letter was read from the Antarctic Committee Melbourne, inviting the co-operation of the Royal Society of New South Wales in the carrying out of the proposed Swedish-Australian Expedition to the Antarctic Regions, and stating that Barons Nordenskiold and Oscar Dickson had promised to defray half the cost of the expedition, providing an equal amount (£5,000) were raised in the Colonies.

Mr. J. F. Mann—I may say that similar communications have been received by the Geographical Society of New South Wales. The Royal Society and the Geographical Society in Melbourne, I am informed are working hand in hand to carry out the objects of these communications. Several Melbourne people have already promised large sums. The idea is that the Royal Societies and Geographical Societies of the different Colonies shall work together with the object of carrying out this proposal. We of the Geographical Society have been asked to communicate with the Royal Society on the matter.

The President—It will be our duty to do the best we can to promote the object in view. The matter will doubtless receive full consideration by the Council.

Annual Conversazione.

The President—I have a communication to make with regard to the Conversazione. It was intended to hold it at the University in September next. The Hall, however, being required from the 15th to the 27th September for examinations the date for holding the Conversazione has been altered to Wednesday, December 10.

Mr. G. H. Knibbs, L.S., read a paper on "The Theory of Repetition Measures of Angles with Theodolites.

Remarks were made by Messrs J. F. Mann, D. M. Maitland and the Chairman.

In the absence of the author, the Hon. Secretary (Mr. Kyngdon) read a continuation of a paper by Baron Ferd. von Mueller, K.C.M.G., M. and Ph.D., F.R.S., &c., "Record of hitherto undescribed plants from Arnheim's Land.

The author had named one of the plants after Dr. Leibius and had informed the President by letter, of his intention to name some further plants after Mr. H. C. Russell and Prof. Liversidge.

In the absence of the author the Hon. Secretary (Mr. Kyngdon) read a paper by Mr. W. T. Wyndham on "The Australian Aborigines: varieties of food and methods of obtaining it." Some coloured drawings of food plants with native names accompanied the paper; the botanical names and description of which had been kindly furnished by the Rev. Dr. Woolls, F.L.S.

Some remarks were made by Mr. T. W. Edgeworth David, F.G.S.

Mr. H. C. Russell, B.A., C.M.G., F.R.S., read a paper on "Some photographs of the Milky-Way recently taken at the Sydney Observatory," some of the photos were afterwards exhibited.

The thanks of the Society were accorded to the various authors for their valuable papers.

The following donations were laid upon the table and acknowledged:—

Donations Received during the Month of July, 1890.

(The Names of the Donors are in *Italics.*)

TRANSACTIONS, JOURNALS, REPORTS, &c.

Adelaide—Government Botanist. Report on the Progress and Condition of the Botanic Garden during the year 1890. *Government Botanist.*

Royal Society of South Australia. Transactions, Vol. xiii., Part i., 1890. *The Society.*

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Caen—Académie Nationale des Sciences, Arts et Belles-Lettres. Mémoires, 1887-88. *The Academy.*

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Miscellaneous.

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Photo of Compressed-air Flying-machine (Framed). *Lawrence Hargrave.*

WEDNESDAY, SEPTEMBER 3, 1890.

Dr. Leibius, m.a., f.c.s., President, in the Chair.

Fifty-five members and twenty visitors were present.

The minutes of the last meeting were read and confirmed.

The Certificates of five new candidates were read for the second time, and of three for the first time.

In the absence of the author, the Hon. Secretary (Mr. Kyngdon) read a continuation of a paper by Baron Ferdinand von Mueller, K.C.M.G., M. & Ph.D., F.R.S., "Record of hitherto undescribed plants from Arnheim's Land."

Prof. Warren read a paper "On the application of the results of testing Australian Timbers to the design and construction of timber structures."

Some remarks were made by Messrs. J. Trevor Jones and O. Burge when the Chairman announced that the discussion upon Prof. Warren's paper would be postponed to the next meeting, in order that the paper and diagrams might be printed and circulated amongst those members interested in the subject, previous to the discussion taking place

The thanks of the Society were accorded to the authors for their valuable papers.

Mr. J. A. Pollock on behalf of Prof. Threlfall exhibited an enlargement for lecture purposes, of a negative of Fresnel's Interference bands. The light used in the production of the bands was that of the electric arc rendered nearly homogeneous by allowing it to pass through a cell containing a solution of strong nitrate of copper and chromic acid. The bands were formed by passing a filtered light through a biprism.

Mr. C. L. Garland, m.l.a. exhibited and described one of Edison's latest perfected Phonographs, he said that he thought his task in explaining the phonograph would be an easy one, seeing that he was speaking to a number of scientific gentlemen. For that reason he did not need to go into the question of the relationship of sound to the human ear. He mentioned that some twelve years ago Mr. Edison suddenly hit upon the the discovery that the human voice could be stored up and reproduced by means of a diaphragm attached to a ball point which travelled over indentations made in tinfoil. An old tinfoil phonograph had, he believed been exhibited some years ago in that very hall. Eight or nine years elapsed after the manufacture of that article, during which time Mr. Edison was busily engaged on the electric light and others of his inventions, and almost neglected the perfecting of his phonograph. In the meantime two gentlemen, Messrs. Bell and Tainter, took up Edison's idea and perfected a machine which is now known as the graphophone, the principle of recording sounds and reproducing them being precisely the same. When one morning Mr. Edison woke up and found such a machine invented which eclipsed his own tinfoil phonograph, he started to work and had been at work some two years in perfecting the Phonograph, and during that time he was said to have spent £32,000 in bringing the machine to perfection. When he (Mr. Garland) went to England and America last year he determined to secure one of Mr. Edison's latest perfected phonographs. He made two trips to America, and during that time spent many days in Mr. Edison's factory examining the method of manufacture. His acquaintance with the machine had extended over a period of nine or ten months, and he certainly could say that the infatuation which was inseparable from an acquaintance with it extended. Mr. Garland then explained the construction of the machine under exhibition. Continuing his remarks, he said that at first it was made purely as a commercial machine, and not with any view of recording music. It was really made to act the part of a shorthand writer, and as such was largely used in many American houses of business. The principal of an office would, on arriving and opening and reading the letters, in lieu of dictating to a shorthand writer, dictate direct to the phonograph, and as he dictated his letters he would place the little grammes in a little box. Those grammes were numbered, and the office boy or girl would afterwards place them upon the machine and typewrite the letters as they had been dictated to the machine. The business man would afterwards read the typewritten letters, sign them and they were ready for the post. That meant an enormous saving of time and labour. The machine never made a mistake. Whatever was dictated to it, it would correctly repeat.

The machine he was about to exhibit was a commercial machine and not a musical one; therefore the audience should not expect too much from it, though he would give a few examples of its capabilities in that direction. He mentioned that Edison was engaged on a machine to be used for the reproduction of music, which would eclipse as a musical box the one he was exhibiting. Edison's laboratory at the town of Orange, New Jersey, was a large concern. He had 400 hands employed there upon the instrument, and had no less than 1,000 machines employed in the manufacture of the phonograph, some of them about as complex as the phonograph itself. All that machinery was driven by electricity. The same principle was being employed with many other things, besides the phonograph. Edison had a clock with a phonograph inside of it which in the morning would warn you it was time to get up and if you were not then inclined to rise a bugle call would be sounded almost immediately in your ear. The phonograph had been amalgamated with the graphophone. There was a company called the United Phonographic Company, which held the rights of the machines outside America and Canada, and it was from that Company that he (Mr. Garland) obtained the two machines he then had. Edison was busily engaged in endeavouring to invent what he termed a collapsible cylinder, or a cylinder that could be folded up. He claimed that when he had achieved that, speech would supersede writing altogether in ordinary correspondence.

Mr. Garland then gave several illustrations of the capabilities of the phonograph.

The thanks of the Society were conveyed to Mr. Garland for his very interesting and instructive exhibit.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF AUGUST, 1890.

(The Names of the Donors are in *Italics.*)

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(Names of Donors are in *Italics.)*

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RECORD OF HITHERTO UNDESCRIBED PLANTS FROM ARNHEIM'S LAND;

By Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S. &c.

[*Read before the Royal Society, N.S.W., November 5, 1890.*]

Calophyllum Soulattri.

N. L. Burmann, flora Indica 121 (1768).

Tall; branchlets at first slightly tomentellous; leaves large, on rather short stalks, from ovate- to elongate-elliptic, glabrous; racemes short, often reduced to fascicules or umbels, always glabrous; flowers comparatively small, on stalklets of generally much greater length; sepals four; petals none; stamens about fifty; anthers several times longer than broad; style fully as long as the stamens; fruit relatively small, globular or verging somewhat into an ovate form, outside dark-coloured, without any lustre.

Not previously recorded from Australia, Mr. Holtze found the tree to be 30 – 40 feet high, and the flowers as those of most congeners white and fragrant. Our plant accords well with specimens collected by Tyesman in Sumatra and by Zollinger in Java. Burmann's description is very brief; for identification therefore must mainly be relied on the Malayan vernacular "Soulattri," which however is applied also to the much rarer *C. Teysmanni*, *C. dasypodum* and possibly to some other species. Nevertheless it is almost sure, that Burmann had our species, the subsequently described *C. spectabile* in view, although Hasskarl regarded the plants of Willdenow and of Burmann as distinct from each other; but as De Candolle, Blume, Miquel, Planchon and Triana all quote unhesitatingly *C. Soulattri* under *C. spectabile*, it seems but just, to restore the earliest name. The short description given on this occasion is solely from Australian specimens. In India the fruit seems to assume occasionally an oval shape. The *Bintangor silvestris*, taken up by Rumphins from M. B. Valentini, cannot be readily identified with our species, as the leaves are figured at reduced size and more pointed, the pedicels shown shorter, and the flowers are not delineated. Thus *C. acuminatum* remains also yet obscure, and could only be re-established by searches in Amboina. *C. Inophyllum*, according to specimens from the great Kew establishment, was found already, 1802, by R. Brown on the Northumberland Islands, where I saw it in 1855, as well as on Lord Howick's group. Furthermore, Cunningham early recorded it in the appendix to King's Voyages. Besides from these localities and those mentioned in the Fragm. Phytogr. Austr. IX., 175, we also know this useful plant now as Australian from Goode Island (Powell), Endeavour River (Persieh) and Russell River (Sayer).

Corchorus capsularis.

Linné, spec. plant. 529 (1753).

Truly indigenous in the vicinity of Port Darwin, according to Mr. Holtze, who finds it there to attain a height of 6 feet. In as much as also *C. olitorius* was found spontaneously growing on Van Diemen's Gulf; furthermore as *C. tridens*, *C. fascicularis*, *C. acutangulus* were already seen by me far inland in Arnheim's Land, long before any settlements there were found, while *C. trilocularis* has been brought as wild under notice from several localities of eastern intra-tropical Australia, it seems safe, to admit also *C. capsularis* now as an indigenous Australian species, although it is one of the principal Asiatic Jute-plants. Seeds occur sometimes also in the accessory cells of the fruit.

Sterculia Holtzei.

Tall; branchlets thick, glabrous; leaves chiefly terminal, on slender petioles, simple, chartaceous, nearly ovate, occasionally with a shallow basal sinus, of an almost equal light green and nearly glabrous on both sides, entire; racemes mostly crowded towards the summit of the branchlets, partly compound; flowers small, their pedicels about half as long or shorter; calyx ellipsoid-urceolar, outside dull yellowish-green and except on the summit glabrous, inside bearing extensively a thin but dense pale somewhat papillular indument, the lobes spreading, of about one-fourth the length of the tube, semi-lanceolar, inside beset with short spreading hairlets; staminal column glabrous, shorter than the globular-ovate mass of anthers or nearly as long; stigmas revolute, considerably shorter than the style; ovularies grey from a close starry vestiture; ovules 3 – 4, rarely 2.

Tree, 30 to 40 feet high. Bast pale, very tough. Leaves probably annual, 3 – 4 inches long, $1\frac{1}{2}$ to 2 inches broad, so far as seen; their secondary venules faint. Petioles about one inch long. Stipules small, tomentellous, from semilanceolar to deltoid, fugacious. Racemes measuring 2 to 3 inches in length, their peduncles and pedicels glabrous. Calyx about $\frac{1}{3}$ inch long. Stamens at the base of the muturating pistils rather copious. Ovularies very obliquely ovate. Fruit not yet obtained.

This species is easily distinguished from *S. Edelfelti* in leaves much broader towards the base and blunter at the apex, in less turgid somewhat longer calyces with lobes less broad, also less invested and not cohering during anthesis, while the fruits are likely also different.

Goodenia Pumilio.

R. Brown, prodr. fl. Nov. Holl. 579.

Of this puny but remarkable plant Mr. Holtze has recently sent well developed specimens, from which the characteristics could now be more fully studied. The leaves attain occasionally the length of one inch. The fruiting calyx may gain a length of nearly $\frac{1}{4}$ inch, as the upper lobe becomes finally somewhat enlarged like in *Euthales*. The corolla is dark-purplish, outside beset with short hairlets; its lobes are almost unilateral, nearly equal, semi-lanceolar, and have no lateral expansions; thus the corolla is comparable to that of *Selliera*, with which genus our plant accords also in the stigma-cover, so far as the absence of cilia around the opening is concerned, but the indusium bears elongated very subtle hairlets outside downward. The capsule is bivalvular and imperfectly septate. The seeds are very minute, lenticular-biconvex, brownish, shining, smooth and devoid of any marginal expansion, thus resembling to some extent those of *G. purpurescens*. The habitual similarity of this plant is with *Calogyne purpurea*, with which species it shares also in the colour of the corolla, and in sometimes also forming short stems.

Utricularia capilliflora.

Annual, minute, glabrous; leaves all radical, spatular-oval, long- or short-stalked, sometimes undeveloped; stem solitary, finely capillulary, constantly one-flowered: bract basifixed, clasping, blunt, very much shorter than the pedicel; bracteoles rather narrow, acute; lower sepal slightly bifid; upper entire, very concave; carolla lightly reddish-brown, the upper portion produced into two erect comparatively much elongated capillulary segments, the lower portion much shorter, fringed by several extremely narrow segments; descending protuberance turgid, blunt, about as long as the lower sepal or a little longer; ovules numerous.

On the Adelaide River; Mr. Holtze junior. Height 1 – 3 inches. Root-fibrils very short and thin. Leaves $\frac{1}{8}$ inch long or even often dwindling to $\frac{1}{12}$ inch. No empty bracts or bracteoles on the stem. Upper portion of the corolla often fully $\frac{1}{2}$ inch long and occasionally reaching $\frac{2}{3}$ inch. Fruit not known.

This is one of the most delicate of all vascular plants within the whole range of our knowledge. The average-weight of a dried specimen is only about ·00617 of a grain, and the fresh plant would likely not weigh very much more. The two long hairlet-like segments, of which the upper portion of the corolla mainly consists, are quite exceptional in the genus.

U. Singeriana has the fruit spherical, measuring $\frac{1}{4}$ – $\frac{1}{3}$ inch; the seeds are brownish, shining, almost linear-cylindric, about four times longer than broad, striolate but otherwise smooth and at both ends truncate. *U. leptroplectra* has the mature seeds dark-brown, from a little longer than broad to twice as long, reticular-foveolate and at both extremities truncate.

(To be Continued.)

GEOLOGICAL NOTES ON THE BARRIER RANGES SILVER FIELD,

By C. W. Marsh, Umberumberka.

[*Read before the Royal Society of N.S.W., November 5, 1890.*]

The Barrier Ranges Silver-field is situated near the western border of New South Wales, and immediately east of the South Australian boundary, its distance from Sydney being about 600 miles, in a direction slightly north of west. The portion to which the silver deposits are more particularly confined comprises an area of about 800 square miles, having, from the Angus and surrounding claims on the south, to Mount Robe, Black Prince, War Dance, &c., on the north, a length of about 40 miles, and from the Thackeringa, Umberumberka, Day Dream, and other mining properties on the west, to the Rockwell Paddock claims on the east, a width of about 26 miles. This silver-bearing portion of the ranges consists of low undulating hills with broad valleys and flats, the hills being principally gneissic or hornblendic rocks, while in the valleys and flats in most cases are found the softer micaceous, talcose and chloritic schists.

The more or less parallel strike and dip of these rocks, together with their different powers of resistance to disintegrating agencies, have resulted in an irregular lineal arrangement of hill and valley in a north-easterly and south-westerly direction. The strata-graphical structure of these ranges is synclinal, the rocks on the western side dipping east, at or about 60 degrees, rising to the horizon again on the eastern side at nearly the same angle; and, though we may not be able to recognise on each side rocks of precisely the same order and character, the differences are not greater than we should expect, considering the changed conditions under which these separated deposits may have taken place.

Besides the main synclinal fold, whose limits are hidden beneath the sediments of the eastern and western plains, there are numerous small folds arising from the effects of local pressure, causing many changes in the dip and strike of the surface rocks. While, irrespective of the synclinal fold and other modifications, there appears to be a general bodily dip of the country to the southward. The more argentiferous rocks occupying the upper or inner portion of this synclinal fold appear, so far as observed, to rest upon a series of strata made up principally of highly granitic gneisses with calcareous and argillaceous schists; greenstones are for the most part absent, but when present, are usually found to run continuous for long distances parallel with the other rocks. The more hilly country, such as the Mount Gipps Ranges on the north-east, the Waukaroo Ranges on the north, and the Mundi Mundi Ranges on the north-west, are principally made up of these rocks, in parts of which however, irregular out-lying portions of the upper rocks occasionally appear. Whether these two apparently dissimilar formations are stratagraphically conformable or otherwise, remains for future study to decide, while if they graduate into each other by almost insensible transitions, as in some instances they appear to do, the solution of the problem, in the absence of fossils, will be no easy task.

The most noticeable differences between these and the metalliferous group of rocks above them are that the argillaceous and calcareous members of the former appear to be represented by the micaceous schists and hornblendic rocks of the latter, while the extensive tracts of highly granitic gneisses in the lower are but sparingly represented in the upper, where as a rule, the gneisses are more decidedly schistose. The whole of these rocks, inclusive, are more or less intersected by dykes of dolerite, often micaceous; diabase, frequently porphyritic diorite, from aphanitic to coarsely crystalline; a hornblendic rock, decomposing readily on exposure, and not easily defined, and granite. These intrusive rocks are often transverse to the strata and traceable for long distances, at other times following the strike of their enclosing rocks. These dykes, so far as observed, appear to be common alike to both divisions, but if any should be found restricted to the lower and absent from the upper rocks, they may greatly assist in fixing the lines of demarcation. Besides these dykes, which have the appearance of being decidedly intrusive, there are veins and irregular masses, very similar to some of them in their more essential mineral ingredients, which are often found passing over by slow graduations into metallic veins and deposits. These irregular deposits, which are usually limited, both in length and depth, and seem generally to have no connection with extensive fissure openings, will be more fully described in connection with ore-deposits.

A systematic classification of these rocks would be very difficult and require a large amount of patience and study, since, not only do progressive changes take place at different horizons, but along almost any continued extension of strata on the same horizon. For instance, talcose schist imperceptibly changes into mica schist, which by the presence and gradual increase of feldspar, passes insensibly into gneissic-mica-schist, and finally into gneiss, whilst the latter, by the loss of its mica, the development of garnets, or the change of its schistose structure, passes respectively into binary granite (aplite), granulite, and granite. Similar changes by the development of the more basic minerals lead us from any point in this progressive change into the various hornblendic rocks. These changes are often so gradual, that it would be almost impossible to fix upon any as true rock types or define their lines of demarcation.

In connection with the study of these rocks, it would be interesting to extend the field of examination to the eastward, where at a distance of 30 or 40 miles, a line of ranges not yet visited appears to run in a northerly direction, and should if continuous, form a junction with the Barrier Ranges between here and Mount Browne. It is quite possible that the higher portions of the plain may in some cases, represent the out-crops of rocks but slightly covered by the products of their own decomposition. These if it were possible to examine them, might afford valuable evidence as to the chances of again picking up this silver bearing formation to the eastward, where if the anticline could be found, the study of the succeeding rocks dipping east might lead to very valuable results.

The irregular and sometimes semicircular trend of these elevated portions of the plain might if carefully studied, be found to have an important bearing on the question of underground currents and reservoirs of water; for instance, the drainage from the hills takes a southerly direction across the plain, following extended lines of greatest depression. In addition to this, the alluvial deepens as we go south, proving the bed-rocks to have a considerable fall in that direction. Now if we admit, as I am inclined to do, that the depressed portions are due to the settling and compression of the deeper alluvial, and the elevations to the shallow deposits overlying raised portions of the bed-rock, it stands to reason that any extensive area of depression surrounded on the east, south, and west sides by elevated country, and consequently opening to the north, must if connected with the underground drainage from that direction, contain accumulations of water proportionate to the southerly fall of the bed-rocks and the area of the partly enclosed basin. I have not yet had an opportunity of studying this question in connection with the underground drainage of the country, but there is no doubt such a study in a comparatively dry country like this would be very interesting, not only to science but to the public generally.

It may be remarked that the presence of detrital iron ore, scattered profusely over the tops of many of these raised portions of the plain, would appear to favour the conclusion, that in some cases at least, rocks may have outcropped along such lines, and that during their decomposition by atmospheric and organic agencies, their contained iron has been concentrated as ferric oxide in nodules and irregular veins and masses, often forming the cementing medium for the more unalterable minerals, such as quartz, &c.; and that, during the removal of the decomposed material by winds and water from the higher to lower grounds, these iron ores, together with the more highly siliceous parts of the rock, have been liberated and subsequently arranged as are now found. We must bear in mind, however, that such concentrations of iron oxide, under favourable conditions may have taken place immediately below the alluvial surface, and have been subsequently laid bare, together with the preserved siliceous fragments, by atmospheric agencies, removing the finer material from the higher to lower horizons.

Ore Deposits of the Barrier Ranges.

It becomes necessary, before taking up the study of the ore deposits in any district, to investigate closely, not only the mineralogical and lithological characters of the rocks, but that of their enclosed mineral deposits arising from the various evolutions through which the rocks may have passed. The ore deposits of the Barrier Ranges occur in crystalline stratiform rocks, represented chiefly by gniess and mica-schist. It may be assumed that these rocks were originally due to sediments and precipitates from ancient oceanic waters, and have been subsequently deeply buried beneath the ruins of other formations, and lowered to positions, where heat and pressure, in combination with alkaline solutions, have produced chemical actions resulting in the molecular rearrangements and crystallization of their feldspathic, siliceous, and argillaceous constituents. Since then they have had their super-incumbent rocks stripped from them by denudation, consequent on their elevation, and their further modifications have been mainly due to local and superficial agencies, such as the actions of oceanic and atmospheric waters, and the presence of organic matters. It is plain that the various earth movements, by which these rocks have been affected, have been accompanied by dislocations and fissures, which under changed conditions of heat, pressure, and chemical solutions, have been filled by different combinations of mineral matter, thus offering historical records of the successive periods of disturbance.

In describing the veins thus formed, we will take them in the order of their apparent formation, and divide them into veins of the first and second class respectively. Those of the first class, apparently corresponding to the periods of most intense metamorphism, closely resembling eruptive rocks, and although seemingly having no connection with them, may be described as siliceous (those in which quartz and alkaline feldspars predominate) and basic (those made up essentially of the more basic feldspars with hornblende). The relation of these veins to their enclosing rocks, though not a constant, is a prevailing feature, the more siliceous being chiefly confined to the gneissic rocks, while the mica-schist appears to have favoured the formation of those made up of the more basic minerals.

Besides the essential minerals before mentioned, the siliceous veins often contain muscovite in bunches, and isolated crystals, seldom uniformly scattered through the rock, and more rarely hornblende, andalusite, staurolite, iron-alumina-garnet, ilmenite, columbite, copper, tourmaline, and oxide of tin. The accessory minerals accompanying the basic veins are, besides many of the above, common to both, epidote, chlorite, lime-alumina-garnet, magnetite, and rarely manganese and cobalt. The compounds of such metals as copper, lead, silver, and bismuth, often met with in each class of vein, are apparently due to subsequent chemical action.

By calling to our aid the beautiful and instructive experiments of Daubree, Friedell and Sarrisin, De Lenarmont, Sterry Hunt, and others, who have, under a wide range of conditions, succeeded in forming, by synthesis, the greater part of the mineral species found in these veins, and assuming these minerals to bear a direct relation to the solutions from which they were deposited, we may from chemical considerations form a reasonable basis on which to construct a theory of such deposits, and under assumed conditions attempt to trace the mode of their formation through the various stages of development with a high degree of probability.

Taking the siliceous veins, for instance, they appear to have been filled by the secretion of highly saturated solutions of alkaline and aluminous silicates derived from the surrounding rock. The predominance of either soda, potash, or silica, above that required to combine with the whole of the silicate of alumina present in solution, might determine the formation of albite, orthoclase, or free-quartz, and by the exhaustion of the silicate of soda to the lowest point of its equivalent combining value, leaving an excess of alumina with potash in solution, these might, by mutual decomposition, generate muscovite, a portion of iron and manganese replacing alumina during the reaction. By the further removal of the alkalies, stages in the process would be marked by the formation of andalusite, and free-quartz, whereas if the action took place in the presence of iron, iron-alumina-garnet might be formed.

The production of veins of the basic class, characterised by such minerals as oligoclase and labradorite, with hornblende or pyroxene, would require solutions with an excess of silicate of alumina, in the presence of silicate of soda and the earthy basis. The reactions of these latter upon each other, and upon the double aluminous silicates, would give rise to such admixtures as oligoclase and hornblende, or labradorite and pyroxene. The elimination of the alkali from such a solution, as above, might, by the reactions of lime and magnesia upon each other, produce such basic silicates as epidote, lime-alumina-garnet, etc., on the one hand, and chloritic minerals on the other.

That these veins have been filled by some such process as the above is probable, considering how their mineral matter is that generally common to enclosing rocks, while their irregular positions in relation to each other, and their limited extent, both in length and depth are distinguishing features from fissures, which have been open channels for the free circulation of mineral solutions, or the extrusion of eruptive rocks. The origin of these openings may have been threefold, some may have resulted from contraction, consequent on the molecular rearrangement and crystallization of the rocks in which they occur, and others to the influence of eruptive rocks in their vicinity. The greater number, however, are probably due to the rocks accommodating themselves to new positions during the wide-spread movements which must have accompanied their gradual subsidence and elevation, while the heat, partly arising from these movements, and in part due to depths at which such movements took place, may have given to these rocks a sufficiently yielding nature to have favoured the formation of numerous small openings rather than extensive fissures. In this connection we may assume that in many cases the opening and filling of these veins have proceeded simultaneously, the banded structure characterizing many of them marking periods during the downward and upward movements of the rocks.

The veins of the second class are often found cutting through those of the first class or running parallel with them, besides frequently filling either one side or other part of the same fissure, showing the re-opening of many of these older veins during or prior to the formation of the latter class. These veins have evidently been formed at a much later date, probably marking periods of elevation and removal of the upper rocks, during which periods rain waters may have intervened, introducing organic acids to the subterranean circulation, resulting in the removal from the rocks of dissolved silica, lime, magnesia, alumina, iron, and many of the more precious metals, which have been afterwards deposited, as circumstances directed, either in the more porous parts of the rocks themselves, or in fissures arising from their movements.

These veins may be described as consisting essentially of quartz, into which, however, feldspathic, hornblendic, and micaceous minerals occasionally enter; the principal accessory minerals being the sulphides of iron, lead, copper, zinc, antimony, and bismuth, together with the carbonates of lime, and iron, and silicates of magnesia, and iron, oxides of iron, alumina, and manganese, soda, lime, and iron garnets, &c., many of these being no doubt introduced subsequently to the original filling of the veins. The presence of feldspathic and hornblendic minerals in these veins shows that the chemical conditions under which veins of the first class have been formed, were, to a limited extent, still active, while the presence of metallic and other salts found but sparingly concentrated in the former, but largely represented in those of later date, point to a change having taken place in the solutions from which they were derived. It is not necessary to assume the absence of these metallic elements from the rocks in which the earlier veins were formed (since certain zones pierced by them appear to have been very rich both in silver, lead, and copper), but rather, that conditions were at that time unsuitable for their free elimination from the rocks and their concentration in veins then forming. In this connection the experiments of Ordway on the solubility of metallic salts in solutions of alkaline silicates is important in throwing light on the probable formation of such metallic combinations as cassiterite, columbite, tourmaline, ilmenite, magnetite, and compounds of manganese and cobalt found in these veins. (Vide Amr. Jr. Sc., 1861, XXXII., 338).

The changed conditions of the latter solutions may be due partly to the exhaustion of the alkalies (especially potash) by the fixation of alkaline silicates, but more largely to the introduction of atmospheric waters from the upper rocks bringing with them the carbonates, sulphates, and chlorides of soda, lime, and magnesia, whose action on the alkaline silicates would result in silicates of these bases, and alkaline carbonates, sulphides, and chlorides. These as is well known, have not only the property of dissolving, but under slightly changed conditions, also of precipitating the greater number of the metallic and other elements found in the veins, and it only remains for us to study the most natural process of such depositions. The solubility of quartz and many highly silicated minerals, in the presence of alkaline carbonates, would give rise to solutions consisting largely of silica, while the resulting carbonic acid, acting upon the rocks, would convert silicates of lime, soda, and probably magnesia, into soluble carbonates, at the same time regenerating alkaline silicates for the further continuance of these reactions. The simultaneous action of alkaline sulphides during their process of lixiviation through the rocks, might remove therefrom the salts of manganese, iron, lead, zinc, copper, silver, &c.; while the actions which take place between alkaline chlorides and hydro-silicates of lime and alumina, and through the mutual decomposition and exchange of these rival bases, also of magnesia, might produce solutions with a high degree of concentration. These solutions would in consequence of relief of pressure in passing from the rocks into fissures, deposit their more insoluble mineral matters ont he walls, such deposits being regulated, partly by the further decrease of pressure and temperature reducing the solvent power of the solution during its upward passage through the rocks, and partly by such solutions coming in contact with rocks containing salts having a sufficiently strong affinity for one or other of those in solution, by which their removal would be more or less complete. That such deposits are not dependent solely on heat and pressure is apparent, since we know that the chemical affinities which determine such precipitates, lead to similar results through a wide range of temperature and pressure. This is very noticeable in the case of metallic deposits, which have apparently been concentrated around certain points leaving other parts of the same vein comparatively destitute of the metals.

Having therefore briefly noticed a few of the reactions which may have assisted in the filling of these subterranean fissures, it will not be necessary to consider any further modifications during their upward passage through rocks, which have been since removed by decomposition and denudation. We may attempt however, to describe such portions of the veins, as by an accident of position, now appear at the present horizon. In doing so we must constantly bear in mind the susceptibility to change of many of their mineral ingredients, due to the reducing and deoxidizing properties of dissolved organic matters in alkaline and earthy solutions, during their downward percolation, thus forming zones of decomposition and alteration reaching to greater or less depths, both in metallic veins and rock masses, which must have at all times preceded the surface disintegration.

In more particularly describing the ore deposits it will be necessary to divide them into (first), those apparently connected with wide spread movements of the rocks, and appearing as fissure veins having a considerable horizontal extension, and (second), those appearing as local deposits or ore shoots, whose surface extensions are generally limited to the rock in which they occur. The Broken Hill line of lode may be taken as a type of the fissure veins having a proved length of about four (4) miles, while the length of the original main fissure is at present unknown. The lode occurs in a formation of gray gneiss, being flanked on both sides by hornblendic rock (chiefly diorite). In the gneiss occur numerous lenticular and irregular masses of feldspathic and hornblendic rocks, chiefly representing veins of the first class. These have in many cases undergone various alterations, both in composition and structure. When occurring near the lode, they are generally found to be ore-bearing.

The more central portion of the main lode, comprising a length of about one mile, has a width varying from a few feet to over 200 feet. The superficially changed out-crop, which was composed chiefly of hydrated manganic iron stone, with quartz and feldspar, rises above the surface of the gneiss rock in places to the height of 30 or 40 feet, the higher portions usually corresponding to those of greatest width. From a surface and underground study of the lode and its wall-rock, I have been led to the conclusion that the diversities in its width are not mainly due to earth movements such as the sliding of the foot-wall on the hanging wall, but chiefly to the decomposition of the wall rocks, and the replacement of the removed material by metallic ores. The most conspicuous portion of the out-crop extends from Block 12 to Block 15, a distance of about one mile, terminating at either end in a bold compact bluff. From the bluff end on Block 12 the lode is seen to continue south-west through Block 11, Central, South, and others. But from the bluff end in Block 15 no direct continuation north-east is perceptible on the surface, the gneiss rocks, which otherwise have a parallel strike with the lode, are here found curving partly round the bluff, thence taking a more northerly direction until reaching half-way across Block 16, after which they again take a north-east course, continuing through North Broken Hill and the Victoria Cross. At a distance of about 320 feet south-west from Block 15 bluff (that is back along the course of the lode) a vein branches off to the northward, in some parts of its extension showing out-crops nearly equal in size and similar in composition to those on the main lode. That this vein opens out considerably below the surface is proved by the underground workings on the British Blocks 15 and 16. This widening of the lode from the surface downwards to depths at present worked (over 400 feet) is a feature, with slight exceptions, characteristic of the whole line, and is evidently due to the decomposition of the rocks on either side of the vein, during its superficial alteration, the soluble matter being removed and replaced by metallic ores, the insoluble material making up a large portion of the gangue now found distributed through the orey mass.

Besides the main, there are three loop veins, one on the south-east and two on the north-west side, which are especially noteworthy on account of the valuable ore deposits they have been proved to contain. The composition of these veins on the surface appear to be mainly quartzo-feldspathic, with a little mica and varying amounts of iron and manganese. They are, in places, porous from the loss of mineral matter, otherwise their surface out-crops would appear to have escaped the chemical actions which have operated so largely on the main lode, excepting at or near their junctions with it, where they gradually change to siliceous manganic iron-stone similar to that of the main out-crop.

Besides these there are numerous branch veins and lenticular masses. The former starting from the main or one of the loop veins break through the rock for some distance, after which they follow the strike of the strata, eventually disappearing, or more rarely continuing as disconnected lenticular masses. The latter apparently have no connection with the fissure openings, and have been proved by underground explorations to be limited alike in depth and horizontal extension, some of these found below not appearing at the surface, and vice versa. None of these surface out-crops are particularly inviting, though at lower depths they have been more or less decomposed, and their removed material invariably replaced by metallic ores. Those nearest the main or the loop veins appear to have suffered the greatest change. This wide spread process of decay and re-formation has not only affected these veins and deposits, together with their wall-rocks, but has more or less decomposed the feldspar and mica of the gneiss rock to a distance of several hundred feet on both sides of the main vein. That the zones of decomposition should have been chiefly confined to these veins and their wall-rocks, diminishing in the surrounding strata with its increase of distance from them, is what we should expect, considering that such fissure lines must have been the battle-ground on which the opposing upward alkaline and downward earthy and organic solutions would meet and contend. This exchange and interchange of bases would ultimately result in the survival of the fittest, and carbonic acid would be cast off and abandoned. A part of the acid being circulated laterally through the rocks by the permeating waters may have been mainly instrumental in the kaolinization of the feldspathic minerals by the removal of their alkalies and lime as soluble carbonates, and the fixing of their aluminous and magnesian bases as insoluble silicates.

The occurrence of garnets, apparently a mixture of colophonite, aplome, melanite, &c., in crystalline and granular aggregates, forming irregular masses often of great size in these veins and their decomposed and partly replaced wall-rocks serve to show the parts taken by the oxides, lime, iron, and manganese, during the fixation of the aluminous silicates ; while the occasional presence in these garnetiferous masses and their surrounding altered rocks of such minerals as pleonaste, and dysluite, in which silicates take little or no part, show that stages in the process have been reached where in the presence of magnesia and the oxides of iron and zinc, the almost complete disassociation of alumina from silica has taken place. It would serve no useful purpose to enter into a minute description of the various associations of these earthy and metallic minerals, even were I prepared to do so, since they are not only constantly changing at different horizons, but in different parts of the lode at the same horizon. I shall therefore only notice a few of their characteristic or prominent features.

The following minerals are those most easily recognisable, as making up the main portion of the lode :—Earthy minerals—quartz, kaolin, garnet, gypsum, glauberite, apatite, and opal; Ferruginous—limonite, chromite, magnetite, franklinite, cacoxenite and mispickel; Manganese—pyrolusite, psilomelane, and their various admixtures with iron; Lead—cerussite, anglesite, galena, pyromorphite, mimetesite, maldonite, wulfenite, percylite, cotunnite and matlockite; Copper—native-copper, cuprite, malachite, azurite, olivenite, bournonite, chalcocite, melachonite, atacamite, and chrysocolla; Zinc—calamine, smithsonite and zinc-blende; Silver—cerargyrite, embolite, iodargyrite, bromargyrite, argentite and native silver. Of these the various ores of iron and manganese, together with kaolin and quartz make up the principal matrix of the lode in which occur irregularly distributed the ore of lead, zinc, and silver, copper appearing to be more confined to favourable positions, while the other minerals are found in geodes, bunches, or sparingly disseminated through the gangue. There appears to be no fixed laws of association (or paragenesis) between these various minerals so far as observed. The different combinations of silver with chlorine, bromine, and iodine are found alike impregnating kaolin, porous iron-stone, and granular cerussite, anglesite, and quartz, often beautifully crystallized in geodes, and implanted in various shapes on stalactites of manganic iron. Silicates and carbonates of zinc associate chiefly with the iron of latest formation, such as the beautiful stalactitic formations of interlaced rods and columns, sometimes resembling miniature temples; they are also found in granular cerussite, especially in the vugs, while zinc blende, together with iron and copper sulphurets, are generally found intercrystallized with galena.

The sources of the various minerals and metallic ores here found accumulated together, may reasonably be supposed to have been threefold. First the feldspathic minerals, from which the kaolin has been derived, together with a large portion of the quartz and possibly metallic sulphurets and manganese, evidently belong to a period of vein-filling by the upward circulation of heated alkaline solutions, while such actions have been partly protected from the disturbing influence of descending earthy and organic waters, consequent on the present horizon being deeply overlaid by superincumbent rocks. Secondly during the removal of these upper rocks, owing to their previous elevation and subaerial decomposition by the agencies of earthy and organic solutions operating from the surface downwards. These fissure lines offering the more easy passage for such percolating waters, it is obvious that the more soluble mineral matters contained therein would be constantly removed to lower levels and deposited only where conditions were favourable for their precipitation, being thus as it were, removed and protected from surface disintegration. The solubility of metallic combinations in the presence of sulphated waters, containing soda or lime, more especially if copper be present, are well known and taken advantage of on a large scale in metallurgy, to separate the various metals from their earthy matrix. In all such experiments the more nearly we imitate natural processes and conditions the greater is our success, thus clearly demonstrating the most natural solutions to be the most universal solvents. Such solutions have not only the power of separating from their various combinations the greater number of the metals found in nature, but of precipitating the same under slightly changed conditions. Taking those veins for instance, the constant association of silver, lead, copper, zinc, &c., with iron, points to one probable mode of their separation by deoxidation, due to the strong affinity for oxygen of the ferrous salts, during their peroxidation out of contact with the atmosphere. The same results may be obtained by the deoxidizing powers of organic matters in the presence of such sulphated solutions, containing metallic salts giving rise to sulphurets of the metals. Such a process, continuing during the slow removal of a vast thickness of rock material, has no doubt accumulated by downward concentration a considerable portion of the metals, not only from the upper removed parts of the veins themselves, but probably also from the rocks in their immediate vicinity. Thirdly there are good reasons for assuming the rocks in which these veins occur to be metalliferous, apart from the fact that a large quantity of iron must have been set free during the decomposition of the mica (apparently biotite) of the surrounding gneiss and probably concentrated in the lode. The presence of small quantities of silver, lead, copper, and sometimes zinc, in these rocks at consideraable distances from the veins, points to a probable source of some of these metals. We must not forget in this connection, that the chemical actions resulting in the alteration of these rocks, may have taken place in the presence of metallic solutions derived from sources far removed, and that these rocks may have become impregnated with metallic salts by a natural exchange of bases, nevertheless the balance of evidence points to their metalliferous character previous to their decomposition.

That the present horizon has, for untold ages, been removed from the more active agencies of disintegration is evidenced by the comparative preservation of the surface, and the extent to which decomposition and replacements have taken place below. These changes, depending mainly on the action of chlorides, sulphates, carbonates, and free carbonic acid, derived from the surface decay of organic matters, and their inter-actions between each other and the earthy alkaline and metallic salts out of contact with the atmosphere, must necessarily have been very slow. The formation of large bodies of altered lead ore has apparently necessitated the lead being first deposited as a sulphuret, by sulphated waters. Its subsequent alteration by carbonic acid in the presence of liberated sulphur and oxygen has determined as conditions directed, its conversion into cerussite or anglesite, the presence of molybdic and phosphoric acids giving rise to wulfenite and pyromorphite. The course of such operations, other conditions being equal, has naturally followed lines of freest circulation, reaching in some cases to considerable depths, leaving zones of unaltered ore at higher levels. Changes such as these extending from the outer sides of ore masses inwards, have formed massive coatings, between which and the unaltered material are found void spaces due to a change of volume and a probable loss of material by solution. The completion of this process on large compact ore masses has resulted in large cavities at the centre, around which are grouped the various metallic combinations in most beautiful crystalline forms.

In describing these larger ore formations as being mainly due to zones of decomposition, in which the removed material has been principally replaced by metallic ores, the evident effects of earth movements must not be overlooked, since they have, no doubt, by re-opening previously filled channels, assisted largely in the free circulation of opposing solutions. The effects of earth movements become more apparent as we pass from the stronger lode developments into the South, Junction, or North mining properties, where in some instances the wall rocks are better preserved, by the sliding of the foot-wall on the hanging wall. Some of the bulges have been brought opposite each other forming narrow places in the lode, while between the opposite cavities large deposits of ore have accumulated, around which the wall rocks have apparently suffered in proportion to the size of the ore bodies formed.

It now remains to notice fissure veins, dependent mainly on earth movements for their ore deposits. For this purpose we will take the Umberumberka vein, because its extensive underground explorations offer special facilities for the study, while the effect of earth movements have been here brought more prominently under notice than elsewhere on the field, so far as observed. This vein has been worked for a length of about two miles, some parts being very rich, especially in silver. The more central portion, for the distance of nearly a mile, has a dioritic hanging wall, the foot-wall being graphite-schist. Behind the hanging wall are numerous veins and lenticular masses of felds-pathic and hornblendic rocks, none of which appear to be metalliferous, while similar veins, accompanied by graphite on the foot-wall side, are for a distance of several hundred feet from the lode invariably found to carry more or less the ores of silver, lead, zinc, and sometimes copper. These interposed masses, corresponding to veins of the first-class, have in many cases, by gradual changes in their composition, passed over into those of the second class ; the organic matter originally present in the rocks, may have been mainly instrumental, during their meta-morphism, in affecting this change.

The open spaces between the wall rocks, in which the various metallic ores have been accumulated, appear to have been partially due to the subsidence of the hanging wall rocks on those of the foot-wall. This is shown by the steeper parts of the lode being the wider, and the hanging wall resting on the flatter parts of the foot-wall. Also partly to lateral movements, the foot-wall side having moved south-west, or the hanging wall north-east in the direction of the fissure. This is evident by comparing the irregularities of the opposite walls, which have given rise to ore shoots, having generally a diagonal north-east dip along the lode. In addition to the earth movements already described, which apparently belong to ages and conditions long since passed away, there are periodical expansions and contractions of the foot-wall rocks, probably due to the differences of temperature and moisture of the changing seasons. This alternate upward and downward motion, besides crushing and fracturing the foot-wall and smooth-ing the hanging wall by planing off its inequalities, has resulted in many modifications of the vein matter by repeatedly opening and closing fractured portions of the vein and its foot-wall rocks. The composition of the vein itself is not only constantly changing by solution and re-formation, often one metallic ore replacing another, but branch and small parallel veins are gradually being formed by the removal of metallic salts from the main vein and adjacent rocks. The value of the lode as an ore-producer depends largely on the ore shoots occurring at intervals along its course. Many of these have been proved to be continuous) with the exception of pinches arising from local irregularities of dip and strike) from the surface to depths at present worked, that is at No. 6 level 360 feet, Nos. 7 and 8 levels not having been sufficiently extended yet to reach them. There are however, good reasons for assuming their downward continuation, not only through these levels but to any reasonable working depths. The intermediate parts of the vein, connecting the ore shoots with each other, are very irregular, oftentimes being only traceable by a thin compressed layer of impure graphite on the smooth regular face of the hanging wall. As a rule, where the latter bends to the west (or the foot-wall side), generally resulting in a steeper dip, ore makes in greater or less bodies, from a few inches to ten or twelve feet in width, the length greatly depending on the dip of the walls. The ores occurring in this vein may be roughly classed as galena, zinc-blende, stephanite, and native silver, generally with more or less antimony and bismuth, the matrix being chiefly siderite, in which is often embedded large clearly defined crystals of galena, zinc-blende, with sometimes iron and copper pyrites. In some cases one or other of these are found penetrating crystals of different kinds. From the inter-crystallization of these metallic sulphides with siderite, we may assume their contemporaneous formation from water holding the necessary elements in solution. The occurrence of alternate layers of these several metallic ores, on one or both sides of masses of such crystalline aggregates, show that the later circulating waters must have been subject to periodical variations in composition during the formation of these different layers. Silver is generally confined to the lead ores or associating with zinc or iron in their immediate vicinity. When found in payable quantities with either of the latter ores, in the absence of lead, there is often conclusive evidence of the replacement of lead by zinc or iron, the lead, during its removal, having left the silver behind, combined with the replacing material. The lead ores, besides being highly argentiferous, carry considerable quantities of native silver, either finely disseminated through the mass, or lining crevices or vugs, the latter being often filled with a friable mixture of native silver and iron, arising from the decomposition of embedded crystals of siderite. The zinc, when argentiferous, carries the silver chiefly as frosted incrustations around and between its crystals, either in the forms of native silver, or mixed with antimony and arsenic. In many cases crystalline masses of galena and zinc-blende have had their metallic salts removed and replaced, more or less completely, by silver, iron, antimony, arsenic, copper, &c., giving rise to antimonial silver and fahlerz ores (collectively designated by the miners as grey ore); as a general rule the crystalline forms of the lead and zinc ores are retained. By decomposition these ores are often changed to impure friable native silver. Siderite rarely carries sufficient silver to pay for extraction, unless it occurs in close proximity to lead ores, or has replaced them. Silver is also occasionally found associated with veins of earthy graphite, especially in the near vicinity of ore bodies, such veins being looked upon as a favourable indication when following an otherwise blind lead.

