JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR

1892.

INCORPORATED 1881.

VOL. XXVI.

EDITED BY

THE HONORARY SECRETARIES.

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

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH.
LONDON:
KEGAN PAUL, TRENCH, TRÜBNER & Co., LIMITED.
PATERNOSTER HOUSE, CHARING CROSS ROAD, LONDON, W.C.

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.

The Director of the Colonial Museum, Harlem, Netherlands, requests that Authors of papers on tropical botany, zoology, &c., will be kind enough to send a printed copy of such paper to that Museum.

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.

ERRATA.

Page	178, first line from the top,		for object read *subject*.
,,	180, seventh	,,	for 23,512,176 read 24,512,176.
,,	199, second line from the bottom,		for dimimish read *diminish*.
,,	205, eighth	,,	top, for stock-yard read *stack-yard*.
,,	209, second	,,	bottom, for *Mendicago* read *Medicago*.
,,	212, ninth	,,	top, for on read *an*.
,,	217, third	,,	,, for found read *once found*.
,,	217, sixth	,,	bottom, for larvæ read *larval*.
,,	226, eighteenth	,,	top, for in read *of*.
,,	234, ,,	,,	,, for *circutarium* read *cicutarium*.
,,	234, nineteenth	,,	bottom, for *Meliotus* read *Melilotus*.
,,	235, eleventh	,,	,, for *porriflolius* read *porrifolius*.
,,	236, second	,,	top, for *currassavica* read *curassavica*.
,,	327, fourth	,,	bottom, for molybdenum read *molybdate*.
,,	327, second	,,	,, for a blue read *no blue colour*.
,,	330, fifth	,,	top, for lead read *bead*.
,,	331, eighth	,,	,, for latter read *former*.
,,	331, ninth	,,	,, for former read *latter*.

PUBLICATIONS.

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

Vol.	I.	Transactions of the Royal Society, N.S.W.,	1867,	pp.	83,		,,
,,	II.	,, ,, ,, ,, ,,	1868,	,,	120,		,,
,,	III.	,, ,, ,, ,, ,,	1869,	,,	173,		,,
,,	IV.	,, ,, ,, ,, ,,	1870,	,,	106,		,,
,,	V.	,, ,, ,, ,, ,,	1871,	,,	72,		,,
,,	VI.	,, ,, ,, ,, ,,	1872,	,,	123,		,,
,,	VII.	,, ,, ,, ,, ,,	1873,	,,	182,		,,
,,	VIII.	,, ,, ,, ,, ,,	1874,	,,	116,		,,
,,	IX.	,, ,, ,, ,, ,,	1875,	,,	235,		,,
,,	X.	Journal and Proceedings ,, ,,	1876,	,,	333,		,,
,,	XI.	,, ,, ,, ,, ,,	1877,	,,	305,		,,
,,	XII.	,, ,, ,, ,, ,,	1878,	,,	324,	price	10s. 6d.
,,	XIII.	,, ,, ,, ,, ,,	1879,	,,	255,	,,	10s. 6d.
,,	XIV.	,, ,, ,, ,, ,,	1880,	,,	391,	,,	10s. 6d.
,,	XV.	,, ,, ,, ,, ,,	1881,	,,	440,	,,	10s. 6d.
,,	XVI.	,, ,, ,, ,, ,,	1882,	,,	327,	,,	10s. 6d.
,,	XVII.	,, ,, ,, ,, ,,	1883,	,,	324,	,,	10s. 6d.
,,	XVIII.	,, ,, ,, ,, ,,	1884,	,,	224,	,,	10s. 6d.
,,	XIX.	,, ,, ,, ,, ,,	1885,	,,	240,	,,	10s. 6d.
,,	XX.	,, ,, ,, ,, ,,	1886,	,,	396,	,,	10s. 6d.
,,	XXI.	,, ,, ,, ,, ,,	1887,	,,	296,	,,	10s. 6d.
,,	XXII.	,, ,, ,, ,, ,,	1888,	,,	390.	,,	10s. 6d.
,,	XXIII.	,, ,, ,, ,, ,,	1889,	,,	534,	,,	10s. 6d.
,,	XXIV.	,, ,, ,, ,, ,,	1890,	,,	290,	,,	10s. 6d.
,,	XXV.	,, ,, ,, ,, ,,	1891,	,,	348,	,,	10s. 6d.
,,	XXVI.	,, ,, ,, ,, ,,	1892,	,,	426,	,,	10s. 6d.

CONTENTS.

VOLUME XXVI.

The Royal Society of New South Wales.

OFFICERS FOR 1892-93.

Honorary President:

HIS EXCELLENCY THE RIGHT HON. THE EARL OF JERSEY.
G.C.M.G.

President:

PROF. WARREN, M. Inst., C.E., Wh. Sc.

Vice-Presidents:

C. W. DARLEY, M. Inst. C.E.	PROF. LIVERSIDGE, M.A., F.R.S.
PROF. T. W. E. DAVID, B.A., F.G.S.	H. C. RUSSELL, B.A., C.M.G., F.R.S.

Hon. Treasurer:

ROBERT HUNT, C.M.G., F.G.S.