This vein, like most other metallic formations on the Barrier, has suffered superficial alteration, the intensity of which has apparently been proportionate to the metallic and other salts acted upon, the siderite having been changed to limonite, or rarely to hematite, either being more or less manganic. The greater portion of the lead appears to have been removed to lower levels, while a part of its originally combined silver has remained concentrated as chlorides in small cavities in the masses of limonite, where it has evidently been protected from disturbing agencies. Quartz, though largely represented along the course of the surface outcrop, is rarely met with in the lower levels, where it has apparently been replaced by siderite and probably by galena and zinc-blende. This change has probably been effected by the actions of carbonic and other acids, set free during the superficial alteration of the iron, and the exchange of bases between earthy and metallic salts in the presence of organic matter from vegetable decay. The removal of metallic salts from the upper rocks, by the solvent actions of descending solutions, is evidently still in active progress. The lead and zinc ores, affected by the periodical movements of the foot-wall rocks, have their fractured surfaces frosted over by lead carbonate, native silver, or a combination of silver with antimony or arsenic. At other times fine irregular layers of antimonial galena, with graphite, and sometimes siderite or zinc, often not thicker than sheets of paper, and variously arranged, have been the cementing medium. The most suitable conditions for this process would probably exist at or above water level, where the concentration of lixiviating solutions from the surrounding rocks to the fissure, would be constantly taking place. Below the water level the free circulation would not only be impeded, but the dissolved salts might be diffused laterally through the rocks by their permeating waters. Furthermore, the drainage of the rocks, by the deeper workings of the mine, is lowering the water level from 50 to 100 feet per year, thus throwing open fresh ground for downward lixiviation, while the atmospheric oxygen, admitted by such deeper workings, may be playing an important part in the arrangement and distribution of the various salts set free from solution.

The carbonaceous matter occurring in these rocks appears to have been deposited simultaneously with the sediments, periods during its deposition being marked by strata richer or poorer in carbon. These deposits may have taken place on the ocean's bed, or in land-enclosed basins, most probably the latter; in either case the metals present in the waters at the time appear to have been eliminated and fixed by the decomposition of the organic matter in the sediments.

Along an approximate extension of this same horizon, both north-east and south-west, though not proved to be continuous, are found similar zones of carbonaceous-metalliferous rocks, particularly rich in silver. As some of the better developed mining properties occurring in such zones the following may be mentioned, around which, however, are grouped many others not so extensively prospected: Thackeringa, Umberumberka, Day Dream, Apollyon, Terrible Dick, New Year, War Dance, &c., many of these in some parts of their course appearing as contact vein deposits between crystalline schists, generally graphitic, and granitic or dioritic rocks; a characteristic feature of the veins occurring in these graphite bearing rocks being that their enclosed iron ores are invariably in the form of carbonates, in most cases superficially changed to limonite, or more rarely to hæmatite. This change of siderite into limonite of similar density has been accompanied by a decrease in volume, which should be equal to nearly one-fifth. These changes, having taken place from joints and crevices and proceeding from the outer side inwards, have resulted either in spongy masses or compact crusts, enclosing cavities of various dimensions, in which are often found accumulated the ores of lead, zinc, silver, copper, &c., which appear to have been originally disseminated through the siderite. Silver chloride is frequently found in these cavities, sometimes in large masses, generally associated with lead, antimony, copper, and sometimes zinc. These deposits, while buried in the rocks, have been largely protected from the actions of alkaline and earthy sulphated waters, but where by disintegration of the surface they have been brought to or above the present horizon, and their enclosing iron removed by deoxidation, they have been set free as surface slugs, where by further concentration, due to their associating metals being less stable in the presence of prevailing atmospheric agencies, they are found in a comparatively pure state, oftentimes having only an incrustation of carbonate of lime or oxide of iron. Native silver is also found in many of these veins, sometimes in the form of wire in cavities in the lead or iron, but frequently lining crevices or disseminated through the lead ores. Some of these veins are extremely rich, yielding large returns for small out-puts, a vein one or two inches wide often containing sufficient silver to cover all working expenses.

There is another class of ore deposits apparently due either to the imperfect filling of veins, generally of the first class, or to fractures arising from local contractions, rather than to extensive earth movements. Solutions circulating through these have deposited their metallic and other salts as chemical affinities directed, one or other of the metallic ores being often concentrated round certain points, forming bunches or banded deposits, or otherwise occurring as pipes, which in some cases reach to considerable depths. The sides of such openings are invariably more or less decomposed and impregnated with metallic salts, which have in some instances penetrated to considerable distances as small irregular pipe veins, often opening out to fairly sized chambers filled with ores and earthy matters similar to the main body. By the subsequent decomposition of these deposits near the surface, their enclosing rocks have been further changed to what the miners call kindly ground.

The ore veins and deposits of the Barrier Ranges are not strictly confined to any particular rock, being found alike in gneiss, mica-schist, hornblende-schist, diorite, or granite, often occurring along junction lines between any two of these rocks. Grey gneiss appears to be the most favourable to large ore bodies, while the more concentrated silver deposits accompany the carbonaceous schist and rocks mineralogically and lithologically similar, except that graphite is not always visible, in which case disseminated iron is generally more abundant. The removal of this iron from terrestrial circulation has, no doubt, decomposed a large amount of carbonaceous matter during its peroxidation; in fact, in all such ferruginous rocks we may reasonably look upon their disseminated ferric oxide as the equivalent of oxygen consumed and organic matter decomposed prior to the carbonate of iron, which they invariably carry in their veins, being deposited. Some of the contact deposits are very rich in silver, especially when occurring between mica-schist or gneiss, and granitic or dioritic rocks. Many of these are purely local, no fissure being discernable passing beyond the deposit itself. The origin of these deposits appear to be due to simple replacement of the rock's material by ores. Several of these are sometimes found at greater or less depths below each other, connected only by thin seams of ferruginous clay adhering to the hanging wall, or otherwise passing into it along some of its joints, where nice pockets of ore have been sometimes found. The superior richness of the ore generally found in these deposits have caused them to be much sought after by prospectors, but beyond the more fortunate discoveries made near the surface, the results so far have not been encouraging.

The following are the only statistics I have been able to gather :—

Mine.	Deepest Shafts.	Total Ore Produced.	Value—Ore.	Levels Driven
Umberumberka..	553 Feet.	2,500 tons	£250,000	11,050 Feet.
Broken Hill......	500 „	387,300 tons	£4,000,000	—
Round Hill.......	600 „	—	—	—

During the last three and a-half years the value of ore and bullion dispatched from the field was £4,510,966. The value of imports for the same period, £3,344,511.

SOME FOLK-SONGS AND MYTHS FROM SAMOA,

Translated by Revs. T. Powell and G. Pratt,

With an Introduction and Notes by Dr. John Fraser.

[*Read before the Royal Society of N.S.W., November 5, 1890.*]

Introduction.—The Samoans are poets. Their language consists mostly of vowel and liquid sounds, and, for this reason, is called the Italian of the South Seas; its words readily adapt themselves to figurative applications of their meaning; the imagery of the language is oriental; these and other qualities render it a fit vehicle for poetical composition. There is among the Samoans a privileged class of bards who alone know, and can recite, the genealogies of the native chiefs and the legends about the gods; yet the common people, when assembled together, turn ordinary passing events into song, and sing in concert to lighten their toil, while they are engaged in heavy work out of doors, or are using their paddles on board their vessels.

Samoan poetry sometimes has rhyme, but it has no metre; from the nature of the language, the poetry can scarcely have metre; and the lines of a poem may be of very unequal length. A few voices commence the song, and sing a portion of it; then all the rest join in full chorus; along with this, there is dancing and the accompaniment of a native drum or the rhythmical tapping of sticks on a roll of native mats. Of this sort of song—the most common of all—are the Vii and the Muli'au, in praise of chiefs. The Fatu, the Langisolo, and the Vila have no dancing; they are the funeral dirges of chiefs. The Fangono, of which the following love-tale is an example, is a kind of recitative, with bits of song in it here and there. The Solo is a song in praise of the islands or lands over which the chiefs rule, and is sung by one person; the Tala is any narrative tale.

Mr. Powell went to the Samoan group in 1844 and left about five years ago; he died recently in England. He was settled as a missionary on the island of Tutuila, but had also under his charge the island Taū, the largest of a cluster of three islands—Manu'a—which forms an eastern portion of the Samoan group. Taū is visible from the top of a mountain in Tutuila, and is about 70 miles distant. All Samoan traditions centre around Manu'a as the first resting place of the race, and there alone dwelt the *sacri vates*, whose duty it was to preserve in their memories and to recite the old legends and myths. Mr. Powell was thus on classic ground; and, having gained the confidence of the bards, he wrote down from their lips many of the 'traditions which they had received from their ancestors,' and he assures us that, if the whole had been written down and printed, the book thus made 'would be larger than the Bible.' One of these, a long one—'A Samoan tradition of the Creation'—was communicated by him to the *Victoria Institute of Great Britain*, and is published in the Journal of the Institute, Vol. xx. On Mr. Powell's death, his widow sent his Samoan MSS. to Mr. Pratt of Sydney, as the only man who understood the old Samoan language thoroughly and could translate the manuscripts. Mr. Pratt had been Mr. Powell's fellow-labourer in the Samoan islands, having gone to Samoa in 1839 and remained there for forty years.

In conjunction with Mr. Pratt, I am now endeavouring to preserve these old traditions and songs. As they were collected many years ago, before Europeans had become numerous on the islands, they seem to me to be very valuable as illustrating the thoughts and the manner of life of the Samoans long ago. And here, before reading the four, which I have selected for your consideration to-night, I may be permitted to express to this Society my regret that, in these colonies, we have no means of giving permanency to the literary labours of our missionaries and others, except through the Journal of such a Society as this. Our colonies, and especially the port of Sydney, are now gaining thousands of pounds annually from their trade with the islands of the Pacific, and this trade is rapidly increasing. They have to thank the work of the missionaries for all that; the preaching of the gospel, and the civilization and peace flowing from it, have alone made such a trade possible. If each of our colonial Governments, or our own Legislature singly, would devote to literature a small pittance every year from the direct advantages of this commercial connection, I am sure I could name at once half-a-dozen men able and willing to write as many volumes on the history, the social institutions, the customs, the traditions, the languages, the physical phenomena of the islands, past and present,—volumes which would convey to the next generation a faithful record of a state of things there which is now fast passing away; the men too are passing away who can give such a record of the old times. In fact, I know of two or three MS. volumes in private hands, which could at once be printed, were it not for the cost involved. The testimony and the knowledge of those who have been thirty or forty years on the islands, and in trustful contact with the natives, would surely be of some value to those who may take our places in the twentieth century,—certainly of more value than the passing impressions of tourists, who spend a few months on the islands and then write a book! But, alas! there are no funds.

I.—Tingilau and Sina,

a Samoan love-tale.

A 'Fangono.'

Tafitofau and Ongafau[1] had a daughter named Sina.[2] She became an object of attraction to a crowd of young fops. Many of them were suitors, but she refused every proposal; her heart was set upon Tingilau,[2] from whom she expected an offer. This lady had never done any work except the plaiting of fine mats.[3] While she was cherishing a fond desire for Tingilau, she knew not that her parents had a different person in view as her future husband.[4]

The king of Fiti[5] came with his retinue to seek an alliance with her. He anchored[6] opposite her home. He did not land, but called out from his vessel:—

O maiden Sina, thy plaiting forego; the darkness is nigh;
Come hither then to me; to my home we shall fly.

'Wait awhile,' responded the lady, 'I must consult my parents.' She goes to them. 'A suitor is in the offing,' she exclaims. 'What suitor?' they ask. 'Tui-Fiti.'[5] 'Tell him to wait till you are of marriageable age; and reserve thou thyself for Tupu-o-le-fanua.'[7]

The next suitor was Tingilau of Sa-Vavau.[7] He too came with his retinue in a vessel, and called out from the deck:—

O maiden Sina, thy plaiting forego; the darkness is nigh;
Come hither then to me; to my home we shall fly.

She went to her parents and reported this suitor also, but received the same answer. Tingilau accordingly departed, but met, coming on the same errand, Tupu-o-le-fanua, whom her parents wished her to accept. He too called out from the deck of his vessel:—

O maiden Sina, thy plaiting forego; the darkness is nigh;
Come hither then to me; to my home we shall fly.

She reported to her parents that Tupu-o-le-fanua was now her suitor. They were delighted, and began at once to make arrangements for her marriage. But the lady wept. She was not willing. She earnestly desired Tingilau. Then came her parents and conveyed her forcibly on board the vessel;[8] the pair sailed away for the home of this chief.[9] He had a sister named Mataiva.[10] His family name was Sifo. When they arrived at their destination the chief was ill of fever. He was taken up to the house in a state of unconsciousness.[11] In a few days he was better, and then Sina said to him, 'Is it true that your household are birds?' 'Quite true,' he replied. He then said to his sister, 'Call the members of our household.' Then she called out :—

Assemble, O ye birds of the land;
Assemble, O ye birds of the sea;
Assemble, O ye birds of the east;
Assemble, O ye birds of the west;
Descend from above, ye birds of the sky;
Ascend from below, ye birds of the deep.

The house was soon filled with flocks of different kinds of birds. Then said the chief to Sina, 'Select for yourself any bird you please, and dismiss the others; their din distresses me.' She chose a young pigeon.[12] Tingilau had assumed that form.[13] The bird's leg was tied with a string and fastened[14] to a perch, which was placed in the sleeping apartment of Sina and her husband. In the night the pigeon cooed. Sina said to her husband, 'My dear, tell your sister to shut some of her eyes.' So he said to his sister, 'Shut your eyes; Sina is terrified.' The lady became angry, and closed all her eyes. The bird again cooed, whereupon Mataiva sang :—

O Sifo, awake, O Sifo, awake
To the voice of the pigeon there cooing;
No pigeon is there, 'tis a man I declare;
Is it not Tingilau there wooing?

Sina became angry and said to her husband, 'Tell your sister to have done talking, and to go to sleep.' His sister was offended at this rebuke; she held her peace, and was soon asleep.

The pigeon again cooed. Sina arose. The bird had changed into a man. Tingilau had resumed his own form.[13] Off went the couple and arrived, unpursued, at the home of Tingilau. . . .

NOTE.—The tale goes on to say that, when Sifo awakes in the morning and finds his wife has fled, he is in great distress, but meets with only ridicule from his sister for having rebuked her watchfulness. It winds up with a poetic call to bring the best and sweetest breadfruit for the reciters. While they enjoy their feast, any one who pleases may take up the song and carry on the tale.

T. Powell.

1. The '*fau*' is the Samoan *hibiscus* tree; '*tafito*' is the stump of the tree, and '*onga*' is a log or detached portion taken from the tree. There is probably some esoteric and sexual meaning in the names *Tafitofau* and *Ongafau*. These names are not uncommon in similar Samoan poetry.

2. *Tingilau* also is a common name in song. The syllable '*lau*' means 'a leaf'; the meaning of *tingi* is not clear. *Sina* means 'white'; and so she is the 'fair' daughter of the '*fau*' tree. The Samoans are very partial to the name Sina; the moon is, in their language, Ma-sina. The name occurs in many of their tales. An Arab or an Indian might prefer a lady of a dark complexion, but Samoans speak disparagingly of a black skin. The standard of female beauty among them seems to be, from of old, something much fairer than their own brownish colour, if we may found an inference on the meaning of the name Sina. Can this imply that the Samoans and other Polynesians have an innate feeling that they are descended from a superior 'white race'? With regard to the origin of the brown Polynesians, my own idea is, that they are the product of the mingling of a fair race with a black or, at least, a dark-coloured one. Or, does the frequency of the name Sina imply that the Samoans feel themselves so much beholden to the Moon that she has become a special favourite? They fish by moonlight; and to escape the heat of the day, they often travel by night, both by land and sea.

3. The plaiting of mats is the common employment for ladies in their leisure hours in Samoan households, just as spinning was in other days in the homes of England. The material is got from the leaf of a native plant or tree, the 'fala'; this, when dressed, is plaited into mats, large and small. The small 'fine mats' are worked with fine strips of the 'fala,' and are ornamented on the borders with feathers of the crimson parrot, 'sega.' These 'fine mats' are much valued, especially when they have acquired a brown colour through age; and are often handed down as heirlooms. On high occasions, they are used as an article of dress; and a bride's ambition is not only to have a good dowry of 'fine mats,' but to be arrayed in the finest of these on the happy day. Mats were used as an article of exchange in the Fijian, Tongan, and Samoan groups of islands and elsewhere.

4. 'Her parents had a different person in view.' This portion of the story shows that human experience is much the same everywhere. There is more than one touch of nature in this Samoan Fangono.

5. '*Tui-Fiti*' means 'king of Fiti,' that is, 'Fiji.' In the whole field of Samoan song, Fiji constantly comes up, although that is a Melanesian region; and there seems to have been, of old, an intimate connection between the Fijians and the Samoans. *Tui* is not a native Samoan word for 'high chief' or 'king' (see note 7, below), and yet in the Samoan group there are certain families which are even yet called 'Tui A'ana,' 'Tui Atua,' 'Tui Manu'a' 'Tui Tele,' which mean 'king of A'ana,' 'king of Atua' 'king of Manu'a,' 'Great king.' On Savai'i, one of the islands, Tui-Fiti has no local habitation, but is reckoned a god; he is so revered or dreaded that his name must not be even whispered. All the Tui families that I have named now occupy only inferior positions in the islands. Can this mean that they are the representatives of a black Melanesian race that was once the owners of the soil, but was dispossessed and reduced to subjection by the incoming of a light coloured race, superior in numbers and in power? The deification of Tui-Fiti appears to me to point in that direction; for in it I see the exaltation of a hero of the conquered race, just as the Brahmanical Aryans may have taken the Avatâr of Krishna, 'the black or dark one,' from the black aborigines of India whom their invasion displaced.

6. The old Samoan anchor was a big piece of basaltic rock with a hole bored through it for the rope, or a basket with stones in it.

7. *Tupu* is the Samoan word for a 'king' or very 'high chief.' *Tupu-o-le-fanua* means 'king of the land.' There was once a Tupu-Samoa, a king of all Samoa, but, until recently, the governing power has been in the hands of many chiefs. Malietoa is now called Tupu-Samoa. *Sa-Vavau* means 'the race of ancient times.' But Vavau is also a place in Tonga. Tingilau was neither a *Tui* nor a *Tupu*, but yet he was of ancient lineage, perhaps a scion of the ancient lords of the land.

8. Parents in Samoa compel their daughters to marry whom they will.

9. 'The pair sailed away to his home'—on another island or on a different part of the same island. The *fanua*, or 'land,' of which he was king, is not mentioned in the story.

10. Mata-iva ('Eyes-nine') reminds us of Argus who, as school boys know, '*centum habebat oculos.*' Why Samoan poetry gives Mataiva only 'nine eyes' I do not know. Mataiva had the same kind of work to do in this tale as Argus in Grecian story. Juno was burning with jealousy over the amours of her faithless lord, and got 'him of the hundred eyes' to keep a sleepless watch on Zeus and the fair Io. But Mataiva's task was self-imposed, for her brother suspected nothing. There must be some meaning in the number 'nine' here, for the Samoans have a legend about a fabulous pigeon with 'nine' heads (Lupe-ulu-iva). Piliopo, a well-known mythical personage, threw a stick at it and killed it; he then proceeded to cook and eat the flesh; the entrails he threw away; they became a rock in Savai'i, and there the rock may be seen to this day! That rock is volcanic. There is a crater in Savai'i which, according to the testimony of the natives, was active till about 150 years ago. (See note 29, page 215.) The Samoan use of the number nine, in this connection, may be founded on the mystical virtue of 'three times three' (*cf.* the Roman 'ter terni cyathi'). Thus also, Samoan myths speak of 'nine heavens.'

11. The maker seems to have introduced the 'fever' and the 'unconsciousness' into the story, in order to give Tingilau and Sina an opportunity to concert their plans, unobserved.

12. In another legend, a 'ground-pigeon' is reverenced as a god in the village of Mata-Utu ('eyes-of-Utu').

13. 'Tingilau had resumed the form of a man.' This shows that Tingilau belonged to a deified race, for he had taken the form of the sacred pigeon.

14. The Samoans tame birds in this way and make pets of them; they even talk to them in 'chiefs' language,' that is, address them in such words of respect as are reserved for chiefs alone. Birds are tamed in the same manner and used as decoys. A native clears a space in the bush, puts the bird on a perch in the midst of it; from a place of concealment, he catches the birds that come down, by throwing over them a net fixed to the end of a long pole.

II.—The Story of Le-fale-i-le-Langi.

A 'Tala.'

Preface.—The genealogy in this tale is intended to account for the names of the various districts in the two little islands, Ofu and Taū, and to explain why certain chiefs there claim precedence in rank. It also shows us how a small island, such as Tau, may have been peopled by several families, sprung from the same parents; and how the descendants of these families, if they had no common bond of union, might, in the course of ages, become tribes hostile to each other. If the five sons here had been named from land-animals or birds, these would have been the *totems* of the families.—Ed.

The land of Atafu[1] has no houses; the people sleep on the ground; the sky is their house. It was this custom that caused the girl to have the name of Le-fale-i-le-langi.[1] This girl and her parents swam from Atafu. They reached a part of the sea opposite to Vai-tele. Fa'a-gata-nu'u[2] and Fa'a-malie-nu'u[2] are the names of her parents. They approached Taū.[3] Fe'e[4] ('octopus') and his son came down to fish at Vaitele.[3] The name of his son was Faia,[4] and he was very handsome. The parents of Le-fale-i-le-langi said to her, 'Do you see that chief?' Her answer was, 'Yes, I see him.' 'If you like him, go to him; if you are received, bring us a bunch of cocoa-nuts.[5] The girl went ashore. Faia saw her, and they fell in love with each other. Then he walked towards her; he made himself agreeable to her. But, in returning, she forgot to take a bunch of nuts to her parents. Then they were angry, and said, 'For this, a curse be on you; let not your people catch fish; only get a fish now and then.' Then they went and dwelt at Ofu.[3] In those days there was only one land besides Tau; Olosenga did not then exist. Afterwards the gods brought up Olosenga.[3]

Then they two married; she conceived and reached the time of her delivery; then she went into the bush,[6] and was delivered there. A search was made and she was found crying gently; and she brought forth her child, and it was called Tau ('gentle pain').

Again she conceived; her time came on, and she went into the bush to be delivered. Search was made, and the child was found when it was near night. Then it was called Aua-pō ('reaching to night'),

Again the time came for her to bring forth, and she fled to the bush. Again she was sought, and she was seen at the bottom of a precipice, down which she had fallen. Then they tried to descend the precipice in the chain of mountains in Analuma[7]; they succeeded in descending; they took up the child and called it Fa'a-lea-sao or Tau-sao ('hardly able to get down').

Again she conceived, and went into the bush. They found the woman panting; then that child was named Nga-nga-nga'e or A-nga'e ('panting or gasping').

Again she conceived, and went to Ofu. She reached the bush, and there she was delivered; then the bush was called Vao-sa[8] ('the sacred bush'), but the child was called Lua-nu'u ('two lands'), because two lands were peopled by Fale-i-le-langi. They fetched Fale-i-le-langi from the 'sacred bush' in Ofu, but the child sojourned there.

After awhile, she and Faia made their will.[9] The children were gathered together at Fonga-olo-'ula to have their shares assigned to them.

1. Tau had the first share, being the eldest. They said to him, 'You will be the representative of your mother's family.'[10] And so the arrangement was that, on a day of work,[11] his brothers were to present him with offerings.[12]

2. 'Aua-po, let him be of the male side of the family.[10] His share is the shoots[12] of the breadfruit and the branch of cocoa-nuts.[12] When the breadfruit tree bears fruit, he will bring the first fruits to the female branch of the family.'

3. 'Tau-sao, let his land be on the north-side of the island, named Falea-sao. He is of the male branch of the family. His share is the shoots of the breadfruit. When there is a crop of breadfruit, let him bring the first fruits to Tau, of the female line, the firstborn.'

4. 'As to Nga-nga-nga'e, his land shall be on the east called A-nga'e. Let him be a relation on the male side; his share is the shoots of the breadfruit. When there is a crop of breadfruit, the first fruits shall be brought to the representative of the female line.'

5. 'Lua-nu'u shall also be a relation on the male side; his share shall be the shoots of the breadfruit. When he goes to Sina,[13] he shall bring the first fruits to the representative of the female line.'

G. Pratt.

1. *Tafu* is the 'god of Fortune' in the Samoan mythology, and *Atafu* may be his land. *Le-fale-i-le-langi* means 'the sky for a house'; the word *fale* means 'house,' 'that which covers.' Atafu must have been a highly favoured country; the climate there was so fine that the inhabitants had not yet invented houses; the sky was their only covering.

2. *Fa'agata-nu'u* means 'to bring the country to an end,' to destroy it; *Fa'amalie-nu'u* means 'to make the country pleasant.' Here is the union of two contrary principles; how this ill-assorted pair managed to get along in their domestic life, I cannot tell; but in Atafu, the land of 'luck,' such things may be possible.

It appears that, in this land of Atafu, it was customary to offer human sacrifices to the Sun; for other couples, besides those named in this story, are said to have swum away from it to save their lives, Toalolongo and Toapaipai, Tufu and Taua, Lalo and Se'e These faithful ones, being the only survivors of their families, resolved rather to perish in the ocean than shed each other's blood; for either the husband must have immolated the wife, or the wife the husband. So they swam to Samoa, and died there shortly after. They were turned into rocks, and so became immortal.

3. The Manu'a cluster, in the east of the Samoan group, consists of three islands *Tau, Ofu,* and *Olosenga*; of these, Taū is the largest, and is about eight miles long. *Vai-tele* (tele, 'great,' vai, 'fresh-water,') seems to be a river in it.

4. *Fe'e* is the octopus; *Faia* means 'created or made.' Fe'e has a very bad reputation in Samoa as the enemy of man; he and his progeny (Sa-Fe'e, 'the family of the octopus') are consigned to the lower regions, and are grandees there. A Samoan mother, when very angry with her children, will say to them, 'Be off to Sa-Fe'e.'

5. As a token of respect.

6. 'She went into the bush.' That is not customary now. The 'bush' is the thickly timbered land near the villages.

7. *Analuma* means 'caves in front.' The lava in that district is often worn into caves in the sides of the mountains by the action of water.

8. *Vao-sa.* 'At the back of Mata-Utu, my place in Savai'i,' says Mr. Pratt, 'was a thicket of teak tree—a kind of wood well fitted for building houses or ships, but the villagers believed that Tui-Fiti or some aitu ('spirit') was in the clump of trees, and so did not touch them. One day, necessity overcame their fears for a time; for, seeing a tree fit for the keel of a canoe, they cut it down; but it had to lie there; they were afraid to take it home.'

9. Samoan parents 'make their will,' and dispose of their property by word of mouth. This mode is binding on all the children.

10. The native terms to denote these two relationships are—*tama-fafine* and *tama-tane* (*tane* = 'a man,' *fafine* = 'a woman,' *tama* = 'a woman's child'). Tama-fafine may be translated 'my sister's child.' When a man died, it was the *tama-fafine* who had the privilege of performing the last office of respect at the grave; just before the body was covered up, he approached and poured a flask of oil on the face of the dead.

11. 'A day of work.' The old men of a village could at any time appoint 'a day of work,' say, to-morrow, for the building of a wall, or a fishing excursion, or any similar object of general interest. Any one who failed to come to work was fined a pig or pigs, at the pleasure of the elders. A man who was necessarily absent would get a relative to take his place. To shirk duty was a disgrace.

12. However inferior in social position the *tama-fafine* might be, he always received from his relations tokens of honour, such as the first of the fish which were caught. In this tale, the honorary offerings of the shoots of the breadfruit and the branch of the cocoa-nuts seem to indicate, in an oriental way, that these trees and their fruit were his; just as the local magistrate in Britain might offer to our Queen the keys of their city, when she enters it.

13. What this clause means is not clear.

III.—The Story of Alele.*

A 'Tala.')

Alele[1] was the name of a people far away to the east, beyond Tua-langi;[1] they were notorious plunderers,[2] and so swift that they were named Alele, 'swift-fliers.' They had wings, and also recesses[3] in their backs, in which to stow away their plunder. Their king also was named Alele; he was the first king.[1] The name has become a proverb; for when a plantation is robbed, and the thief is not discovered, the exclamation is—Ai se mea a Alele, 'Oh! it's Alele.' These people used to alight upon one land and then on another, stow the crops of the plantations in their backs, and fly off. Thus they used to carry off great spoil, and lay waste many lands. On one occasion, they made a descent on the yam plantation of a chief named Tui-Samata,[4] who resided at Le-futu[4] on Tutuila. They carried off in the night all the crop of yams. On finding in the morning that his plantation had been plundered, he called his grandson named Le-le'a-sapai, child of his daughter Amete, and bade him go in search of the plunderers and bring back the yams. The lad set off, passed place after place, and at length arrived at a land of spirits, the chiefs of whom were Sa-le-vao[5] and Tulia; their land was near the land of the Alele. When he approached, they asked him whither he was going; he told them; they said it was doubtful if the yams were not all gone—all eaten up except a basket or two. They then said, 'Stop here till night; and then, before daylight, go to the place where the robbers alight with their plunder.' He said, 'Let me stop till the moon is up, and then I will go.' They answered, 'There is no moon at present; it is the change of the moon.' 'The moon will rise towards morning,' said he. 'It will not,' they replied. And so the argument went on and became vehement; and at last they said to him, 'Well, we will see; and if the moon does not rise, then you shall die.' All the spirits had assembled. He remained there; darkness fell; the night was passing away, and no moon arose. They began to talk about killing Lele'a; then Salevao, touched with compassion for the young man, went inland to behind the brow of a hill, and his presence was so radiant that it caused an appearance as though the moon was rising. Then said Lele'a, 'The moon is rising.' 'No,' answered Tulia, 'it is not; it is the pity of Salevao, who has gone and caused that appearance.' They then became his friends, and Tulia said to him, 'Come near; take this war-club;[6] put it in the place where the plunderers bathe, and hold this string in your hand. They will fight with this, and it will cause their death. Pass on straight along this road here; evil spirits will be sitting on your right and left, but pass on; they will not molest you.'

He went as directed, before daylight, to the meeting-place of the plunderers, and put the club in the water. Just about dawn, down they came, singing and shouting, Fata-tu, fata-tu.[7] Down went their burdens, and into the water they rushed; the fight began; in contest with the club there was an indescriminate slaughter, so that the bathing place became full of dead bodies. All this time Lele'a had been concealed. Their king now came to bathe: Lele'a stood forth and demanded to know where his grandfather's yams were. The king responded that there were only two or three left, and begged Lele'a to acept them and spare his life. He did so on condition that they should no more invade Samoa.[2] He returned to his grandfather with the yams. These people existed prior to the bringing down of the cloud from heaven.[*]

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*'I got this legend from Taua-nu'u (on Manu'a), Mar. 23, 1871.'

'This man, Taua-nu'u was Recorder (or Keeper of the Traditions) for the island of Taū.'

T. Powell.

1. The name *Aléle* is composed of *a*, an intensive particle, and *léle*, 'to fly.' *Tua-langi* means 'the back of the sky'; an Irishman would probably call it 'the back of beyont.' In Samoan myths, Alele is said to have been the first king of Manu'a. (See page 210.)

2. This tale reminds one strongly of what is said about the Grecian 'Harpies.' They too had wings, were very swift fliers, and were plunderers. One of them was called Aëllo, 'swift as the storm wind;' another was Okupete, 'swift-flying.' In the Grecian story, the lives of the Harpies are spared on their promising that they will no more molest Phineus; in this story, the life of the chief of the Alele is spared, on his promise that they will never again invade Samoa.

The binding obligation of such an oath is illustrated by the following facts. About the beginning of this century, the Tongans, in great force, invaded all the Samoan islands and conquered them. In token of their victory, the Tongans made the Samoans set up for them an oblong pile of stones in Savai'i, covering about an acre of ground; it was flat on the top and seven feet high. The invaders remained in possession of the islands for some time, but ultimately the Samoans recovered strength, and drove them out, taking from them a sacred oath that, except for peaceful purposes, such as barter or trade, they would never return. 'When I was in Savai'i,' says Mr. Pratt, 'a report spread that the Tongans were about to make another hostile descent, but an old man assured me that he was certain they would not come, for they were bound by that heavy oath, which they could not break.'

3. 'Recesses in their back.' Of course, as these Alele people went off with whole loads of yams at once, it was necessary for the old story-makers to describe them as having some means of carrying their plunder, and these receptacles in their backs just suit the purpose. But the idea may have been suggested by a similar Samoan custom; the women there carry heavy burdens on their backs, suspended in a net by a thong passing across the forehead. We know that the Centaurs of old Thessalian times were supposed to be man and horse all in one; and so our myth may find it convenient to represent the Alele and the net-basket on their back as all one piece. At all events, we have here an old folk-lore story; for the name Alele has passed into a proverb, as above.

4. *Tui-Samata*, 'king of Samata.' (See pages 199 and 208.) The *futu* is a large Samoan tree. A landing place in Tonga is named from such a tree; and so elsewhere.

5. The *Sa* in all such words means 'race of;' so also in the name Sā-moa.

6. The word here is *anava*, and that is 'the club of a great warrior,' handed down as an heirloom. So, on the principles of fetichism, this war-club is supposed to be endued with the 'spirit' of its warrior-owner, and will fight disastrously when Lele'a pulls the string to set it a-going.

7. 'Singing and shouting.' This incident is thoroughly Samoan; the plunge into the salt-water is the earliest enjoyment of the day. The words 'fata tu' are somewhat obscure; they may mean 'bearers, stand,' and may be the rallying cry of the plunderers, equivalent to 'stand and deliver.'

8. 'Before the cloud.' If so, the subject of this story must be very ancient.

IV.—Chaos and Strife.

A 'Solo.'

Preface.—I am thoroughly convinced that this Story of Creation is genuine, and in no degree coloured by infiltrations from Europe. When Mr. Pratt went to Manuka in 1839, there were only two white men on the island, and these were so brutish in mind and body, that a dog seemed as likely to know and to communicate the Mosaic account of Creation as they were. These men were despised by all, and even if they had possessed either the power or the inclination to talk about Creation, the natives would not have cared to listen to tales from such as they, much less adopt these tales into their own cosmogony. And there were no Samoan Bibles then, nor could any of the natives read English. Then again, I have the Samoan text in Mr. Powell's own hand writing, and on it a declaration that it was given to him by an old official of Tau. Any one who knows the natives will find it impossible to believe that such men of honour as Fofo and Tauanuu were, and occupying, as they did, so exalted positions in the islands, would allow their sacred records to be corrupted by intermixture from abroad, or would recite them as genuine, when they knew them to be corrupt. In the islands, such a thing would be considered a disgrace to all.

Any one who attentively examines the poem, will see that it has the whole cast of genuineness and nationality, and that its very thoughts are Samoan. The style is quite unlike prose; it has the abruptness and figurativeness of poetry, and of ancient poetry too; for there are words and expressions in it, which even Mr. Pratt, who knows Samoan better than the Samoans themselves, found it hard to understand and explain, except from the context and the composition of the words.

I print the Samoan text for reference. I have sacrificed Mr. Powell's rhymes in many places, in order to bring the translation closer to the original.—Ed.

The introductory stanzas seem to describe the condition of the waters before the land was called up from the deep. In fact, this introduction looks like a description of Chaos; Tangaloa and the Tuli alone moved on the face of the waters. If the poet who first composed these lines had been an Englishman of our time, the critics might have accused him of trying to imitate the lines on the 'Falls of Lodore.'—Ed.

Chaos and Strife.—(*Continued.*)

In a note prefixed to the original Samoan of this poem, Mr. Powell says, 'I received this from Fofo, an old chief of Taū, Dec. 28, 1870. I met him at Ofu, in company with the Teacher Iosefa.'

A song about Strife.[1]

The word of the Tuli,[2] which is the emblem of Tangaloa-the-messenger,[3] to Tangaloa-the-creator-of-lands.[3]

Mr. Powell's translation.

Rollers flooding, rollers dashing,
Rollers fighting, rollers clashing :—
The sweep of waters and the extension of waves,
Surging high, but breaking not :—
Waves reclining; waves dispersing ;
Waves agreeable; waves that cross not ;
Waves frightsome; waves leaping over ;
Waves breaking; waves warring ;
Waves roaring; waves upheaving ;
The peopled waves; waves from east to west,
Whose companion is the wandering current.[4]

The Tuli[2] *speaks.*

'O Tangaloa, who sittest at the helm [of affairs],
Tangaloa's [bird] desires to rest ;[5]
Tūli from the ocean must rest[5] in the heavens ;
These waves below affright my breast.'

O le solo o le Va.

Le 'upu a le Tuli, o le ata lea o Tagaloa-savali, ia Tagaloa-fa'atutupu-nu'u.

The Samoan text.

Galu lolo, ma galu fātio'o,
Galu tau, ma galu fefatia'i :—
O le auau peau ma le sologā peau,
Na ona fa'afua a e le fati :—
Peau ta'oto, peau ta'alolo,
Peau mālie, peau lagatonu,
Peau ālili'a, peau la'aia,
Peau fātia, peau taulia,
Peau tautala, peau lagava'a,
Peau tagata, peau a sifo mai gaga'e,
O lona soa le auau tata'a.

'Tagaloa e, taumuli ai,
Tagaloa fiamālōlō ;
E mapu i le lagi Tūli mai vasa ;
Ta lili'a i peau a lalō.'

The poet's account of Creation.

Where is the land which first upsprang?
Great Manu'a[6] first uprose.
Beats on [Manu'a's] rock his well-loved waves;
On it the Moon's[7] desired light looks down;
The Sun, like statue,[7] changeless found,
[Darts his refulgent beams around;]
The waters[8] in their place appear;
The sea, too, occupies its sphere;
The heaven ascends, the sky is clear.
To visit [the scene] Tangaloa comes down;
To the west, to the east, his wailing cry he sends;
A strong desire to have a place whereon to stand
Possesses him; [he bids the lands arise.]
Savai'i with its high mountain[9] then sprang up,
And upsprang Fiti and all the Tongan group;
Arose Savai'i; and afterwards,
The Tongan group and the group of Fiti,[10]
Together with the group of small lands;
With the home of Alamisi [the two Samatas[10]
Arose]—Samata-inland and Samata-by-the-sea:
The seats of Tangaloa, and his footstool.
But great[11] Manu'a first grew up—
The resting place of Tangaloa—
After that, all other groups of islands.

Fea le nu'u na lua'i tupu?
Manu'a-tele na mua'i tupu.
Se papa le tai lē a o'o atu;
Ma le Masina e solo manao;
O le La se tupua lē fano;

E tupu le vai, tupu le tai, tupu le lagi.

Ifo Tagaloa e asiasi;
Tagi i sisifō, tagi i sasaē;

Na tutulu i le fia tula'i.

Tupu Savai'i ma Mauga-loa,
Tupu Fiti ma le atu Toga atoa;
Tupu Savai'i; a e muli,
Le atu Toga, ma le atu Fiti,
Atoa le atu nu'u e iti;
Ma Malae-Alamisi,
Samata-i-uta ma Samata-i-tai:
Le nofoa a Tagaloa ma lona taatuga.
O Manu'a na lua'i gafoa—
O le mapusaga o Tagaloa—
A e muli le atunu'u atoa.

The peopling of Upolu and Tutuila.

Abide in thy mountains,[11] these visit and rest ;
Abide, Tangaloa, on Manu'a's high crest,
But fly now and then to thy group in the west :[12]
To measure and compare the space
Which lies between, from place to place.[13]
The ocean between is long and breezy;
Terrific waves affright Tangaloa ;
'Oh for a little coral strand!' thus to heaven he cries:
Upolu,[14] a very small bit of rock,
And Tutuila,[14] a little stony land,
Are isles that thereupon immediately arise :
Where chiefs in aftertimes may find a place of rest;
And gods, tho' pinched for room, have many a feast.[15]

The Origin of Man.

And hither came from heaven the peopling vine,[16]
Which gave to Tutuila its inhabitants,
And to Atua and A'ana, with Le-tuamasaga in Upolu.[17]
[Forth from the vine they come,]
The bodies only move, they have no breath,
Nor heart's pulsation.
The god-like Tangaloa learns [in heaven] above,
The sacred vine to gender life has now begun,
But that its offspring only wriggle in the sun ;
No legs, no arms they have ;
No head, no face,
Nor heart's pulsation !

Tumau i lou atu mauga, ta'alolo ;
Tumau, Tagaloa, i mauga o Manu'a,
A e lele i lou atululuga :
E fuafua ma fa'atatau,
Le va i nu'u po ua tutusa.
E levaleva le vasa ma savili ;
E lili'a Tagaloa ia peau ălili ;
Tagi i lagi sina 'ili'ili :
Upolu, sina fatu lāitiiti,
Tutuila, sina ma'a lāgisigisi,
Nu'u faaō e ā sisii :
E mapusaga i ai ali'i,
Tagaloa e 'ai fa'afē'i'i.

Na fa'aifo ai le Fue-tagata,
Fa'atagataina ai Tutuila,
Ma Upolu, ma Atua, ma A'ana,
Atoa ma Le-tuamasaga.
Ona gaoi fua o tino, e le a'ala,
E leai ni fatumānava.
Logologo Tagaloa i lugā,
Ua isi tama a le Fue-sā,
Nā ona gaoi i le la;
E le vaea, e le limā;
E le ulua, e le fofogā,
E leai ni fatumanavā !

Tangaloa then, descending to the west,[18]
Speaks but the word[19] and it is done:
'These fruits, the product of the vine are worms,
But them I fashion[20] into member'd forms;
To each of you from above I now impart a will;[21]
Opacity must be the portion of your bodies still;[22]
Your faces,[22] they must shine, [I so ordain,]
That they may Tangaloa entertain,
When he comes down to walk this earth again.'[23]

The poet re-asserts the priority of Manu'a.

O Great Fiti,[24] with all thy eastern iles,
And thy mountains scattered throng,
Yet each and all to Great Manu'a[6] look:—
Fiti, Tonga, the Slippery Rock,[25]
The spreading Masoa,[26]
Which raised again the fallen heavens;
Savai'i, leafy like the teve,[27]
In vain displays its lofty range;
She cannot supplant the firm seed-stone of Manu'a,[28]
[Their father] the Stone, and [their mother] the Earth.

Manu'a and its first king.

The Rock[29] produced and soon could show
At least ten hundred sons.[29]
Let none the truth gainsay [in unbelief],
Alele[29] was Manu'a's first known chief;
The son of Tangaloa; he wrought unrighteous judgment.

Ifoifo Tagaloa i sisifo,
I fetalaiga e tu'u titino:
'Fua o le Fue, ni nai ilo,
E totosi a'u fa'asinosino;
Outou loto na momoli ifo;
Ia pouli outou tino;
Ia malama outou mata,
E tali a'i Tagaloa,
A e pe ā maui ifo e savalivali.'

Fiti-tele, ma lou atu sasaē,

E ta'ape mauga, a e fa'atasi Manu'a-tele:—

O Fiti, o Toga, o le Papa sese'e,
Ma le Masoā felefele,
Na pāu le lagi toe tete'e;
Savai'i e lalau fa'ateve;
E mamalu fua mauga ina tetele, a e le au 'ese;
E āuga ia fatu-le-gae'e i Manu'a,
Ia le Fatu, ma le Eleele.