Hon. Secretaries:

F. B. KYNGDON	PROF. ANDERSON STUART, M.D.

Members of Council:

JAMES GRAHAM, M.A., M.D. *Edin.*	J. H. MAIDEN, F.L.S., F.C.S.
W. M. HAMLET, F.C.S., F.I.C.	CHARLES MOORE, F.L.S., F.Z.S.
A. LEIBIUS, PH.D., M.A., F.C.S.	J. ASHBURTON THOMPSON, M.D.
J. A. McDONALD, M. Inst. C.E.	PROF. THRELFALL, M.A.
H. G. McKINNEY, M.E., M. Inst. C.E.	H. G. A. WRIGHT, M.R.C.S.E., &c.

Assistant Secretary:

W. H. WEBB.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

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

Vice President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.

1878 Professor Sir Richard Owen, K.C.B., F.R.S., Hampton Court.

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

1880 Professor Huxley, F.R.S., The Royal School of Mines, London, 4 Marlborough Place, Abbey Road, N.W.

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

1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G , M.D., PH.D., F.R.S , F.L.S., Government Botanist, Melbourne.

1884 Alfred R. C. Selwyn. LL.D., F.R.S., F.G.S., Director of the Geological 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.

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

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

ANNIVERSARY ADDRESS.

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

[Delivered to the Royal Society of N.S. Wales, May 4, 1892.]

This is the third time that I have had the honour of addressing you from the President's Chair, and I can only regret that I am unable to bring to the duties which devolve upon me the qualifications which, in my opinion, the President of a large and influential Society like ours should possess.

I had proposed to myself as a subject for this address a short *resumé* of the results of scientific work in New South Wales during the past year, but I soon found that the subject was far too large, unless I could count upon your undivided attention for three or four hours. That, of course was out of the question, and I have made an effort to condense it to the ordinary limits of an address from this Chair, and, I fear, that in many places I have been obliged to omit much that would, under other circumstances have been interesting to you and most valuable as a record for reference. It is a matter for congratulation that our Society maintains its position, and is increasing its influence, and that in spite of the general depression which has brought about the resignation of many members, we have not only kept up, but considerably increased our members during the past year.

We have lost by death one honorary and eleven ordinary members. Eleven have resigned, and no less than eighteen have ceased to be members by non-payment of subscriptions, making a loss of forty contributing members. On the other hand we have gained by election sixty-one new members; so that while we had on the roll at the end of last year four hundred and fifty-seven, they number to-night four hundred and seventy-eight. Of those who have passed away several were of world-wide fame and held in very high esteem amongst us.

Honorary Member:

	Elected.	Died.
Sir George Biddell Airy, M.A., F.R.S.	1884,	4 Jan. 1892

Ordinary Members:

Abbott, T. K.,	1877,	1 Aug. 1891
Allwood, Rev. Canon, B.A.,	1856,	27 Oct., 1891
Campbell, Alexander,	1876,	8 Nov. 1891
Collie, Rev. Robert, F.L.S.,	1878,	18 Apr. 1892
Delarue, L. H.,	1881,	12 July 1891
Hay, Sir John, K.C.M.G., M.L.C., M.A.,	1874,	20 Jan. 1892
Josephson, J. Frey, F.G.S.,	1863,	26 Jan. 1892
Neill, William,	1873,	24 Mar. 1892
Robertson, Thomas	1871,	1 Oct. 1891
Wilkinson, C. S., F.G.S., F.L.S.,	1874,	26 Aug. 1891
Woodhouse, E. B.,	1879,	23 July 1891

The Society has sustained a great loss in the death of one of its most distinguished Honorary Members. Sir GEORGE BIDDELL AIRY, M.A. *Cantab.* Senior Wrangler and First Smith's Prizeman, K.C.B. D.C.L. *Oxon.*, LL.D. *Cantab. et Edin.*, F.R.S.; made Fellow in 1836, and 1871 to 1873 President of the Royal Society, Fellow of the Council of the Royal Astronomical Society, 1830 to 1886; President of the Royal Astronomical Society five times; one of the eight Foreign Members of the French Institute; Corresponding Member of many foreign academies, &c., &c.; received the Copley Medal of the Royal Society 1831. Twice he was awarded the Gold Medal of the Royal Astronomical Society. Received the Lalande Medal of the French Académie des Sciences. Was awarded the Albert Medal of the Society of Arts, and in 1875 was presented with the Freedom of the City of London.

George Biddell Airy was born 27th July 1801, and died Jan. 1892. Very early in his school days he gave indications of his great mathematical ability, and having acquitted himself with great credit at school, in 1819 he entered Trinity College, Cambridge, as a sizar. His college career was a most distinguished one. In 1822 he was made a Foundation Scholar, and in 1823 graduated as Bachelor of Arts with the honours of Senior Wrangler and First Smith's Prizeman, coming out so far ahead of the second man that virtually he was without a rival competitor. In 1824 he was made a Fellow of Trinity College and appointed to the Lucasian Chair of Mathematics. Here he distinguished himself by his contributions to "Optics." In one of his papers at this time he announced his discovery of an optical malady of the human eye, now known as "astigmatism," and provided a remedy for it. In 1828 he resigned his position to accept that of Plumian Professor of Astronomy and Superintendent of the newly-erected Cambridge Observatory. His ability, energy, and singularly methodical habits introduced so many improvements into observatory practice in this position as to make this period of his life quite an epoch in modern astronomy.

In 1835, Mr. Pond, the Astronomer Royal died, and the Prime Minister at once conferred the appointment upon Mr. Airy. The appointment warrant contained the old clause which had been in the first warrant of appointment of Astronomer Royal for England in which he was directed "to apply himself with the most exact care and diligence to the rectifying the tables of the motions of the heavens and the places of the fixed stars in order to find out the so much desired longitude at sea for the perfecting the art of navigation." Greenwich Observatory was established two hundred and seventeen years ago, and Mr. Airy throughout the forty years he was Astronomer, felt that his primary duty was to carry out these instructions. It is needless to say that in his new capacity he entirely reorganized the Observatory: furnished it with new and powerful instruments of his own design, and from time to time added new departments—extrameridian observations, spectroscopy, solar photography, magnetism, meteorology, &c., &c., as the progress of science demanded. Time would fail me to even give a mere outline of his varied and invaluable labours. Perhaps the strongest testimony is found in the fact that Greenwich became by the force of his strong individuality the model Observatory for Europe and America, and eventually modified the systems of working in most other Observatories. Outside his observatory labours Sir George Airy's ever active mind produced an endless stream of contributions to the furtherance of science.

So early as 1857, he gave an oral statement to a meeting of the Royal Astronomical Society on the means which would be available for correcting the Sun's distance—one of the fundamental factors in astronomy, during the following twenty-five years. He repeatedly engaged in experiments in mines and on mountains to determine the density of the earth. He devoted a great deal of time to the reduction of tidal observations and published a masterly treatise on tides and waves. He undertook the printing of the account of the verification and extension of Lacailles arc of the meridian by Sir Thomas Maclear, and edited many other works, and with Prof. Struve determined a great arc of the meridian, from the Ural River to Valencia.

In 1845 Mr. Airy was appointed one of three members of a Royal Commission to test the merits of railway gauges then in use, the report embraced the whole question, and the difficulties of break of gauge were duly considered, and finally after acknowledging that in some respects the broad gauge was to be preferred, recommended that as the majority of railways had adopted the narrow gauge, it alone should be maintained and permitted in all railways then under construction or hereafter to be constructed in Great Britain, and the transfer of the Great Western Railway trafic in this year to the narrow gauge is a striking comment on the wisdom of the report of the Royal Commission. He was Chairman of the Commission appointed to consider the general question of Standards, and of the Commission intrusted with the superintendance of the new standards of weight and length, after the great fire which destroyed the Houses of Parliament in 1834. To the testing and improvement of Marine Chronometers Sir George devoted a great deal of time and with most beneficial results to the accuracy of navigation. He contributed more than two hundred valuable papers to the Royal Astronomical Society and numerous contributions to other societies and publications, and published several books, perhaps the best known is that founded on six lectures on Astronomy delivered at the Museum at Ipswich. His great scientific reputation was acknowledged by several foreign Governments and many honorary titles were conferred upon him. He was a Chevalier of the Order Pour le Mérite of Prussia, of the Legion of Honour of France, of the Polar Star of Sweden, of the Danneborg of Russia, of the Rose of Brazil &c., and in 1871 he was knighted by Her Majesty the Queen at Osborne. But though Sir George was so much honoured, he was really a man of essentially simple nature and habits, and cared little for the social advantages of his position.

Although it is unusual for your President to refer in the annual address to the death of anyone not a member, I am sure that in departing in this instance from that rule I shall have the concurrence of every member present, when I express on behalf of our Council and the members generally profound regret at the great loss which science has sustained by the death on 7th December last of Sir WILLIAM MACLEAY, who for so many years held the foremost position in this community in the promotion of science. He was the father of the Linnean Society, and was fitly spoken of by a member of that body "as at once its head and its heart." For many years he provided the Linnean Society with a hired home, with the money for current expenses, and special investigations, and he finally built for it its present commodious home, which he presented to the Society in October 1885 as a free gift. Finally he gave the Society £6,000 as a fund, the interest of which should cover current expenses, and he placed a further sum of £35,000 in the hands of the Linnean Society as trustees, who are to use the interest of this sum for the establishment of four "Linnean Fellowships," each of the annual value of £400, tenable only for one year, but renewable at the will of the Council. At infinite pains and great cost he collected a Natural History Museum, valued at £25,000, this together with a sum of £6,000 to provide a salary for the curator he presented to the University, and at his death bequeathed a further sum of £12,000 to the University for the purpose of establishing a Chair of Bacteriology. Altogether his contributions to science must exceed £100,000. During the later years of his life he had offered science fellowships to students of natural history and several were granted. In 1875 Sir William was elected a fellow of the University Senate, and as a Senator he invariably threw the weight of his great personal influence and knowledge into the science schools. Few men in this world have ever thrown themselves and their fortune more unreservedly into the cause of science.