Fanua le Papa e faitau i nunu,
Fua selau e fua sefulu.
Ne'i ai se tăese
O le lua'i ali'i Alele—
O le alo o Tagaloa—na ta faase'e.

Where is that land which first upsprang?
I answer, great Manu'a first upsprang.
The eastern point Saua is thy eastern bound,
At Ofu and Tufue'e thy west limits are found.

Tangaloa's Council.

Descend, ye gods, to the fono[30] of Confusion.
But rest quietly at the fono of Tranquillity.
Here Tangaloa-the-Builder's council was convened,
The council[31] of the circle of the chiefs on high—
While thus he spake a solemn silence reigned[32] :—
'Let the Builder have the first kava cup in his circle,[33]
Then perfect will be the ship whose keel is laid![34]
To heaven's disposal leave all fish besides,
But offering unto Tangaloa made must be bonito.[35]
Let fisher Losi[36] ply his craft the wide seas o'er,
But offer unto heaven the choicest of his store.
And ye of Tangaloa's race,[37] when ye desire to meet,
May make the heavens your noble council seat,
Or fono of the Rock, or where Confusion[30] reigned,
Or peaceful fono which Tranquillity is named;
The fono of Asia,[38] the fono of Assembly,
Or of Lolongo, or Pule-faatasi.
At fono of Tranquillity, your councils you must hold,
When ye build ship or house;
But whether ship or house be first, [this is my will,]
In heaven will Tangaloa sit at peace, with his peers,
But the Builder and his workmen will come down.

O fea le nu'u na lua'i tupu?
O Manu'a-tele na lua'i tupú,
E te matāfanua i le Mata-saua i Manu'a-tele;
A e mulifanua i Ofu ma Tufue'e.

Ifoifo i Malae a Vevesi,
Lepalepa i Malae a Toto'a.
Na sao ai le alofi o Tagaloa,
Po o fono ia le alofi;
A e lomaloma :—
''Ava mua Tufuga i lona alofi,
A e olā atu le vaa lalago!
Toe i le lagi i'a atoa,
A e atu le ola a Tagaloa.
Fagotalia le tai e Losi,
E tau i le lagi ona tăfo'e.
Sa-Tagaloa i tou aofia ane,
Tou fono i le malae i lagi,
I Malae-Papa, ma Malae a Vevesi,
Ma Malae a Toto'a,
I Malae-Asia, ma Malae-Tafuna'i,
I Lologo, ma Pule-fa'atasi.
Malae a Toto'a tou fono ai,
I si oa mōu inā 'a'e;
Pe mua va'a, pe mua fale,
Alaala Tagaloa ma lona au tapua'i,
A e ifo Tufuga ma ona au tauave.'

Confusion and Strife.

Pray, who was first, a work so honoured to begin?
The first to own a ship was great Manu'a's king.
This errand brought the people of the Builder down—
A clan of workmen as ten thousand known,
With Architect-in-Chief, but one alone.[39]
* . . . .

The rafter-breaking[40] god came down,
[With wrath inflamed and angry frown ;]
Alas ! my building all complete
Is scattered in confusion great.

O ai ea na lua'i oa ?
Na lua'i va'a Tui-Manu'a.
Na fa'aifo le fale Tufuga—
O le fale Tufuga e toamano,
A e toatasi le fatamanu.
. . . .

Faaifo le atua gau-aso ;

Sātia si o'u tă fale ua ato.

O ! ![41]

* Note.—The tradition proceeds to say, that the workmen next went on to build a splendid house for the king of Manu'a, without first consulting Tangaloa. The god, therefore, descended in anger and destroyed the building, and scattered the builders.

T. Powell.

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1. The title of this poem in the original is *O le solo o le Va*. Now *Va* means 'a space between two objects, variance, confusion.' I cannot help thinking, both from the meaning of the word *va* and from the nature of the opening lines of the poem, that there is here a parallel to the Mosaic account of the opening acts in Creation; for this 'solo' shows an antecedent state of Chaos, in which the waters are surging about; there is, 'a space between,' *va*, which (Gen., c. I.) "divides the waters from the waters," for the Tuli (lines 12 – 14) flies away from the 'lower waves' of the ocean to Tangaloa's seat above; in the poem, after the creation of Manu'a's land, the heavens grow up (line 21); the moon first looks down benignly on the land (line 19), and then the sun; the waters and the sea occupy their appointed sphere. Tangaloa comes down and calls for other lands (line 24); then, much later, he creates mankind (line 65). Now in Genesis, the heaven and the earth are first created, and the waters long continue to sweep over the face of the earth ; a firmament—'the heaven,' *lit.* 'that which is lifted up'—is placed between the waters; the seas retire into their place and various portions of the dry land appear; later on, the sun and the moon are made to shine on the earth; then after fish, fowl, and beast, comes man, the last act of Creation.

The view which I here take of the application of the Samoan word *va*, is confirmed by the word *pada* in the Motu language of New Guinea; *pada* is the same root-word as *va*, and means 'the space between earth and sky.'

2. *Tuli* or *Turi* is a common bird in Polynesia; it is the *Charadrius fulvus*, the 'Golden Plover' of Australia. Every family in Samoa has its own 'tutelary animal'—*aitu*—a pigeon or some other bird, a fish, &c. This *aitu* is specially reverenced by the members of the family from generation to generation, and none of them will ever mention its name. A convert renounces heathendom by publicly destroying his *aitu;* the spectators stand by, expecting that he will immediately fall down dead.

It is an odd coincidence that some of the Australian blacks connect this 'plover' with the acts of Creation. The tribe at Lake Tyers, Victoria, call the 'grey plover' *bunjil borandang*. Now *Bunjil* is the Victorian name for the Creator of all things, and the verb *punjiliko* means 'to make, fashion, create.'

3. *Tangaloa* is the chief god of the Polynesians. In this poem, line 90 and elsewhere, he is represented as a quiescent god, the origin and cause of all things. In these respects he resembles the Indian Brahmă. Tangaloa loves absolute rest (line 12) and peace (line 108). Although he rests in the heavens, he intervenes in the affairs of men (lines 64 and 115); in his active manifestations he has many forms, as *T. fa'a-tutupu-nu'u*, T. who 'makes *(fa'a)* the lands *(nu'u)* spring up' *(tutupu)*, *T. savali*, T. who 'walks,' that is, 'the messenger' or 'ambassador,' *T. totonu*, T. who puts everything 'straight,' *T. le-fuli*, T. 'the immoveable,' *T. asiasi-nu'u*, T. 'the visitor-of-lands,' the omnipresent.

4. The 'wandering current' here seems to be the great Equatorial current, which crosses the Pacific from east to west.

5. In the text, the word *malolo* means 'to rest absolutely,' 'to be quiescent,' but *mapu* means 'to rest from work,' *sc.* here, from the work of Creation.

6. *Manuka*, in Samoan *Manu'a*, is not 'great' because of its size, for the three islands are small (see note 3 on page 203); but it is 'great' in importance, as the first resting place of the Polynesian race; like the Delos of ancient Greece, it is the sacred hearth-stone of the race.

7. The Polynesians, like the Gauls and other ancient nations, gave precedence to the moon, and counted by nights, not by days. The sun, they say, is 'changeless,' like a statue, and every day is very much like another; whereas the moon changes, and they can reckon by its phases.

8. The 'waters' here are *vai*, 'fresh water,' and in the next line, *tai*, 'salt water,' is the 'sea.' The poem makes a distinction between *vai*, the waters "above the firmament" (Genesis I.), and *tai*, the waters below; the space between is *le Va*. The science of this passage seems to be correct enough; for as soon as the sun (line 20) sends his hot beams on the ocean, vapours arise and form reservoirs of fresh water in the clouds above.

9. There is, in Savai'i, a lofty mountain, called *Mauga-loa*.

10. The two *Samatas* are now villages on the south side of Savai'i; at the west end of the island is the descent to Sa-Fe'e, the Samoan Hades.

Alamisi is another place on the island; the word means a 'land crab'; but the Samoans have a tradition that Alamisi was a quadruped brought down from heaven for them to feast on long ago.

In line 32, it will be observed that the Fijis, which are Melanesian islands, are included in Tangaloa's realm, and there he dwells. This is quite in harmony with statements made in other Samoan poems. In one of these, Tangaloa in anger changes the colour of two sons of his, the one he makes brown and the other black. (See note on the name Sina, page 199.)

11. All the legends agree in giving priority to Manuka, and its bards continually assert this priority (*cf.* line 72). 'Thy mountains' are the mountains of Manuka.

His footstool. Warriors sat on a wooden stool, and an armour-bearer carried this about for their use, when required.

12. 'Thy group in the west' may be Fiji.

13. It was the duty of Tangaloa, as the Great 'Artificer' (line 114), to see that the islands were all at their proper distances from each other, and that everything was in order.

By a poetical ellipsis, line 41 implies that he is flying towards the west, and describes his experience while doing so.

14. Two of the islands of the Samoan group.

15. 'Pinched for room,' *i.e.*, the islands are too small for the dignity of the gods. At all feasts, the gods received the first share of the food and the drink.

16. The 'vine' here is a native climbing-plant called *fue*. The Samoan tradition asserts that from this vine came the worms or maggots, which ultimately were turned into men and women. It is described in the text as *fue-tagata, lit.*, the 'mankind-vine,' and one variety is called by the Samoans *fue-sa*, the 'sacred' *fue*. In another legend, the *fue* is represented as the special gift of Tangaloa; he causes it to be brought down from heaven and set in a place exposed to the sun; there 'it brought forth something like worms, a wonderful multitude of worms'; these he fashioned (see line 64, *infra*) into men and women.

I think that the *fue* bears some relation to the sacred *Soma* plant of India, or its more modern substitutes. Like the Soma, the *fue* is a creeper and climber, and is a sacred plant; one variety of it in Samoa is a Hoya, and this belongs to the same natural order, the Asclepiads, as the Sarcostemma, which is generally considered now as the nearest approach to the original Soma. Another variety of the *fue* is full of a refreshing juice which the natives drink; so also the Soma juice was used as a drink in the Vedic sacrifices. The Soma had reference to the generative power of the sun; so also the *fue* in the Samoan legend here. The word Soma comes from the Sanskrit root *su*, 'to bear, bring forth, squeeze out juice,' and, from it, *suta* means 'a son, daughter, children'; so also the Samoan word *fue* is allied to *fua*, 'to produce fruit,' *fua*, 'fruit, a child,' and *sua*, 'juice of any kind.'

17. These are the three portions of the island of Upolu.

18. Tangaloa comes down to the west on the declining rays of the sun.

19. *Fetalaiga*, in the text, means a decisive decree spoken by one having the highest authority; it is a word which none but chiefs may use. With this compare 'Let there be light, and there was light.'

20. The 'fashion' here corresponds with the meaning of the French verb *tailler*, and equals 'to cut and shape into form and limbs.'

21. The word here is *loto*, 'the heart,' 'the inward parts'; this, as in the Homeric age, was taken to be the seat of the affections and desires.

22. Literally—'Let your bodies be darkness, let your eyes (face) be light.' *Mata*, 'the face,' comes from a root which means 'to shine.'

23. This is *Tagaloa-savali*, 'T. the walker.' See note 3, *supra*.

24. *Fiti-tele*. This is the largest of the islands in the Fiji group. The Fijians themselves call it Viti Levu (*levu* = 'great').

'To Great Manuka look,' *i.e.*, they cannot overshadow the importance of Manuka. See note 6, *supra*.

25. There is such a rock on Tutuila; boys slide on it.

26. The *Masoa* is the arrow-root tree of Tahiti, found there and in all the other islands. As it grows up, its leaves spread out like the surface

of a round table; hence the fable, that it was by the growth of a prodigious tree of this Tacca genus the heavens were raised aloft. Can the sacredness of the Dodonean oak and of the Norse Ygdrasil have originated in some such idea as this? *Masoa* seems to be used here as a synonym for the name of some one of the islands of the Pacific.

27. The *Teve* is also a variety of the arrow-root tree; but the root of it is so acrid that criminals are compelled to bite it as a punishment. The bite causes severe blistering of the lips and mouth.

28. *Fatu-le-gae'e* means the 'immoveable seed-stone.' For 'immoveable,' see note 24, *supra*. The *fatu* is 'the hard stone of a fruit, the kernel'; it suggests the idea here that Manuka had a heavenly seed dropped into its bosom, which sprang up and became a mighty tree, spreading its branches into all the islands of the Pacific.

Fatu, as an adjective, means 'hard,' and is quoted as a proof that the Polynesians are of Malay origin, for the Malay word *batu* means 'hard.' But on the same reasoning, the Papuans of the New Hebrides must also be Malays, for the Aneityumese say *inhat* (*i.e.*, *in-fat*) for 'stone,' and the Eromangans say *nevat* (*i.e.*, *ne-vat*); the negroid natives of New Britain and of the Duke of York Island must also be Malays, for they say *wat*, 'a stone,' and *pat-ina*, 'the hard seed of a fruit.' I observe also that the New Hebrideans treat 'stone' as a word of their own, for they give it the prefix-formatives which belong to words used as nouns in their own languages. The same word is found in New Zealand; there *whatu* is 'hail,' 'the pupil (*i.e.*, kernel) of the eye,' and *ko-whatu* is 'stone.'

29. *Manuka* consists of rocky islets, uplifted by volcanoes. (See note 3, page 203). The population of the three is now about 1,200.

For the full story of *Alele*, see page 203. 'Pretence of justice,' *lit.*, 'he caused the blows (of justice) to glance aside'; this describes him as a perverter of justice, for he was a plunderer.

The Rock. How the Samoans came to regard 'the Rock'—a hard parent—as their first progenitor, I cannot tell. In the 'Genealogy of the kings of Samoa,' the very first words are 'Papa-tu ('standing-rock') married Papa-ele ('earth-rock') and their son Ma'a-taanoa ('loose-stone') married Papa-pala ('mud-rock'). I suppose man has always been 'of the earth, earthy,' for Adam was 'red' earth.

But in the mythology of the Hervey Islanders, 'Papa' is a woman, the last of the primary gods. Her name there means 'foundation,' and that is more appropriate than 'rock' in Samoan.

30. The *fono*, in this and all the other names, corresponds, in its use, to the Latin Appii-*forum* and the English *Market*-Bosworth. The Samoan word is *malae* (= marae), but *fono* has been used in the translation, for convenience' sake, to mean 'a place where assemblies of the people could be held.' Every village had a *malae*, or open space, where the villagers came together for public purposes, but only certain places had the right to hold a *fono* or general assembly for the discussion of weightier matters.

31. He is called *Tufuga*, 'the carpenter, builder,' two lines below. Tufunga is not now a word of dignity; it would not now be applied even to a chief, much less to a god. This fact, and other similar words in the poem, go to prove its antiquity. Is 'chiefs' language' a recent thing?

32. Literally, 'but (they were) very quiet.' Compare with this, the Homeric Councils.

33. This first libation to the gods is well-nigh universal.

34. To the Polynesian islanders canoe-building is the most important of all architectural achievements; and so, they will prosper in it, if they have first shown, by libations, due reverence for the gods.

At great feasts in Polynesia, the proper ritual is this:—the kava drink having been prepared in the usual way, the official cup-bearer approaches the bowl which contains it, puts in his hands, and, with his fingers, lifts the fibre from the liquid, and so drains it; he then calls out the name of the god, either Tangaloa or some local god, to whom the first libation is made; he next carries the cup to the chief who, of those present, is highest in rank, and so, in succession, to the others. With this compare Ganymede and the libations to the gods, both in Greece and Rome.

35. Tangaloa here claims the *bonito* as his favourite fish; and the fishers, if they wish to secure his favour and get prosperity, must show him respect by offering a *bonito*, as first fruits, as soon as they come to land. Any neglect will bring disaster.

36. *Fisher Losi* often appears in the legends. He is the foremost of his craft.

37. *Tangaloa's race* = Sa-Tangaloa. There were numerous chiefs in Samoa who bore the name of Tangaloa, and claimed descent from him, and yet none of them were 'high chiefs'; *cf.* the Homeric *Diotrephees basilées*.

38 This name Asia or Atia occurs also in the traditions of the Rarotongans, for they say that their ancestor-land was in Atia. Where was Atia?

39. In the building of a house or a canoe, there is always a 'chief architect' to give orders and to superintend the work.

40. Tangaloa destroys 'the beams' of the house, that is, the whole house. The next line is the exclamation of the king on seeing his house destroyed.

41. Samoan recitations end with a long-drawn O-o! from the mouth of the speaker.

POSTSCRIPT to Notes on Legend No. I.—I now find that Tingilau is called Tinirau by the Hervey Islanders, and that he is one of their six primary gods.—ED.

DISCUSSION.

Rev. Dr. W. WYATT GILL, B.A., *Lond.*—These traditions are perfectly new to me. Of course, they are deeply interesting to me, as I have spent most of my life in these islands, not in that particular group, although I have passed it, and the locality is perfectly familiar to me. I only wish the documents referred to could be translated. I have published a good deal myself on the subject in days gone by, but age has perhaps prevented my doing more. The question I have often asked myself is what is to become of the collections of so many years. Is there anybody in the world who can take more interest in them than I do? As to the lady referred to in the first story as Sina, where I lived she is called Ina—in another place she is called by another name. But she is one and the same. I went lately to hear my friend the Rev. Mr. Harley lecture about the moon. He told about the 'man' in the moon, and I was disappointed that he had never heard about the 'woman' in the moon of Polynesia. Any little boy or girl there would say, 'There is Sina, and she is preparing the evening meal for her husband.' She is at one and the same time the goddess and the model wife of Polynesia. I would like these little bits of folk-lore gathered together in some shape for the study of the generations to come. The world seem to be getting very prosaic, and while these little bits of poetry remain, we should preserve all we can.

The President—I think the vote of thanks of the Society is due to Dr. Fraser. With reference to the wish that these records should be printed and put into a permanent shape before they are lost, I think that would be hoped for by every one who wishes to see these interesting traditions preserved. Some day, when there is not so much opportunity of meeting people who have spent so many years as these gentlemen have amongst the natives, there will be less authentic accounts than at present. With reference to the natives' belief as to the creation of the world, I know some people are sceptical as to whether some of the missionary teachings have not filtrated into and tinctured a belief already existing. But if that is not so, and the belief existed before the arrival of the missionaries at the islands, then it is still more interesting.

WEDNESDAY, OCTOBER 1, 1890.

Dr. Leibius, M.A., F.C.S., President, in the Chair.

Twenty members and eleven visitors were present.

The minutes of the preceding meeting were read and confirmed.

The Certificates of five new candidates were read for the third time, of three for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Brown, J. Ednie, F.L.S., Director-General of Forests ; Sydney.
Marshall, Hezlett Hamilton, L.R.C.P., L.R.C.S. *Edin.*, Lic. Fac. Phys. & Surg. *Glas.;* Sydney.
McMurray, Wahab, M.D., M.Ch., L.M.K. & Q.C.P. *Irel.*; Sydney.
Olliff, Arthur Sidney, Government Entomologist ; Sydney.
Rennie, Geo. Edward, B.A., *Syd.* M.D. *Lond.* M.R.C.S. *Eng.*; Sydney.

The Chairman announced that Dr. Fiaschi had been appointed to the vacancy in the Committte of the Medical Section and the

Hon. Dr. H. N. MacLaurin, M.A., M.L.C., as Chairman of the Section for the remainder of the Session.

The Chairman also announced that the business before the meeting was to discuss the paper read by Prof. Warren at the September meeting, on "Some applications of the results of testing Australian timbers to the design and construction of timber structures," and stated that any visitor present desiring to take part in the discussion, would be allowed to do so upon this occasion.

The following gentlemen then spoke, Messrs. J. Trevor Jones, J. I. Haycroft, J. Vicars, H. H. Dare, W. Shellshear, P. N. Trebeck, J. F. Mann, D. M. Maitland, O. Burge, Prof. Warren and the Chairman.

The following donations were laid upon the table and acknowledged :—

Donations Received during the month of September, 1890.

(The Names of the Donors are in *Italics.*)

TRANSACTIONS, JOURNALS, REPORTS, &c.

Baltimore—Johns Hopkins University. Circulars, Vol. v., No. 48, 1886; Vol. viii., No. 75, 1889. *The University.*

Berlin—K. Preuss. Geodätische Institutes. Astronomisch-Geodätische Arbeiten I. Ordnung. Telegraphische Längenbestimmungen, 1888 and 1889. *The Institute.*

Bonn—Naturhistorischer Vereines der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück. Verhandlungen, Jahrgang xlvi., Folge 5, Jahrgang 6, Hälfte 2, 1889; Jahrgang xlvii., Folge 5, Jahrgang 6, Hälfte 1, 1890. *The Society.*

Brisbane—Chief Weather Bureau. Weather Chart of Australasia at 9 a.m., August 30, September 1 - 6, 8 - 13, 15 - 17, 19 - 21, 23 - 25, 1890. *Government Meteorologist.*

Calcutta—Asiatic Society of Bengal. Journal, Part i., Vol. lviii., Supplement 1889, Vol. lix., Nos. 1 and 2 1890; Part ii., Vol. lvii., No. 5, 1888; Vol. lix., No. 1 and Supplement No. 1, 1890. Proceedings, Nos. 1, 2, 3, Jan. - Mar., 1890. *The Society.*

Cambridge (Mass.)—Museum of Comparative Zoölogy at Harvard College. Bulletin, Whole Series, Vol. xvi., (Geological Series, Vol. ii.) No. 9, July, 1890. *The Museum.*

Ceylon—Royal Asiatic Society (Ceylon Branch). Journal, No. 1, Part i., 1845, No. 2, 1846, 1847-48, Vol. ii., Part i., No. 4, 1848; Vol. ii., Nos. 2, 3, 1853; Vol. ii., Part ii., No. 6, 1853; Vol. iii., Part i., No. 9, 1856 - 58, 1865-66, Parts i. and ii., 1867 - 70, 1871-72, Part i. 1873, Part i. 1874; Vol. vii., Part ii., No. 24, 1881, Part iii., No. 25, 1882, Extra Number 1882; Vol. viii., Nos. 26 - 29, 1883-84; Vol. ix., Parts i. and ii., Nos. 30 - 33, 1885-86. Proceedings, 1873 - 1886, inclusive. Pānini's Eight Books of Grammatical Sūtras: edited with an English translation and Commentary by William Goonetilleke, Vol. I., Part i., 1882. The Veddás of Ceylon: translated from the German Monograph of Professor R. Virchow, 1888. *The Society.*

EDINBURGH—Geological Society. Transactions, Vol. VI., Part i., Session 1888-89. „

Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. VI., No. 7, 1890. „

Royal Society of Edinburgh. Proceedings, Vols. XV. and XVI., Sessions 1887-89. Transactions, Vol. XXXIII., Part iii., Session 1886-87, Vol. XXXV., Parts i.-iv., Sessions 1887-90. „

GLASGOW—University. Calendar for the year 1890-91. *The University.*

HAMBURG—Deutsche Meteorologische Gesellschaft. *Meteorologische Zeitschrift*, August 1890. *The Society.*

JENA—Medicinisch-Naturwissenschaftliche Gesellschaft. Jenaische Zeitschrift fur Naturwissenschaft, Band XVII., Heft 4, 1890. „

LEIPZIG—K. Sächsische Gesellschaft der Wissenschaften. Berichte über die Verhandlungen. Mathematisch-physische Classe, Part i., 1890. „

LONDON—Geological Society. Quarterly Journal, Vol. XLVI., Part iii., No. 183, August 1, 1890. „

Meteorological Office. Summary of the Observations made at the Stations included in the Daily and Weekly Weather Reports for the Calendar Months April-September 1888; August-December 1889; Jan.-Feb., 1890. Weekly Weather Report, New Series, Vol. VI., Appendix 1, Fourth Quarter, Values for the whole year 1889; Appendices 2, 3, and 4, and Title-page &c.; Vol. VII., Nos. 1-20, 4 Jan.-17 May and Appendix 1, First Quarter, 1890. *The Meteorological Council.*

Pharmaceutical Society of Great Britain. Journal and Transactions, Third Series, Vol. XX., Part 240, June 1890. *The Society.*

Quekett Microscopical Club. Journal, Ser. 2, Vol. IV, No. 27, July 1890. *The Club.*

Royal Astronomical Society. Memoirs, Vol. XLIX., Part ii., 1887-89. Monthly Notices, Vol. L., No. 8, June 1890. *The Society.*

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MELBOURNE—Field Naturalists' Club of Victoria. *The Victorian Naturalist*, Vol. VII., No. 5, Sept., 1890. *The Club.*

Mining Department. Reports and Statistics for the Quarter ended 30 June, 1890. *The Hon. the Minister for Mines.*

MONTREAL—Natural History Society. *The Canadian Record of Science*, Vol. IV., No. 3, 1890. *The Society.*

MULHOUSE—Société Industrielle de Mulhouse. Bulletin, Avril-Mai, 1890. „

NAPLES—Società Africana d' Italia. Bollettino, Anno IX., Fasc 5–6, 1890. *The Society.*

Stazione Zoologica. Mittheilungen, Band IX., Heft 3, 1890. *The Director.*

NEW YORK—School of Mines, Columbia College. *The School of Mines Quarterly,* Vol. XI., No. 4, July 1890. *The School of Mines.*

The Journal of Comparative Medicine and Veterinary Archives, Vol. XI., No. 8, 1890. *The Editor.*

PARIS—Académie des Sciences de l'Institut de France. Comptes Rendus hebdomadaires des Séances, Tome CXI., Nos. 3–6, 21 Juillet–11 Août, 1890. *The Academy.*

Feuille des Jeunes Naturalistes, Année XX., No. 238, 1er Août, 1890. *The Society.*

Société de Biologie. Comptes Rendus hebdomadaires des Séances, Serie 9, Tome II., Nos. 27, 28, 1890. „

Société de Géographie. Bulletin, Serie 7, Tome XI., Trimestre 1, 1890. Compte Rendu des Séances, de la Commission Centrale, Nos. 12 and 13, 1890. „

Société Entomologique de France. Bulletin, Nos. 12–14, 1890, pp. 113–152. „

Société Géologique de France. Bulletin, 3e Serie, Tome XVIII., No. 4, 1890. „

Société Française de Physique. Séances, Janvier–Avril, 1890. Résumé des Communications faites dans la Seance du 18 Juillet 1890. „

Société Zoologique de France. Bulletin, Tome XV., No. 6, 1890. Mémoires, Tome III., Nos. 2 and 3, 1890. „

PHILADELPHIA—Franklin Institute. Journal, Vol. CXXX., No. 776, August, 1890. *The Institute.*

ROME—Accademia Pontificia de'Nuovi Lincei. Atti, compilati dal Segretario. Anno XLII., Sessione 4a., 17 Marzo, 1889. *The Academy.*

Biblioteca e Archivio Tecnico. *Giornale del Genio Civile,* Anno, XXVIII., Fasc. 4, Aprile, 1890. *The Minister of Public Instruction, Rome.*

Biblioteca Nazionale Centrale Vittorio Emanuele di Roma. Bollettino delle Opere Moderne Straniere acquistate dalle Biblioteche Publiche Governative del Regno d' Italia, Vol. IV., No. 6, Nov.–Dec. 1889. *The Minister of Public Instruction, Rome.*

Reale Accademia dei Lincei. Atti, Serie Quarta, Rendiconti, Vol. VI., Fasc 11, 12, 1890. *The Academy.*

ST. ETIENNE—Société de l'Industrie Minérale. Comptes-Rendus Mensuels, Juin, 1890. *The Society.*

SYDNEY—Department of Mines. Memoirs of the Geological Survey of New South Wales, Palæontology, No. 8, 1890. *The Hon. the Minister for Mines and Agriculture.*

Linnean Society of New South Wales. Proceedings, Second Series, Vol. V., Part ii., 1890. *The Society.*

TAIPING—*The Perak Government Gazette,* Vol. III., Nos. 23 and 24, Aug. 8 and 22, 1890. *The Secretary to the Government.*

WASHINGTON—United States Hydrographic Office. Notice to Mariners, Nos. 17 - 27, April 26 - July 5, 1890. Pilot Charts of North Atlantic Ocean, Feb. - May, 1890. CHARTS—North America, West Coast of Lower California No. 1193; San Quentin Bay to Cerros Island; No. 1194, San Benito Islands; No. 1204, Port San Bartolomé; No. 1197, Arctic Ocean, Dominion of Canada, Sketch of Herschel Island; No. 1198, Guano Islands in the Pacific Ocean, Baker Island and Howland Island; No. 1196, West Indies South Coast of Cuba, El Portillo; No. 1210, West Indies, Island of Santo Domingo, Manzanillo Bay.
The U.S. Hydrographer.

WEDNESDAY, NOVEMBER 5, 1890.

Dr. LEIBIUS, M.A., F.C.S., President, in the Chair.

Twenty-six members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three new candidates were read for the third time, of three for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Harris, Rev. Edward, M.A. *Oxon. & Syd.*, D.D. *Oxon.*; Parramatta.

Loir, Adrien, Director of the Pasteur Institute of Australia, Rodd Island, N.S.W.

Neill, Leopold Edward Flood, M.B., Ch.M. Univ. *Syd.*; Prince Alfred Hospital.

The Chairman announced that a Conversazione would be held in the Great Hall of the University on the evening of Wednesday the 10th of December, and requested the members to kindly assist by the loan of objects of either scientific or artistic interest.

In the absence of the author, Prof. Liversidge read extracts from a paper by Mr. C. W. Marsh, "Geological Notes on the Barrier Ranges Silverfield," he said, this paper is hardly one to be read in its entirety, neither is it very suitable for abstraction, but I may say perhaps a few words about it and draw attention to the specimens which of course are of interest to most of us, they will convey a great deal of information without the whole of the paper being read. In the first place, Mr. Marsh, the author of the paper, apologises for not being able to make it more complete than it is, on account of the difficulty of getting specimens from different mines, but as far as possible he has sent specimens of the rocks collected from over a large area, together with specimens of ore deposits from certain mines.

Professor Liversidge concluded by saying, "Mr. Marsh has been good enough to present to the Society a few crystal models he has cut from ripidolite. They are very well cut, and I think he deserves the thanks of the Society for these and for the specimens he has also presented to us."

The thanks of the Society were accorded to Mr. Marsh for his paper, and the specimens illustrating it.

The Chairman stated that Baron von Mueller had sent a continuation of his paper :—" Record of hitherto undescribed plants from Arnheim's Land," in which five plants were described, dried specimens of the same being laid upon the table for inspection; in order to expedite the publication of the paper it had been already set up in type.

Dr. John Fraser, read a paper on "Some Folk Songs and Myths from Samoa," translated by Rev. T. Powell and Rev. G. Pratt, with introductions and notes written by himself. He made the following prefatory remarks :—Mr. President, your predecessor, in vacating the Chair in May last, devoted a paragraph in his address to some words of sympathy with Australasian and Polynesian research. I know there are some in this room now who received these words of sympathy with pleasure, for it is not often we get any notice from those high in authority. In our schoolboy days we used to learn, in classic language, that "virtue is its own reward," but I am not quite sure that that maxim is altogether appreciated as a motive to research of this kind. Most of us, in this community, like a little word of encouragement now and then. It is very fortunate that our studies do not belong to the bread-and-butter sciences. If our living depended upon them, it would be but a scanty one. So any encouragement we receive is all the more grateful to us. I consequence of the sympathy shown in Professor Liversidge's address, I venture to offer you this evening a few bits of song and tradition from Samoa.

Some remarks upon the paper were made by the Rev. W. Wyatt Gill, B.A., LL.D.

Mr. H. C. Russell, B.A., C.M.G., F.R.S., exhibited and described 'Some Star photographs recently taken at Sydney Observatory,' the photographs were afterwards kindly presented to the Society:

" A few weeks since I had the honour of bringing before the members of our Society some photographs of the Milky-Way and

I then hoped to have completed ere this, the photographs of the whole southern part of the Via Lactea, but the weather kept so bad that the work was not concluded before the Milky Way had got too far west to admit of the necessary time of exposure for a photograph, and I thereupon directed my attention to the Magellan clouds. Beginning with three hours exposure, I had gradually to increase the time to seven and even eight hours to bring out the wonderful details of these objects. The result has been startling, and will I think be interesting to the members of the Royal Society.

On September 18th a photograph was taken of Nebecula Major with 4½ hours exposure. Seeing that it wanted still more exposure, I did not at first study it very closely to see what it revealed, but on October 1st I had a silver print taken from it, and saw at once that there was a clearly marked spiral structure involving the whole of the central parts of the nebula, and two secondary spirals forming outlying portions. If we consider for a moment the enormous extent of *Nebecula Major*, which, according to Sir John Herschel, covers 48 square degrees, we shall see how this mighty spiral system dwarfs all others with which we are acquainted; and what strong support this photograph gives to the late Mr. Proctor's conception of the form of our Milky Way, the Universe in which we live, which, it will be remembered, he looked upon as a series of great spirals. Here in the Nebecula Major we have spread out before us another Universe with its Suns and its Nebulæ, away out in the infinity of space, its spirals so situated that we can see their convolutions, which are in a plane almost at right angles to our line of sight. In the great central spiral the stars are masses like sands on the sea-shore, and yet when carefully examined with a microscope they all seemed to be arranged in parallel curves, as if to show the roundness and wonderful complexity of this object. I have seen nothing like it in any other photograph of any stellar object, excepting that of the brightest portion of our own Milky Way; that in Sagittarius of which also a photogragh copy is exhibited. Perhaps the most remarkable of all the markings in this object, is a dark space, because it is so suggestive of the rift in our own Milky Way. You will see, as it were in the neck of the great spiral, a great, roughly triangular-shaped darkness which seems to blot out the brilliance belonging to that part—as if a dark cloud intervened between us and it. Most of these details appear in the negatives of October 17th and September 18th, and particularly the dark mark, which therefore cannot be a fault of the negative.

I have also a photograph of Nebecula Minor, which brings out in a very marked way a structure almost identical with that just described as characteristic of Nebecula Major. In other words, the smaller Magellan cloud is, by this negative, and eight hours exposure, proved to be—shall we say another Universe—certainly it is another great spiral object, with almost exactly the same form as the greater one; it is vastly more distant if we may judge its distance by its faintness and its size. The exposures given to these negatives in order to bring out the details of the Nebeculæ are, so far as I am aware, the longest yet given to celestial photographs; and the results obtained are quite as startling as the earlier ones in Europe, which revealed stars and nebulæ which never had or could have been seen otherwise than by photography. Photography has here distinctly revealed in the Magellan clouds a spiral structure and a wealth of detail indicating structural arrangement in those far distant Universes which never has, or could be seen with any telescope, for from the very nature of a telescope—and the larger it is the more pronounced is this fault—it can only present to the eye small parts of such an object at a time, and hence so to speak, severs the arrangement and continuity of the object in such a way that the eye so aided could never see their mutual interdependence.

I have brought two other photographs, of interest for very different reasons. The first is of the brightest part of our own Milky Way, "that found in Sagittarius" and which has also been photographed at Lick Observatory, and reproduced in *Knowledge*, July 1st, 1890. I want to place it on record for comparison to show results obtained with similar instruments (portrait lenses of about six inches aperture), but the one used at an elevation of 4,000 feet, and the other in Sydney, and I think you will agree with me in thinking that the Sydney picture shews much better definition than the other. The other photograph includes the great nebula about Theta Orionis, and it was taken to afford a measure of the work I have been doing; that is, a photograph taken with the same apparatus, plates, &c., as those taken of the Magellan clouds and Milky Way, by which means we can see how very much fainter photographically some of the southern objects are than Orion. Eta Argus for instance, is very much under exposed with three hours exposure, while Orion is very much over exposed in four hours. Compared with those of the Nebeculæ Major and Minor, it brings out conspicuously two points: first, its miniature size compared with Nebecula Major; and second, its intense relative photographic brilliance which makes it much over exposed with four hours, while the others are still under-exposed with seven and eight hours.

Orion was chosen because conveniently situated for other observatories and because it had been frequently photographed in other observatories. The exposure given on Orion was four hours, and the whole picture of the nebula is spoiled by over-exposure, especially the great nebula about Theta Orionis, which here appears as a great white patch, in which detail has been lost by over exposure, and it extends far beyond the ordinary limits as seen with the telescope, for its margin extends beyond the star Iota. The third star in the sword handle is also shown with its nebula about it, in which some structural forms can be clearly traced.

NOTE.—Part of these remarks on Star photographs were sent with the photographs to the Royal Astronomical Society some weeks since; but additional matter is here incorporated with them, and the whole read before the Society with the sanction of the Council.

The thanks of the Society were accorded to the various authors for their valuable papers.

The following donations were laid upon the table and acknowledged :—

DONATIONS RECEIVED DURING THE MONTH OF OCTOBER, 1890.

(The Names of the Donors are in *Italics.*)

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SOME REMARKS ON THE AUSTRALIAN LANGUAGES.

By Dr. John Fraser.

[*Read before the Royal Society of N.S.W., December 3, 1890.*]

1. *The Grammars.*

No large effort has yet been made to master the difficulties that present themselves in the study of the comparative grammar of the Australian languages. The only thing in this direction, that I know of, is a paper on the "Position of the Australian Languages, by W. H. J. Bleek, Esq., Ph.D.," published in 1871. Dr. Bleek was a philologist who, in 1858, assisted in cataloguing the Library of His Excellency Sir Geo. Grey, K.C.B., then Governor of Cape Colony. Twenty years previously, Sir George (then Captain Grey), as leader of an expedition into the interior of our continent, had excellent opportunities of seeing the native tribes in their original condition; and the knowledge thus gained was enlarged by him and matured, while he was Governor of South Australia. Any one of us, although not specially interested in Philology or Ethnography, can understand how valuable to science would be the publication of the MS. records of the knowledge of so intelligent an observer as Sir Geo. Grey. These records are now in the South African Public Library, Cape Town, having been presented to that Library by him, along with his collection of books and other manuscripts. The Government of the Cape is not likely to take so liberal an interest in our aborigines, as to publish Sir George's account of what he saw and learned of the natives in South Australia; but I think that any one of our Colonies would do itself an honour if it got these manuscripts copied for publication here. Their contents would certainly be interesting to Australians.

The catalogue of Sir George Grey's Library was published by Trübner & Co., London, and Dr. Bleek devotes a portion of the second volume to the philology of the Australian languages.*

The earliest of individual efforts to deal with any single language of the Australian group was made by the Rev. L. E. Threlkeld, who, for many years, was engaged as a missionary among the blacks of Lake Macquarie, near Newcastle, New South Wales. His

* Throughout I say 'languages'; although, in fact, there is but one Australian language with many dialects; I also use the word 'language' instead of dialect, wherever the meaning is clear.

Grammar of their language was printed in Sydney in 1834, at the "Herald Office, Lower George Street." A few years previously, Mr. Threlkeld had translated the Gospel by St. Luke into the same language. This translation remained in manuscript, and had disappeared ; recently I discovered that it still exists and is now in the Public Library of Auckland. I am glad to be able to inform you that this work, and the Grammar, and some smaller fruits of Mr. Threlkeld's labours on that language, will shortly be published by the Government Printing Office, Sydney. The volume will be the most important that has yet appeared on an Australian language. But it deals with only one dialect, and, for the purposes of comparative grammar, more languages than one are required. In searching for another Grammar, I remembered that Mr. Hale, the philologist of the United States' Exploring Expedition (1838-42), when he was in this colony, got access to the Rev. William Watson, missionary to the aborigines at "Wellington Valley," and that Mr. Watson had drawn up for him "an account of the most important peculiarities of the Wiraduri language, modelled as nearly as possible on the Grammar of Mr. Threlkeld, for the purpose of comparison." Further search disclosed the fact that, as early as 1835, a Dictionary and a Grammar of that language had been prepared, and the Gospel by St. Luke had been translated. How valuable these materials would now be, to illustrate the Awabakal of Lake Macquarie ! but Mr. Watson had no relatives in this colony, and on his death his MSS. were sold as waste paper ; so I am told. Fortunately, the late Archdeacon Günther of Mudgee, where a dialect of the same language was spoken, collected a copious Vocabulary of that dialect and wrote a Grammar of it. The Vocabulary I found to be in the hands of his son, the present Archdeacon of Camden, and I hope that I shall be able to get it published ; the Grammar was, many years ago, sent to the home country, and I fear that it cannot now be recovered.

The next labourers in the field of Australian grammar were the Lutheran Missionaries, Messrs. Teichelmann (E. G.) and Schürmann (C. W.); in 1840 they published a "Grammar, Vocabulary, and Phrase-book" of the aboriginal language of the Adelaide tribe. Then, in 1856, appeared the primer "Gurre Kamilaroi," by the Rev. W. Ridley. Mr. Ridley, who was a man of rare devotedness and self-denial, went among the aborigines of Liverpool Plains and shared the privations of their wandering life, in order that he might learn their language, and so be able to tell them the message of the Gospel. In 1866 (2nd edition, 1875), our Government Printing Office issued his book on the "Kamilaroi, Dippil, and Turrubul languages." I do not know that, since 1875, any other book has appeared on the grammar of our languages. But there have been some valuable short papers in various journals, such as that in the Anthropological Journal for 1880, on the "Kabi dialect of Queensland," by the Rev. John Matthew, now of Coburg, Victoria. The substance of this, with many important additions, will be found as a portion of his prize essay on the aborigines of Australia, published in the Journal of the Royal Society, N.S.W., for last year. So far the history of the grammars.

2. *Influences affecting the Language.*

The position of our Australian dialects in their relation to the great families of language has not yet been determined. That task demands leisure, labour, and skill. A collection of carefully prepared Grammars and Vocabularies would make the task much easier; but where are these to be had? With the exception of those that I have named, I know of none. Australian Vocabularies have been collected in abundance, but, for the most part, these are quite useless to the philologist; they consist of dialect-names for native customs and weapons, for the birds of the air, the beasts of the field, and the trees of the forest.* All this is mistaken labour which yields no fruit. What we want is to get from each dialect a sufficient number of words expressing the ideas essential to a language, in the form of substantive, adjective, or verb, and a sufficient number of simple sentences; this would enable the philologist to ascertain what is the structure of its grammar and its vocables.

The Australian languages are subject to a principle of change which it is worth our pains to consider here. Our native tribes name their children from any ordinary occurrence, which may have taken place at the birth or soon after it. For instance, if a kangaroo-rat were seen to run into a hollow log at that time, the child would be named by some modification of the word for kangaroo-rat. At a later period of the boy's life, that name might be changed for another, taken from some trivial circumstance in his experience; just as our own boys get by-names at school. When a man or a woman dies, his family and the other members of the

* I wish here to express my strong regret that, in two of the largest publications which these colonies have produced, on the subject of our aborigines, so much space has been given to mere local names, such as those for the mountains, lagoons, animals, and birds in a district. Such details are absolutely valueless to the philologist. In a general investigation as to the character of the Australian language, no help is to be gained from a bare knowledge of the names for all the Frying Pan Creeks and Doughboy Hollows in the land, or for the scores of varieties of the eucalyptus tree. Instead of these, let us have the words essential to the language, 'to see,' 'hear,' 'speak,' 'smite or kill,' and the like, and, with them, samples of the manner in which they form derivatives; let us also have similar lists of root-words used as substantives and adjectives to express simple ideas; such collections would be useful both now and hereafter.

tribe, as far as possible, never mention his name again, and discontinue the use of those ordinary words which formed part of his name; other words are substituted for these common ones, and become permanently established in the daily language of the clan or sub-tribe to which the deceased belonged.* In this way new words arise to designate those familiar objects, the previous names of which have been cast aside; and these new words are formed regularly from other root-words, that describe probably another quality inherent in the thing in question. Let me illustrate this matter by examples. A man or a woman may get a name from some peculiar physical feature, such as a large mouth, or chin, or head; or a name taken from an animal or tree, or any similar object, animate or inanimate, which had some relation to his birth. A Tasmanian woman was called Ramanalu, 'little gull,' because a gull flew by at the time of the child's birth. After her death, the word rama would never be used again for 'a gull'; a new name for 'gull' would be invented, formed, it may be, from a root-word meaning 'white,' because of the whiteness of the bird. This new word would be used by all the kindred and acquaintances of the deceased, and would ere long establish itself in the language of that portion of the tribe as the right name for 'gull.' Again, a boy of the Dungog tribe of blacks, in our own colony, was receiving instruction from the old men of the tribe; he was required to make a spear, and was sent into the bush to select a suitable piece of wood; he cut off and brought to them a piece of the kulai ('cockspur') tree; this choice was so absurd, that forthwith his instructors dubbed him Kulai-kat, and that was his name ever after. When he died, the word kulai would disappear, and some other name be found for the cockspur tree. And the operation of this principle is not confined to Australia; it is found also in Polynesia; but there it has respect to the living, not the dead. High chiefs there are regarded as so exalted personages, that common people must not make use of any portion of their names in ordinary talk, for fear of giving offence. If, for example, a chief's name contains the word pe'a, 'bat,' the tribe calls the 'bat,' not pe'a, but manu-o-le-lagi, 'bird of the sky.' In languages which are not subject to these influences, the derivation of such a word is usually very plain; the Latin vespertilio, 'bat,' for instance, bears its origin on its very face; but if a philologist, not knowing the history of the word manu-o-le-lagi, were to find it to mean a 'bat' in a Polynesian tongue, he would be puzzled to explain how it is that a creature so peculiar as the 'bat,' should have been named by a word having so indefinite a meaning as the 'bird

* It is possible that the discarded word resumes its place in the language after a while; this point I have not ascertained; at all events, the adopted word remains.

of the sky.' Any one of you, who has had the curiosity to look into lists of names for common things in Australian vocabularies, must have been surprised to see how diverse are these names in the various tribes, but your wonder ceases to be wonder when the cause is known. In fact, we do find that among conterminous tribes, and even in the sub-sections of the same tribe, these words vary greatly ; for the presence of death from time to time in the encampments had the effect of maintaining a continual changing of the names of things. Hence it is that, as I have said, the labour spent on these lists of words is often labour mis-spent, for to the philologist it must be barren of results, *unless* we have in the lists at the same time a due proportion of the simple roots from which such words are taken ; thus only is it possible to see and understand the mechanism of the language.