We have sustained another great loss by the death on 26th August, 1891, of CHARLES SMITH WILKINSON, late Government Geologist. Mr. Wilkinson was born in Northamptonshire in 1843, and was the fourth son of the late David Wilkinson, C.E., who was one of the associates of George Stephenson in designing the improvements in locomotive engines. In 1852 Mr. David Wilkinson decided to make his home in Australia, and accordingly proceeded there with his family, and settled in Melbourne as a civil engineer. Here he took a very active part in promoting engineering works in the young colony. He was instrumental in starting the first steamboat company on the Upper Yarra, and took an active interest in the introduction of railways. Mr. C. S. Wilkinson's early school days were spent at Ebly, near Stroud in Gloucestershire, a county abounding in remarkable geological formations, which almost from his infancy possessed a great attraction for him. In Melbourne his education was continued in a Collegiate school under the Rev. T. P. Fenner, M.A. Through his school life he devoted his whole attention to work, and carried off many prizes in Latin, French, geography, mapping, and Divinity. In December 1859, being then only sixteen years old, he was offered a position in the Geological Survey Office by Mr. A. R. C. Selwyn, F.G.S., Director of the Geological Survey Department. Nothing could have been offered more congenial to his tastes, and he at once accepted it. In 1861 he was made field assistant to Mr. Richard Daintree, F.G.S., Geological Surveyor who was then carrying out the Geological Survey from Bass' Straits northwards, including the districts of Geelong, Bacchus Marsh, Werribee, Ballan, Steiglitz Meredith, and Leigh River. The geology of these districts is a sort of epitome of that of the whole Colony, and studied as it was under the guidance of Mr. Selwyn and Mr. Daintree, proved to be a most important school for the young geologist, and one that he made the best possible use of. In 1863 Mr. Wilkinson with Mr. R. A. F. Murray who is now Government Geologist for Victoria, as field assistant, was dispatched in charge of a party to survey and explore the then almost unknown Cape Otway Mountains, which consist of oolitic and coal formations. Amongst the interesting discoveries made during this period was a new phocodon or squalodon, which Professor McCoy named *Squalodon wilkinsoni*, and a description of it was published in the Prodromus of the Palæontology of Victoria.

In 1866 Mr. Wilkinson was appointed to fill the vacancy caused by the resignation of Mr. R. Daintree, who left to take charge of the Geological Survey of Queensland. In the same year while engaged upon the geological survey of the Leigh River, south of Ballarat, Mr. Wilkinson made a most careful investigation relating to the deposition of gold, and the formation of gold nuggets, a work of great value, which was embodied in a paper read before the Royal Society of Victoria, which paper has been referred to by Sir Roderic Murchison, Prof. Ulrich, and others. At this time, Mr. Wilkinson was prostrated by a severe attack of inflammation of the lungs, brought on by a cold caught while working with Mr. Selwyn at the geology of the Grampian Mountains, and in 1868 he resigned his appointment in order to take a much needed rest, and he continued without official position for four years, the greater part of which time was spent at Wagga Wagga, in this Colony, where he regained his health and decided to join the Survey Department here. He came to Sydney in 1872, passed the examination for a license to survey, and was appointed licensed surveyor and sent by the then Surveyor General Mr. P. F. Adams, to make some surveys in the newly discovered tin mining districts of New England. I well remember Mr. Adams shewing Mr. Wilkinson's report on the tin country to me, and his expression of satisfaction that he had obtained such a valuable officer. That good opinion increased upon acquaintance, and a year later Mr. Wilkinson was appointed Geological Surveyor in the Survey Department, in order that he might devote the whole of his time to a work for which he was so well fitted. In 1875 he was made Geological Surveyor in the then newly organized Department of Mines. From that time onwards Mr. Wilkinson marked his career by intense application to the study of that science which both inclination and duty called him to follow. Some indication of the success of that work is found in his successful creation and organization of the Geological Department and the Museum in connection therewith, of which he was without doubt the founder, and in the multitude of valuable contributions to science which are left as a record of his untiring energy and zeal. He was the first to urge upon the Government, for geological reasons, the necessity for seeking subterranean waters in our western districts, and the first bore for water was put down under his direction.

The end came unexpectedly; he had it is true, been ailing for some time, but he thought it was nothing more serious than a passing fit of indigestion, and he made all arrangements to go on an official visit to the silver mines. Meanwhile the symptoms of disease became so severe that he was obliged to rest, and instead of gaining strength as he anticipated, he became rapidly worse, and in a few weeks passed away. He was a sincere Christian and gave much of his spare time to the elucidation of the connection between science and religion, and in his later years at Burwood, had a class of working men to whom he regularly lectured on every available Sunday afternoon upon geology in its bearing upon religion. He was a truly scientific man, unostentatious but enthusiastic in his work, and at all times ready to help those who needed it. In manner, courteous and kind, a cheerful and pleasant companion, he was the friend of every one who knew him. I cannot better express the estimation in which Mr. Wilkinson was held by his colleagues and the public, than by quoting what Mr. Geological Surveyor David, now Professor in the University, said in a letter to the Government Geologist, Mr. Pittman: "While reiterating my feeling of gratitude to my late chief, Mr. C. S. Wilkinson, conveyed in my formal resignation, I am forced to admit that it is impossible for me to express in words all that I owe to him. It was not only his skill as a field geologist, but also his large hearted love of humanity, his unselfishness and unvarying courtesy which endeared him to us his colleagues, as well as to the whole mining community and people of New South Wales."