You may possibly ask me why our blackfellows had so strong a disinclination to mention the name of a friend who had died. We ourselves have a feeling of the same kind. We speak of our friend as 'the deceased,' 'the departed,' 'him who is gone'; and if we must mention his name, we apologise for it by saying 'poor' Mr. So-and-so, and seem afraid to use the simple word 'dead.' But our indigenes have a stronger reason than that. They believe that the spirit of a man, especially if he is killed by violence, is excessively uncomfortable after death, and malicious, and in its fretfulness ready to take offence at anything, and so pour out its wrath on the living. Even the mention of the dead man's name would offend, and bring vengeance on them in the night time. Our blacks seem also to have the idea that the deceased, for a certain number of days after death, has not yet got his spiritual body, which slowly grows upon him, and that, while in this undeveloped state, he is like a child, and is specially querulous and vengeful. But I fear that this digression is leading me off the track of the Australian languages.

3. *Tests in examining Languages.*

I now proceed to show you some results which may be obtained even from our Australian words, by comparing them with others elsewhere. It is agreed among philologists, that there is no surer test of the affinity of different languages than that which comes through the identification of their pronouns, numerals, and, to a less extent, their prepositions. To this I would add, in our present inquiry, the identity of such common words as 'eye, foot, hand, water, fire, sun, moon,' and the like ; for these words cannot have been used much in the names of individuals, and are therefore not likely to have suffered from the fluctuations which I have already explained. It is true that, in all languages, the pronouns and the numerals are subject to abrasion and decay, from the frequency and rapidity with which they are pronounced, and from a natural tendency everywhere to shorten the words which are most in use. But it is the function of the philologist, not only to understand these causes of decay, but to show the process by which the words fell away, and to restore them to their original forms for the purpose of identification.

It is agreed, then, that the numerals, the pronouns, and, to some extent, the prepositions, are a strong test of the affinity of languages. On this principle, such languages as the Sanskrit, the Greek, the Latin, the German and Gothic, the Lithuanian, the Keltic, have been tested and proved to be so much akin that they are grouped as a well-defined family of languages—the Aryan. Some anthropologists, especially when they are not linguists themselves, sneer at the labours of philology as deceptive and liable to serious error; so are all sciences, if not managed with care and ability. A student in chemical analysis and synthesis may get results which are clearly erroneous; instead of declaring the prescribed methods to be faulty or his materials to be bad, he ought to blame only his own want of skill in manipulation. As to the utility of philology, I would only remind you, that it was by the study of languages that the place of Sanskrit (and consequently of the Hindu race) was determined in its relation to the other members of the family I have named, and it was philology alone that settled the claim of the Keltic, and consequently of the Kelts, to be regarded as one of the most ancient members of the Aryan family. In the case of the cuneiform inscriptions, the services which philology has rendered are inestimable. And it is quite possible that, amid the conflicting opinions as to the origin of our Australian race, the *via prima salutis*, the first dawn of a sure daylight, may in the future arise from a careful examination of their language.

As is well known, the Australian numeral system is very limited in its range; our natives say 'one,' 'two'; sometimes 'three'; occasionally 'hand' for 'five'; all else is 'many,' 'a great number.' It was alleged by Sir John Lubbock, and has since been repeated by everybody, that their having separate words only for 'one' and 'two' is a proof that Australians possess very limited mental powers, since they cannot count higher than 'two.' Every colonist, who has been much in contact with the blacks, can adduce proofs to show that their mental powers are not so limited, and that, when our indigenes are taken out of their adverse environment and encouraged to cultivate their intellectual faculties, they readily develope a decided capacity for improvement. A friend of mine, 50 years ago, taught two young black boys to play chess; they soon acquired a liking for the game, and learned to play with caution and skill, and even with success. If it were possible to surround the blacks with favourable influences continued from generation to generation, I have no doubt that their whole position would be altered; but any final separation from their ancestral habits would lead to their speedy extinction as a race; this was the issue that was rapidly approaching after the last remnants of the Tasmanians were removed to Flinders' Island. But for many hundreds of years, no one can tell how many, the Australian race, has lived in the midst of adverse surroundings, tribe warring against tribe, each tribe restricted to its own boundaries, the supply of food in our precarious climate often scanty, the paralysing terror produced by their strong belief in the supernatural power of demons and of their own wizards, the ravages of waves of disease and death sweeping over them from time to time; all these and other causes compelled them to think only of their daily subsistence and the preservation of their lives, fixed and deepened their degradation, and prevented even the possibility of amelioration and elevation. The natives of the South Sea islands, whose lot has been a fairer one, have had many yams and cocoa-nuts and bananas and other things to count, and so have developed a wide system of numbers; but our poor blackfellows, whose only personal property is a few spears or so, have not felt it necessary to speak of more than 'one,' 'two' or 'three' objects at once. Then, as to the linguistic question on which Sir John Lubbock builds his charge, I think it could be shown that even the Aryan system of numbers—the most highly developed system of any—is founded on the words for 'one,' 'two,' 'three,' and no more, all the rest being combinations of these by addition or by multiplication. Further, the Aryans have singular and dual forms for nouns and pronouns, that is, they have number-forms for 'one' and 'two,' but all the rest beyond that is included in the general name of plural, that is 'more'; indeed the Sanskrit uses its word for 'four' in a general way to mean a considerable number, exactly as to our blackfellows all else beyond two or three is bula, 'many.' For these reasons I think that this charge against our blackfellows ought to be laid on better ground than that afforded by their numerals.

4. *The numeral 'one.'*

(*a*). Of the words for 'one,' I take up first that which is least common, pir 'one.' And here I beg to say that, like other investigators, I have to depend upon the accuracy of others for the facts quoted. I have not been in the districts where the word pir is used, and so cannot verify the word for myself, but I have no doubt it is correctly given as a word for 'one.' I am responsible only for the arguments I draw from the evidence produced in this inquiry. So far as I know, these arguments have never been advanced previously; for my practice is to form my own opinion on the evidence independently, and I seldom read the opinions of others until after I have made my own. Indeed, I am convinced that no one has ever discussed these numerals before, for it is commonly alleged that it is impossible to give any account of them. The word pir is said by Bonwick to be used by the blacks on the Namoi,* and a modification of it is in use in Queensland. These are, so far as I know, the only two places where it is to be found. But I think it is correctly quoted, for I know the word piriwul means 'chief,' and pir seems to me to bear the same relation to piriwul that the Latin primus, 'first,' bears to princeps, 'chief,' 'first,' or the Latin preposition pro, 'before,' to proceres, 'chiefs,' or our English word 'first' to the German Fürst, 'a prince.' In fact I regard pro and pir as the same word originally.

Now, do not mistake me here; for I do not assert that the languages spoken by our Australians are uterine brothers to the Latin and the Greek; but I do assert that all languages have one common, although ancient, origin, and that, in the essential words of these languages, there are proofs of that common origin. Pir, then, as allied to pro, means the number which comes 'before' all others in the row, the one that comes 'first.' The Latin primus is for pri-imus (*cf.* Sk. pra-thamas, 'first'), in which the root pri, not unlike pir, is the same as the Latin pro and prae. In the Aryan family, the nearest approach to the Australian pir is the Lithuanian pir-mas, 'first,' and pir-m (a preposition), 'before'; other remote kinsmen are the Greek pro-tos, 'first,' pru-tanis, 'a prince,' 'a president' (*cf.* piriwul), prin, 'before'; the Gothic fru-ma, 'first'; the Aryan prefixes pra, fra, pro, pru, prae, pre and fore, as in our English 'fore-ordain.' The Keltic languages drop the initial *p* or *f*, and say ro, ru, air, ari, to mean 'before.' In the Malay region ar-ung is a 'chief,' and in Polynesia ari-ki is 'a chief,' which the Samoans change into ali'i; these words, I would say, come from eastern forms corresponding to the Keltic ro, air, 'before.' In Samoan i lu-ma means 'in front,' and in Malay de-alu-wan; these are like ru; in Aneityum, a Papuan island of the New Hebrides, a 'chief' is called natimi arid, where arid is 'high,' 'exalted,' doubtless from the same root as ariki; and arid is to ariki as the Latin procērus, 'tall,' to procĕres, 'chiefs'; natimi means 'man.' From the abraded form ru I take the New Britain word lūa (Samoan lua'i), 'first.'

In the Dravidian languages of India, from which quarter, as I suppose, our Australian languages have come, there is a close parallel to our word pir, for there pir-a means 'before,' and piran

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*** Since this was written, I find that Hale, the philologist to the U.S. Exploring Expedition, 50 years ago, quotes this word; there can, therefore, be no doubt of its antiquity and genuineness.**

is 'a lord.' Dravidian scholars themselves acknowledge that piran comes from the Sanskrit preposition pra, 'before'; this corroborates my derivation of the Australian word piriwul and the Maori ariki. The Aroma dialect of New Guinea says pirana, 'face'; and, in my opinion this pirana bears the same relation to the Dravidian pira that the Latin frons has to the preposition pro, the Samoan mua-ulu to mua, and the English forehead, to be-fore. The Motu dialect says vaira for 'face, front'; I take this to be a corruption of pira, for the Motu also says vaira-nai 'before'; another dialect says vari; with this *cf.* pro, para and frons. I may add here, in passing, that on the Upper Nile, west of Khartoum, the negroes say ber, bera, for 'one.'

The Australian postposition bir-ung, 'away from,' seems to be connected with this root in the same way as the Greek para. The dictionary meanings of the Sanskrit preposition pra are 'before,' 'away,' 'beginning'; if these three meanings were carried to Australia through the Dravidian form pira, they abundantly justify my arguments as to the origin of the Australian words pir, 'one,' and birung, 'away from.' In New Britain, pirai means 'odd,' 'not a "round" number' (*cf.* the game of 'odds and evens'), and this sense must have come from a numeral meaning 'one.'

Results in this Section are:—Preposition forms to mean 'before' are, in the primitive languages, *pra, pri, pro, prae, pru*; other forms are *par-a, par-os, pur-as*; modes of all these are, *fra, fru, vor, fore*, and, without the initial letter, *ro, ru, air*; the Lithuanian has *pir-*, and with this correspond the Dravidian *pir-a*, 'before,' the Australian *pir*, 'one,' and the Turkic, *bir*, 'one.' In Sanskrit, the old ablative form *purâ* means 'formerly,' 'first'; cognates are the Gr. *paros*, 'before,' and the Zend *para*, 'before.'

(*b*). But the most common word for 'one' in New South Wales is wākul. In fact, it is our Sydney word for 'one,' and there can be no doubt of its genuineness, for it is noted by Lieut.-Colonel Collins as a Port Jackson word in his book on the Colony, published 1802; he spells it wogul. At Newcastle it was wākōl; in the Williams River district wākul-bo, and on the Manning wakul. From my manuscript notes I write down the various forms which this word assumes, beginning with Tasmania and passing northwards to the Timor Sea:—Tasmania, mara-i, mara-wa; in Victoria, bur; on the Murray River, near Wentworth and Euston, mo, mata, marda, meta-ta; on the middle course of the Darling, waichola; on the Upper Murray, mala; on Monero Plains, yalla; at Moruya, med-endal; in the Murrumbidgee district, mit-ong; at Jervis Bay, met-ann; on Goulburn Plains, met-ong; in the Illawarra district, mit-ung; at Appin, wôgul; at Sydney, and northwards to the Manning River and the Hastings, wakul;

on Liverpool Plains, mal; at Wellington, mal-anda; in Southern Queensland, beahda, mūray, bardja, beaiya; in the Northern Territory of South Australia, mo-tu, wa-rat; at Port Essington, wa-dat.

Besides these, some other words for the number 'one' are used in various parts of Australia, but those I have given all proceed from one original root, which it will be our duty now to discover. And I notice, first of all, that one word in the list stretches along the whole extent of seaboard from the Illawarra district to the Hastings—the word wakul—and this fact affords the presumption that all that coast line was occupied by the same tribe, or by tribes closely akin; for the tribes a little inland say mal and malanda for 'one.' Wakul, then, was the word used by the Sydney blacks, as Collins testifies. If a chemist has a compound substance handed to him for analysis, he experiments on it, and tests it in order to discover its elements. Let us do so with wakul; it is a compound, for simple roots are usually monosyllables; but are its parts wa + kul or wak + ul? Here I remember that, in the same region where wakul exists, there is a word kará-kul, 'a wizard, doctor or medicine-man,' but inland he is called kará-ji. This satisfies me as proof that the -kul is merely a formative syllable, and that the root is wa. And this conviction is strengthened when I cast my eye over the above list of words; for they all begin with the syllable ma or some modification of it, the rest of each word consisting of various formative syllables. As I have now got hold of a clue to a solution, I reflect that the initial labial of a root-word may assume various forms; thus, *p*, *b*, *m*, may interchange, and may easily become *f*, *wh*, *v*, *w*. There can be no doubt, for instance, that the Latin pater, the German vater, and the English father, are the same word; there *p* = *f* = *v*; and in one district in Scotland, the people always say fat for what and far for where; so also the Maori whatu is the Samoan fatu; that is *f* = *wh*; *b* and *m* also are interchangeable, in oriental languages especially, for *m* is only the sound of the letter *b* modified by the emission of a breathing through the nose; *m* is therefore regarded as a *b* nasalized. I note also that the words under consideration all begin with the cognate sounds of *m*, *b*, or *w*, except yalla; and this example I think must have been at one time walla, that is, uala, of which the *u* has obtained the sound of *i* (y); or wa-la may come from the same root as wa-kul, the difference lying only in the termination. The other vowels of our root word are *o*, *u*, *e*, *i*, *ai*, all of which in Australian are modifications of the original sound *a*.

Having now discovered the root-germ from which our Sydney friend wakul proceeded, and having noted the various guises which he has assumed in these colonies, we must next ask where he came from, and see if he has any kinsmen in other lands; for, when by searching we find that out, we may perhaps be justified in saying that the Australians brought the root-word with them from those lands. Before setting out on this quest, I observe that when a number of men are arranged in a row, he who is number one is (1) 'before' all the others, and 'in front' of them; he is thereby (2) 'first or foremost'; he has (3) the 'pre-eminence' in honour or authority, and (4) he may be regarded as the 'beginning or origin' of all the others.* We may therefore reasonably expect that words for 'one' will be akin to other words, bearing some one or other of these four meanings. I have already shown that the Kamilaroi numeral pir, 'one,' is related to Aryan prepositions meaning 'before,' and to the Maori word ariki (Samoan aliʻi), 'a chief,' as one having authority and eminence;† I shall now show that the kindred of wakul have the other meanings as well. And, first, I note that the word bokol is used for 'one' in the island of Santo, one of the New Hebrides. Bokol is so like wogul, the Port Jackson word, that I cannot doubt their identity; and yet it is impossible to suppose that the one word can be borrowed from the other. The islanders of Santo can never have had any intercourse with the blacks of Sydney; nor, if they had in any past time, can we believe that either language was so miserably poor as to be without a word of its own for 'one.' The blacks of Santo are a woolly-haired negroid race; I therefore argue, from the evidence of this word, that these blacks and our blacks have, in some way, one common origin.

I next take you to another Papuan region having a negroid population—a group of islands off the east end of New Guinea and consisting of New Britain, New Ireland, and some others. In the Duke of York Island there, I find the following words, all akin to wakul, viz., makala, 'for the 'first' time,' mara, mara-kam, 'for the 'first' time,' marua, 'to bear fruit for the 'first' time, to enter on a new course, to begin,' mara, 100 (= the 'beginning' of a new reckoning), muka, 'first,' muka-na, 'first-born son,' muka-tai, 'first,' mun, 'to go 'first.'‡ In all these, the root is ma, mu, as in Australia, and the abundance of these derived forms in this Tukiok language proves that the root is indigenous, not borrowed. Among them I observe mara, 'for the 'first' time,' and mara 100, and this is exactly the Tasmanian word (mara-

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* *Cf.* the Hebrew ạhādh, kedam, rôsh, aûl or yaāl, for these meanings.

† The Insular-Keltic words for 'chief,' 'principal,' are priomh, ard, araid; and roimh is 'before.' It is evident that these are only corruptions of the root pri, pro, prae, pra, 'before.' In Ku, a Dravidian dialect, 'one' or 'first' is ra (*cf.* Sk. pra) and in Duke of York Island (New Britain Group), 'one' is ra, re.

‡ Compare with this the Tamil postposition mun, 'before.'

wa) for 'one'; another of them is muka, 'first,' and this word, by dropping the k, which is never* sounded in Samoan, becomes the Samoan mua, 'first,' and mua-ulu, 'the fore-head.'† Mua also is very common in Samoan (as in foe-mua, 'the 'first' or stroke oar,' a-fua, 'to begin'), and thus proves itself to be native to the language. Further, you may have observed that some of the Australian words for 'one' are mo, mata. With mo compare the Santo word mo-ig 'to begin,'—another proof that the Santoans and the Australians are kinsmen; with mata compare the Motu (N. Guinea) word mata-ma, 'to begin,' and, as an adjective, 'first'; the Fijian matai, 'first,' and tau-mada 'before-hand'; the Maori ti-mata 'to begin'; the Samoan a-mata 'to begin'; the New Britain a-ma-na 'before, in front,' mata-na, 'the front,' biti-na 'the commencement'; the Motu badi-na, 'origin,' and the Aneityumese ni-mti-din, 'the front'; with mu compare the Fijian vu-na, 'to begin,' and the New Britain wa-vuna, 'to begin,' and the Santo mul, 'a chief,' as being the 'first' man. All these I have noticed in the course of my reading, but I believe there are many other words in these islands which are of the same origin as our Australian word wakul.‡ I pray you to remember that, with the exception of Samoa and New Zealand, these words all come from Papuan regions and afford indirect evidence that our Australians are allied to the Papuans.

As to the Maori and Samoan congeners that I have quoted, it is commonly alleged that these races are Malayo-Polynesians, on the theory that their languages are of Malay origin;§ but let us look at this theory in the light of our present inquiry. It is

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* The one solitary exception is puke, 'catch you!'—a word used by children in their games.

† An uncommon form of the root ba is va; and from it the Mangaians (Hervey Islands) say va-ri, 'a beginning'; but in the Koiari dialect of New Guinea this same word means 'the forehead,' 'the face.' This word thus illustrates the procession of meanings from the root pra (para) pro, 'before'; for vari is equivalent to 'that which is before,' hence 'a beginning,' 'the forehead' as the 'front' part of the human body, 'the face'; it also throws some light on the derivation of frons, which has so puzzled Latin etymologists that some of them derive it from the Greek ophrus, 'the eyebrow'! The Motumotu dialect of New Guinea says hali, instead of vari, for 'forehead'; several other dialects there say i-piri-ti, paru, para-na, pira-na, for face'; these are all connected with the Dravidian pira, 'before.'

‡ These and all other words from the New Britain and Duke of York Islands I quote from manuscript dictionaries of these languages, prepared by the Missionaries there. It is much to be regretted that, in these Colonies, we have no public fund from which to defray the cost of printing these and similar works, which would be so valuable to Science.

§ The name and authority of K. Wilhelm von Humboldt first gave this theory a standing; but we have now much fuller materials on which to form an independent judgment.

said that the Polynesians are Malays. Well, let us see. If the Samoans are Malays, then the Duke of York Islanders are Malays; for the word mua, which is essential to the Samoan language, is the same word as the Tukiok muka; therefore the Papuans of that island also are Malays! But the corresponding Malay word is mūla, 'in front,' 'foremost,' 'at first,' and it is certain that muka can never be formed from mula; for, while *k* may become *l*, the letter *l*, when once established in a word, cannot revert to *k*. Thus the Malay language might be said to have come from the Duke of York Island, at least so far as the evidence of this word goes! But I acknowledge that they may both be taken from one common source, and this I believe, is the true solution of the question. Where shall we find that common source? The root-form of mula, muka, mua, and of all the others, is ma, mu, and if we can find that root, it will be easy to understand how all these words have been formed independently from that original root; and it will then be unnecessary to say that the Samoan language is of Malay origin, or that the Papuans of the New Britain isles are using a Malay language. Now, in Southern India, there is a group of languages called the Dravidian, from the Sanskrit word Dravida, which, in the Mahâbhârata, is the name given to these aboriginal inhabitants of India. They now occupy the mountains of the Dekkan, and the coasts both to the east and the west of that. There are twelve dialects; some of these people are very barbarous, the mountaineers; others, again, are very civilized; the Klings, for instance, of Madras are clever at figures and intelligent; their services are much in demand all over the Eastern Archipelago; and in Penang, Singapore, and elsewhere, you may be sure to find a Kling engaged as a head book-keeper in a warehouse, or thriving as a merchant; they are said to be the Scotch of the East. Some of these Dravidian tribes are considered by the best authorities to be certainly negroid, and in England Prof. Flower, from an examination of their crania, has classed them as kinsmen of the Australians. One of the most cultivated languages of the group is the Tamil, and the Tamilians are known to have class-marriage laws similar to those in Fiji and Australia. Now for 'first' the Tamil says mudal, and this mudal is a verbal noun meaning 'a beginning,' 'priority' in time or place. The root is mu, and dal is a formative syllable. The mu is, without doubt, our Australian root ma, mo, mu. Bishop Caldwell of Tinnevelly, who has carefully examined the Dravidian languages, says—"Mudal is connected with the Tamil postposition mun, 'before'; mudal is used as the root of a new verb 'to begin.' Mu evidently signifies priority, and may be the same as the Tamil mu, 'to be old,' mudu, 'antiquity.'" I think there is a better derivation than that. The Sanskrit mûla means 'origin, cause, commencement,' and is the same word as the Malay mula already referred to, and both of these I take from the Sanskrit root-verb bhû, 'to begin to be, to become, to be,' with which is connected the Latin fore (fuere), 'to be about to be,' fui, &c. From bhû come such Sanskrit words as bhava, 'birth, origin,' bhâvana, 'causing to be,' bhuvanyu, 'a master or lord' (*cf.* piran, &c.), and many other words in the Aryan languages. At all events, wakul and these other Australian words for 'one' are assuredly from the same root as the Dravidian mu-dal, 'first, a beginning.' I, for one, cannot believe that words so much alike both in root and meaning should have sprung up by accident over so vast an area as India, Malaya, New Guinea, Fiji, Samoa, and back again to the New Hebrides and Australia. The only rational explanation seems to me to be that these races were all at one time part of a common stock, that in their dispersion they carried with them the root-words of the parent languages, and that in their new habitations they dressed out these root-words with prefixes and affixes by a process of development, just as circumstances required.

Results.—The root in its simplest form is *ba*, 'to begin to be,' 'to begin'; other forms are *bo*, *bu*, *bi*; *ma*, *mo*, *mu*; *fa*, *fu*, *vu*; *wa*. The nearest approach to the Australian *wakul*, 'one,' is the Ebudan *bokol*, 'one,' and the Tukiok *makal-a*, 'for the first time,' but many other cognate words are found all over the South Seas in the sense of 'first,' 'begin.' The Tasmanian *mara-wa*, 'one,' is the same as the Tukiok *mara*, 'for the first time,' and *mara*, 100; and in New South Wales, *mara-gai* means 'first' in the Mudgee dialect.

5. *The numeral 'two.'*

Almost the only other Australian numeral is bula 'two.' It is true that several tribes have a distinct word for 'three,' and a few have a word for 'five' taken from the word 'hand,' but in most parts of Australia the number 'three' is expressed by 'two-one,' 'four' by 'two-two,' 'five' by 'two-two-one' and so on. But the word bula is universal; with various changes of termination,* it

* Note—In my manuscript notes I have the following forms:—Tasmania, bura, pooali, piawah; Victoria, būlum, pollit; South Australia, bulait, purlaitye; New South Wales, blula, buloara, buloara-ba; Southern Queensland, bular, pūbul, bularre, bulae; Northern Queensland, bularoo. It is evident that some of these words have been written down by men who were not acquainted with the phonology of languages, and that the spelling does not adequately represent the real sounds. This is generally the case in vocabularies of Australian words, and is a source of much perplexity to linguists. One of the commonest mistakes is bular for bula. In pronouncing that word our blackfellows let the voice dwell on the final *a*, and an observer is apt to think that this

exists from Tasmania in the extreme south, right on to the Gulf of Carpentaria. If you ask me why there is only one word for 'two,' while the words for 'one' are so numerous and different, I reply that, among other languages, and especially in the Turanian family, there is a similar diversity in the words for 'one'; and the reason is this that, wherever there is a considerable number of words for 'origin,' 'commencement,' 'before,' &c., there will be a similar variety in the words for 'one,' which are formed from them. But the range of ideas for 'two' is somewhat limited; the only ideas possible are 'repetition,' or 'following,' or something similar. Let me show you this by a few examples. The Hebrew shenāim, 'two,' is a dual form, and is connected with the verb shânâh, 'to repeat;' the Latins also say 'vigesimo altero anno' to mean in the 'twenty second year;' but alter is 'the other of two,' and in French and English it means to 'change;' and secundus in Latin comes from sequor, 'I follow.' Thus we shall find that words for 'two' are the same as words for 'follow,' 'repeat,' 'another,' 'again,' 'also,' 'and,' and the like; and most of these ideas are usually expressed by forms of the same root-word.

As to the form of the word bula, we have here no friendly karaji to tell us whether the -la is radical or not. I think that the -la is formative, and that it indicates the dual number, the bu- being thus the root. The Tasmanian bu-ali (Milligan writes it pooalih) is probably the nearest approach to the original form, the bu being the root and the -ali the dual affix; these would easily coalesce into bula. In the Tasmanian pia-wa, the pia seems to me to be a dialect form of bula, for the liquid *l* easily drops out, and in the Aryan languages a modified *u* approaches very nearly to the sound of *i* (*cf.* Eng., sir); in the Polynesian, *i* often takes the place of *u*. Thus, bula would become bu-a, bi-a, pia. The wa in pia-wa, as in marawa 'one,' is only a suffix, the same as ba in our colony. All the other words for 'two' are only lengthened forms of bula.

As to the kindred of bula, I find that, in the Papuan island of Aneityum (New Hebrides), the word in-mul is 'twins'; there the in is the common prefix used to form nouns; the mul that remains is bul, 'two'; there also um, for mu, is 'and'; in the other islands it is ma, mo. In New Britain, bal-et is 'again,' bul-ug, 'again,' 'also,' 'another,' mule, 'again,' bula, 'another,' 'an additional one' (*cf.* ma, 'and'), bula, ka-bila, 'also' (with -bila *cf.* Tasm.

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is the sound of *ar*; just as a Cockney will say 'idear' for 'idea,' 'mar' for 'ma,' or 'pianer' for 'piano.' In one vocabulary that I have seen almost every word terminates with *r* on this principle!

It is evident also that the same mistaken principle vitiates the spelling of some of the words for 'one,' given on a previous page; for instance, marda ought to be mâ-da, and bardja should be bâ-ja.

pia-), muru 'to follow.' In Samoan, muli is 'to follow,' fo'i is 'also,' ulu-ga (for fulu-) is 'a couple.' The Fijian has tau-muri 'behind' in the sense of 'following,' just as tau-mada in Fijian means 'first' or 'before.' The Malay has ulang, 'to repeat,' and pula, 'again, too, likewise.' In some of the Himalayan regions, to which a portion of the aboriginal inhabitants of India was driven by the Aryan invasion, buli, pli, bli means 'four,' that is, as I suppose, 'two-twos,'—a dual form of 'two.'

It seems to me that the Dravidian words maru, 'to change,' muru, 'to turn,' muri, 'to break in two' are from the same root as bula, and that root is to be found in Aryan words also, such as Lat. mu-to, mu-tu-us; for there is a Sk. root ma, 'to change.' It is known that the Sanskrit dvi, dva, 'two,' gives the Greek dis (for dvis), 'twice,' and the adjective dissos, 'double,' and that dvis gives the Latin bis; but the Sk. dva also gives the Gothic twa, 'other, different,' and the Eng. twain, 'two,' as well as words for 'two' in many languages. Hence I think that our root bu, ba gives the Samoan vae-ga, 'a division,' vaega-lemu, 'the half,' and other words; because, when people are 'at one' on any subject they are agreed, but when they are at 'twos and threes' they are divided in opinion; and in the same sense I would connect the Lat. divido with the Sk. root dvi. Probably the Latin varius and the English variance are connected with the root ba in that same sense. But I must now leave the word bula; for this discussion is getting too lengthy.

I would only add a line to say that our blackfellows use the word bula also to mean 'many.' I do not believe that this is the same word as bula, 'two.' I consider it to be from the same root as the Sanskrit pulu, puru, 'many,' and that root under the form of par, pla, ple, plu has ramifications all through the Aryan languages, in the sense of 'fill, full, much, many, more,' &c. The eastern form of this root gives, in New Britain, bula, 'more,' mag, 'many,' buka, 'full'; in Motu, bada, 'much,' and hütu-ma, 'multitude'; in Aneityum, a-lup-as (lup = plu), 'much'; in Fiji, vu-ga, 'many'; in Duke of York Island bu-nui, 'to increase.' In Dravidian, pal is 'many,' pal-gu, 'to become many, to multiply, to increase.' It thus appears that the Australian bula, 'many,' has kindred, not only in Melanesia and the Dekkan, but also all through the Aryan region.

Results.—The root is *bu*, which denotes 'repetition,' 'change,' and this is the idea which resides in the Hebrew numeral 'two,' and in the Latin *alter*, 'second'; another, but cognate, idea for 'two' or 'second' is 'that which *follows*'; of the root *bu* other forms are *ba*, *bi*, *pi*, *ma*, *mo*, *mu*, *fu*, *fo* and *u*; from *ma*, *mu*, come Dravidian words meaning 'to turn,' 'to change'; and from the same root-forms there are, in the New Hebrides, New Britain, and Polynesia, numerous words in the sense of 'follow,' 'again,' 'another,' 'a couple,' 'also.' The Melanesian word *mu-le*, 'again,' and the Malay *pu-la*, 'again,' connect themselves, not only with the Dravidian *ma-ru*, *mu-ru*, but also with the Sanskrit word *pu-nar*, 'back,' 'again,' and also with the Greek *pa-lin*, 'again,'

6. *Words for 'water' and 'blind.'*

(*a*). And, for the same reason, I must forego the consideration of the Australian words for 'water,' 'fire,' 'sun,' 'eye,' &c., all of which could be proved to have their roots in India, and to have stems and branches from these roots in Aryan Europe, in Malay lands, and in the islands of the South Seas. Let me before closing, just give you a glimpse of the line of argument which I intended to follow. Collins quotes bado as the Port Jackson word for 'water'; others write it badu; it is found in various parts of our colony and in Western Australia. The root is ba (=ma); and du is a Dravidian formative to neuter nouns. The root ma means 'to be liquid,' 'to flow.' It is a very old word; for the Assyrian cuneiform inscriptions have mami, 'waters,' and this is a plural by reduplication; the Hebrew has mo, ma(i), 'water,' moa, 'to flow;' the ancient Egyptian has mo, 'water,' whence the name Moses; the Sanskrit has ambu (am for ma, by metathesis), 'water,' the Keltic has amhainn, abhuinn, 'a river,' whence come the river-names, 'Avon.' From ma come the words wai and vai which are so common for 'water' in the New Hebrides and in the Polynesian islands, and from the same root, in a sense known to the Arabs, by an appropriate euphemism, as 'the water of the feet,' come the Melanesian and Polynesian words mi, mim, mimi, miaga, &c., the Sanskrit mih and the Keltic mùn. From am (=ab=ap) comes the Sanskrit plural form âpas, 'water,' while from ma may come the Latin mad-idus, 'wet.' We found that wa-kul, 'one,' comes from root ba, ma; so, from the root of ba-du, comes the Australian word wa-la, which means 'rain,' and in some places, 'water.'

As to the kindred of our Sydney badu, I would remind you that 'water,' 'rain,' 'sea,' and 'wave,' are cognate ideas; hence the Samangs, who are the Negritos of the peninsula of Malacca, say bat-eao for 'water'; the Motu of New Guinea say medu, 'rain,' batu-gu, 'shower'; the Aneityumese in-cau-pda,* 'rain'; New Britain says bata, 'to rain,' ta-va, 'sea'; and the Maori say awa, 'water.' As a coincidence, it is remarkable that the old high German word awa (*cf.* the Ger. wasser, Eng. water) means

* Cau is the Fijian tau, 'to fall as rain,' and -pda is the same as the New Britain word bata, 'rain'; au in Samoan is 'a current.'

'water,' and bedu is quoted as an old Phrygio-Macedonian word meaning 'water.'

Some observers have remarked that our blacks soon master the dialects spoken by other tribes, and have ascribed this to a natural readiness in learning languages. But the present inquiry shows that there is another cause for this. A man or woman of the Sydney tribe, which said ba-du for 'water,' would easily recognize ba-na in an adjacent tribe as the same word, the termination only being different, just as it is not hard for an Englishman to remember that the German wasser is water, and that brennen means burn. So also, a Kimilaroi black, who says mu-ga, would soon know the Wiraduri mu-pai; and elsewhere mata, 'one,' is not much different from meta and matata for 'one,' or even from the Tasmanian mara.

Results.—*Ba*, *ma*, *mo*, *am*, *ap* are forms of an original root meaning 'water,' 'that which is liquid and flows'; derived forms are *mi*, *me*, *wa*: from *ba* comes the Sydney word *ba-du*, 'water'; the *du* here is a suffix in Dravidian also, and exists in the New Guinea word *ba-tu*, elsewhere *ba-ta*; the Samang Negritos say *bat-eao*; the old language of Java has *banu*, 'water,' where the *n* has the liquid sound of *gn*, and takes the place of *d* in the suffix *du*. From all this it is clear that our Australian *badu* is of good and ancient lineage.

(*b*). In the Maitland district a 'blind' man is called boko; in Polynesia poko is 'blind,' or, more fully, mata-poko, mata-po, 'eyes-blind.' As there can be no suspicion of borrowing here, how is so striking a resemblance to be accounted for? Do you say that it is a mere coincidence? Well, let us examine the matter. In the Kamilaroi region mu-ga is 'blind'; in the Mudgee district mu-pai is 'dumb'; in Santo (New Hebrides) mog-moga is 'deaf'; in Erromanga, another island of that group, bu-sa is 'dumb'; in Fiji bo-bo is 'blind'; in Duke of York Island, ba-ba is 'deaf'; in Sanskrit, mu-ka is 'dumb'; in Greek, mu-dos, mu-tis is 'dumb,' Lat. mut-us. In Keltic, bann is 'to bind, tie,' balbh is 'dumb,' and bodhar is 'deaf.' Now, there can be little doubt that in all these words the root is the same (mu, mo; ba, bo, bu; po), and yet these words extend over a very wide area indeed, from Tahiti right across through India to Greece, Italy, and even to John o' Groat's. The meanings are 'blind,' 'deaf,' 'dumb,' and yet the root is the same. The general root-meaning which suits them all is 'to close,' 'to bind'; this meaning shows itself in the Greek verb mu-ō (from which mudos comes) —'to close the eyes or mouth,' and in the Sanskrit mu, 'to bind'; similarly the Hebrew (a) illäm, 'dumb,' comes from the verb âlām, 'to bind,' 'to be silent'; in the Gospels, the blind man's eyes were 'opened,' and Zacharias, who had been for a time dumb, had 'his mouth opened and his tongue loosed.' The root of our Australian words boko, muga, is therefore the same as the Sanskrit mu, 'to bind.' From the same source come the Samoan pu-puni, 'to shut,' po, 'night'; the Aneityumese at-apn-es (apn = pan), 'to shut,' nā-poi, 'dark clouds,' the New Britain bog, 'clouded,' and the Tukiok bog, 'to cover up'; (*cf.* the Sanskrit bhuka, 'darkness'). In Aneityum, a-pat is 'dark,' 'deaf,' and po-p is 'dumb.' In Malay, puk-kah (*cf.* mu-ga) is 'deaf,' and bu-ta is 'blind'; ba-bat (*cf.* ba-ba, bo-bo) is to 'bind'; Fiji has bu-ki-a, 'to tie,' 'to fasten'; New Zealand has pu-pu, 'to tie in bundles,' pu, 'a tribe,' 'bunch,' 'bundle.' It is even possible that our English words, bind, bunch, bundle, come, through the Anglo-Saxon, from this same root, ba, bu, mu.

I suppose that these examples will suffice to prove that the similarity between the Australian boko and the Polynesian poko is not a mere coincidence. Where have we room now for the theory that the natives of the South Sea Islands are of Malay origin? I might, with equal justice, say that they came from the Hunter River district in Australia, if I were to look only at the words boko and poko!

Results.—The ideas 'blind,' 'deaf,' 'dumb,' may be reduced to the simple idea 'bound'—the eyes, ears, mouth or tongue 'closed, bound, tied.' This idea is, in the Aryan languages, expressed mostly by *mu*, but, in our Eastern languages, by *ba*, *bo*; *mu*, *mo*, *pu*, *po*; all these root-forms are identical, and are the basis of cognate words spreading from the region of '*ultima Thule*' across the world to Tahiti. Can this be the result of accident, or of the spontaneous creation of language in several different centres? Is it not rather proof of a common origin? Even in the development of the root, there is a singular correspondence; for the Sanskrit adds -ka, and so do the Malay, the Kamilaroi, the Santoan, and the Polynesian; others use *t* instead of *k*.

7. *Miscellaneous words.*

(*a.*) There are just two or three other words which I would glance at very rapidly. The Malay kutu means 'louse'; in all Polynesia also that word means 'louse'; therefore, as some persons say, the South Sea islanders must be Malay-Polynesians. But I find that in Aneityum also, a Papuan region, in-ket is 'louse,' and in South Australia kŭta. To complete the analogy, these persons should now say that the Papuans of the New Hebrides and the blacks of South Australia are Malay. This looks like a *reductio ad absurdum.*

(*b*). The word kutu reminds me that there are some unsavoury words, which are a strong proof of identity of origin among races; for if these words have not come from one common source, it is scarcely possible to imagine how they are so much alike. For instance, gū-nung here means *stercus hominis aut bestiae;* in Sanskrit the root-verb is gu. In Samoan, gū-nung is (k)i-no, the same word. Among our Port Stephens blacks, the worst of the evil spirits is called gūnung dhakia = '*stercus edens.*' In Hebrew, a variant for the name Beelzebub is Beelzebūl, which means *dominus stercoris.* Again, kak is an Aryan root-verb; in New Guinea it becomes tage (*t* for *k*, as is common); in New Britain, tak; in Samoa, ta'e; in Aneityum, no-hok and na-heh. The Sanskrit bhaga, which I need not translate, is in Fiji maga; and pi, mi, as I have already shown, is as old as the Assyrians.

(*c*). The Tasmanian word for 'sun' is 'pugganubrana or pukkanebrena or pallanubrana or panubrana,' according to Milligan's list. Of these the first is clearly the original form, for the last is merely a contraction of it, and the third substitutes *l* for *g*. The last syllable -na is formative, and is exceedingly common in Tasmanian words; it is, I may observe in passing, exactly the same syllable which is used as a common suffix to form nouns in New Guinea and in the New Britain group, and in a slightly different way also in Aneityum. The remainder of the Tasmanian word is pugga and nubra. Now, nubra or nubré in Tasmanian is 'the eye,' but the vocabularies of that language do not enlighten me as to the meaning of pugga. I would write it bŭg-a, and connect it with the New Britain word bŭg (pronounced bŭng) which means 'day'; thus bŭganubra would mean 'the eye of day,' that is, 'the sun'; and that is exactly the meaning of mata-ari, the Malay word for the 'sun.' Bug is allied to the Dravidian pag-al, 'day.' Bŭg I take from the Sk. bha, 'to shine'; with this compare the derivation of the English word 'day.'

(*d*). In the Kamilaroi dialect (N.S.W.), kagul means 'bad,' 'no good'; the -gul here, as elsewhere, is formative, and ka is the root. Now kâ is a Sk. prefix meaning 'bad'; in Fiji it is ca, and in the New Hebrides sa; in New Britain it is a-ka-ina.

(*e*). The last Australian word which I quote is chínna. This word brings up memories of a blackfellow who often came to my house, and whom we knew as King Bonny—so named, perhaps, because he was so ugly. And yet he was the best specimen I have ever seen of the Negro-Australian, for he had all the typical features of the Negro, although under Australian skies. I have often regretted that I did not get his photograph carefully taken, as a good example of one of the types of Australian blacks. But regrets are unavailing ; he is gone, like most of the blackfellows who used to visit me. Bonny was also the one man who was the most angrily-disposed among all my sable friends. The others were calm and amiable ; several, chiefly the women, were talkative; and some of the men, especially Henry William and King Cocky, were amusing. Henry William was proud to show us how he could use a knife and fork, like a white man, and write his name on a slate. On one occasion, Cocky had been making his rounds in town on a Saturday, and some lady friend of his had given him an old dishevelled bonnet and a faded silk gown of a chequered pattern. Cocky was not enough of a philosopher to be superior to some of the weaknesses of humanity ; he liked to busk himself in gay attire. So, knowing that Christians put on their best apparel on Sunday and go to church, Cocky dressed himself in his new garments next morning, and, shortly after the bells had ceased ringing, he walked gravely into St. Mary's, passed up the aisle and took a seat in front of the choir, which, fortunately, was located behind the people. There he sat during the whole service, behaving like a gentleman! Bonny used to come in at my gate, sit down on a stool near the back door, and make himself quite at home. One day, after sitting there for a while he opened a bundle he had with him, took out a razor and a broken piece of mirror, and began to shave off the grey hairs, which were pretty thick on his cheeks and chin. I suppose he had at some time seen his betters do that. I do not know if he had some ceremonial visit to make that afternoon, and so wished to look clean and spruce ; there was certainly a camp of gins not far off, but I cannot suppose that he wished to pay court to any of them ; he was too old for that. But I am drifting from my subject and must return to it. Bonny usually called in to see me about breakfast time, or towards twelve or one o'clock. He would sit down in his usual place, and, if my servants did not attend to him soon, he would knock loudly with his stick on the stone flagging and call for Massa. When I appeared, his demand was always chínna, chínna. I took this to be a corruption of our word *dinner*, and used to say to him, "Oh, yes ! you'll have dinner very soon ; just wait a little." But chínna may be a native word for 'food'; I cannot find it anywhere on Australia, but it may be the Motu word kani, 'food,' from the root ka, for ta, 'to eat.' It resembles the Dravidian word tín, 'to eat'; for 'eat' and 'food' are cognate ideas, as is shown by the Latin esca, 'food,' and edere or esse, 'to eat.' The ch in chínna is only the palatal sound of the cerebral or the dental *t* of tin. The Dravidian word tin is connected with the root ta, Sk. ad, 'to eat,' -âda, 'eating;' Lat. edo, Eng. eat. It would be very odd, if it should prove true that my black friend, when he said chín-na, was using the very same root-word we use when we say 'eating.' In one island of the New Hebrides this verb 'to eat' becomes jena, in another, ca-ig, in others, ka-ni; in fact, the same word is found in various forms in all the islands both of Melanesia and Polynesia. Can this be the result of accident or of borrowing?

Summary of Results.—I have not touched the Australian pronouns; that is a large subject, and requires separate treatment. But I have shown that the Australian numerals, and, incidentally, one of the postpositions, are connected with root-words, which must be as old as the origin of language; for such ideas as 'before,' 'begin,' 'first,' 'another,' 'follow,' 'change,' 'many,' seem to be essential to the existence of any language. I think I may safely say the same thing about the root-words for 'water' and 'dumb,' &c. It thus appears, from the present investigation, that our Australians have a common heritage, along with the rest of the world, in these root-words; for if these blacks are a separate creation and so have no kindred elsewhere, or were never in contact with the other races of mankind, I cannot conceive how they have come to possess primitive words so like those in use over a very wide area of the globe. I therefore argue that they are an integral portion of the human race. If so, what is their origin? On this point too, our investigations in language may have thrown some light.

8. *Conclusion.*

And now that I have said all that I can venture to say without trying your patience too much, I think I can hear some utilitarian voice asking, 'What's the use of all this talk about words; what profit does it bring?' Well, I acknowledge that the money value of it is small; but still it may be of some interest to us, Australians, to know where our natives came from, and even a very little assistance towards the attaining of that knowledge may have a value, although not in gold. I have therefore endeavoured to show that, so far as some words in their language can be cited in proof, our indigenes are connected with the blacks of the New Hebrides and the New Britain groups of islands, and ultimately with the black races of Southern India. This present argument is founded entirely on considerations drawn from language. But some of you may remember that, nearly ten years ago, in Volume XVI. of your Journal, I advanced arguments drawn from what I call religious beliefs and customs, to prove that on that view, apart from any other, our indigènes are related to the black races of Africa as well as of India. I pointed to the Dravidians of the Dekkan as the connecting link. I was not aware at that time that M. de Quatrefages of Paris, the well-known authority on ethnology, had just the year before given a very decided opinion to the same effect. Of course, the theory that the Dravidians and the blacks of Australia and Melanesia are intimately related was not new; for, even twenty years before that, Bishop Caldwell had drawn attention to the similarity in structure between the Australian pronouns and those of what he calls the Scythian group, which includes the Dravidian. But I held then, and still hold, the belief that our black race came originally from Babylonian lands in two streams, at different times, and passed through India, resting there for a time before it reached Australia. Of these two streams, the first, I imagine, was of tolerably pure Hamite blood; the next much mixed. I can give reasons for holding this opinion; perhaps I may some day ask you to listen to them.

ON THE 74oz. COMPRESSED-AIR FLYING-MACHINE.

By Lawrence Hargrave.

[With Four Diagrams.]

[*Read before the Royal Society, N.S.W., December 3, 1890.*]

A larger compressed-air flying-machine than that described on June 4 last, has made two flights that are worth recording here. They are numbered, in the writer's memoranda, Trials 5 and 6 of No. 5 Tin cylinder vibrating engine. No. 4 Tin engine with a receiver capacity equal to that of No. 5, was fitted with the expansion gear that was exhibited in this room, but its irregular working and intermittent action on the piston soon showed it to be unsuitable for such small models. A new Richard's Indicator revealed the fact that the air pipe and ports were too small.

Another form of reducing valve was tried and from the chronograms taken it was inferred that the cylinder pressure was uniform for a number of strokes. The chronographic apparatus was remodelled and Diagram 4 shows its simplicity and handiness. Three simultaneous records are made; the time in seconds, the double vibrations of the engine, and the receiver pressure. The first two are automatic, the last depends on the quickness of the eye and hand. It has since been made to record antomatically the receiver pressure and the reduced pressure.

A comparison of the pressure gauges with the Marine Board standard, necessitated a correction to the pressures on Plate 2, Vol. XXIV. of this Society's Proceedings, they should be—

Test pressure ... 347 ℔s. per square inch.
Working pressure 207 ℔s. ,,

This will considerably modify the theoretical amount of work supposed to have been done in the experiment described. Instead of 2500 ft. ℔s. it should be 3000, an error in computation having also been discovered. Practically, an equal volume of air is now forced to develope 450 ft. ℔s. in 25 seconds; this is actual weight-lifting.

An enlargement of about 6 cubic inches capacity was made in the air pipe of No. 4 Tin engine, this was surrounded by a jacket. A piece of cotton wool soaked in methylated spirits was placed in the jacket and lighted shortly before turning on the air. No appreciable difference in the number of double vibrations or their rapidity was produced thereby.

Two other forms of flapping engines and another rotary one were designed, but they are vastly inferior to Diagram 2, which was then made. The valve gear is now forward of the cylinder, but its exposed position has not led to its damage in any of the six trials, and it is very accessible for adjustment. The steel wing levers are soldered to tin sleeves which form the sockets for the wing arms. The wings are exactly the sâme area and length as those of the 40·5 oz. machine, but they are made of oak with five ash cross bars instead of four.

The reducing valve, Diagram 3, is a modification of a dead weight one shown to the writer by Mr. Cruikshank, and the plotting of the mean of four chronograms shows its action to be reliable, although in Trials 5 and 6 it was necessarily screwed up so tight that its action must have been very slight. There is a counter attached to the side of the receiver, it consists of a 60 tooth clock wheel with two ratchets, one of which is pulled up and down by a string fastened to the wing arm. The interest felt in the flight of the machines has always prevented any attempt being made to count the flaps. The indicator diagrams are rectangular so the pipes and ports are now the right size.

The sides of the body plane slope upwards 18°, and the paper area is slightly less per pound weight than the 40·5 oz. machine has. The large area might be considered a defect, but when we consider that it consists only of a few sticks and tissue paper, and that the atmosphere is not by any means crowded with flying-machines, the objection ceases to have much weight.

On Diagram 3, the apparent trajectories of trials 5 and 6 are shown. The machine in trial 5 turned up and almost stopped, but resumed its course when the preponderance of the forward part brought it horizontal again. A lump of lead was put on the end of the breaking stick for Trial 6. This shifted the centre of gravity one inch further forward and produced the undulatory flight that is shown in the drawing. Each observation adds fresh weight to the assumption that the true position of the centre of gravity for a continuous rectangular surface is situated between ·25 and ·2 of the length from the forward end.

After trial 6, the machine was attached to the chronograph to see what the receiver pressure was at the 38th double vibration, the number registered by the counter; but after making three or four flaps at the rate of about 200 per minute, all the paper was dashed out of the wings, and the port link lugs were dragged out of the cylinder cover. But again knowledge is gained from failure; we learn that the chronographic test of the wing speed of the stationary machine is no guide to the speed of the flying-machine, as the rapidly flapping wing creates a vacuum behind it of sufficiently low pressure to allow the return stroke of the wing to pass so quickly through it that the shock of the wing against the air at the other side of the vacuum is strong enough to destroy the paper. The efficiency of the wings during the free flight is not impaired by this cause as every stroke is taken in new and solid air: and the wing speed is obviously not in excess of 120 per minute.

Mr. J. A. Pollock has again ascertained for the writer the theoretical work done by the engine, and he finds 2,720 foot-pounds were used in reducing the pressure from 150 to 70 pounds per square inch with 38 double vibrations. This is terribly wasteful of power when we compare it with the india-rubber driven machines.

The two observations with the compressed-air machines confirm the two cross-bow model experiments recorded on page 73 of the Royal Society's Proceedings 1889, which are added to the table for comparison. The cross bow takes 7½ lbs. to bend it 12 inches. It appears that the same power propels different weights the same distance provided the area per pound weight is the same.

COMPARISON OF FLYING MACHINES.

Observations made with.	Total area, square inches.	Square inches area per pound weight.	Weight, pounds.	Power used, foot-pounds.	Distance flown, feet.
24 Band A.	1236	841	1·47	164	120
„ B.	1381	1132	1·22	197	170
„ C.	1177	997	1·18	246	201
48 Band F.	1606	873	1·84	371	189
48 Band G.	1551	843	1·84	341	171
24 Band H.	1986	1555	1·28	193	192
24 Band J.	1974	1542	1·28	208	203
24 Band K.	1974	1542	1·28	218	209
48 Band L.	2130	1019	2·09	·470	270
48 Band—Screw	2090	1045	2·00	196	120
40·5 oz.—Compressed Air	2344	925	2·53	3000	368
74 oz.—Compressed Air	4266	922	4·63	2720	343
Cross bow model F.	216	1384	·156	7·5	18
Cross bow model C.	756	1862	·406	7·5	20

The air pump shown to the left in the photograph exhibited is new ; it has a cylinder 2 inches in diameter and 8 inches stroke. With this one the receivers can be pressed to 150 ℔s. per square inch with one hand ; with both hands a receiver can be charged to 250 ℔s. per square inch. The bottom of the cylinder gets uncomfortably hot, so that the tin thing you see on the top of the pump was made to convey some of the heat away to the water in it. It will be advantageous to turn the pump the other way up so that it can stand altogether in a vessel of water, the handle will then have to be bent instead of straight.

THE COAL MEASURES OF NEW SOUTH WALES AND THEIR ASSOCIATED ERUPTIVE ROCKS.

By T. W. EDGEWORTH DAVID, B.A., F.G.S.

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INTRODUCTION.

THE Coal-measures of New South Wales may be ranged provisionally into three groups, and if the lignites and brown coals of Tertiary age are also to be included in the term Coal-measures, a fourth group must be added. These four groups are as follows, the oldest and lowest being placed first :—

Group I.—*Rhacopteris and Lepidodendron Series.* Age Palæozoic, Carboniferous. Contains a few thin unworkable coal seams. Thickness over 10,000 feet.

Group II.—*Glossopteris Series.* Age Palæozoic, Permo-Carboniferous. All the productive coal seams at present being worked in New South Wales belong to this group, which contains in the aggregate a thickness of about 150 feet of workable coal, in those localities where each division of this series are fully developed. Thickness about 11,000 feet.

Group III.—*Thinnfeldia and Tæniopteris Series.* Age Mesozoic, Triassic (?). In the Clarence District contains some seams of coal, which are likely to be workable. Thickness about 2,500 feet.

Group IV.—*Brown Coals or Lignites.* Age Tertiary, Eocene to Pliocene. Greatest thickness of a single seam of brown coal in New South Wales about thirty feet. Greatest thickness of strata proved up to the present about 100 feet.

Detailed description of various Groups.

Group I.

(A) SEDIMENTARY.

The sedimentary rocks of this group have been studied by the Rev. W. B. Clarke, F.R.S., Mr. C. S. Wilkinson, F.G.S., Mr. J. Mackenzie, F.G.S., Mr. Odenheimer, Mr. Surveyor Herborn, Mr. R. Etheridge junr., Mr. S. H. Cox, F.G.S., and many others. They have been examined most in detail in the Stroud District, where Mr. J. Mackenzie, on behalf of the Australian Agricultural Company, cut trenches across the upturned edges of these strata, which proved them to have a thickness here of at least 10,000 feet. The upper half of this thickness appears to be in that locality, partly of freshwater and partly of volcanic origin, and is characterised by an extraordinary predominance of *Rhacopteris*, to the entire exclusion, as far as my observations extend, of *Lepidodrendon*. The lower half contains *Lepidodrendon* associated with *Rhacopteris*, and interstratified with them, there is at least one bed containing marine Carboniferous fossils.

Mr. Mackenzie in his sections published in "Mines and Mineral Statistics of New South Wales," and in "Mineral Products etc. of New South Wales," shows that on a horizon about 2,000 feet below the topmost of these Rhacopteris beds there are the following coal seams and strata, the upper being placed first:—

Ft.	In.	
2	3	Inferior coal and indurated clay.
2	0	Chert shale and conglomerate.
5	0	Coal, inferior.

Beds of limestone from a few feet up to eight feet thick are associated with the Lepidodrendron beds, and just above the limestone is a remarkably persistent bed of magnetic ironstone from one foot up to eight feet thick, which is interbedded with these Carboniferous strata. The bed of magnetic ironstone has evidently been formed by the mechanical concentration, through the action of the waves on a sea beach, of crystals and grains of magnetic and titaniferous iron out of the volcanic tuffs and massive eruptive rocks, which are so plentifully interspersed through this group. The bed was therefore formed in Carboniferous times in a manner analogous to that in which the iron-sands of Taranaki, New Zealand are now accumulating.

No exact upward limit can at present be assigned to this group but it is probable that there is somewhat of an unconformity between it and the rocks of the succeeding group. The junction line however is rendered somewhat complex and obscure by the great development of volcanic rocks, which are observable almost everywhere in the type district of Maitland along the line of junction, and which were contemporaneous either with the uppermost strata of the Rhacopteris group, or with the lowest strata of the succeeding Glossopteris group.

(B.) Associated Eruptive Rocks.

These are partly contemporaneous and partly subsequent.

(i.) *Contemporaneous.* The contemporaneous eruptives are chiefly diabasic basalt lavas and tuffs, and felsite lavas and felsite tuffs. Some of the tuffs are very coarse containing blocks up to three feet in diameter. They are nearly all partly of sedimentary origin, as the component particles are mostly rounded, and graduate into arkose sandstones. But for the occasional presence of pebbles and the intercalated beds of carbonaceous clay shale, these arkose rocks might easily be mistaken for granites. It is, as yet, a little doubtful, as Mr. C. S. Wilkinson has pointed out, how far these rocks owe their origin to the detritus from massive eruptives, and how far they are formed of true tuffaceous material. The remarkable freshness however and freedom from decomposition of the fragments of felspar inclines me to the belief that their origin was chiefly tuffaceous. If this latter surmise be correct the immense development of tuffs in this formation may greatly account for the rather sudden disappearance of *Lepidodendron* in the upper strata of this group.

(ii.) *Subsequent.* The eruptive rocks which have intruded into these strata subsequent to the time of their deposition are chiefly granitic quartz and felspar porphyrites, and dolerites, principally the former, which are of earlier origin than the dolerites.

Group II.

(A.) Sedimentary.

The formations belonging to this group, geologically considered, form in New South Wales a single main coal-field, with a few less important outlying coal-fields. The main coal-field commences near Ulladulla on the coast, and extends northerly to Port Stephens, then bends inland and tends viâ Maitland, Singleton, Rix's Creek and Ravensworth to Murrurundi, thence to Gunnedah, thence near Inverell and viâ Warialda to Yetman on the Queensland border. Its further northerly extension is masked by a covering of such newer formations as the Rolling Downs Series, and the strata belonging to this basin do not reappear at the surface until the head of the Dawson River is reached. From here they extend to a short distance beyond Fort Cooper, to the north of which they have been isolated by denudation from the outlying coal-field of the Bowen River. Still further north beyond the Bowen River Coal-field Mr. R. L. Jack, F.G.S., the Government Geologist of Queensland, has discovered a small outlying field near Townsville, the strata of which contain *Glossopteris*, so that it may be co-related with some of the formations in this group. The Little River Coal-field between Cooktown and the Palmer Goldfield is the northermost coal-field, so far as at present known, belonging to this group, and may perhaps at one time have formed part of the main basin. It owes its preservation, as Mr. Jack has shown, to the existence of some very heavy trough faults, which have dropped the whole basin deep down into the surrounding Devonian rocks.

The main basin extends westwards in New South Wales from the coast at Ulladulla towards the head of the Clyde River thence in a north-westerly direction to Bundanoon, thence by way of the Burragorang Valley to Hartley, thence viâ Wallerawang to near Mudgee, and is perhaps united by way of the head of Cooyal Creek, and of the sources of the Talbragar River to the Spicer's

Creek Coal-measures, which form part of the Talbragar Coal-field. The latter, however, may be an outlier. From the head of the Talbragar northwards the coal-basin becomes somewhat contracted in width from east to west, as towards the west it becomes rapidly overlapped by the red soil formation of the Western Plains, which latter is probably of late Tertiary age. From here it extends in a comparatively narrow strip, as already explained by way of Gunnedah and Warialda to the Queensland border.

Of the small outlying coal-fields perhaps that of the Ward's River, near Stroud, is the most important, and therefore deserves special mention.

Although geologically united the main basin is divided geographically into several distinct coal-fields, owing to the measures being capped in places by new formations of sedimentary, or volcanic origin. The main basin may therefore be conveniently divided into the following fields:—

Main Basin:
- (1) The Hunter River Coal-field.
- (2) The Sydney Coal-field.
- (3) The Illawarra Coal-field.
- (4) The Mittagong Coal-field.
- (5) The Blue Mountain Coal-field.
- (6) The Talbragar Coal-field.
- (7) The Namoi (Gunnedah) Coal-field.
- (8) The Gwydir Coal-field.

Outlier (9) The Ward's River Coal-field, near Stroud.

Coal-fields (1), (2), (3), (4) *and* (5).

The first five coal-fields are so intimately related to one another that it will be more convenient to consider them together than separately. In the Hunter River Coal-field, where the formations belonging to this group are most typically and extensively developed, the following classification of the formations is proposed based on the observations of the Rev. W, B. Clarke, Mr. C. S. Wilkinson, F.G.S., Mr. Wm. Keene, F.G.S., Mr. J. Mackenzie, F.G.S., Mr. R. Etheridge junr., and many others; the formations being ranged in descending order:—

Feet.	Inches	—Thickness.
1,150	0	(about)—Newcastle Series, productive coal-measures containing an aggregate of over 100 feet of coal, without considering seams less than three feet thick. Characteristic fossils *Glossopteris*, *Vertebraria*, *Noëggerathia*, *Gangamopteris*, etc. A fossil forest of coniferous trees occurs in the upper part of these measures, the woody material having been converted into wood-opal, and dark chalcedony.
2,000	0	(about)—Dempsey Series, freshwater beds containing a flora similar to the preceding, but not productive coal.

Feet.	Inches—Thickness.	
570	0	Tomago (East Maitland) Coal-measures. Freshwater beds containing an aggregate thickness of about 45 feet of coal, and a similar flora to the preceding.
5,000	0	(about)—Upper Marine Series, containing a marine fauna of Permo-Carboniferous affinities, and a few corals, principally *Stenopora*. Specially characterised by the predominance of *Productus brachythærus*. Large erratics of granite, slate, and quartzite occur near the lower half of this division.
300	0	Greta Series, freshwater productive coal-measures containing a similar flora to the Tomago and Newcastle Coal-measures, and an average aggregate thickness of abont 20 feet of coal.
2,000	0	(about)—Lower Marine Series, containing a marine fauna somewhat similar to that of the Upper Marine, but comprising exceedingly few corals. Specially characterised by the predominance of *Eurydesma cordata*.

In the Illawarra District it is probable that both the Newcastle and Tomago Coal-measures are developed, and that the Dempsey Series have almost entirely thinned out. It is also possible that the uppermost coal measures there developed may represent the upper portion of the Newcastle Series, and that the Tomago measures may have thinned out before reaching the Illawarra District, owing to a slight unconformity between the top of the Upper Marine Series and the base of the Tomago Series. The following is a descending section of the Glossopteris group, as developed in the Illawarra District in the neighbourhood of Nowra:

Feet.	Inches—Thickness.	
200	0	(about)—Bulli Coal-measures, containing an aggregate of about 45 feet of coal where more fully developed, near Bulli.
700	0	(about)—Dolerite andesites and basalts, with laumonite and often zeolites.
150	0	Red tuffs.
100	0	Doleritic andesite with *metallic copper* in minute quantities, occurring interstitially in joints.
2,500	0	Upper Marine Series containing a Permo-Carboniferous marine fauna, *Productus brachythærus* and *Stenopora* being specially characteristic.
150	0	(about)—Clyde (Greta) Coal-measures. Total coal about nine feet thick.
50	0	(about)—Sandstones and quartz-breccias without fossils, perhaps the equivalents of the Lower Marine Series. These rest unconformably on vertical Silurian slates.

In the Mittagong and Blue Mountain Coal-fields the coal seams at present being worked are the equivalents of the Bulli Coal-measures. The marine beds which there underlie the productive coal-measures are probably the equivalents of the Upper Marine Series, the Greta measures, and Lower Marine Series having thinned out under the overlapping beds of the Upper Marine Series, against an unconformable surface of Silurian and Devonian rock. It may be of interest to give here for the sake of comparison, a section of the Bowen River Coal-field, which I have compiled from the able and elaborate Report on that field by Mr. R. L. Jack, and side by side I have ventured to place the probable equivalents in New South Wales of the different divisions of this typical Queensland Coal-field. The following is the approximate section, the strata being given in descending order :—

HUNTER RIVER COAL-FIELD.	Thickness. Feet	In.	BOWEN RIVER COAL-FIELD.
Newcastle and Tomago Series.	—	—	Beds containing silicified wood.
	—	—	*Marine* grey and ferruginous sandstones of Rosella Creek, containing :—*Streptorhyncus crenistria, Productus cora, Productus scabriculus, Spirifer* sp., *Goniatites Woodsii.*
	400	0	(about) Grey sandstones with silicified trees.
	10	6	*Havilah Coal Seam,* burnt by white trap.
	30	0	Dark grey shales and sandstone with trees showing thirty annual rings of growth, bluish grey shales with plants, lenticular coal and ironstone nodules.
	—	—	Gap.
	150	0	(about) Bluish cross-bedded sandstone weathering spheroidally, full of carbonised and silicified plants, including coniferous trees. Large unrounded boulders of metamorphic rock occur sporadically throughout these strata.
	10	0	*Dolerite sheet.*
	60	0	Grey shales and finely laminated sandstone.
	—	—	Gap.
	20	0	*McArthur Coal Seam and Dolerite.*
			3 6 *Coal,* burnt.
			2 1 Blue shale.
			0 3 (?) *Coal,* burnt.
			0 3 Black clay.
			3 0 *Coal,* burnt.
			Ferruginous shale crowded with *Glossopteris.*
	—	—	Gap, sheets of *Dolerite.*
	200	0	(about) *Dolerite.*
	23	8+	Blue shales with thin coals and ironstones.
	100	0	(about) Gap. Brown sandstone. Dolerite. Brown sandstone. Dolerite. Thin coal and bituminous shale.
	4	0	*Dolerite.*
	3	0	*Coal* burnt.
	—	—	Gap.
	25	0	*Dolerite.*
	10	0	Gap.
	14	11	*Daintree Coal Seam.*

Hunter River Coal-field.	Thickness. Feet	Ins.	Bowen River Coal-field.
			Details of Daintree Coal Seam.
	3	7	Burnt *coal*, partly columnar; somewhat coked in part; veins and pockets of "white trap" in upper part; concretions of ironstone in vertical and horizontal joints; nodules of decomposed pyrites; *Glossopteris* recognizable in parts.
	0	1	Black shale.
	0	3	Burnt *coal*.
	0	1	Black shale.
	0	6	Burnt *coal*.
	0	1	Black shale.
	0	10	Burnt *coal*.
	1	2	Bluish grey shales.
	0	6	Stony burnt coal with silky plant débris.
	0	8	Light porous crumbling *coal* with concretionary nodules of better *coal*.
	0	2	Coaly shale.
	7	0	Light brownish black laminated *coal* (some of the laminæ rather *oil shale* than coal) fair quality.
Upper Marine Series.	1848	0	Middle Marine Series with Permo-Carboniferous fauna. Details.—Black shales impregnated with alum. Sandstone 100 feet thick packed full of *Productus Clarkei (P. brachythœrus* (?)). Grey and yellow sandstones, blue and grey shales with here and there bands of reddish ferruginous, probably once calcareous sandstones, sometimes varying to sandy impure ironstones very full of fossils as casts: while in the grey sandstone the substance of the shell is preserved. Upright rootlets occur in the sandstones and shales, and coniferous trunks in the sandstones. Conglomerate bands, the fragments composed of granite, schist, slate, quartzite and porphyrite, some of the granite blocks measuring four cubic feet. These erratics occur in groups. Corals.
	51	0	Whitish flaggy sandstone with a little dark blue shale.
Greta Series	1	10	*Kennedy Seam* .. ... { *Coal* ... Ft. 0 Ins. 3; Dark blue clay shale 0 ft. 1 in.; *Coal* ... 1 ft. 6 ins.; total 1 ft. 10 ins. }
	70	0 (?)	Sandy shale and white and yellow sandstone with sandy ironstone.
	4	7	*Garrick Seam, Coal* four feet seven inches.
	10	0+	Gap.
	—	—	*Coal Seam.*
Lower Marine Series. ?	100 – 200	0 (?)	Grey shales and sandstones which (*fide* Daintree) contain *Glossopteris*. Mr. Jack however could not find any. These strata, said to contain *Glossopteris*, are apparently overlaid by beds containing *Streptorhyncus crenistria*.

Hunter River Coal-field.	Thickness. Feet.	Ins.	Bowen River Coal-field.
Lower Marine Series. ?	90	0 (?)	Chiefly dark shales, coaly in places, with bands of sandstone.
	100	0 (?)	Sandstone flags and conglomerates.
	30	0 (?)	White gritty sandstone resting on felspathic sandstone.
Rhacopteris Beds. (?)	1000	0 (?)	Amygdaloidal porphyrites with prehnite, laumonite, and *carbonate* of *copper;* and basalts and melaphyres.
	880	0	Yellow and white siliceous sandstone and conglomerates composed of pebbles of quartzite and yellow porphyry. [No fossils mentioned, but Mr. Jack considers these may be the equivalents of some portions of the *Lepidodendron Series.*]

From this section it is apparent that in the Bowen River Coal-field, Permo-Carboniferous Marine strata are developed on three distinct horizons, the uppermost occurring in strata, which should probably be correlated with the Newcastle or Tomago Coal-measures of New South Wales. *Glossopteris* according to Daintree has been found here as low down as the basement beds of the Lower Marine Series.

(B.) Associated Eruptive Rocks.

(i.) *Contemporaneous.* In the Illawarra Coal-field, as shown in the section quoted, there is evidence of contemporaneous volcanic activity on a grand scale, towards the close of the Upper Marine Series, previous to the deposition of the Bulli Coal-measures. These contemporaneous volcanic rocks consist of doleritic andesites in two sheets, separated from one another by a thick and very persistent bed of red tuff. The upper sheet, which is quarried on a large scale at Bombah, near Kiama for road metal, is capped by sheets of basalt, and these in turn are surmounted by basic volcanic agglomerates, as seen at Bong Bong Mountain, near Kiama, which has evidently formed one of the points of eruption. The aggregate thickness of this volcanic series at Kiama, where it appears to attain its maximum development, is about 1600 feet. The andesitic lavas, as shown by Mr. C. S. Wilkinson and Professor Liversidge F.R.S., contain laumonite in their joints, and lately Mr. Cameron has presented specimens of this lava to the Department of Mines, containing thin films of metallic copper in joints.

In the Newcastle District doleritic andesites of a diabasic character are also extensively developed, having a maximum thickness of about 1600 feet, and occurring in two sheets separated from one another by a bed of volcanic breccia. The exact horizon of this series has not yet been determined with precision. It is certain however that it overlies a coal seam which contains *Glossopteris.* This seam, inclusive of bands, is nine feet thick, rests on volcanic tuff, and is capped first by 300 feet of fine tuff, then by 1000 feet of diabasic andesite. This section is exposed at the Seven Mile, on the Raymond Terrace to Stroud road. Formerly it appeared to me that this seam, as well as the overlying diabasic andesites, belonged to the top of the Rhacopteris beds. Having lately however found undoubted specimens of *Glossopteris*, identified by Mr. R. Etheridge, junr., as such, in the Seven Mile Coal-seam, I think the seam should be referred to some part of the Glossopteris Series, and the overlying volcanic rocks may in that case be correlated with the Kiama Series in the Illawarra Coal-field.

The lavas in the Hunter River Coal-field near Raymond Terrace, like those of Illawarra and of the Bowen River, contain a good deal of red laumonite in their joints. Copper however has not yet been detected in the Raymond Terrace lavas. One point of eruption of the latter lavas is observable in a hill called Paddy's Sugarloaf, thirteen miles from Raymond Terrace towards Stroud. Part of the old crater is there capped by a thin sheet (about eight feet thick) of a beautiful banded rhyolite, which has now been rendered felsitic through devitrification. The exact age of the contemporaneous volcanic series of the Bowen River in Queensland is not known, but apparently it underlies the Lower Marine Series, and may be of Permo-Carboniferous age. Like the Kiama Series it contains copper, in the form of carbonate, as well as laumonite.

(ii.) *Subsequent.* The Hunter River, Sydney, Illawarra, Mittagong, and Blue Mountain Coal-fields have been intruded subsequent to their deposition by a variety of eruptive rocks, chiefly dolerites, which in places, as near Mittagong, pass into syenite. In the Hunter River Coal-field, the Greta, Tomago, and Newcastle measures have been cut by dolerite dykes of a later date than the intrusive red granitic quartz-porphyries of Port Stephens, as at Morna Point. At the latter locality, the quartz-porphyres are seen to be intersected by the dolerites. In the Stockton mine the coal in the Borehole Seam has been much damaged by the dolerite; and the lower Tomago Seams have also suffered considerably from the same cause at Hexham and Ash Islands, being converted into natural coke or being completely cindered in places. In the Illawarra and Mittagong districts large areas of coal have been injected with flat sheets of eruptive rock. These have however not altogether destroyed the coal, but have converted it chiefly into a natural coke, which may yet have an economic value.

Near Bulli, and at Cambewarra near Nowra, are remarkable dykes of what may provisionally be termed gabbro-dolerites. These contain large crystals of hornblende over an inch in diameter, and nests of olivine two to three inches in diameter, enclosed in a basaltic base. Fragments of granites are observable entangled in the mass of one of these dykes at Cambewarra.

Coal-fields (6), (7), *and* (8).

The Talbragar, Namoi, and Gwydir Coal-fields have as yet been very little explored. It is probable that they are the equivalents of the Newcastle or of the Tomago Coal-measures. A short description of portion of the Talbragar Coal-field is given by my colleague Mr. W. Anderson in the "Annual Report of the Department of Mines for 1888," and of portion of the Namoi Coal-field by my colleague Mr. G. A. Stonier, in "Records Geological Survey New South Wales," Vol. II., Part ii.

Coal-field (9).

The Ward's River Coal-field is an outlier from the main field, and is from one to two miles wide, and over twenty miles long occurring in the form of a long narrow trough infolded between the strata of the Rhacopteris beds. It contains several seams of workable coal, one of which lying near the bottom of the basin is as much as thirty feet thick, and below this is another seam, which, inclusive of bands, is thirty-two feet thick. The coal in these seams has been converted into anthracite by the heat and pressure, to which it has been subjected. The strata on either side of this basin dip at an angle of 45° towards the centre of the trough. The flora of this coal-field is remarkable for the predominance of *Gangamopteris* in the lower strata of the field, this plant becoming much scarcer in the upper beds, where its place seems to be taken by *Glossopteris*. It is probable that these coal measures are the equivalents of either the Tomago or of the Newcastle Coal-measures.

Group III.

Thinnfeldia and Tæniopteris Series.

The formations belonging to this group are developed principally near Sydney in the basin of the Hawkesbury River, near Dubbo, and in the Clarence District. In the Sydney and Clarence Districts the group may be divided into the following three formations, the newest being placed first :—

Wianamatta Shales	Upper Clarence Series.
Hawkesbury Sandstone	Middle "
Narrabeen Shales (including cupriferous tuffs and Estheria shales	Lower "

In the Dubbo district, according to the observations of the Rev. J. Milne Curran, F.G.S., the group may also be divided into three series as follows, in descending order :—

Tæniopteris beds. Hawkesbury Sandstone. Ballimore beds.

Macrotæniopteris, *Thinnfeldia*, and *Pecopteris* occur throughout the whole group, while in the Sydney District a species of *Estheria* is very abundant in the lower beds of the Narrabeen Shales. Remains of Labyrinthodonts have been obtained from the horizon of the Wianamatta Shales by Mr. W. B. Dunstan, from a Railway cutting near Bowral, and a large number of fossil fish as well as Labyrinthodonts have been collected by Mr. Charles Cullen, Collector to the Department of Mines, from the top of the Narrabeen Series, from a railway ballast-quarry near Gosford.

In the Sydney and Dubbo Districts this group is not known to contain any payable seams of coal though at South Creek, near St. Mary's, the Rev. W. B. Clarke describes a seam of coal in the Wianamatta Shales, which inclusive of bands, is about four feet wide.

In the Clarence District however there are several seams of coal in this group, one of which at least is likely to prove productive. The relation of these Clarence River Coal-measures to the Mesozoic rocks of Sydney and Dubbo was obscure until Mr. C. S. Wilkinson made the important discovery that the well known Hawkesbury Sandstone of Sydney was developed in the Clarence district. He is of opinion that there are certainly several seams of coal in the Lower Clarence Series, below the Hawkesbury Sandstone, and probably also seams in the Upper Clarence Series. Some of the coal-seams in the Clarence District will probably soon be worked profitably for local purposes, such as for the supply of fuel for the river steamers and for the sugar mills. The coals so far discovered are splinty steam coals, containing a good deal of ash, and poor in volatile hydrocarbons, but rich in fixed carbon, so that they are almost smokeless.

The coal-fields of Ipswich Burrum and Broadsound in Queensland are the equivalents of the Clarence Group, and in Victoria it is perhaps partly represent by the Mesozoic Coal-measures, constituting the Carbonaceous Series of Wannon, Cape Otway, and South Gippsland.

The absence of productive coal-seams from the lower division of this group in the Sydney District, may be partly due to the considerable development of contemporaneous tuffs, which in places contain scales and films of *metallic copper*. The diamond drill bore at Cremorne Point, on Sydney Harbour, now being put down by the Department of Mines under the superintendence of Mr. W. H. J. Slee, F.G.S., has already passed through some of the upper tuff beds in the chocolate shales of the Narrabeen Series. The depth of the bore on November 29th, 1890, was 1230 ft. 3 in. The following is a generalised section :—

To 943 ft. 4 ins.—Grey sandstone and shaly sandstone.
,, 1112 ft. 1 in.—Chocolate Shales.
,, 1230 ft. 3 ins.—Various coloured shales with chocolate shales intermixed and beds of gritty tuff.

It is expected that this bore may strike the productive coal-measures belonging to the *Newcastle* or *Tomago Series* at a depth of approximately 2600 feet. The associated eruptive rocks of this group have not yet been studied with the exception of the cupriferous tuffs. These are evidently related to the copper bearing andesites of Kiama. Possibly the volcanic eruptions, which produced the older Kiama lavas were prolonged into early Mesozoic time, or were renewed then, and produced the cupriferous tuffs; or the copper in the latter, supposing them to be principally of detrital origin, may have been derived secondarily from the Kiama andesites.

Group IV.

Brown Coals.

Brown Coals and Lignites are developed principally in the deep leads of Tertiary age at Gulgong, Home Rule, Tingha, Forest Reefs, Kiandra, etc. The Rev. W. B. Clarke also describes beds of lignite at Chouta Bay, about 42 miles north of Cape Howe, which he thinks may be of Tertiary age. The lignites are in most cases capped by basalt. At Kiandra the lignite beds which there overlie the gold gravel is as much as thirty feet thick, as described by Mr. C. S. Wilkinson. These lignites contain too much water to admit of them being advantageously used as fuel at present.

At the Morwell Mine in Victoria, however, lignite beds are at present being worked for industrial purposes, and have been proved according to the Reports by Mr. R. A. F. Murray, the Government Geologist, and Mr. J. Stirling, F.G.S., to have a thickness of from fifty to over one hundred feet. Possibly the lignites on some of the deep leads of New South Wales may be utilized when wood supplies become scarcer.

The foregoing paper purports to be a rough sketch of the author's present views of the Coal-measures of New South Wales and their eruptive rocks. The whole subject will be treated of at greater length it is hoped in the Memoir on the Coal-fields of New South Wales, which is now being prepared by the Geological Survey. The work of correlating these coal-fields is very far from being completed at present, though year by year our knowledge of them is being constantly increased by fresh observation. It is chiefly to the Rev. W. B. Clarke that the credit belongs of the provisional classification of our coal-fields, and it may truly be said of his work that there has so far been nothing in it which we can alter, and up to the present we have been able to add very little to it.

In compiling the above paper I have also to acknowledge my indebtedness to Messrs. C. S. Wilkinson, R. Etheridge, Junr., J. Mackenzie, W. Keene, Stutchbury, Odenheimer, the Rev. J. Milne Curran, F.G.S., the late Professor W. J. Stephens, F.G.S., and my colleagues Messrs. W. Anderson, and G. A. Stonier.

Discussion.

Mr. Mann—This is one of the most interesting papers I have ever heard, as I know most of the places referred to. There was one name I expected to have heard mentioned amongst the list of those gentlemen who reported, viz., that of Mr. Keene.

Mr. C. Moore—It was mentioned.

Mr. David—As regards Mr. Keene's name, his work is so well known in the department that we would not think of omitting it from any list. I am very much indebted to him for many facts I have given in my paper to night.

The Hon. L. F. De Salis—The lecture is one of the most interesting that could possibly be given to the inhabitants of New South Wales, and especially to this portion of the Colony, which is doubtless going to become a large manufacturing district. A great deal of the information given by Mr. David is absolutely new to me. There are one or two points that perhaps he will explain. Have we kerosene and natural gas in this country, both of which are so prevalent in America? I hope that though his verbal explanation of certain points was perfectly clear to us that he will incorporate it in his paper, for the benefit not only of the members of the Society not present this evening, but of those persons in other parts of the world who are interested in the subject.

Mr. David—As to kerosene, the so-called kerosene shale of course exists. It was formerly supposed that kerosene shale belonged exclusively to the Greta coal measures. That was at the time we supposed these Bulli coal measures to be the Greta, because the kerosene shale used to be worked at American Creek, near Wollongong. It is now known however that the kerosene shale at Hartley Vale and Joadja and at Wollongong belongs to the Newcastle measures, and that the kerosene shale at Greta is on a totally distinct horizon. As regards whether we have kerosene in the same sense as it exists in America in the Ohio shales, as far as I am aware, no true natural bitumen has ever been found in this colony. We have often had substances brought to us that have been supposed to be residues of mineral oil, but it has proved to be some kind of resin or some nitrogenous substance. It resembles bitumen externally only, as far as I know. We have no conditions as far as I can see in New South Wales for the existence of this rock oil in any of the formations so far known. Had we conditions such as obtain in Pennsylvania and Ohio, we might expect mineral oil. In these places there are all the conditions incident to the production of rock oil.

The President—I am sure we all listened to this paper with great pleasure. I think what Mr. David calls his "rambling remarks," was really a great feature. The reading of a paper is sometimes very dry work, but the explanations as given by Mr. David in such a popular manner makes it doubly intelligible. It is a most gratifying circumstance to notice from Mr. David's remarks that the work of a late President of this Society, (the Rev. W. B. Clarke) has not required to be altered through further researches, and very little to be added. Testimony of this nature coming from such an authority as Mr. David is very conclusive as to the valuable nature of the work of the Rev. W. B. Clarke.

WEDNESDAY, DECEMBER 3, 1890.

Dr. Leibius, M.A., F.C.S., President, in the Chair.

Forty-three members and four visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three new candidates were read for the third time, of five for the second time, and of six for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Anderson, William ; Sydney.
Macgeorge, W. J. ; Sydney.
Sellors, Richard Pickering, B.A. *Syd.;* Newtown.

It was resolved that Messrs. P. N. Trebeck and H. O. Walker be appointed Auditors for the present year.

The Chairman made the following announcements :—

i. 'That the Clarke Medal for 1891 had been awarded by the Council to Prof. F. W. Hutton, F.G.S., Canterbury College, Christchurch, New Zealand.'

ii. 'That the Council had issued the following list of subjects with the offer of the Society's Bronze Medal and a prize of £25, for each of the best researches, if of sufficient merit':—

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

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

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

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

iii. 'That in compliance with the request contained in the following letter, it had been decided to form a Civil Engineering Section of the Society, which would come into operation at the commencement of next Session.'

Athenæum Club,

Sydney, Dec. 1st, 1890.

Gentlemen,—For some years the Engineering Profession in this Colony have felt that it would be a great advantage if some society were formed in Sydney for the discussion of Civil Engineering questions, but for several reasons it has not been thought advisable to form a distinct Society. Lately a large number of representative Civil Engineers have joined the Royal Society, and it is probable that many more will yet join. After consultation with the leading engineering members, I have come to the conclusion that it would be of advantage, both to the Royal Society and also to the engineering profession, if a Civil Engineering Section, on the same basis as the Medical Section, was formed as a branch of the Royal Society.

The interest manifested in the paper of Prof. Warren, on "Timber as applied to Works of Construction," I think will support me in this application. I would therefore ask the Council to allow a Civil Engineering Section of this Society to be formed for the reading and discussion of papers on both Civil and Mechanical Engineering, as I am sure it will not only bring in new members but forward the interests of the Society itself.

I have the honour to be Gentlemen,

Yours faithfully,

JOHN A. MACDONALD,
M. Inst., C.E.
M. Inst., M.E.
M. Am. Soc., C.E.

The Council,
Royal Society of N.S.W.

iv. 'That the Society's Journal, Vol. XXIV., Part i., was ready for distribution to Foreign Societies, and that bound copies of the volume would be forwarded to the members when complete.'

Mr. T. W. Edgeworth David, B.A., F.G.S., read a paper on "The Coalfields of New South Wales and their associated Eruptive Rocks."

Some remarks were made by Mr. J. F. Mann, the Hon. L. F. De Salis, the Chairman and the author.

Dr. John Fraser, read a paper entitled "Some remarks on the Australian Languages."

A paper by Mr. Lawrence Hargrave, "On the 74oz. Compressed-air Flying Machine," was taken as read, a model of the same was exhibited and explained.

The thanks of the Society were accorded to the authors for their valuable papers.

The following donations were laid upon the table and acknowledged :—

Donations Received during the month of November, 1890.

(The Names of the Donors are in *Italics.)*

TRANSACTIONS, JOURNALS, REPORTS, &c.

Baltimore—Johns Hopkins University. American Chemical Journal, Vol. xi., No. 8, 1889; Vol. xii., Nos. 1 - 5, 1890; General Index of Vols. i. - x. (1879 - 1888). American Journal of Mathematics, Vol. xii., Nos. 3 and 4, 1890. American Journal of Philology, Vol. x., No. 4, Whole No. 40, 1889; Vol. xi., No. 1, Whole No. 41, 1890. Studies from the Biological Laboratory, Vol. iv., No. 6, 1890. Studies in Historical and Political Science, Seventh Series, Nos. 10 - 12, 1889; Eight Series, Nos. 1 - 4, 1890. Register for 1889-90. *The University.*

Berlin—Königlich Preussische Meteorologische Institut. Ergebnisse der Meteorologischen Beobachtungen im Jahre 1890, Heft 1. *The Institute.*

Brisbane—Chief Weather Bureau. Weather Charts of Australasia at 9 a.m., October 30, 31, November 1, 3 - 8, 11 - 15, 17 - 22, 24 - 27, 1890. *Government Meteorologist.*

Calcutta—Geological Survey of India. Memoirs, Vol. xxiv., Part ii., 1890. *The Director.*

Cambridge (Mass.)—Museum of Comparative Zoölogy at Harvard College. Bulletin, Vol. xx., No. 2, August 1890. *The Museum.*

Cincinnati—Cincinnati Society of Natural History. Journal Vol. xiii., No. 1, April 1890. *The Society.*

Colombo—Royal Asiatic Society. Journal of the Ceylon Branch, Vol. ii., Part ii., No. 5, 1849, [Reprint, 1890.] ,,

Florence—Società Africana d' Italia. Bullettino della Sezione Fiorentina, Vol. vi., Fasc. 5 and 6, 1890. ,,

Frankfurt am Main.—Senckenbergische Naturforschende Gesellschaft. Bericht, 1886, 1890. ,,

Hamburg—Deutsche Seewarte. Archiv der Deutschen Seewarte xii., Jahrgang, 1890. *The Observatory.*

Leipzig—Vereins für Erdkunde. Mitteilungen, 1889. *The Society.*

Manchester—Geological Society. Transactions, Vol. xx., Parts xi. - xxi., Sessions 1888-89, 1889-90. ,,

Melbourne—Field Naturalists' Club of Victoria. *The Victorian Naturalist,* Vol. vii., No. 7, 1890. *The Club.*

Metz—Vereins für Erdkunde. Jahresbericht, Vol. xii., für 1889-90. *The Society.*

Mexico—Observatoire Météorologique Central. Informes y Documentos relativos á Comersia Interior y Exterior Agriculture é Industrias, Numeros 58 and 59, Abril and Mayo, 1890. *The Observatory.*

Minneapolis—Minnesota Academy of Natural Sciences. Bulletin, Vol. iii., No. 1, 1883-86. *The Academy.*

Mulhouse—Société Industrielle de Mulhouse. Table des Matières des Sujets traités au Comité de Mécanique de la Société Industrielle de Mulhouse de 1826 à 1889 dressée par M. F. Poupardin. *The Society.*

NEW YORK—*The Journal of Comparative Medicine and Veterinary Archives*, Vol. XI., No. 10, 1890. *The Editor.*

OTTAWA—Minister of Finance. Dictionary of the Language of the Micmac Indians, by Rev. Silas Tertius Rand, D.D., LL.D., [4° Halifax, N.S. 1888.] *The Hon. George E. Foster.*

PARIS—Académie des Sciences de l'Institut de France. Comptes Rendus hebdomadaires des Séances, Tome CXI., Nos. 12 – 15, 1890. *The Academy.*

Feuille des Jeunes Naturalistes, Année XX., No. 240, 1 Oct., 1890. *The Society.*

Société de Biologie. Comptes Rendus hebdomadaires des Séances, Série 9, Tome II., No. 29, 1890. ,,

Société de Géographie. Bulletin, Série 7, Tome XI., Trimestre 2, 1890. ,,

Société Geologique de France. Bulletin, 3 Série, Tome XVIII., No. 5, 1890. ,,

Société Zoologique de France. Bulletin, Tome XV., No. 7, 1890. ,,

PHILADELPHIA—Academy of Natural Sciences. Proceedings, Part i., Jan. - Mar., 1890. *The Academy.*

American Entomological Society. Transactions, Vol. XVI., No. 4, 1889; Vol. XVII., No. 1, 1890. *The Society.*

American Philosophical Society. Proceedings, Vol. XXVII., No. 131, 1889; Vol. XXVIII., Nos. 132, 133, 1890. ,,

Franklin Institute. Journal, Vol. CXXX., No. 778, October, 1890. *The Institute.*

RIO DE JANEIRO—Observatoire Impérial. Annales, Tome IV., Partie i., Observations et Mémoires Astronomiques; Partie ii., Observations Météorologiques, 1883 à 1885. [4° Rio de Janeiro, 1889.] Annuario, Anño IV., V., VI., 1888 - 1890. Revista, Anno V., No. 8, 1890. *The Observatory.*

ROME—Biblioteca e Archivio Tecnico (Ministero dei Lavori Pubblico). *Giornale del Genio Civile*, Anno, XXVIII., Fasc. 5 and 6, 1890. *The Minister of Public Instruction, Rome.*

Reale Accademia dei Lincei. Atti, Serie Quarta, Rendiconti, Vol. VI., Fasc 3 and 4, Semestre 2, 1890. *The Academy.*

Società Geografica Italiana. Bollettino, Serie 3, Vol. III., Fasc 9, 1890. *The Society.*

SALEM—American Association for the Advancement of Science. Proceedings, Vol. XXXVIII., 1889. (Toronto Meeting). *The Association.*

SYDNEY—Australian Museum. Records, Vol. I., No. 5, 1890. *The Museum.*

Department of Agriculture. A Census of the Grasses of New South Wales together with a popular description of each species, by Fred. Turner, F.R.H.S. 1890. *The Director.*

Linnean Society of New South Wales. Abstract of Proceedings, 26 November, 1890. *The Society.*

TAIPING—*The Perak Government Gazette*, Vol. III., Nos. 27 – 30, Oct. 3 – 31, 1890. *The Secretary to the Government.*

TOKIO—Imperial University of Japan. Journal of the College of Science, Vol. III., Part iv., 1890. *The University.*

WASHINGTON—Chief of Engineers U.S. Army. Report upon United States Geographical Surveys West of the 100th Meridian, in Charge of Capt. G. M. Wheeler, Vol. I., Geographical Report [4° Washington, 1889.] *The Chief of Engineers.*

Smithsonian Institution. Annual Report of the Board of Regents for the year ending June 30, 1886 Part ii., and for the year ending June 30, 1887, Parts i. and ii. *The Institution.*

U.S. Geological Survey. Annual Report (Eighth) Parts i. and ii., 1886-87. Bulletins, Nos. 54–57, 1889-90. Monographs, Vol. xv., Parts i. and ii.; Vol. xvi., 1889. *The Director.*

United States Hydrographic Office. Notice to Mariners, Nos. 35 and 36, 1890. *The U.S. Hydrographer.*

WINNIPEG—Historical and Scientific Society of Manitoba. Annual Report for the year 1889. Transactions, Nos. 35–39. *The Society.*

MISCELLANEOUS.