Mr. Wilkinson received many honours, in 1863 he was made a fellow of the Royal Society of Victoria; in 1874, a fellow of the Royal Society of New South Wales; in 1876, a fellow of the Geological Society of London, and a fellow of the Linnean Society of London; in 1880, a fellow of the Linnean Society of New South Wales; in 1883 and 1884, he was President of the Linnean Society of New South Wales; in 1887, President of the Royal Society of New South Wales; in 1885, he was made a fellow of the Victoria Institute, London. In 1872 he published a work on the Geology of New South Wales. In 1888 he represented New South Wales at the Mineral Exhibition, held in the Crystal Palace at Sydenham. He was a member of the Government Prospecting Board, a duty involving great responsibility. A member of the Board of Technical Education. A Trustee of the Australian Museum, &c.

The following list of lectures, addresses, papers &c., is, I fear, not complete, but it is as nearly so as I have been able to make it:

The Royal Society of New South Wales.

Papers read Dec. 3, 1879—"Notes on the occurrence of remarkable Boulders in the Hawkesbury Rocks,"
May 2, 1888—Presidential Address.
Exhibits, Oct. 1, 1879—See Vol. XIII., p. 133.
" Aug. 4, 1880—See Vol. XIV., p. 303.

Exhibits, May 17, 1882—See Vol. xvi., p. 251, illustrating discussion upon Rev. J. E. Tenison-Wood's paper, Geology of the Hawkesbury Sandstone.

„ Nov. 5, 1884—See Vol. xviii., p. 139.

„ Dec. 3, 1884—See Vol. xviii., p. 141. Experiments illustrating the formation of Comets.

Contributions to the Linnean Society of New South Wales.

1. Notes on a collection of Geological specimens collected by William Macleay, Esq., F.L.S., from the coast of New Guinea, Cape Yorke and the neighbouring Islands; Vol. i., p. 113.
2. Notes on the Abercrombie Caves, Vol. iv., p. 460.
3. Notes on some customs of the Aborigines of the Albert District of New South Wales; Vol. viii., p. 436.
4. Presidential Address, 1884; Vol. viii., p. 535.
5. Presidential Address, 1885; Vol. ix., p. 1207.

Lectures to the Young Men's Christian Association.

July 13th 1886—Geology, illustrated by lime light.

Oct. 17th 1887—Geology, illustrated by lime light.

Aug. 11th 1891*—Grand Caves of New South Wales, with lantern illustrations.

Maps by Mr. Wilkinson.

Geological sketch maps of New South Wales, compiled from the maps of the late Rev. W. B. Clarke, M.A., F.R.S., scale eight miles to one inch and twenty-two miles to one inch.

Geological map of Hartley, Bowenfells, Wallerawang, and Rydal.

Map of Silver Mining Country Barrier Ranges.

Official Notes, Reports, &c.

1863-4—Report on the Geology of the Cape Otway District; *Report of the Director, Geol. Survey Vict.* 1863-4.

1865 (about)—Geology and Timbers of Victoria; *Trans. Royal Soc. Vict.*

1868—On the theory of the formation of Gold Nuggets; *Trans. Roy. Soc. Vict.* 1868.

1873—Report on the Tin-bearing Country of New England, New South Wales; *Sydney* 1873, also *Mines and Mineral Statistics, N.S. Wales* 1875.

1873—Report on the Tin-bearing Country of Inverell, New South Wales; *Sydney* 1873.

1874—Tin Deposits of New South Wales; *Iron* 1874, *Mining Journal* 1874.

1875—Notes on the Geological and Mineralogical Collection exhibited at the Metropolitan Intercolonial Exhibition 1875; *Mines and Mineral Statistics, N.S.W.* 1875.

1876—Notes on a collection of Geological specimens from the coasts of New Guinea, Cape York, and neighbouring islands, collected by Wm. Macleay, Esq. &c.; *Proc. Linn. Soc. N.S.W.* 1876; *Annals Nat. Hist.* 1876; *Geol. Mag.* 1876; *Canadian Nat.* 1876; *American Journ. Sc.* 1877.

* This lecture was given by Mr. J. Carne, owing to Mr. Wilkinson's illness.

1876—Report on the discovery of Tin and other Metals in the Burra-Burra District, between the Bogan and Lachlan Rivers; *The Queenslander, Sep.* 1876.

1876—Report to the Minister of Mines on the occurrence of Gold in the Coal Measure Conglomerates of New South Wales; *Sydney Evening News,* No. 2940, 1876; *Sydney Morning Herald,* Dec. 2, 1876; *The Queenslander,* Dec. 16, 1876.

1877—On the Depth at which coal will be found under Sydney; *Ann. Report Dept. of Mines, N.S. Wales for* 1877.

1878—Report on Auriferous and other specimens from New Guinea; *Ibid for* 1878.

1878—Report on the Barrington Gold-field; *Ann. Report Dept. of Mines, N.S. Wales,* 1878.

1878—The Discovery of Gold in New Guinea; *Sydney Morning Herald,* Jan. 7th, 1878.