(Names of Donors are in *Italics*.)

Russell, H. C., B.A., C.M.G., F.R.S.—Ten Star Photographs: Two from a negative of Nebecula Major, taken Oct. 17, 1890, exposed 7 h. 3 m; two ditto ditto, taken Sept. 18, 1890, exposed 4 h. 30 m. Two from a negative of the Milky-Way in Sagittarius, taken Oct. 2, 1890. Two from a negative of Orion, taken Oct. 19, 1890, exposed 4 h. 5 m; two from a negative taken Oct. 14, 1890, exposed 8 hours. *Note.*—One of each of the above photographs is on *glass.*

H. C. Russell, B.A., C.M.G., F.R.S.

WEDNESDAY, DECEMBER 10, 1890

A Conversazione was held in the Great Hall of the University under the management of a Committee composed of the Officers and Council of the Society.

The Hall and approaches were tastefully decorated with ferns, palms and rare pot plants kindly supplied by Mr. Charles Moore, F.L.S., Director of the Botanic Gardens.

The University grounds were illuminated with coloured fairy lights &c., thus lighting the way for the guests to visit the Chemical, Physical, Engineering and Biological laboratories in which experiments were conducted by the Professors and their assistants.

The Macleay Museum, Library, and the various Lecture Rooms were also thrown open to the visitors.

Mr. F. Morley presided at the Organ.

The guests numbered about 800.

His Excellency the Lieut. Governor was unable to attend, but the Misses Stephen, His Excellency Lord Charles Scott and Lady Scott, the Premier Sir Henry Parkes and Lady Parkes, and various members of the Ministry and of both Houses of Parliament were present.

Catalogue of Exhibits—The Laboratories in the University Grounds.

1. Chemical Laboratory (Prof. Liversidge, M.A., F.R.S.)—The new Chemical Laboratory was for the first time thrown open for the inspection of the friends of the Royal Society. The extensive class rooms and students' laboratories are in a forward state of completion, and the collection of apparatus for science teaching was displayed in the various rooms.

An account of the Chemical Laboratory, together with plans and details of the fittings, was published in the report of the Aust. Assoc. for the Advancement of Science for 1888; since then the laboratory has been built, and is now approaching completion.

1. The principal room or main laboratory, 72 x 36 feet, has benches for between 50 and 60 students. 2. The practical class room has benches for 40 students at a time. 3. The class room seats 130 students, and the lecture room about 240. 4. On the floor are the gas analysis, volumetic, balance, store, dark, and other rooms.

On the basement are the furnace room, metallurgical laboratories, balance, store, and engine room, in the latter is a 7-horse power Otto gas engine, dynamo for the electric light, grinding mill, blower, exhaust pump, and similar machinery. As a supplement to the exhaust pipe laid on to each student's bench, there is a special tap for filter pumps.

In fitting up the laboratory, time-saving appliances and arrangements are adopted as far as possible; draught cupboards are provided for each student, each has an abundant supply of gas and water, an exhaust for filtration; sulphuretted hydrogen and water are laid on to all the side draught cupboards, and distilled water along the W. wall from the self-acting still and cistern in the S.W. angle.

2. Physical Laboratory (Prof. Threlfall, M.A.)—The following demonstrations were given during the course of the evening: Electric welding. Hertz's recent experiments on the propagation of Electro-magnetic waves. (Mr. Pollock.) Gravity-meter and apparatus, for measuring the elastic constants of quartz threads

(new design by Prof. Threlfall). Electric discharges in nitrogen —vacuum tubes, &c. Experiment on the thermal changes accompanying diffusion, and a fundamental experiment of Electro-dynamics.

3. Engineering Laboratory (Prof. W. H. Warren, M. Inst. C.E., Wh. Sc.)—The collection of mechanical models was displayed, and the large testing machine was used at intervals to demonstrate the methods employed in testing metals, woods, also the tensile strength of steel and steel-wire rope, Australian timbers, etc.

4. Biological Laboratory (Prof. W. A. Haswell, M.A., D.Sc.—) There were exhibited beneath numerous microscopes a large series of Zoological and Botanical preparations, also series of loan models by Dr. Zieglar of Freiberg, representing the brains of various vertebrates.

The University Hall.

5. The Sydney Observatory (H. C. Russell, B.A., C.M.G., F.R.S., Government Astronomer.)—Series of Star Photographs showing Milky-Way. Photographs of Nebecula Major, Nebecula Minor, and Orion. Photographs of instruments employed in the work.

6. Department of Agriculture—(H. C. L. Anderson, M.A., Director.)—Models of standard fruits now in process of execution as types of the true varieties. (N. A. Cobb, D.Sc., Ph.D., Government Pathologist.)—Rust in Wheat; parasitic Fungi; parasitic pests; microscopes displaying slides of the above. (A. Sidney Olliff, Government Entomologist.)—Insects showing transformation of various species. (Fred. Turner, F.R.H.S., Botanist to the Department.)—Collection of Australian grasses.

7. Department of Public Instruction—(J. H. Maiden, F.L.S., F.C.S., Curator Technological Museum.)—Model of first locomotive steam engine, by Murdock, 1781; model of Formosan Catamaran; specimens of Wood-engraving by Norwegian peasantry; six specimens of Flora Artefacta [Jauch's], *e.g.*, ordinary artificial flowers constructed on strict botanical principles; lacquer hat of a Japanese gentleman, not used for half-a-century past; coloured plates of Australian plants; ornamental Australian timber.

8. Technical Education Branch—(Prof. D. Codrington Selman, A.M. Inst. C.E., Wh.Sc.,)—Model shewing the condition of invariability of a trapezium under force action; model of tower shewing the economical substitution of a trapezium for two triangles as an element in construction: these models illustrate the application of a new principle of construction in lofty structures subject to wind pressure.

9. Department of Public Works (J. Barling, Under-Secretary.) —Contract drawings for the Cowra Bridge.

10. Forest Department (J. Ednie Brown, F.L.S., Director.)—Samples of silk cocoon, reared by Mr. Thorn of Castle Hill; sample of pierced cocoon, from Mr. Thorn; sample of raw silk, reared and reeled by Mr. Thorn; sample of raw silk grown by Mr. Arthur Gellatly, Parramatta; sample of silk cocoon reared by Dr. Cleland of Adelaide; sample of raw silk, reeled from cocoon reared by Dr. Cleland; sample of silk fabric from silk raised by Dr. Cleland; nine parts of the illustrated work by J. Ednie Brown upon the Forest Flora of South Australia; some 30 samples of the timber of New South Wales.

11. Bacteriology (W. C. Wilkinson, M.D.)—Pure cultures of Bacilli on agar agar or gelatine; microscopical preparations of Bacilli.

12. Bibliology (Alfred F. H. Stephen.)—The Bishop's Bible, A.D. 1568, vulgarly called the "Treacle" Bible, for the rendering of Jeremiah viii. 22:—"Is there no treacle in Gilead." [By permission of the Vestry of St. Philip.] The Bible and Prayer Book which came out in the First Fleet, and used by the Rev. Richard Johnson, B.A., the first clergyman in Australia. (Andrew Houison, M.B.)—History of the Post Office and of the Issue of Postage Stamps in New South Wales, 1890; photograph of a page from Capt. Cook's Log [British Museum copy] for period during which he was in Botany Bay; lithographs of the first merinos introduced into Australia; prize ram and ewe exhibited at Parramatta, October, 1828; and of the Irish race-horse "Skeleton," the first Australian race-horse, 1832. (Dr. Thos. M. Martin.)—Copy of works of Tacitus, A.D. 1551. (Rev. W. Wyatt Gill, B.A., LL.D.)—Pomare's letter, with a literal translation, dated 2nd March, 1819; this Pomare is the original one who first embraced the Gospel in Tahiti.

13. Botany (Rev. Robert Collie, F.L.S.)—Collection of cryptogams, algæ, lichens, mosses, ferns.

14. Curios (Hon. G. H. Cox, M.L.C.)—Japanese albums; pair of Cloisonne vases; inlaid metal plate and bronze box.

15. Engineering Appliances (Prof. Warren, M. Inst. C.E., Wh. Sc.)—Oil testing machine; small testing machine, for cement, wire, and other materials (made in the University engineering laboratory); expansion rollers for bridges; valve gears, link motions; Reuleaux's Curvograph; parallel flow, Girard's, outward flow and inward flow turbines.

16. Microscopes (The members of the Microscopical Section.)—Messrs. Dr. Mackellar; H. G. A. Wright (Kock's bacillus of consumption); Ebenezer Macdonald (specimens of pond life); S. Cornwell; T. F. Wiesener (polariscope objects, insects, etc.); F. B. Kyngdon; Wm. M. Hamlet, F.C.S., F.I.C.

17. Photographs (J. Ashburton Thompson, M.D., Brux.)—Illustrations of house building in Sydney, 1890; autotype from original of portrait of Angelica Kaufman, in Dresden Gallery. (Dr. A. H. Fieldstad.)—Stereoscopic views of Norwegian scenery. (T. J. Thompson.)—Collection of photographs. (L. M. Harrison.)—Collection of photographs. (Major T. S. Parrott.)—Photographs of scenery in the Eastern Soudan, taken by the Royal Engineers.

18. Scientific Apparatus (Ebenezer Macdonald.)—Two telephones. (Dr. V. Marano.)—Di-electric machine by Carrè. (S. Cornwell.)—Polariscope and spectroscope. (John Scattergood.)—Faraday Electro-galvanic machine. (W. M. Hamlet, F.C.S., F.I.C., Government Analyst.)—One Micro-spectroscope, showing bright line and absorption spectra at the same time. Mr. Hamlet was in attendance to show spectra of blood-stains.

19. Sundries (John Scattergood.)—Oil painting of Cardinal Wolsey by Hans Holbien; two volumes of printed specimens from all parts of the world; Wedgwood basin with Flaxman's designs; cream jug in old blue glass; reprint of one of Caxton's first books, etc., etc. (S. Sinclair.)—Revolving albums; stereoscope; Russian passport, Cronstadt, 1825; facsimile bond of covenant, 1745; old coins, watch found in a shark, etc. (Photoline Printing Company, 337 Pitt-street.)—Exhibits of their Heliotypes of oil and water colour paintings, engravings, and other work. (T. J. Thompson.)—Patent detaching gear for ships' boats; photographs of Pompeii, Rome, English and Continental pictures; an edition of Longfellow's poems, with autograph, 2 vols.; copy of Carlo Marallas' picture, John the Baptist and Infant Jesus, original in the Palace Rospighosi, Rome.

PROCEEDINGS OF THE SECTIONS

(IN ABSTRACT.)

MEDICAL SECTION.

At the preliminary meeting held in April, the following officers were elected:—Chairman: Professor T. P. Anderson Stuart. Committee: Drs. P. Sydney Jones, S. T. Knaggs, A. Shewen, W. H. Crago, W. H. Goode, and L. R. Huxtable. Secretaries: Drs. J. F. MacAllister and W. Hull.

During the Session the following changes took place among the office bearers:—Prof. T. P. Anderson Stuart resigned the position as Chairman on account of his visit to Europe, and Dr. P. Sydney Jones was elected in his place. Upon the departure of the latter gentleman, Dr. MacLaurin succeeded him as Chairman, and Dr. Fiaschi was elected to the vacancy caused in the Committee.

Seven general meetings were held ; they were well attended and the papers read were received with much interest, and in some cases provoked considerable discussion of a valuable character.

Papers of which special mention may be made, owing to the interest evinced in them by the members, were read by Dr. A. E. WRIGHT, Dr. F. H. QUAIFE, and Professor STUART.

The most valuable and important feature of the work of the Session, was however, the series of Medical and Surgical cases shown at the Society.

Drs. JAMES GRAHAM and CLUBBE showed a patient who had been successfully operated on for hydatid of the brain, and a long discussion as to the diagnosis and treatment of this disease ensued which extended through two meetings of the Section. Dr. FIASCHI opened the discussion with an address, and Drs. P. SYDNEY JONES, MILFORD, SHEWEN, WORRALL, SCOT-SKIRVING, CLUBBE, W. CHISHOLM, F. H. QUAIFE, W. J. O'REILLY, CRAGO, and MEGGINSON, took part in the debate.

A patient was also shewn who had a fistulous opening into his pharynx (the result of an operation for malignant tumour) in whom the mechanism of deglutition could be observed, and thus in the opinion of the members, were disproved some of the generally received views as to the physiology of that act.

Important exhibits were also made or cases shewn by Drs. W. H. GOODE, JAMES GRAHAM, CLUBBE, Prof. T P. ANDERSON STUART, A. E. WRIGHT, SCOT-SKIRVING, MACCORMICK, W. H. QUAIFE, E. J. JENKINS, and H. A. ELLIS.

Papers were read by—

- Professor T. P. ANDERSON STUART—" On a resumé of recent work on the structure of cells with special reference to that of muscular tissue. (Illustrated by models and diagrams).
- Dr. W. H. GOODE—" On eight consecutive cases of operation for hernia," with exhibits. " Notes of two cases of bullet wound of the abdomen," with living exhibit.
- Dr. A. E. WRIGHT—" On a method of removing sugar from milk," with demonstration of the method.
- Dr. JAMES GRAHAM—" On a case of cerebral hydatid," with living exhibit. " On twisting of the pedicle in ovarian disease with notes of two cases."
- Dr. FIASCHI—" An address opening a discussion upon the treatment of hydatid tumours."

Dr. F. H. Quaife—"On Sanitary and Domestic Sewerage, as carried out by the Sydney Water and Sewerage Board." (Illustrated by models and diagrams.)

Dr. MacCormick—"On a case of Pylorectomy," with living exhibit.

WALTER HULL, M.D....... } Hon. Secretaries.
J. F. MACALLISTER, M.B. }

MICROSCOPICAL SECTION.

A preliminary meeting of this Section was held on 2nd May, 1890, Mr. S. MacDonnell in the Chair.

The following officers were elected for the year:—Mr. S. MacDonnell, Chairman; Mr. H. O. Walker, Secretary; Dr. H. G. A. Wright, Mr. F. B. Kyngdon, Mr. G. D. Hirst, and Mr. P. R. Pedley, Committee.

Monthly Meeting held 12th MAY, 1890.

Dr. Wright in the Chair.

Mr. Hirst exhibited a very fine slide of *Arachnoidiscus Ehrenbergii* in situ on zostera, which had been sent him from Japan.

Monthly Meeting held 9th JUNE, 1890.

Dr. Wright in the Chair.

Mr. Hirst read a short paper on the structure of the diatom *Climacosphenia Australis*, and stated that the striae on the margins of the valve were exceedingly close, there being slightly over 110,000 to the inch. Mr. Hirst recommended the diatom as being well worth the attention of those members who possessed high power wide angled lenses. The diatoms exhibited were taken from a gathering obtained from the stomach of a garfish.

Mr. Wiesener exhibited a highly finished microscope by Charles Reichert of Vienna, fitted with two stages, a plain and a mechanical one, the change from one to the other being quickly and easily effected. A set of compensating eyepieces and a number of excellent objectives were also included.

Monthly Meeting held 14th JULY, 1890.

Mr. S. MacDonnell in the Chair.

The Chairman exhibited for Mr. Sharp of Adelong a species of May fly *(Bœtis)*. The insect shown was a male, and was provided with four compound eyes.

Mr. Whitelegge exhibited: Rotifera—*Dinocharis tetractis*, Rhizopoda—*Difflugia pyriformis*, and *Arcella discoides*.

Mr. Charles G. Ewing, a visitor, gave the members present some information respecting the San Francisco Microscopical Society.

Monthly Meeting held 11th AUGUST, 1890.

Mr. P. R. Pedley in the Chair.

Mr. A. P. Bedford exhibited several slides of diatoms and Polycistina.

Monthly Meeting held 8th SEPTEMBER, 1890.

Mr. S. MacDonnell in the Chair.

Mr. Pedley exhibited a fine specimen of *Gorgonia* which he had obtained at Long Reef.

Monthly Meeting held 13th OCTOBER, 1890.

Mr. S. MacDonnell in the Chair.

Mr. Kyngdon exhibited some excellent homogeneous immersion lenses by Reichert.

Monthly Meeting held 17th NOVEMBER, 1890.

Mr. S. MacDonnell in the Chair.

The Chairman exhibited a specimen of the polyzoa *Amathia biseriata*, which he had obtained from North Harbour.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

Periodicals Purchased in 1890.

American Journal of Science and Art, (Silliman).
American Monthly Microscopical Journal.
Analyst.
Annales des Chimie et de Physique.
Annales des Mines.
Annals of Natural History.
Astronomische Nachrichten.
Athenæum.

British Medical Journal.

Chemical News.
Curtis's Botanical Magazine.

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Fresenius Zeitschrift für Analytische Chemie.

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Journal de Médecine.
Journal of Anatomy and Physiology.
Journal of Botany.
Journal of the Chemical Society.
Journal of the Society of Arts.
Journal of the Institution of Electrical Engineers.

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Mining Journal.

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Notes and Queries.

Observatory.

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Philosophical Magazine.
Proceedings of the Geologists' Association.

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Adams, J. E.; Mendeleek, D. J.; Sylvester, J. J. (Nature Series of Portraits).

INDEX.

ERRATA.

Page 16, Line 34, read Microscopical instead of Miscroscopical.

Page 88, Line 24, read $a - p_1$ instead of $a - p_2$ ....(1)

Page 92, Line 26, read $\cdot 845 \frac{\Sigma v}{\sqrt{\{n(n-1)\}}}$ instead of $\cdot 845 \sqrt{\left\{\frac{\Sigma v}{n(n-1)}\right\}}$ ....(19)

Page 103, Line 6, read 539″ instead of 559″.

Page 125, Line 7, read Arts instead of Atrs.

Page 133, Line 16, read distribute instead of destribute.

Page 147, Line 22, read maxima instead of maximum.

Page 176, Line 42, read *U. leptoplectra* instead of *U. leptroplectra*.

EXCHANGES AND PRESENTATIONS

MADE BY THE

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1890.

The Journal and Proceedings of the Royal Society of N.S.W. for 1889, Vol. xxiii., has been distributed as follows :—

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55 TOULOUSE... ... *Académie des Sciences Inscriptions et Belles-Letteres.
56 VILLEFRANCHE-SUR-MER (Alp. Mar.) ... Laboratoire de Zoologie.

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322 ,, ... *New York Academy of Sciences.
323 ,, ... *New York Microscopical Society.
324 ,, ... *School of Mines, Columbia College.
325 PHILADELPHIA ... *Academy of Natural Science.
326 ,, ... *American Entomological Society.
327 ,, ... *American Philosophical Society.
328 ,, ... *Franklin Institute.
329 ,, ... *Second Geological Survey of Pennsylvania.
330 ,, ... *Wagner Free Institute of Science.
331 ,, ... *Zoological Society of Philadelphia.
332 SALEM (Mass.) ... *American Association for the Advancement of Science.
333 ,, ... *Essex Institute.
334 ,, ... *Peabody Academy of Sciences.
335 ST. LOUIS ... *Academy of Science.
336 SAN FRANCISCO... *California Academy of Sciences.
337 ,, ... *California State Mining Bureau.
338 WASHINGTON ... *American Medical Association.
339 ,, ... *Bureau of Education (Department of the Interior).
340 ,, ... *Bureau of Ethnology.
341 ,, ... *Chief of Engineers (War Department).
342 ,, ... *Chief of Ordnance (War Department).
343 ,, ... *Chief Signal Officer (War Department).
344 ,, ... *Commissioner of Agriculture.
345 ,, ... *Director of the Mint (Treasury Department).
346 ,, ... Library (Navy Department).
347 ,, ... *National Academy of Sciences.
348 ,, ... *Office of Indian Affairs (Department of the Interior).
349 ,, ... *Philosophical Society.
350 ,, ... *Secretary (Department of the Interior).

351	WASHINGTON ...	*Secretary (Treasury Department).
352	,, ...	*Smithsonian Institution.
353	,, ...	*Surgeon General (U.S. Army).
354	,, ...	*U. S. Coast and Geodetic Survey (Treasury Department).
355	,, ...	*U.S. Geological Survey.
356	,, ...	*U. S. National Museum (Department of the Interior).
357	,, ...	U.S. Patent Office.
358	,, ...	*War Department.

Number of Publications sent to	Great Britain	85
,, ,,	India and the Colonies ...	57
,, ,,	America	64
,, ,,	Europe	143
,, ,,	Asia, &c.	5
,, ,,	Editors of Periodicals ...	4
	Total	358

F. B. KYNGDON... } Hon. Secretaries.
W. H. WARREN... }

The Society's House, Sydney, 30th June, 1890.

F. W. WHITE, PRINTER, MARKET STREET, SYDNEY.

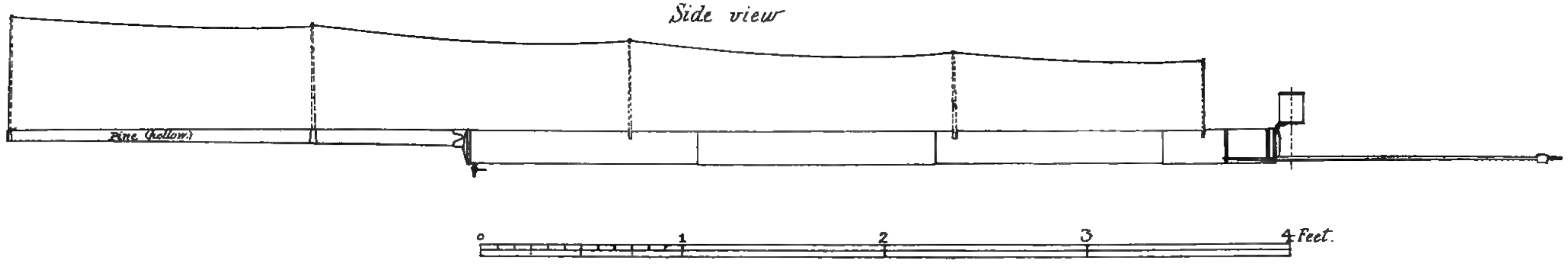
3%

3

Vibratory flying-machine

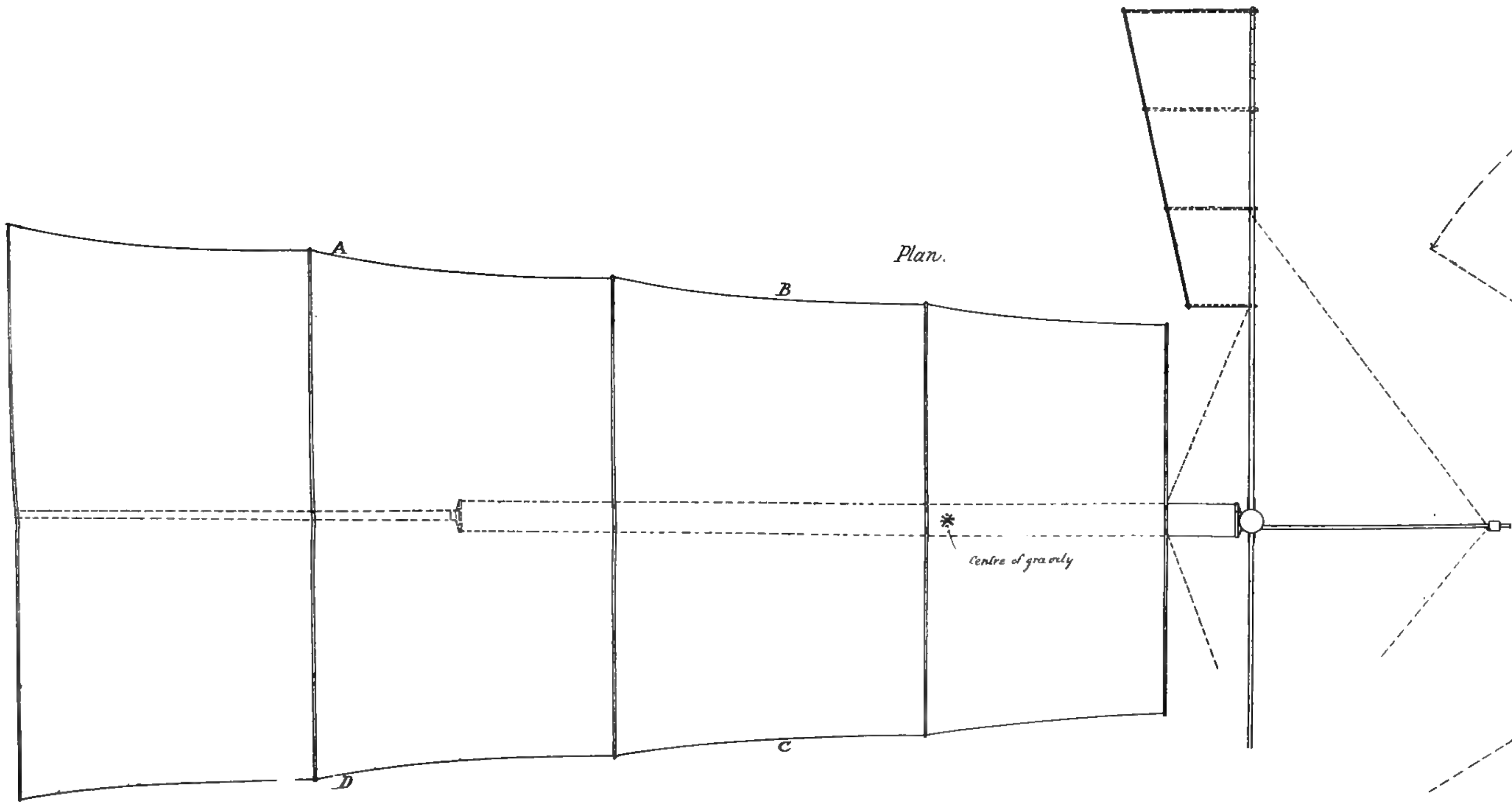
Total weight (charged)	2·53 lbs.
Area of the body	2128 sq. ins.
Area of the wings	216 sq. ins.
Total area	2344 sq. ins.
Area in advance of centre of gravity	546 sq. ins. = 23·3 %

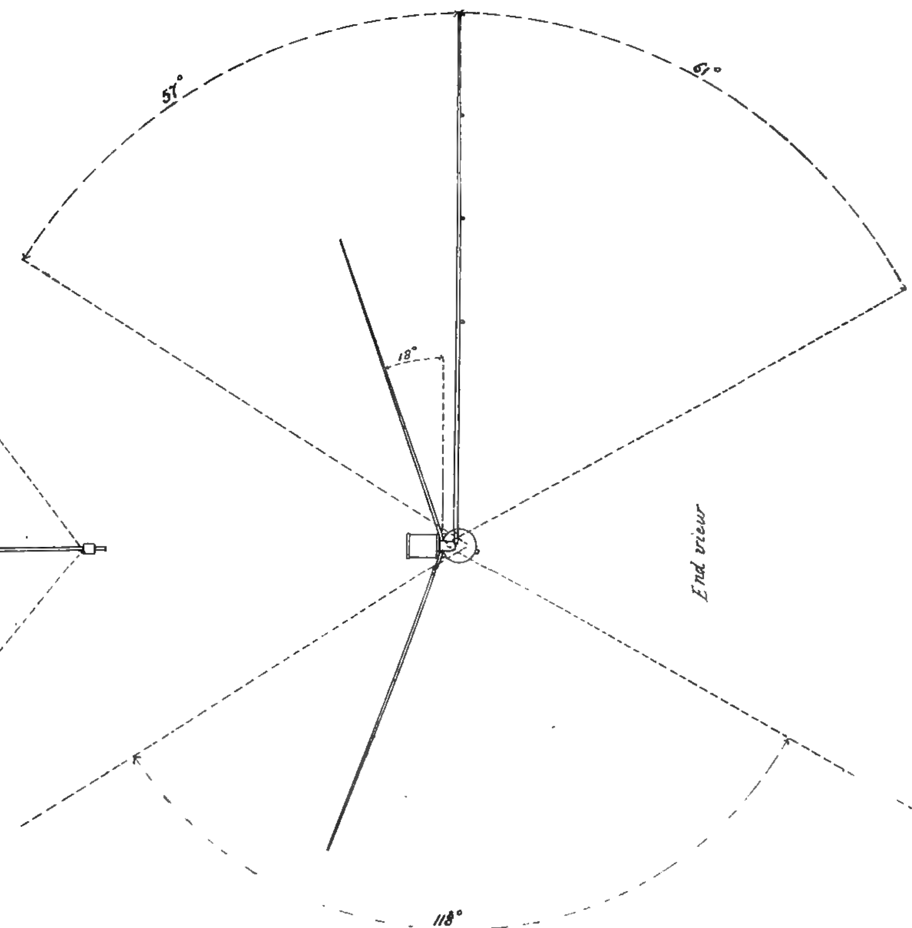
Side view



Scale.

Plan.

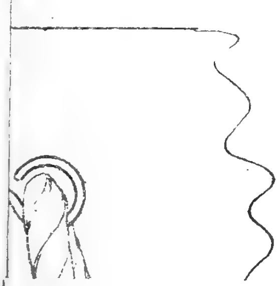


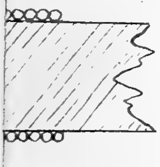


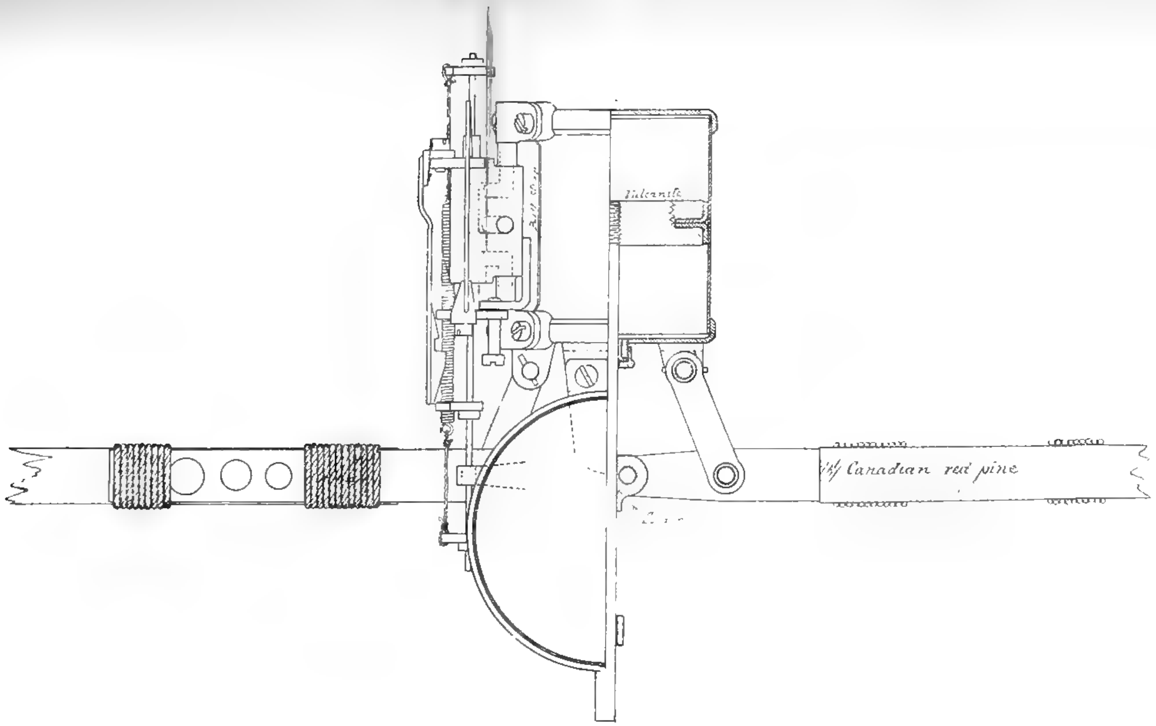
End view

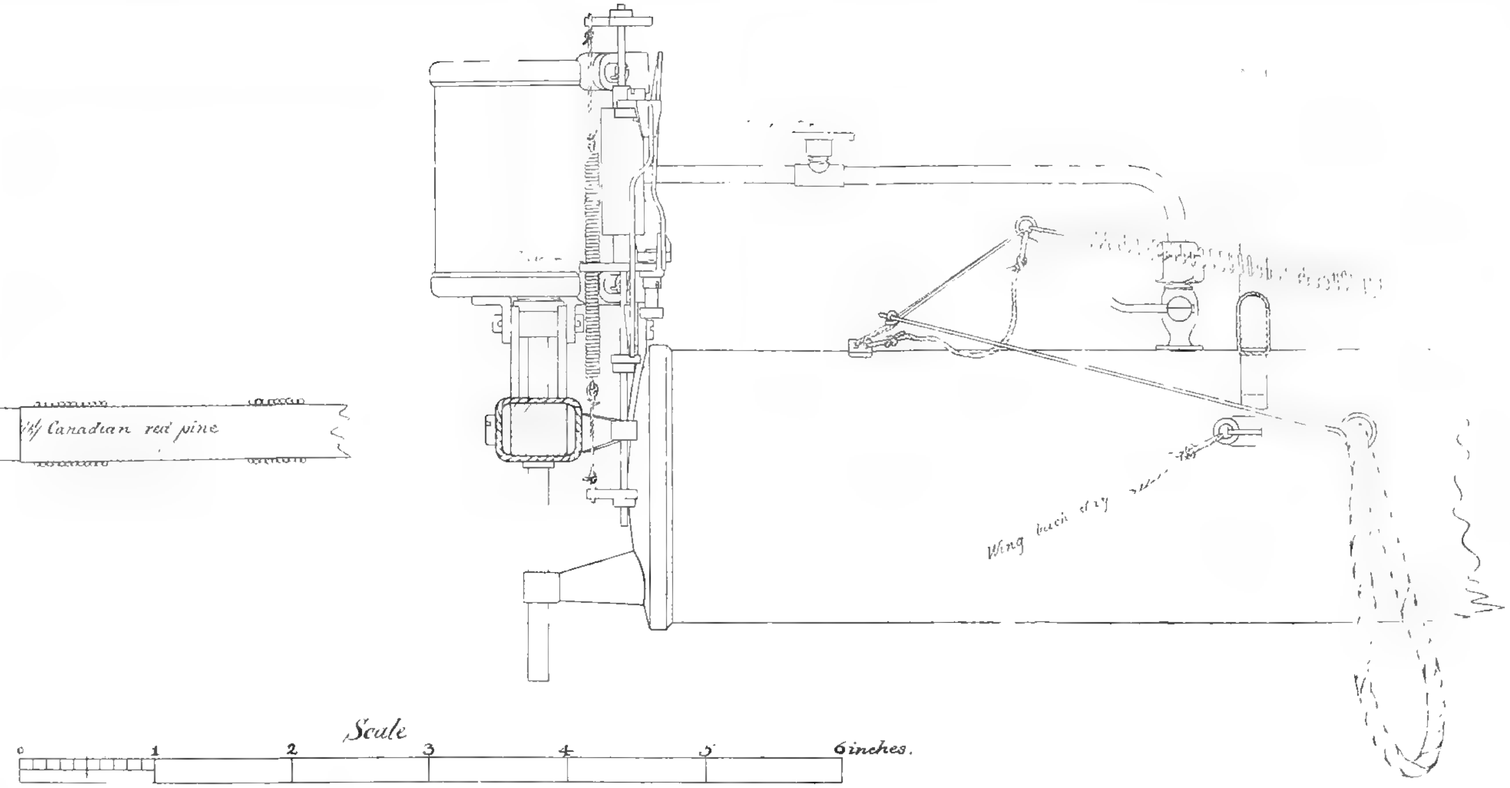
Law. Hargrave
April 12th 1890

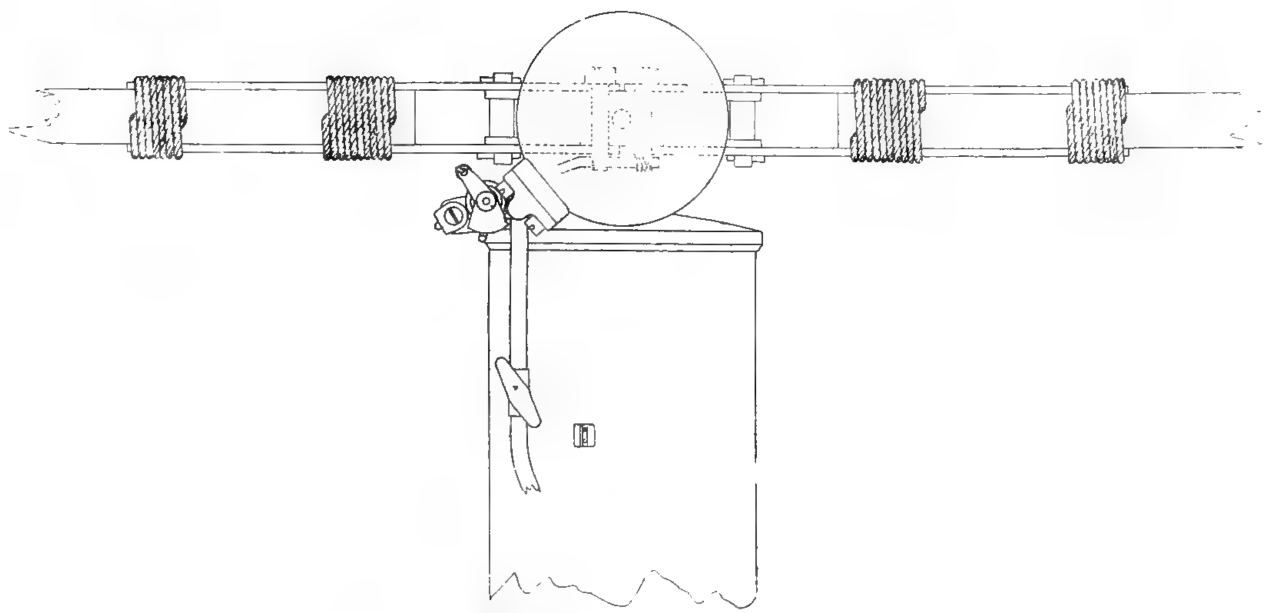
II.









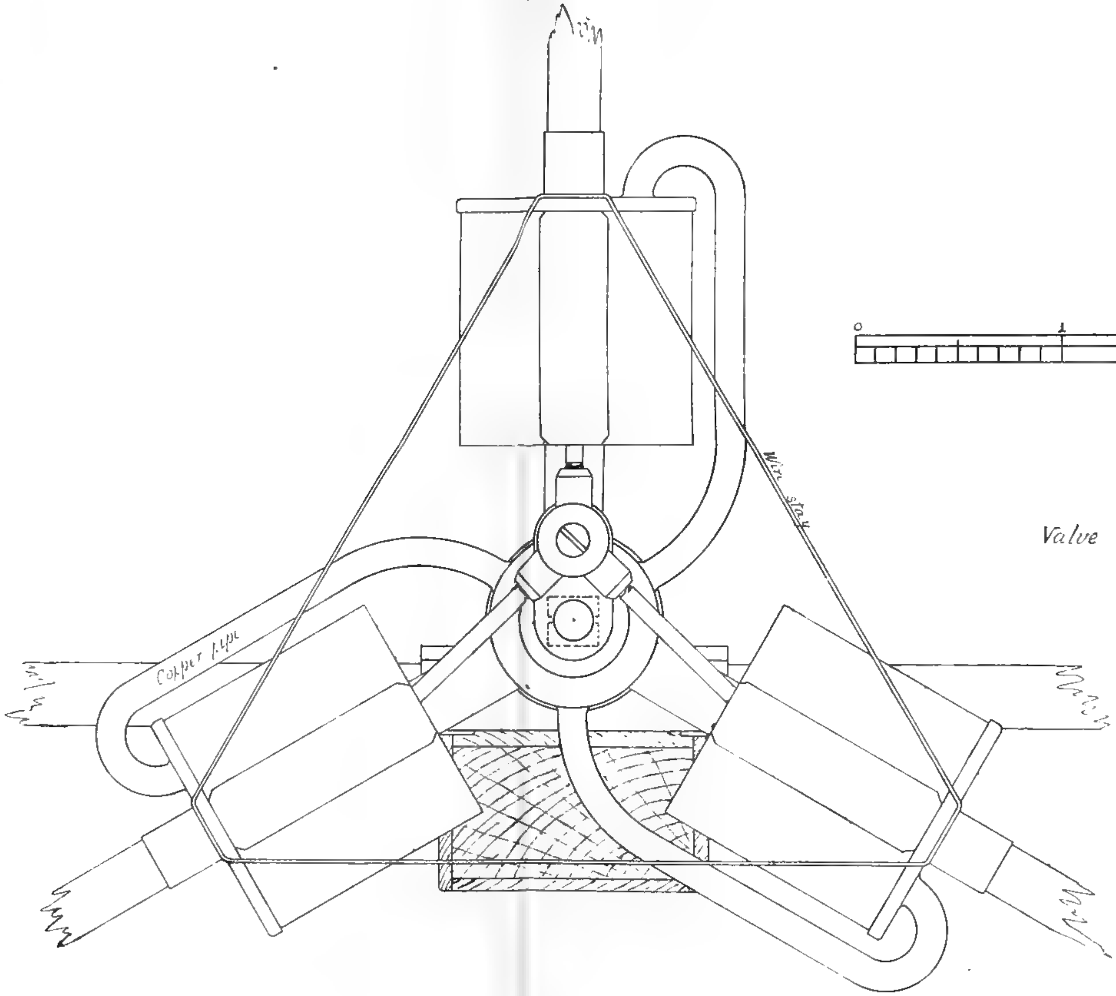


Compressed-air Engine.

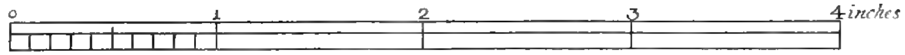
Diameter of the cylinder	1½ ins	Diameter of the receiver	2 ins
Stroke	1¼ ins.	Length ditto	48¾ ins
Cut-off for expansion	nil	Weight ditto	19½ oz
Weight of engine	6½ oz	Weight {charged}	21¾ oz
Weight of wings {wood & paper}	3 oz	Bursting strength	660 lbs pr sq. in
Piston speed	5 ins. per second +	Test pressure	380 " "
		Working pressure	230 "
		Capacity {water measure}	144.6 cubic ins
		Thickness of shell	·32 mills
		" " ends	·70 "
		Lap of longitudinal seams	5/16 inch
		Strength " "	100% +

Law. Hargrave
April 12th 1890

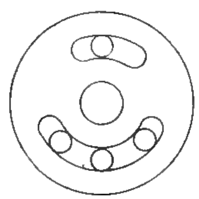
890.

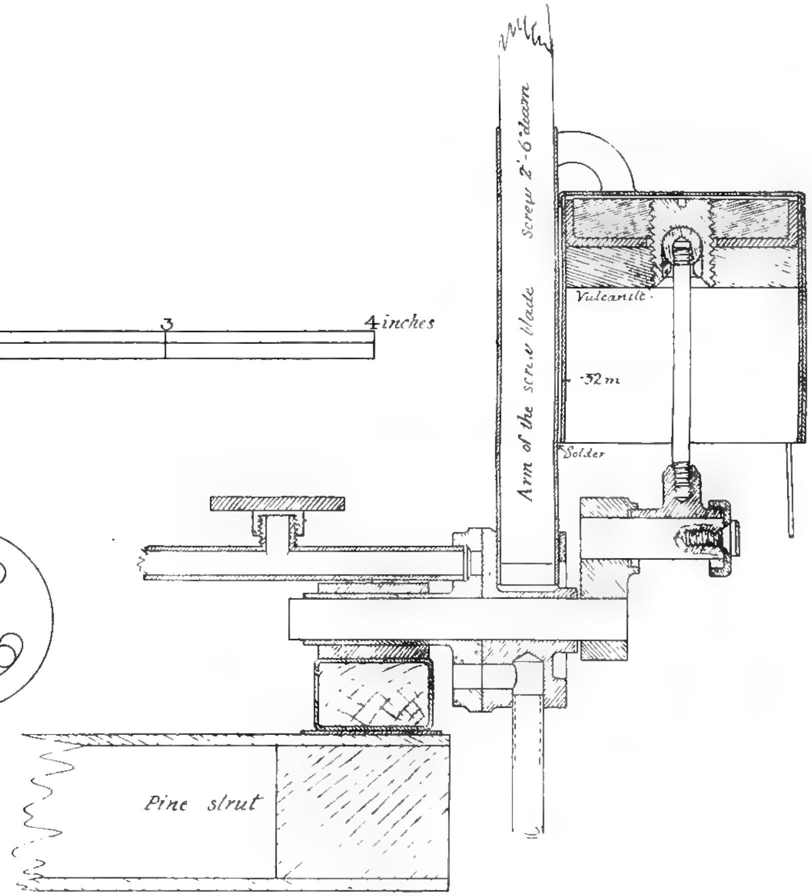


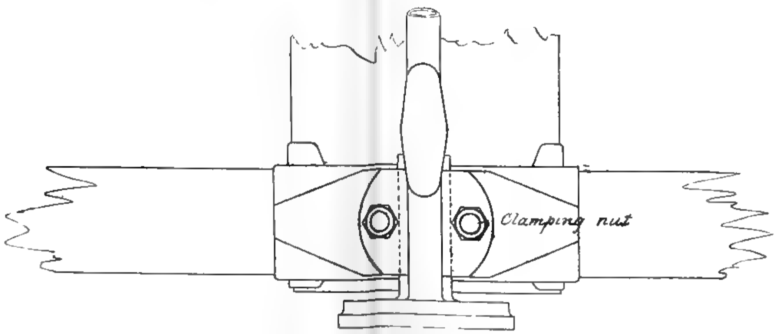
Scale.



Valve face





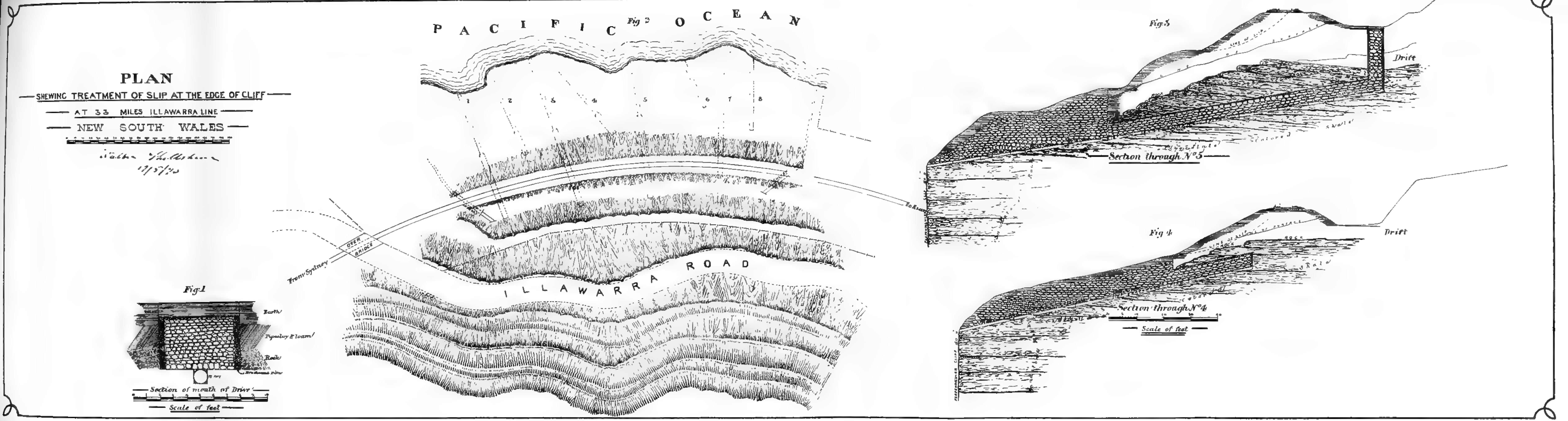


3 Cylinder (tin) screw engine

Diameter of cylinder	$1\frac{1}{8}$ inch.
Stroke.	·79 inch
Cut off	3/4 stroke.
Air pressure pr. sq. in	170 lbs.
Weight of engine and screw	$6\frac{1}{2}$ oz.

Law. Hargrave April 14th 1890.


PERPENDICULAR CLIFF 150.0"

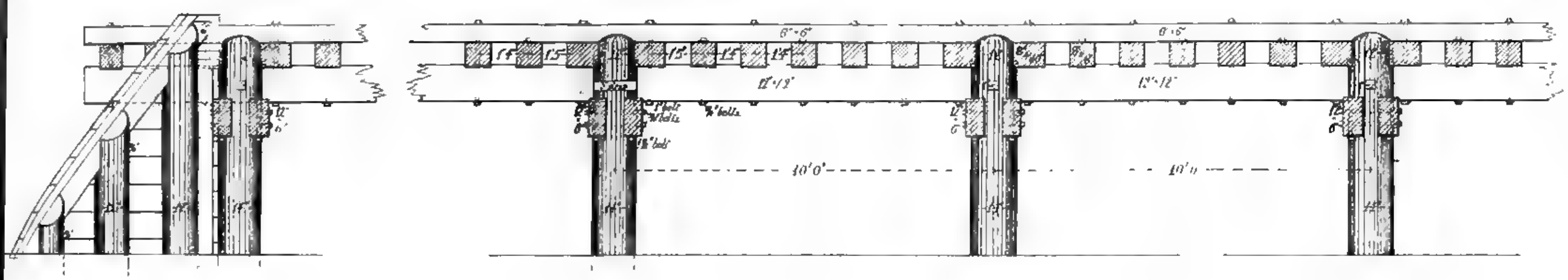

PLAN
SHEWING TREATMENT OF SLIP AT THE EDGE OF CLIFF
AT 33 MILES ILLAWARRA LINE
NEW SOUTH WALES
Fig. 1
Earth
Pipeclay & loam
Rock
Section of mouth of Drive
Scale of feet
Fig. 2
PACIFIC OCEAN
1
2
3
4
5
6
7
8
OVER BRIDGE
From Sydney
ILLAWARRA ROAD
Fig. 3
Drift
Section through No 3
Fig. 4
Drift
Section through No 4
Scale of feet

DU

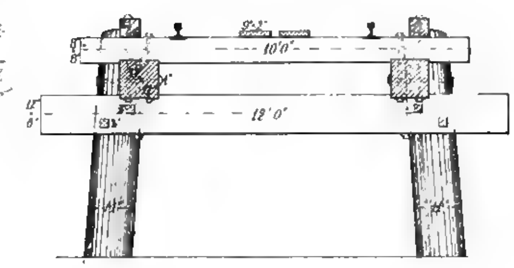
DESIGN FOR TIMBER VIADUCT.

10 FEET CENTRES.

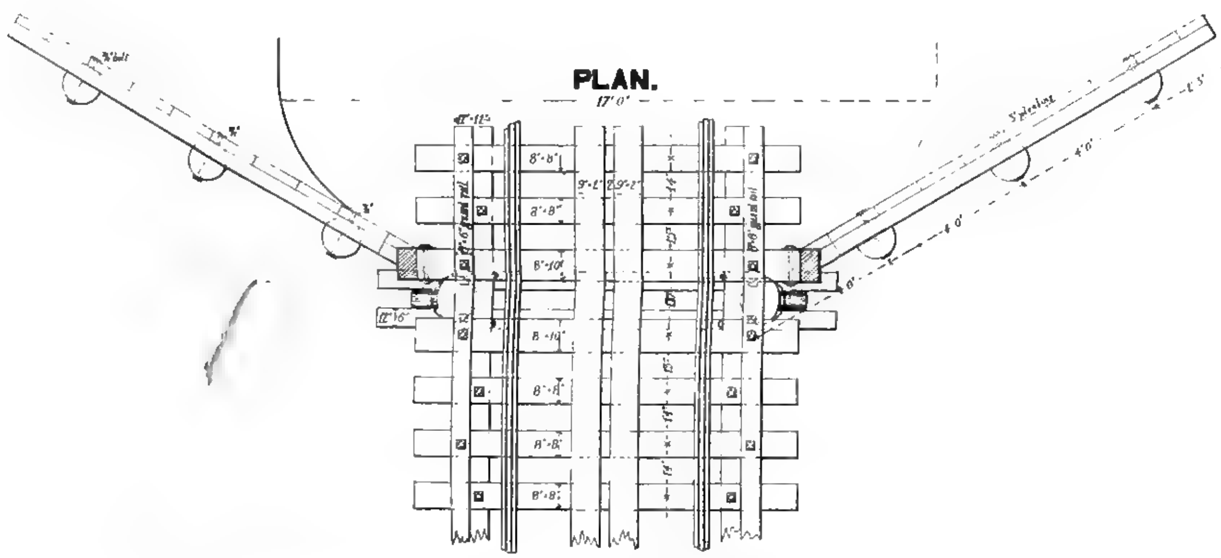
ELEVATION.



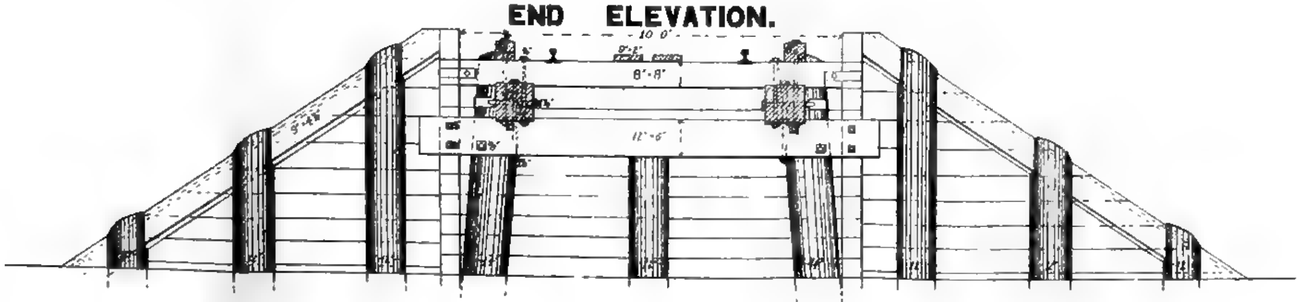
CROSS SECTION.



PLAN.

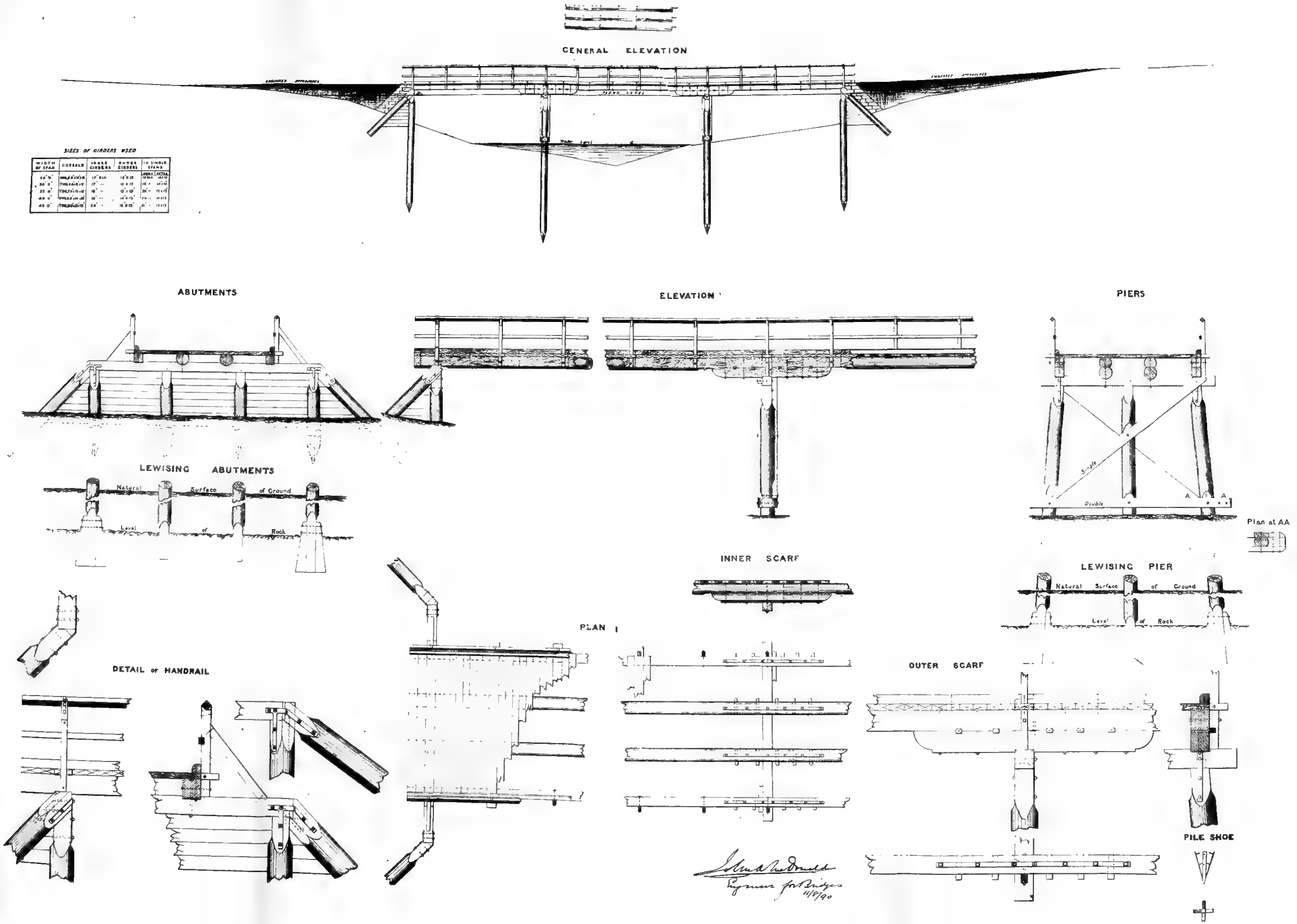


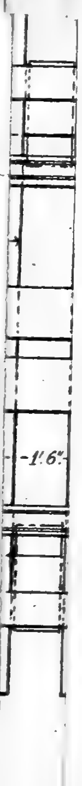
END ELEVATION.



W. H. Ledger. 15-8-91

TIMBER BEAM BRIDGE

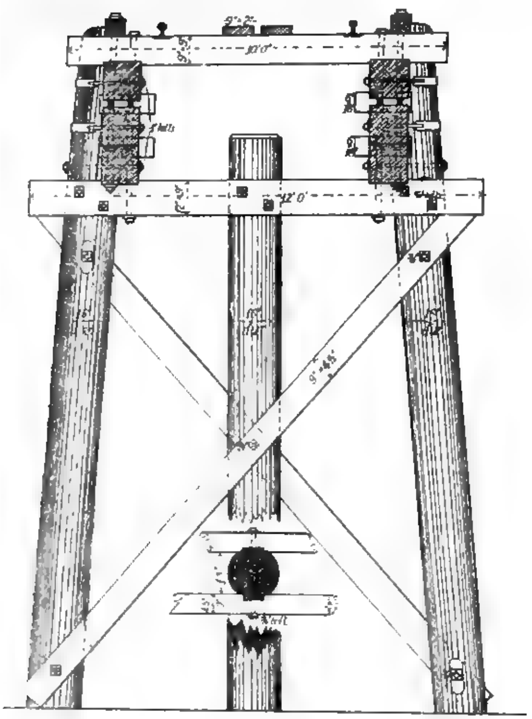



1'6"

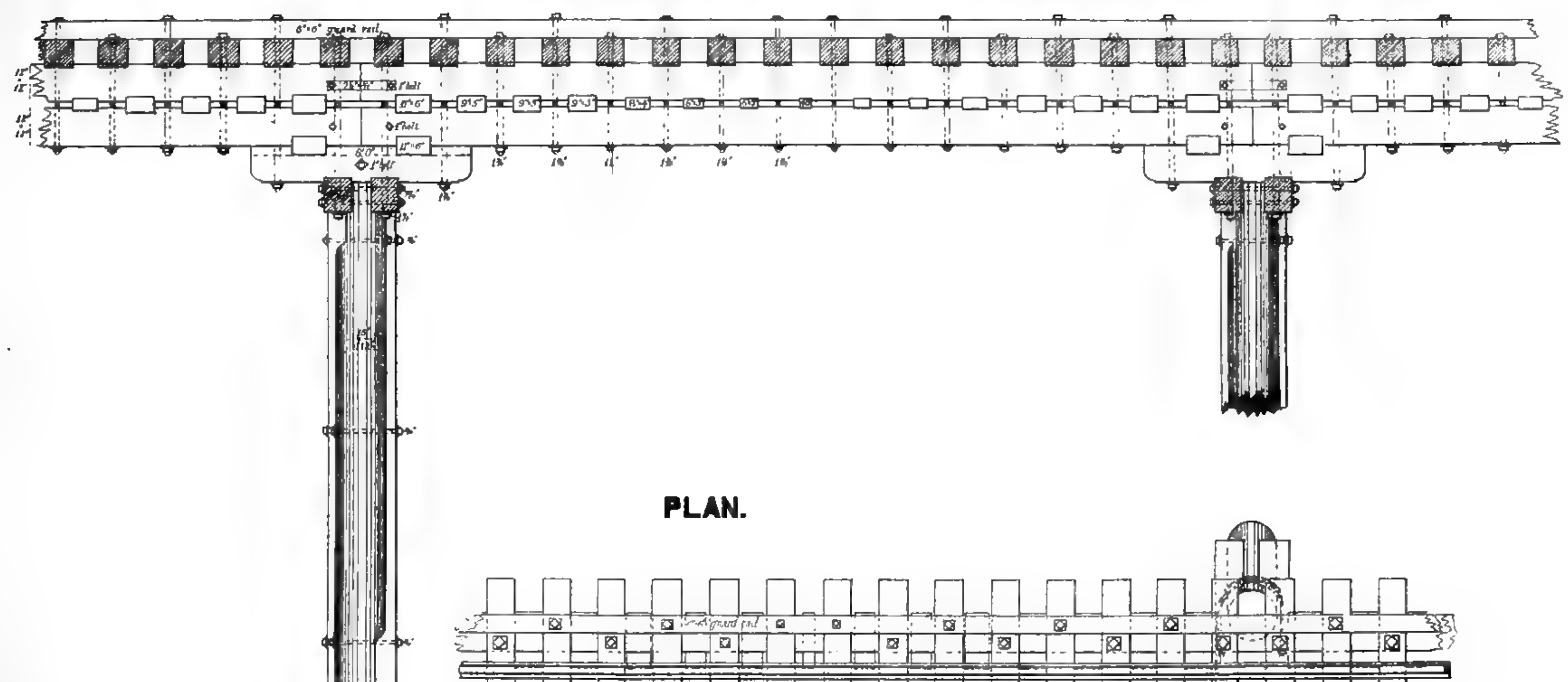
DESIGN FOR TIMBER VIADUCT.

24 FEET CENTRES.

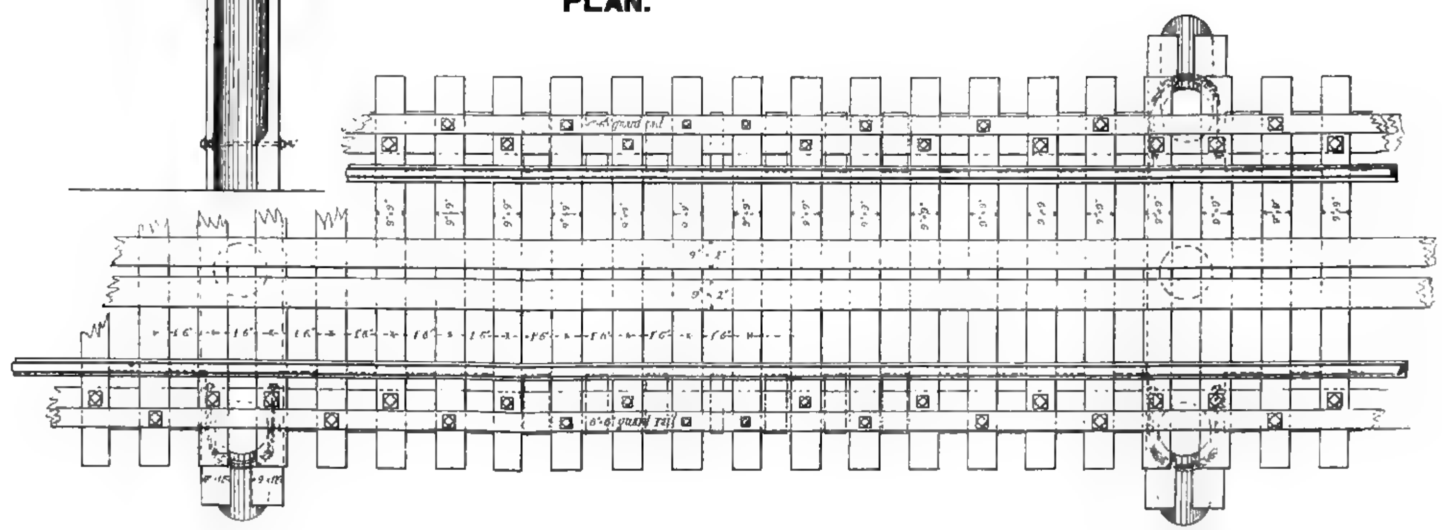
CROSS SECTION.



ELEVATION.



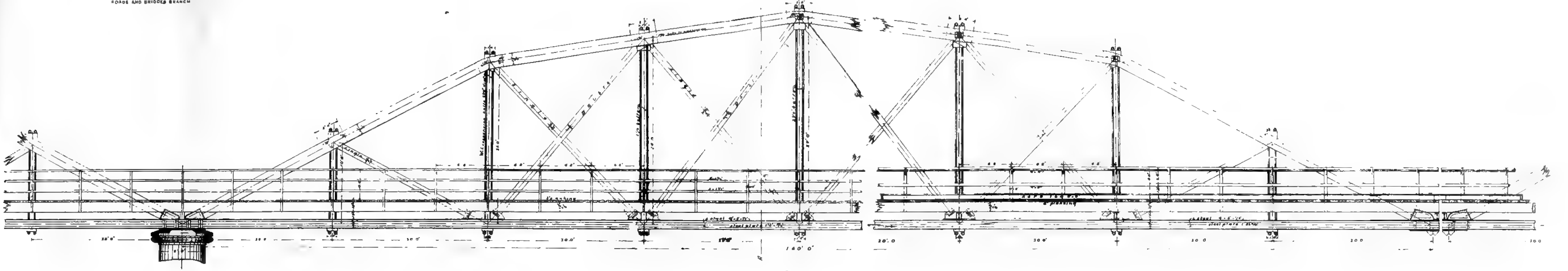
PLAN.



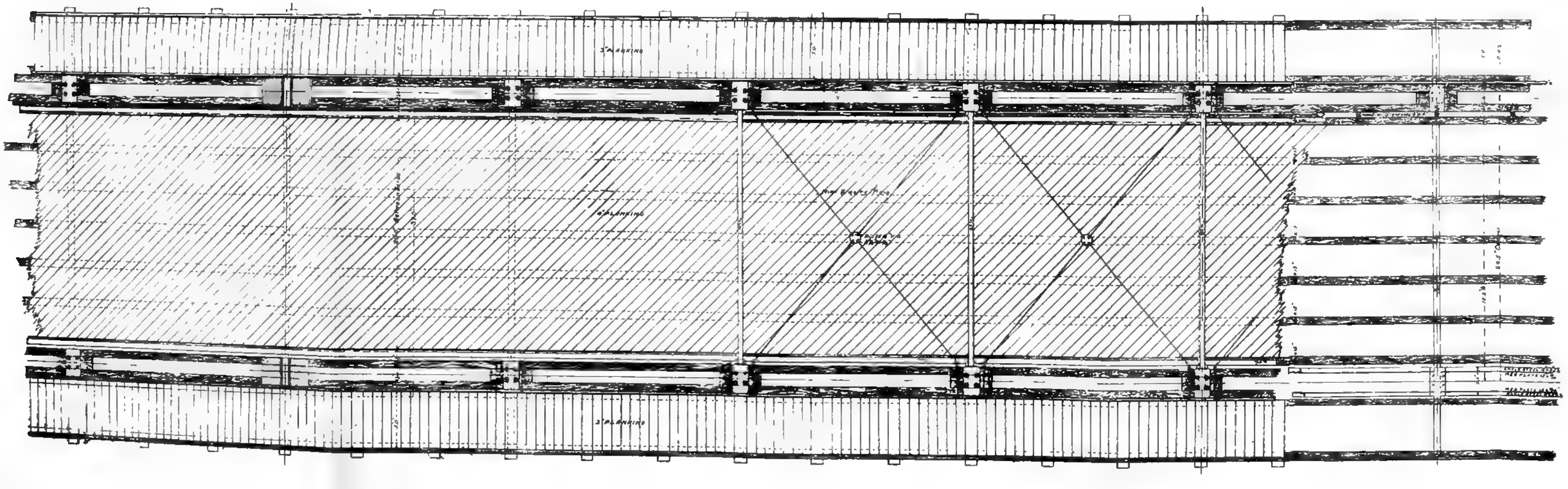
COMPOSITE TRUSS 160'0" SPAN

DEPARTMENT OF PUBLIC WORKS
ROADS AND BRIDGES BRANCH

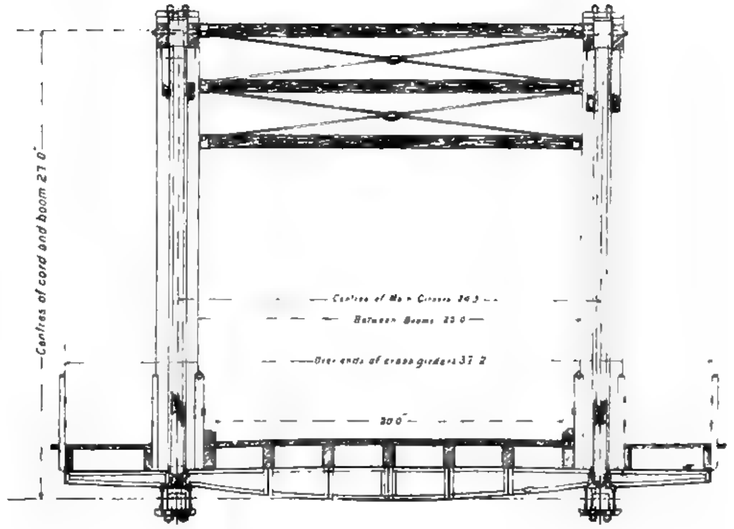
Scale 4 feet to 1 inch



ELEVATION



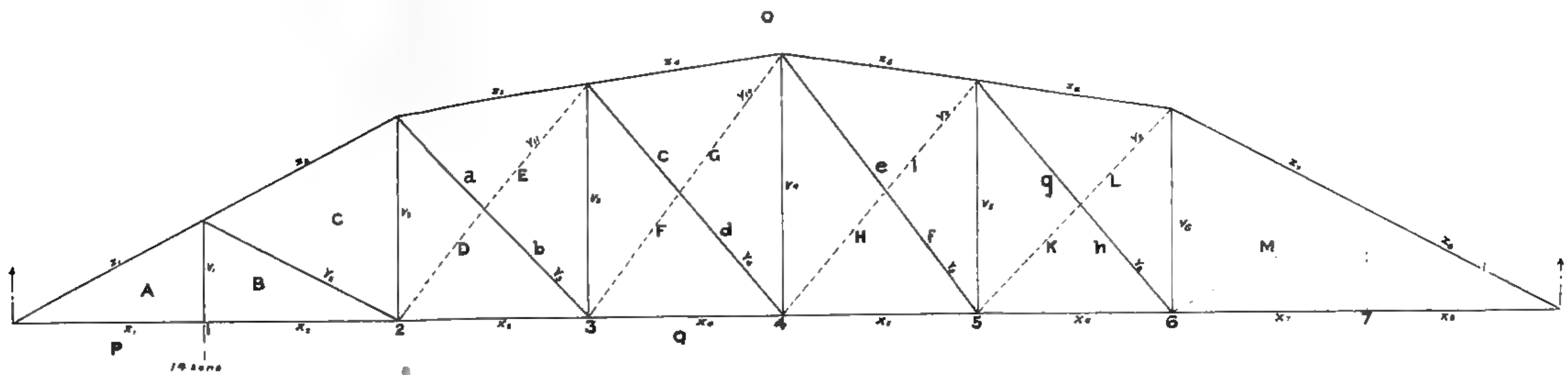
PLAN



CROSS SECTION ON LINE AA

COMPOSITE TRUSS 160 FEET SPAN

Scales

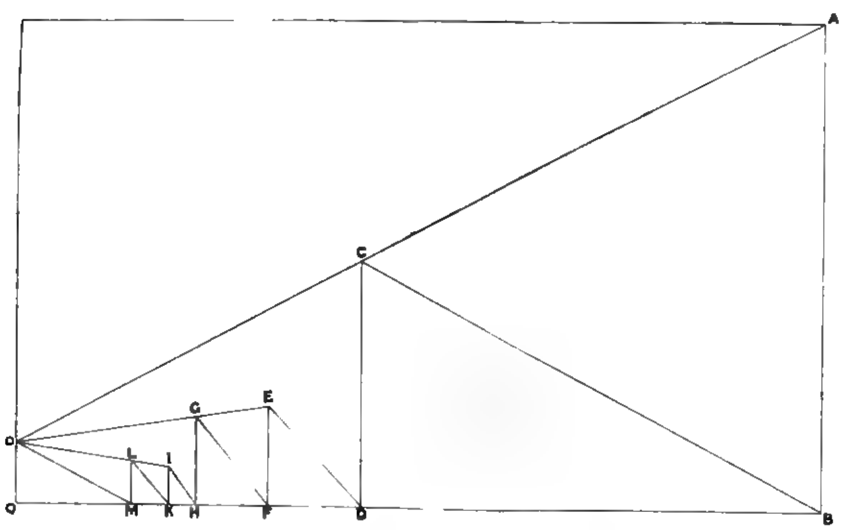


Small letters refer to spaces separated by dotted lines

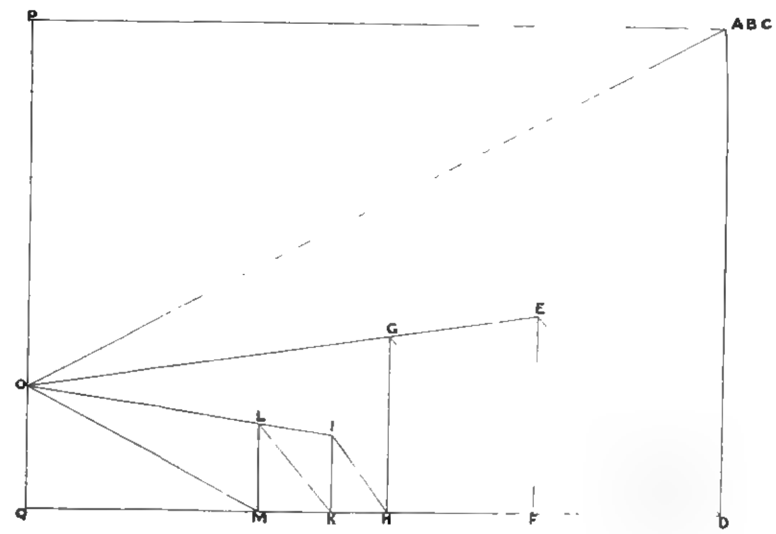
DIAGRAMS FOR DEAD LOAD

Scale 2 tons to one Inch

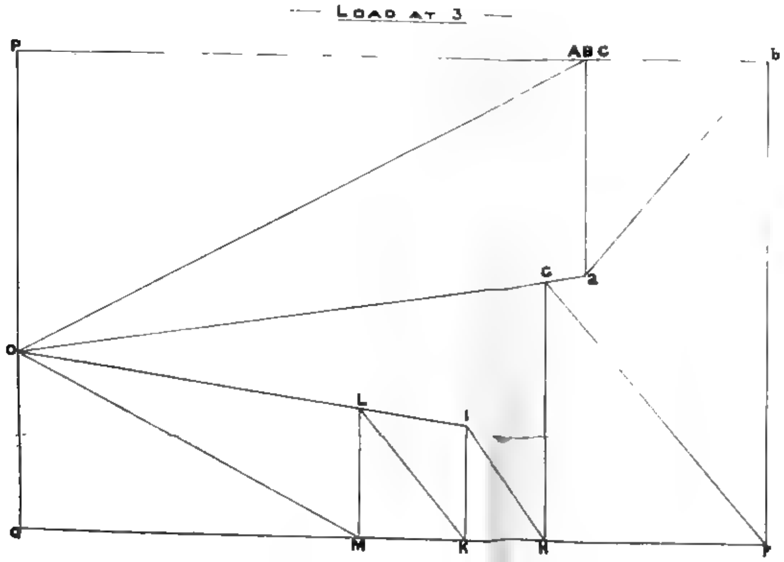
Load at 1



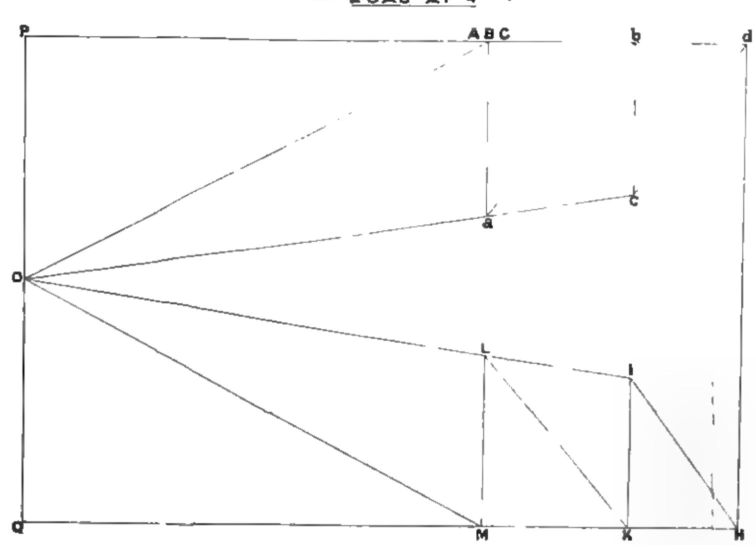
Load at 2



Load at 3



Load at 4



Jour

160 FT. COMPOSITE TRUSS

1/4" Scale

Effective Area of Steel shown thus [hatched square]

" " Timber " " [open square]

The Curve of Areas shews effective areas corresponding to actual stresses.

Maximu stresses are taken due to distributed and rolling live load.

Centres of Main Girders 24.5'. Width of Roadway 20' 0". Two Footways each 5' 0"

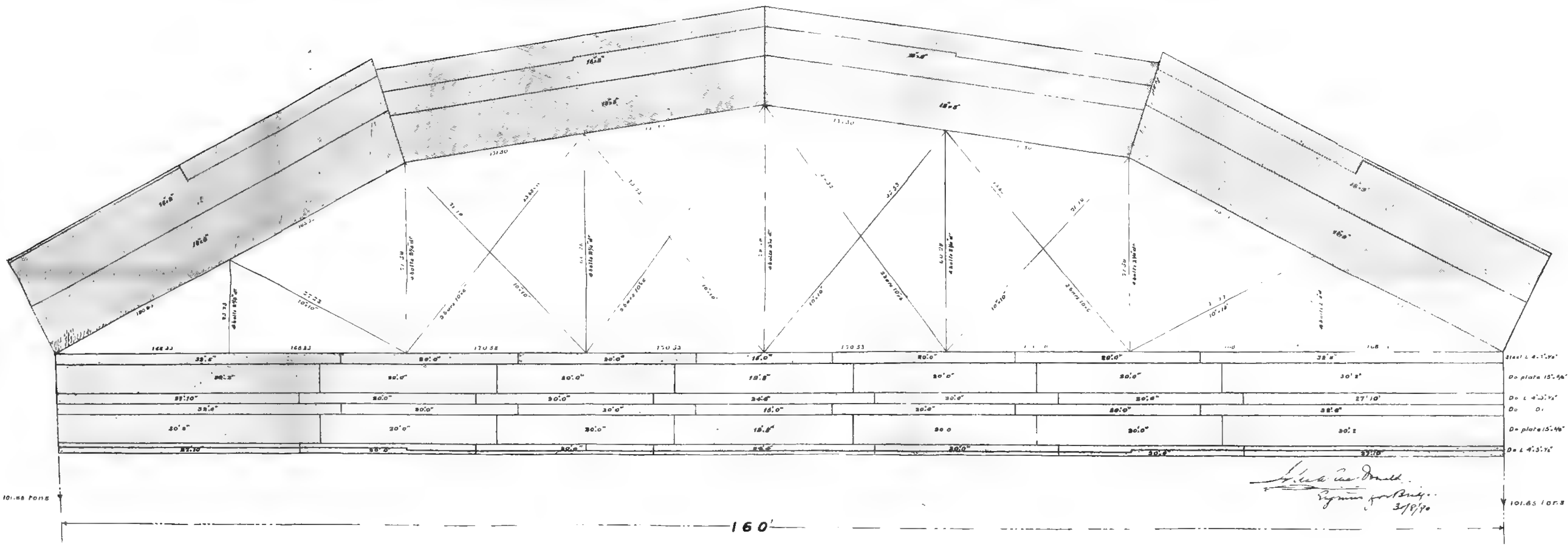
Pitch of cross girders 20' 0". Depth of main girders at centre 27' 0"

Distributed live load 84 lbs per □ feet. ·563 tons per foot run on each main girder

Dead load ·701 do do

Dead and distributed live load [illegible] 1.264 do do

Concentrated load due to traction engine 16 tons; 9½ tons on driving wheels.