1879—Notes on the Occurrence of Remarkable Boulders in the Hawkesbury Rocks; *Journ. Roy. Soc. N.S. Wales,* 1879.

1879—On the Occurrence of Gold in Serpentine and on the Geological History of Sydney Harbour; *Journ. Roy. Soc. N.S. Wales,* 1879.

1879—Report on the Road Metal Quarries at Prospect and Pennant Hills; *Ann. Report Dept. of Mines, N.S. Wales,* 1879.

1879—Report on Water Supply to the Elrington Gold-field; *Ibid for* 1879.

1880—Notes on the Abercombie Caves; *Proc. Linn. Soc. N.S. Wales,* 1880.

1880—On the Formation of the Diamond in the Tertiary Drifts of New South Wales; *Geol. Mag. Dec.* 2, 1880.

1881—On Glacial Boulders in Secondary Deposits, Sydney, New South Wales; *Ibid Dec.* 2, 1881.

1881—Report upon the Wentworth Gold-field; *Ann. Report Dept. of Mines N.S. Wales,* 1881.

1881—Report upon the Temora Gold-field and part of Bland and Merool Districts; *Ibid* 1881.

1881—Report on the Albert Gold-field—Artesian Water; *N. S. Wales Parl. Papers,* 1881.

1881—Notes on the Occurrence of Artesian Wells in the Albert District, New South Wales; *Proc. Linn. Soc. N.S. Wales,* 1881.

1882—Report upon the Coal Measures near Mittagong; *Ibid* 1882.

1882—Notes on the Geology of New South Wales; *Ibid* 1882.

1882—On the Geology of the Hawkesbury Sandstone; *Journ. Roy. Soc. N.S. Wales,* 1882.

1883—Report on Auriferous Antimony Lodes at Hillgrove, and Bismuth Lodes near Glen Innes; *Ibid* 1883.

1884—Report on Coal Measures in the Greta and Branxton Districts; *Ibid* 1884.

1884—Report on the Diamond Drill Bore (for Coal) at Heathcote, Illawarra; *Ibid* 1884.

1884—Report on Cinnabar Deposit near Rylstone, New South Wales; *Ibid* 1884.

1884—The Fish River Caves, published in Railway Guide; *Ibid* 1884.

1884—Report on the Silver-bearing Lodes of the Barrier Ranges in the Albert District of New South Wales; *Ann. Report Depart. of Mines, N.S. Wales*, 1884.

1885—Report on the Metalliferous Lodes at Copper Hill, near Molong *Ibid* 1885.

1885—Report on the Coal Seams discovered in the Milton and Ulladulla District, Jervis Bay; *Ibid* 1885.

1885—Report on the Hanging Rock and Nundle Gold-field; *Ibid* 1885.

1886—Report on the Gold and Silver-bearing Lodes at Jerrara; *Ibid* 1886.

1886—Report on the Mineral Reserves, Molong District; *Ibid* 1886.

1886—Report on the Kings Plains Gold-field; *Ibid* 1886.

1886—Report on the Mudgee and Gulgong District; *Ibid* 1886.

1886—Report on the Silver Lodes at Mitchell; *Ibid* 1886.

1886—Geological Science in accord with Christian Faith; read before Christian Evidence Society, Sept. 13, 1886.

1886—Geology (as applied to New South Wales); *Sydney Morning Herald*, July 16th, 1886.

1887—Geological Examination of Diamond-bearing Formations in the Inverell District; *Ibid* 1887.

1887—Report on Tin Lodes near Poolamacca; *Ibid* 1887.

1887—Report on Antimony Lodes, Fordes Creek; *Ibid* 1887.

1887—Report on Lodes (Gold &c.) Denison Town; *Ibid* 1887.

1888—Report on the Syenitic Quarries, Bowral; *Ibid* 1888.

1889—Report on Old Quarry at Pyrmont; *Ibid* 1889.

1889—Report on the South Cumberland Coal-mining Company at Otford; *Ibid* 1889.

1889—Report on Platinum found at Broken Hill; *Ibid* 1889.

1889—Report in conjunction with Mr. W. H. J. Slee, on Phillips' Dry Concentrator.

1890—Report in conjunction with Mr. W. H. J. Slee, on the Ironbarks, Muckerawa, and Wellington Districts; *Ann. Report Dept. of Mines, N.S. Wales*, 1890.

1890—Report on Mineral Resources of the Mittagong, Bowral and Berrima Districts; *Ibid.*

1890—Report on the Mostyn-Speigel Blast Furnace; *Ibid* 1890.

1890—Report on the Luhrig Coal Washing Process; *Ibid* 1890.

1890—Reports on Mining Applances &c. (appendices C,D,E,F, Progress Report Gov. Surveyor, 1890); *Ibid* 1890.

1882—Notes on the Geology of New South Wales; *Mineral Products of New South Wales, Mines Dept.*, 1882.

1887—Notes on the Geology of New South Wales; *Ibid* 1887.

1875 to 1890—Annual 'Progress Reports,' 1875 to 1890 inclusive, and Geological Maps; *Ann. Reports Dept. of Mines N.S. Wales*, 1875-90.

The article 'Geology' published in the hand-book of the Australasian Association for the Advancement of Science.