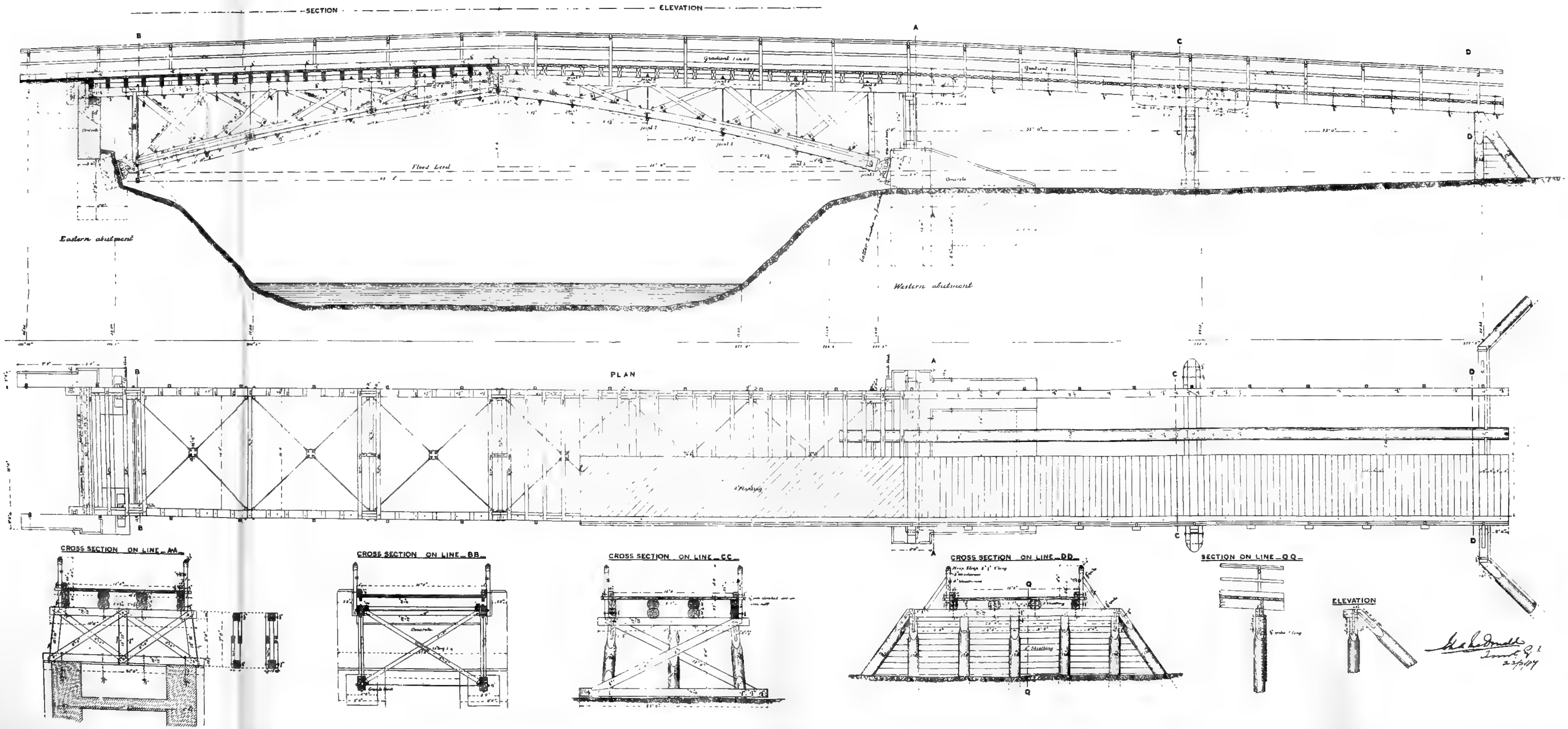


Journal Royal Society N S W Vol XXIV Plate XI

BROUGHTON MILL CREEK

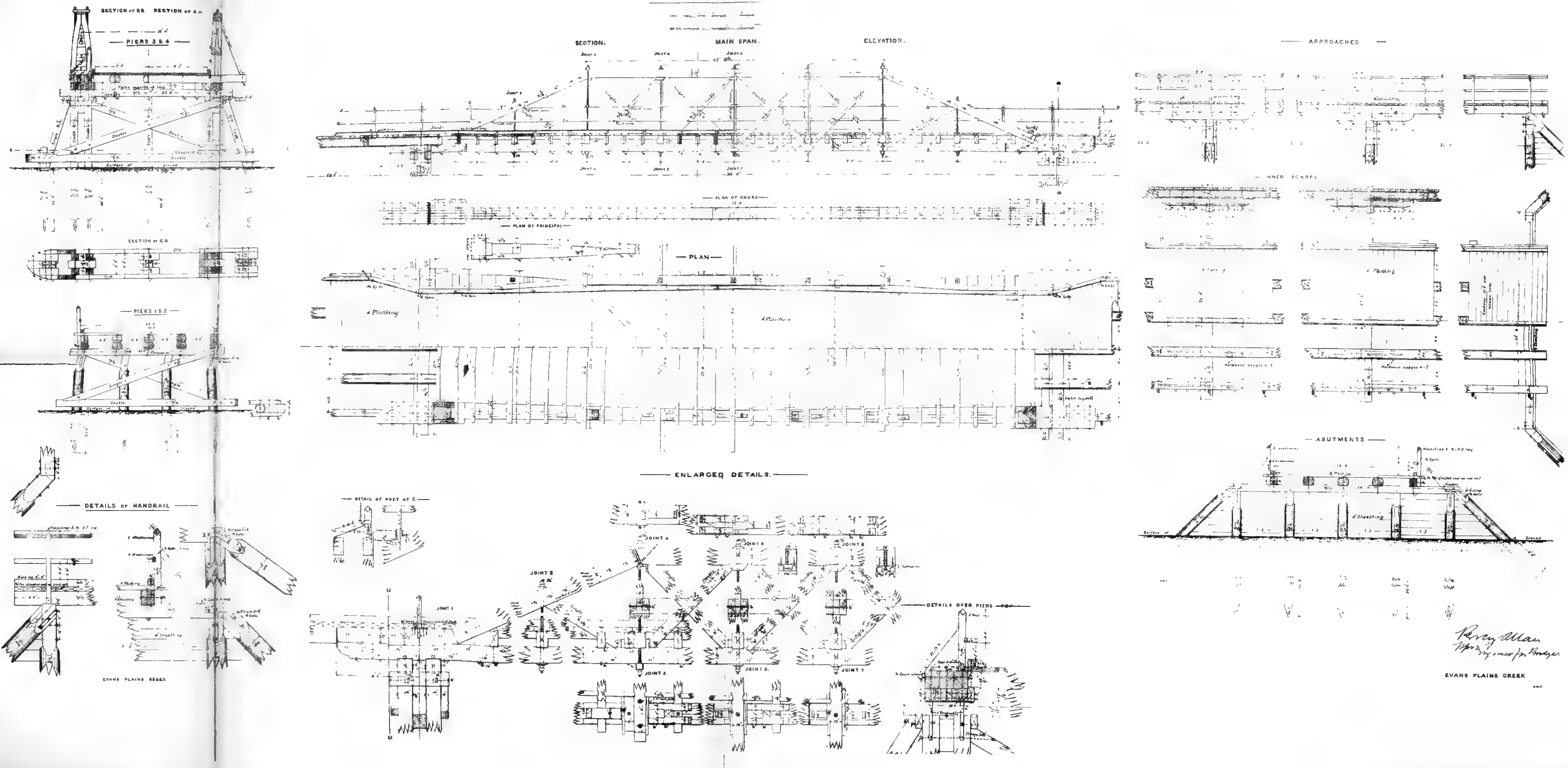
3 HINGED ARCH BRIDGE. SPAN 95 FEET 4 INCHES

SCALE



ROADS AND BRIDGES DEPT

BRIDGE OVER EVAN'S PLAINS CREEK
AT DUNKELD



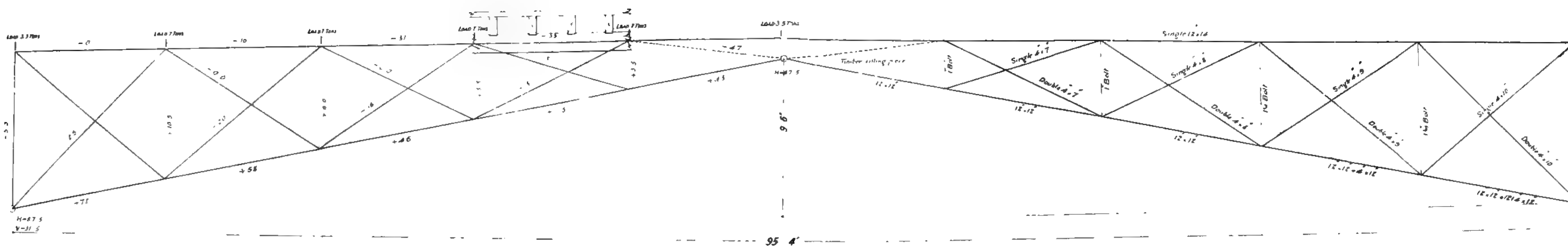
OU

ST

BROUGHTON CREEK

STRESS DIAGRAM

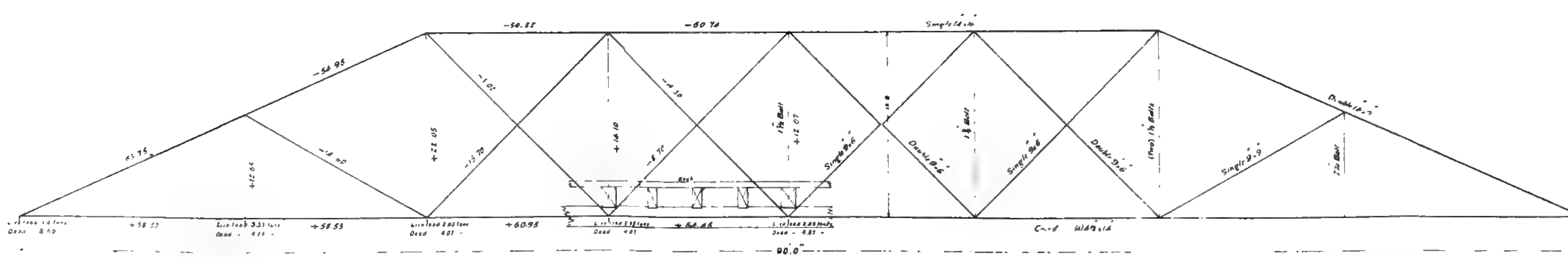
Centre of Ribs 15.4'
Width of Road 15.0'
Live load at 84 lbs per square foot of Road

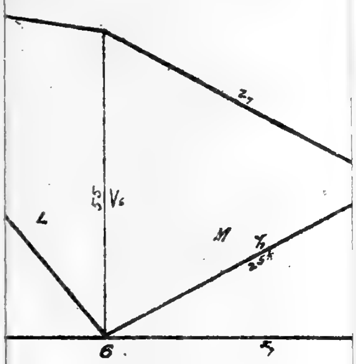


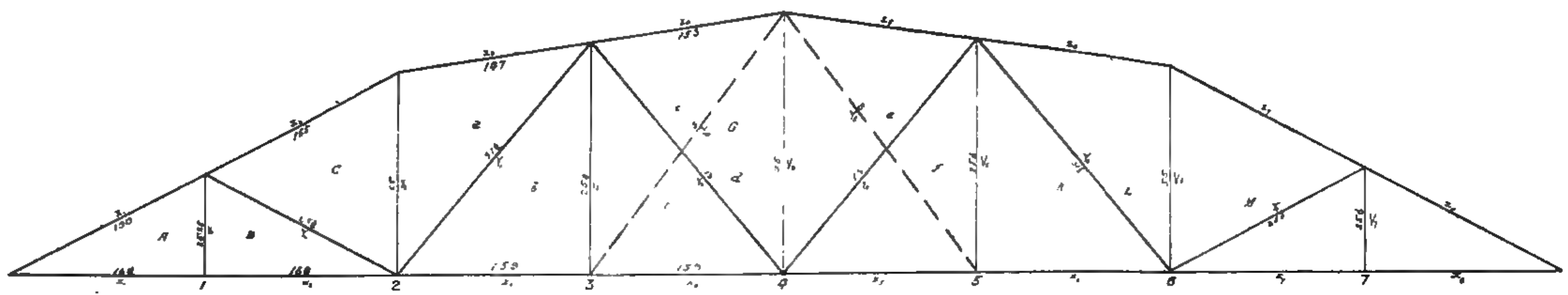
90 TIMBER TRUSS

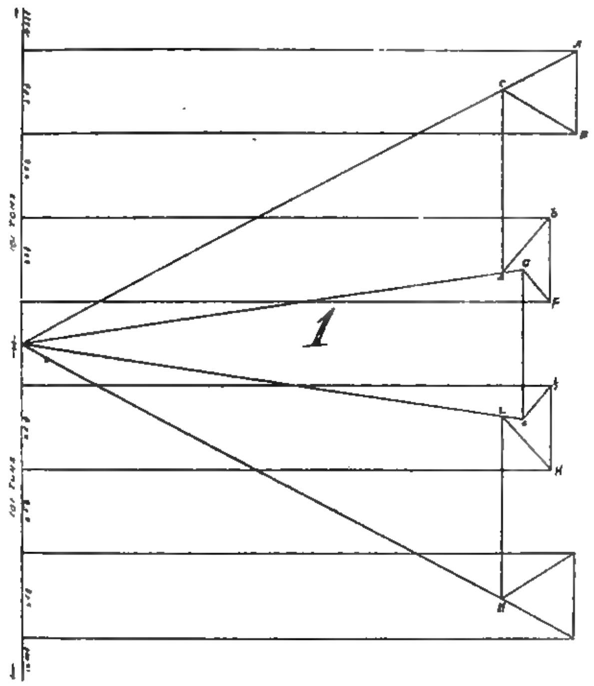
STRESS SHEET

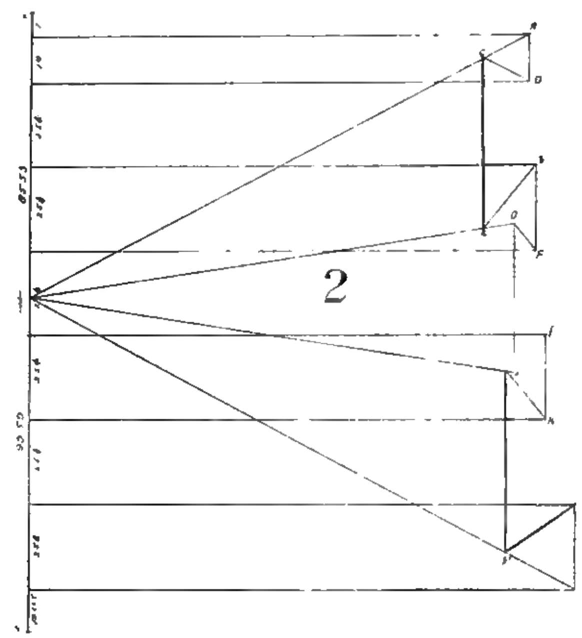
Centres of Trusses 9.0"
Width of Roadway 15.0" clear
Live load at 84 lbs per sq foot of roadway
Traction engine 18 tons

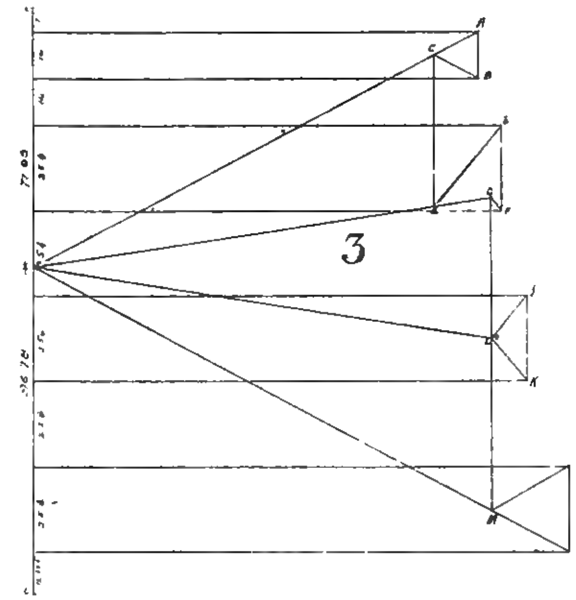


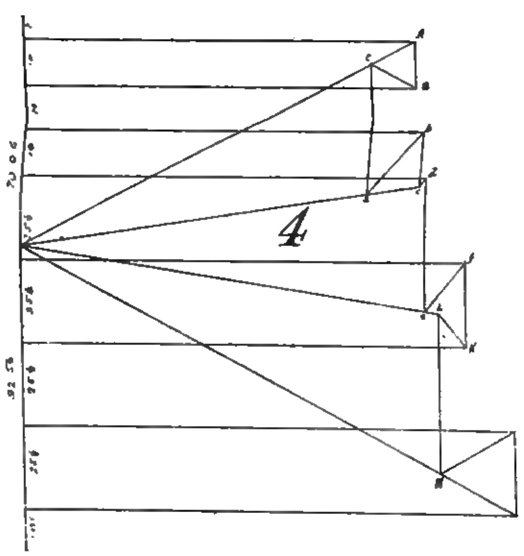

L
M
6







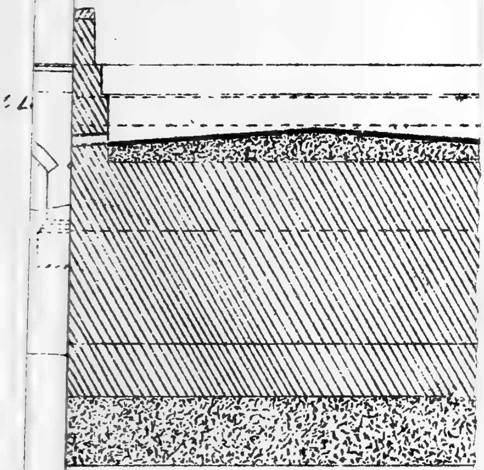




Stress Diagram 1 for full Load
" " 2 live load removed from apex 1
" " 3 " " " " apices 1 & 2
" " 4 " " " " " 1, 2 & 3

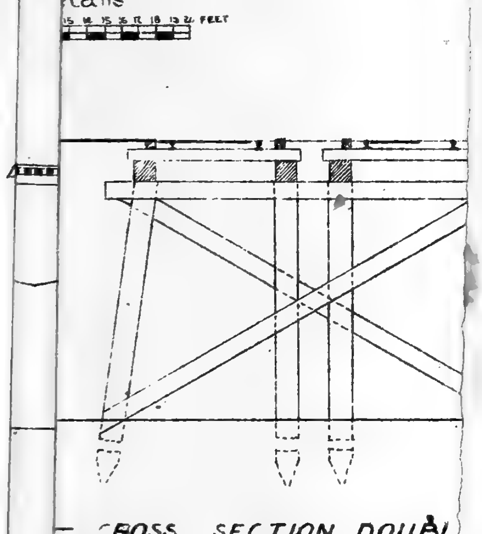
Scale of Truss 10 feet = One Inch
" " Stresses 30 tons = " "

James S. Haycroft
M.E., Q.U.I.
Assoc. M. Inst. C.E.
27th Feb 1890

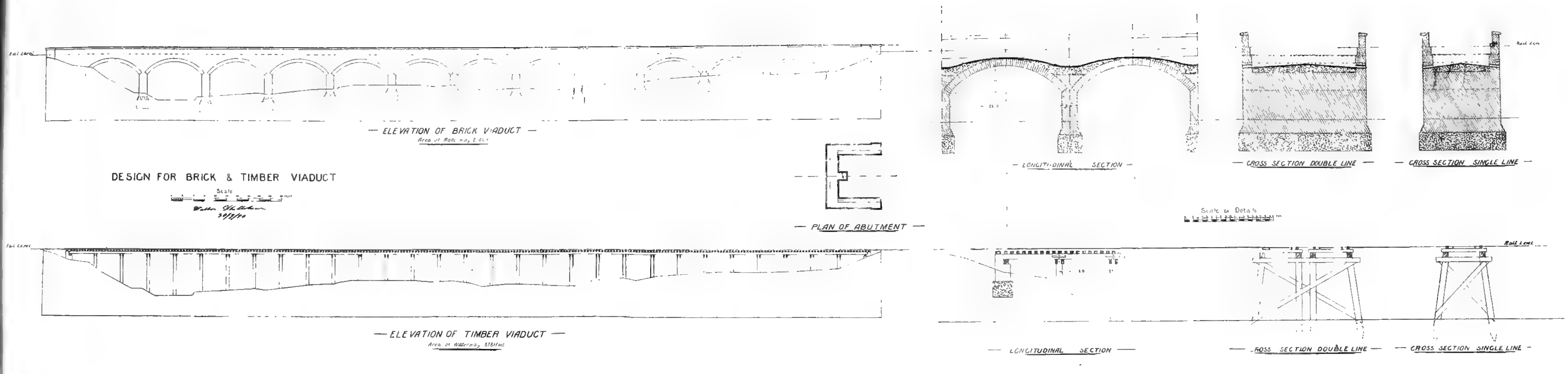


CROSS SECTION DOUBLE L

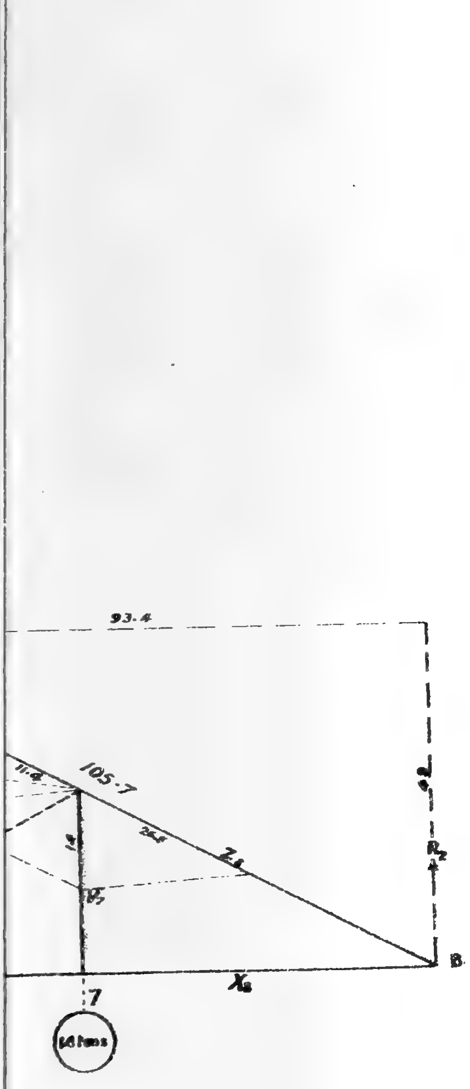
tails



CROSS SECTION DOUBL


ELEVATION OF BRICK VIADUCT
LONGITUDINAL SECTION
CROSS SECTION DOUBLE LINE
CROSS SECTION SINGLE LINE
DESIGN FOR BRICK & TIMBER VIADUCT
Scale
PLAN OF ABUTMENT
Scale of Details
Rail Level
ELEVATION OF TIMBER VIADUCT
LONGITUDINAL SECTION
CROSS SECTION DOUBLE LINE
CROSS SECTION SINGLE LINE

Journal Royal Society N.S.W. Vol Plate XVI.



COMPOSITE TRUSS 160 FEET SPAN

Scale for truss

Do stresses

Reference

Triangles of forces for direct dead loads

Do do live do

Do for transmitted dead do

Do do live do

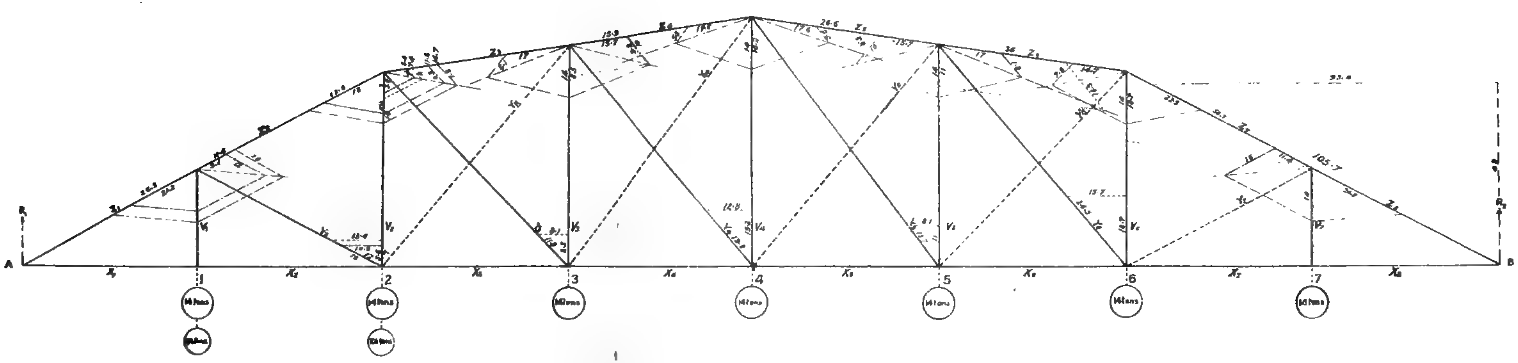
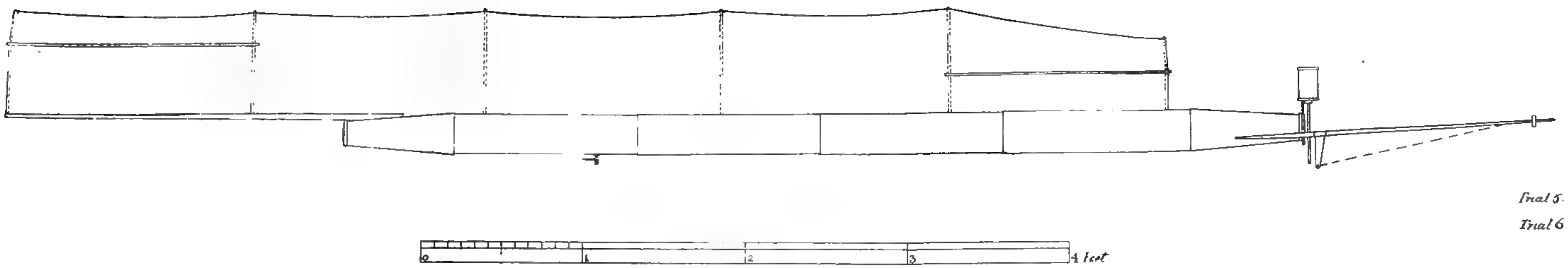


Diagram I.

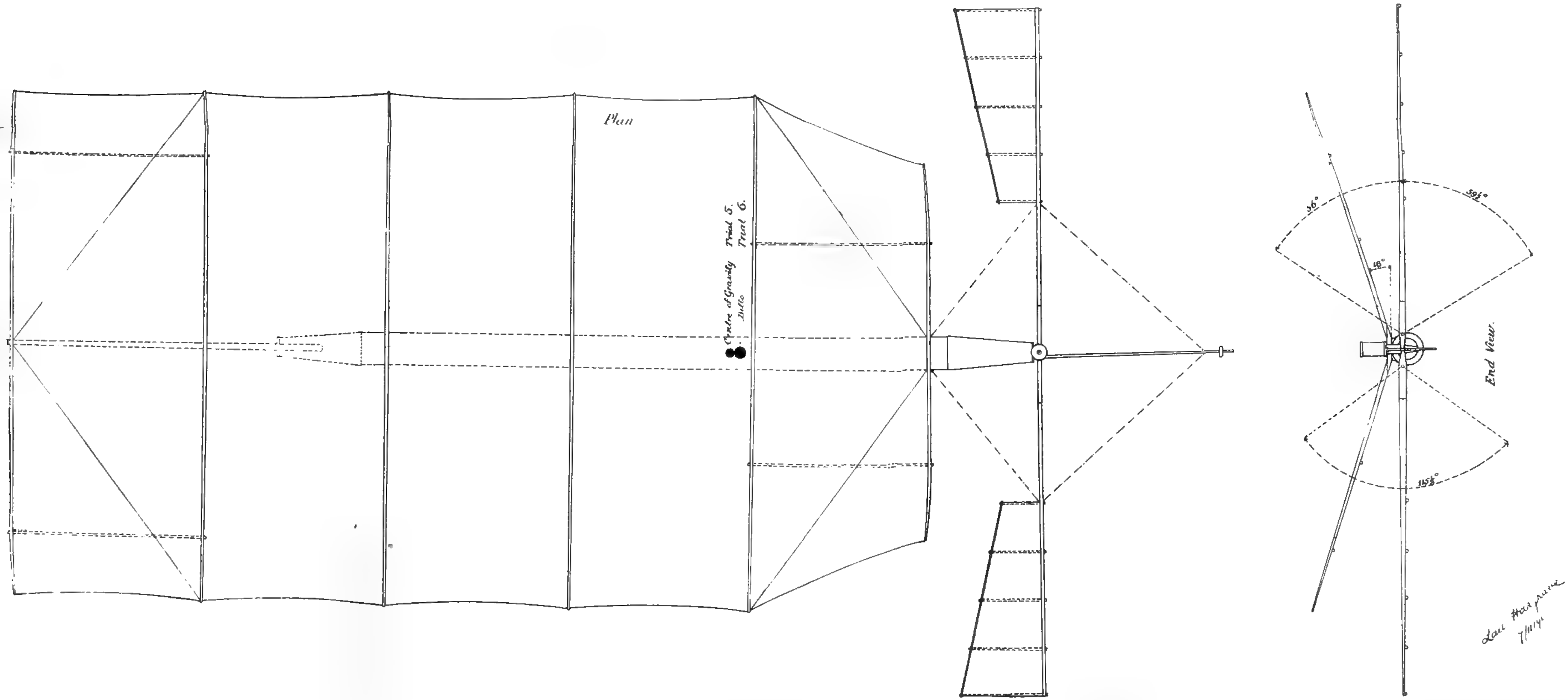
Side View.



Scale.

Vibratory flying-machine

	Total weight Trial 5 {charged}	[illegible]46 lb
	" " " 6 "	4·620 lbs
	Area of the body	4050 sq. ins
	Area of the wings	21[illegible] sq. ins
	Total area	42[illegible] " ins
Trial 5.	Area in advance of Centre of Gravity	972 sq. ins – 22·9 %
Trial 6	" " " " " " "	930 " – 21·8 %



Lau Hargrave
7/11/91

e XVIII.

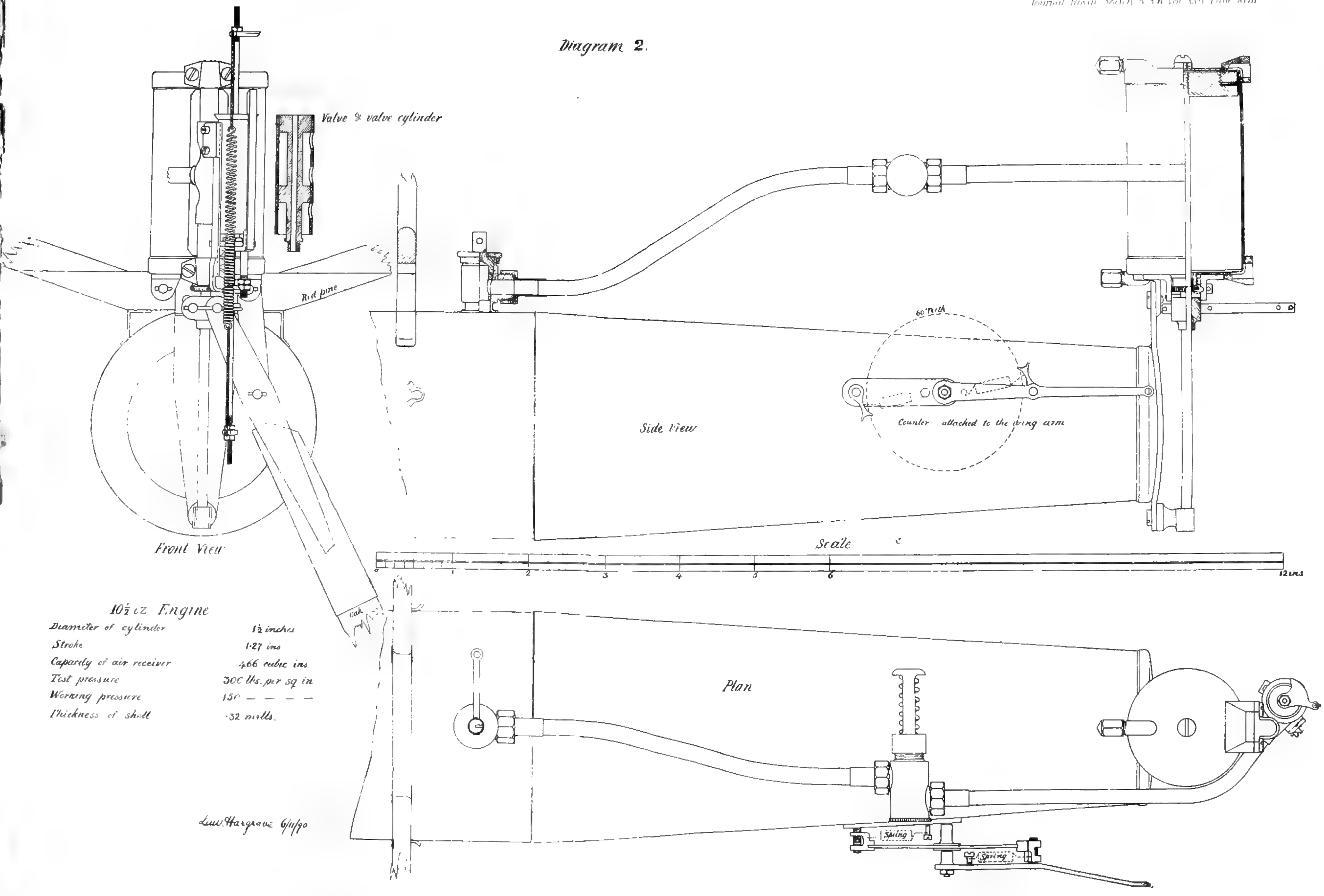
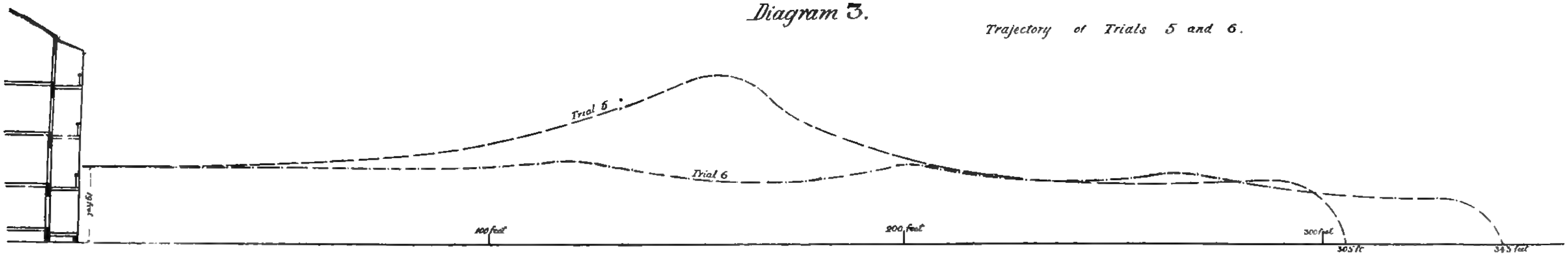


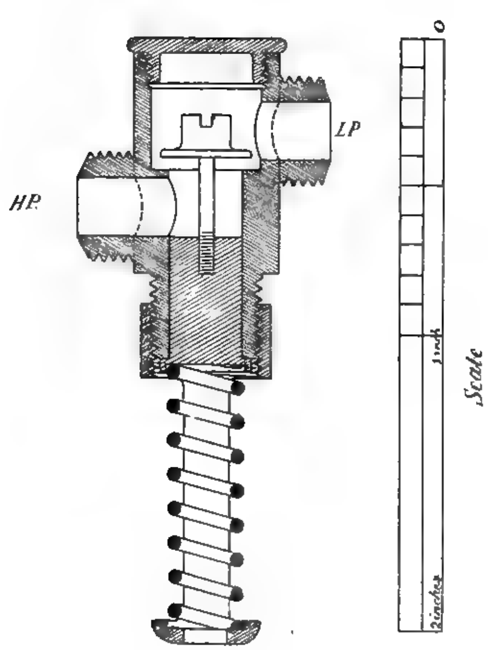
Diagram 2.
Valve & valve cylinder
Red pine
Front View
Oak
60 Teeth
Side View
Counter attached to the wing arm
Scale
0 1 2 3 4 5 6 12 ins
Plan
Spring
Spring
10½ oz Engine
Diameter of cylinder 1½ inches
Stroke 1·27 ins
Capacity of air receiver 466 cubic ins
Test pressure 300 lbs. per sq in
Working pressure 150 — — —
Thickness of shell ·32 mills.
Law. Hargrave 6/11/90

Seconds

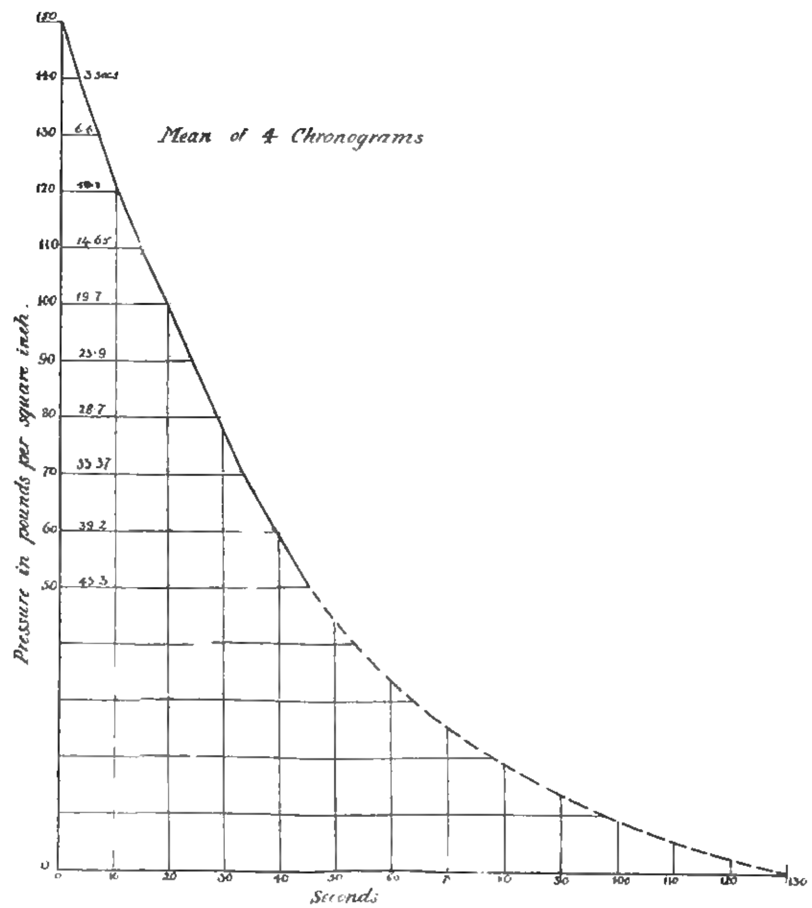
Diagram 3.

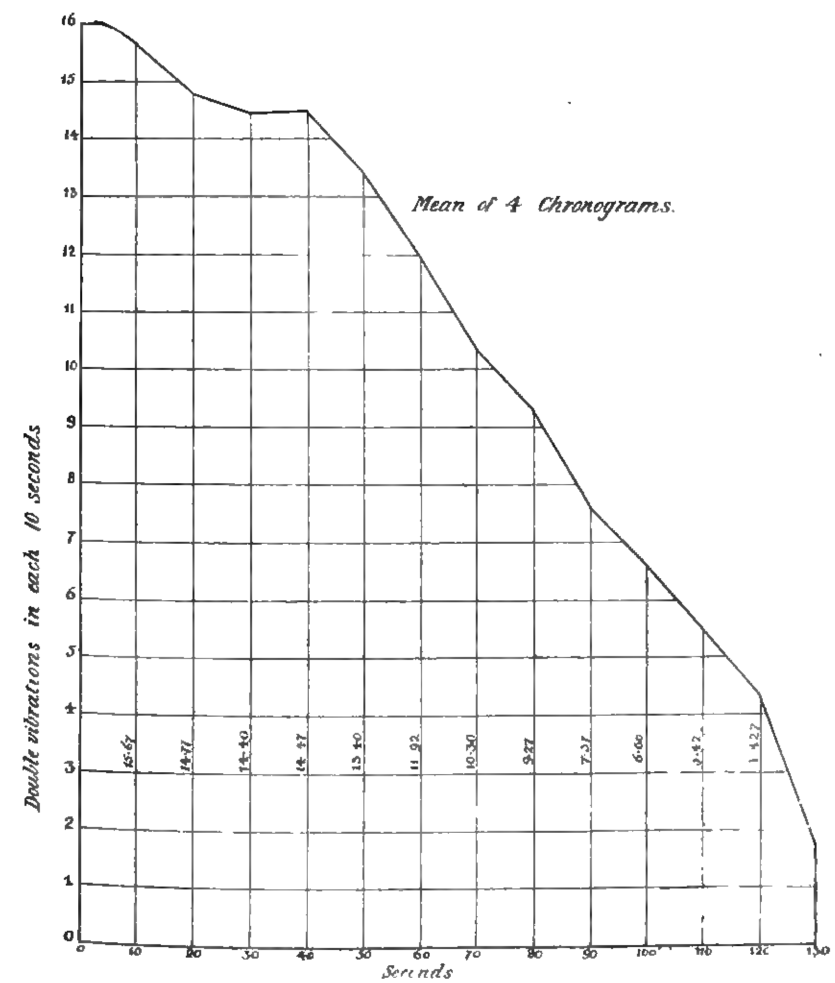
Trajectory of Trials 5 and 6.



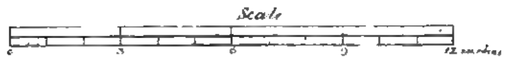


Reducing Valve.

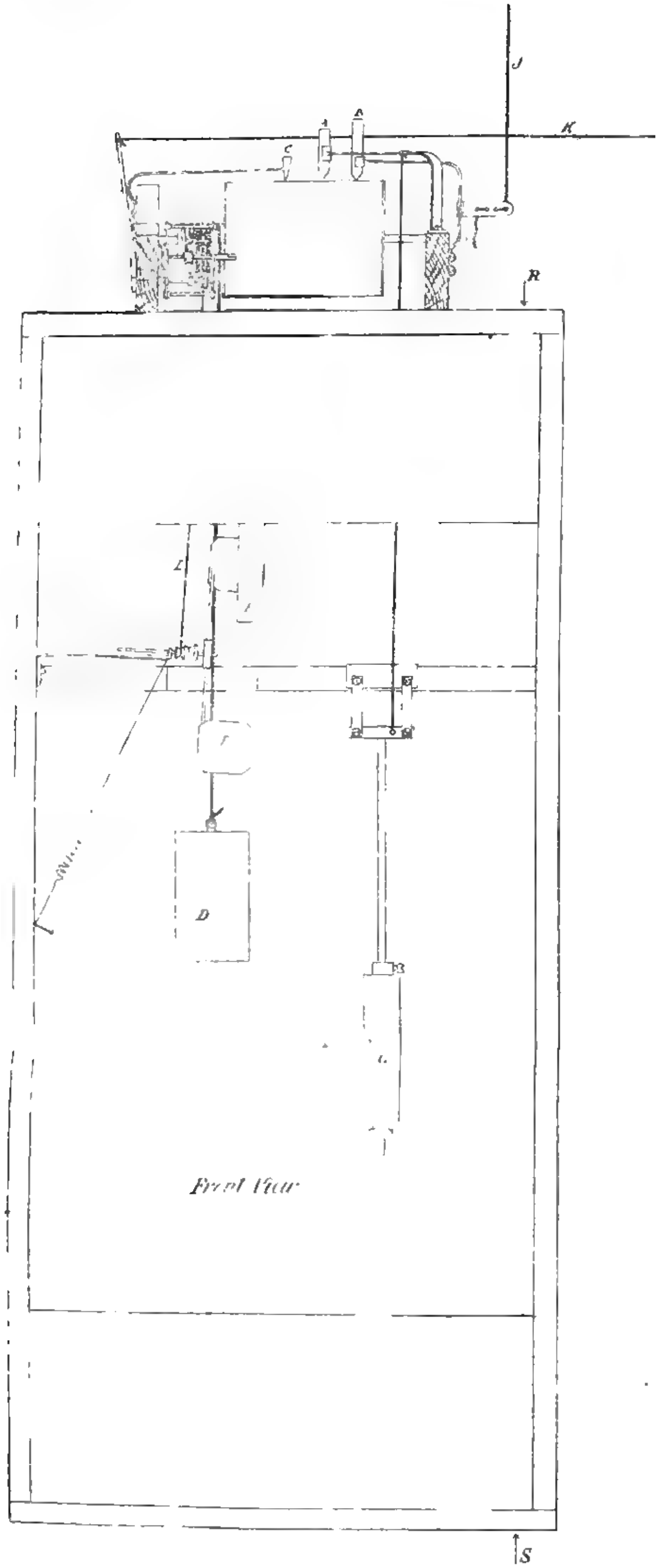


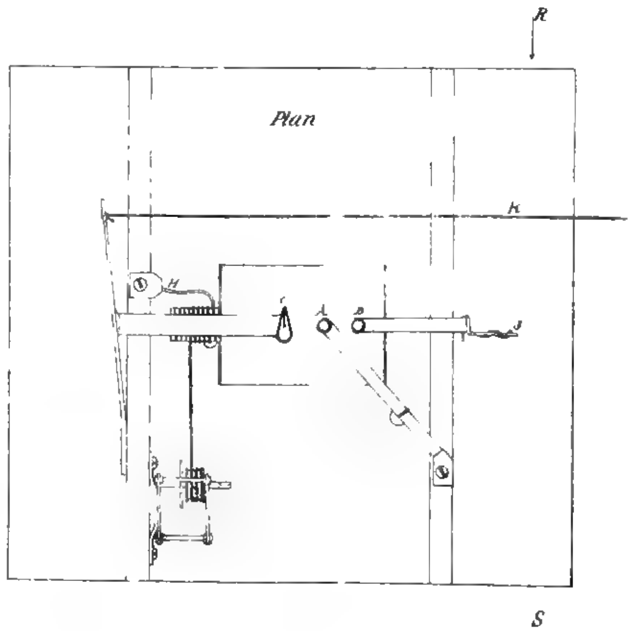


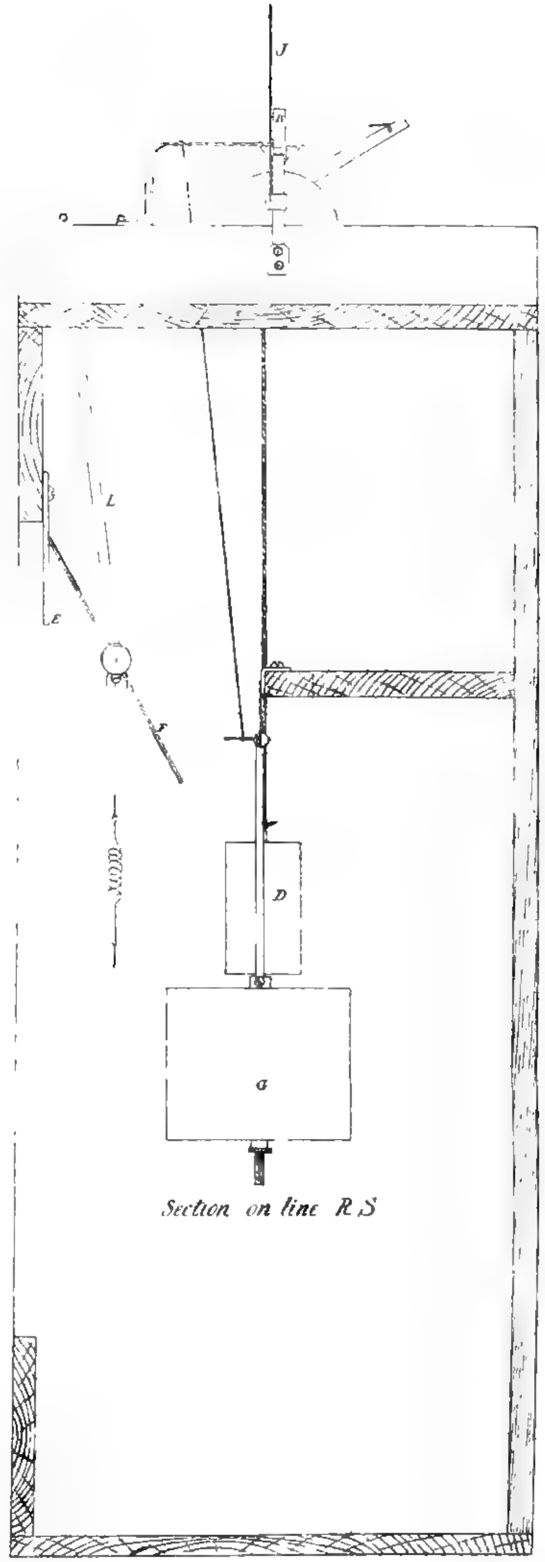
CHRONOGRAPH



- A Glass pen for marking seconds
- B Glass pen for marking double vibrations
- C Fin pen for noting the pressure
- D Driving weight
- E Stop for the clock
- F Fan governor
- G Half-seconds pendulum
- H Catch to make the drum traverse $\frac{1}{8}$ in per revolution
- J String to cross head of the engine
- K String for noting the pressure
- L Thread belt from clock to governor







Law. Hargrave 4/4/90

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WEDNESDAY, (8 p.m.) ...	7	4	2	6	3	1	5	3

SECTION MEETINGS.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
MEDICAL—FRIDAY, (8.15 p.m.) ...	16	20	18	15	19	17	21	19
MICROSCOPY—Monday, (8 p.m.) ...	12	9	14	11	8	13	10	8