Paper on the Mineral Resources of New South Wales, read at Adelaide Exhibition, Sept. 1887.

Paper read before the Victoria Institute dealing with the progress of Geological Science in the Colonies; Feb. 19th, 1889.

Paper on the Mineral Resources of New South Wales, read at Melbourne Exhibition, Jan. 29th 1889.

Paper on "Revelation and Science," read before the Church Congress, May 1st, 1889.

"Geology of Australia" in the Picturesque Atlas of Australasia.

Paper on the Mineral Resources of New South Wales, read before the British Association for the Advancement of Science at Leeds, Sept. 1890.

Paper on the Mineral Resources of New South Wales, published by the Society of Arts, London, 1891.

Sir JOHN HAY, M.A., LL.D., K.C.M.G., M.L.C., President of the Legislative Council, died at his residence Rose Bay, on January 20, 1892. He was elected a member of the Royal Society of N.S. Wales in 1874 and although other duties prevented his attendance at the meetings, he always took a deep interest in the work our Society was doing. Sir John was born at Little Ythsie, Aberdeenshire, Scotland, in 1816. He was educated at King's College, Aberdeen where he carried off year after year, the highest honours and took his degree in 1834. The same year he went to Edinburgh with the intention of taking his degree for the Scottish Bar. After spending some years in legal studies, he determined to alter his plan of life and seek his fortune in Australia. He arrived in Sydney in 1838, and the same year settled on the Upper Murray at Walaregong. Here he spent eighteen years actively engaged in squatting, and found himself then in a position to take part in movements for the advancement of his adopted country. He first sought political honours in 1856, and on 17th September of that year he was chosen to move a vote of censure on the Cowper Government, and from that time up to 1862 he was an able and and energetic politician. This work was cut short by his being made Speaker of the Assembly. After holding that position for three years he resigned in consequence of ill health. A year and a-half later he was summoned to the Legislative Council, and, in 1873, was made President, a position he retained to the end; in 1877 he was made K.C.M.G. His long Parliamentary and official experience eminently qualified him for his position. His rulings in the chair were always respected, and his opinions carried great weight. Outside Parliament he gave much of his time to assisting any movement for the public good. He was elected a fellow of the Senate of the University in 1870, and he was a regular attendant to within a short time of his death; his mature judgment and many services to the University will long be remembered.

THOMAS KINGSMILL ABBOTT, Stipendiary Magistrate, was born in 1845. He was educated in Sydney and entered the public service in 1867. He was appointed Clerk of Petty Sessions at Gunnedah. Then Police Magistrate there; and after being Police Magistrate in West Maitland for some years he was, in 1882, made Stipendiary Magistrate in Sydney. On 1st of August 1891, he died from influenza. In 1877 he was made a member of our Society, and devoted a good deal of time to the study of underground waters, and contributed one valuable paper on that subject to our Society.

Rev. ROBERT COLLIE, died on April 18, 1892. He was born on the banks of the Dee in Aberdeenshire, Scotland. Was ordained a Minister in 1866, and, after spending ten years as a minister in England, he came to New South Wales with a commission from the Free Church of Scotland. Soon after his arrival he was elected minister of the Free Church of Scotland at Newtown, and continued pastor until his death. He made many warm friends wherever he went. He had quite a reputation as a lecturer, and used his gift freely in the great work he had devoted his life to. In spare moments he studied botany enthusiastically, and made many original studies of the flora of Australia and New Zealand, and a number of plants have been named after him. In recognition of his scientific work he was made a fellow of the Linnean Society of London.

It must be gratifying to every member of our Society, that in addition to the expenditure of large sums each year upon our library, the publication of our annual volume, the preparation of a printed catalogue of our library, &c., we are able to continue, year after year to offer prizes for three essays on scientific subjects, all tending to the direct material development of this Colony, or to the furtherance of science ultimately for the same purpose. We find that our efforts in this direction are attracting the talent of other countries as well as our own, and prize essays come from the other side of the equator. The prize for each subject—£25 with the Society's Medal—we do not look upon as the reward for work. It is a contribution towards expenses incurred, and we know that there are more potent influences operating on the competitors—the honour of winning the prize—the world-wide publication which the prize essay gets in the Society's Journal—the desire to help us in the work we are trying to do, and many other motives. Already we have actually paid away in these prizes £225, and we hope in the future to meet a difficulty which has been felt by competitors, and brought to light by some of the essays. Our field for investigation has generally been Australia; but we are assured that for most subjects it is too wide, and that more valuable essays will be written if the field is more limited. The list of subjects for prizes now open is :—

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.

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

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

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

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

The Society's Medal has been awarded seven times and Money Prize nine times, the following is the list of awards :—

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 occurrence of gold-bearing veins and of the associated Minerals."

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

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

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

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

Clarke Medal.—At the meeting of the Council on the 9th December last, it was resolved that the Clarke Memorial Medal for 1892 be awarded to Professor William Turner Thiselton Dyer, C.M.G., M.A. *Oxon.*, B.Sc. *Lond.*, F.R.S., Director of the Royal

Gardens, Kew, in recognition of his distinguished services in the cause of Botanical Science, and especially on account of his labours in connection with the development and organization of the Botanical Departments for the Colonies and India at the Royal Gardens, Kew.

It will be remembered that the Clarke Memorial Medal was founded in 1878, and that through the kindness of the Deputy Master of the Mint, twenty medals were struck off. We are now coming to the end of these, and the list of recipients is interesting. I may mention that the Deputy Master of the Mint with his well-known courtesy and desire to assist the Society, has again consented to strike off a fresh supply of medals for us.

Awards of the Clarke Medal, established in memory of the late Rev. 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 Liege, Belgium.

1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.

1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.

1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William-street, Sydney.

1891 Professor Frederick Wollaston Hutton, F.G.S., Canterbury College, Christchurch, New Zealand.

1892 Professor William Turner Thiselton Dyer, C.M.G., M.A. *Oxon.* B.SC. *Lond.*, F.R.S., Director of the Royal Gardens, Kew.

Financially I am glad to say that we are in a satisfactory condition, the large accession of new members has more than made up the losses caused by deaths and non-payment of subscriptions, so that our total income was £1405 13s. 10d. the largest we have ever had, and on the other hand we have spent freely, and in proportion to our income to the extent of £1,243 14s. 3d., of which sum £137 14s. 9d. went for repairs to building, £225 15s. 5d. for books, and £278 11s. 6d. for publishing our volume. And, notwithstanding the heavy expenditure, we have been able in accordance with our rule to transfer £165 or nearly all the entrance fees to the building fund, which now amounts to £769, towards a better building, I mean one with more accommodation for the members. And lastly, we have a small balance in hand, and no liabilities. During the past year we have exchanged our volume with three hundred and sixty-four kindred societies, getting as many valuable volumes in return, and we have added nine more societies to the exchange list, as follows :—1 Aëronautical Society of Great Britain, London. 2. Civic Museum of Natural History, Trieste. 3. Museum of Natural History, Lübeck. 4. Queensland Museum, Brisbane. 5. School of Anthropology, Paris. 6. Society of Naturalists, Zürich. 7. The Colliery Engineer Co., Scranton (Pa) U.S.A. 8. Weather Bureau, Department of Agriculture, Washington, U.S.A. 9. Yorkshire Geological and Polytechnic Society, Halifax.

In accordance with our practice, we have steadily kept in view the importance of completing serial publications in our Library by the purchase of back numbers, and we have accordingly purchased during the past year the back numbers of (1) Annales de l' Institut Pasteur; (2) Journal of the Royal Asiatic Society of Great Britain and Ireland; (3) Memoirs of the Wernerian Natural History Society; (4) Monthly Notices of the Royal Astronomical Society; (5) Transactions of the Clinical Society; (6) Transactions of the Institution of Naval Architects; and upon application we had presented to us back numbers of the following series: (1) Memoires of the Geological Survey of India, (Palæontologia Indica); (2) Reports of the Aëronautical Society of Great Britain; (3) Reports of the Commissioner of Indian Affairs, U.S.A.; (4) Transactions of the Royal Historical Society. During the past year the Society has received the following donations:—239 volumes, 1427 parts, 283 pamphlets, 1 map (mounted), 1 atlas of maps, 2 atlases and 30 loose meteorological charts, 7 hydrographic charts, 1 volume star photographs; total 1961 publications.

During the past year eight general meetings have been held, the first was devoted to formal business and the President's address, the other seven to usual business. Nineteen papers were read, or nearly three for each meeting. The average attendance of members was 35·7, the greatest in recent years being 36·3 in 1890, the lowest 21·6 in 1887. Visitors were not quite so numerous as in 1890 when the average was 3·7; last year it was 3. At four of the meetings we had instructive exhibits, some of which, from their importance and novelty and the work their preparation had involved might almost be called condensed essays on the subjects they illustrated, notably some by Prof. Anderson Stuart.

Papers read before the Society last Session:—

1891.

May 6. 1—Presidential Address. By A. Leibius, PH.D., M.A., F.C.S.

June 3. 2—Notes on the large death-rate among Australian sheep in Country infected with Cumberland Disease or Splenic Fever. By M. Adrien Loir.

July 1. 3—Compressed-air Flying Machines Nos. 13 and 14. By Lawrence Hargrave.

July 1. 4—A Cyclonic Storm or Tornado in the Gwydir District. By H. C. Russell, B.A., C.M.G., F.R.S.

„ 5—Preparations now being made in Sydney Observatory for the Photographic chart of the Heavens. By H. C. Russell, B.A., C.M.G., F.R.S.

Aug. 5. 6—A contribution to the Microscopic Structure of some Australian Rocks. By Rev. J. Milne Curran, F.G.S.

Sept. 2. 7—On a Wave-propelled Vessel. By Lawrence Hargrave.

„ 8—Notes on a spontaneous disease among Australian Rabbits. By M. Adrien Loir.

„ 9—Notes on some Celestial Photographs recently taken at Sydney Observatory. By H. C. Russell, B.A., C.M.G., F.R.S.

Oct. 7. 10—Notes on the Use, Construction, and Cost of Service Reservoirs in New South Wales. By C. W. Darley, M. Inst. C.E.

Nov. 4. 11—On the constitution of the Sugar Series. By W. M. Hamlet, F.C.S., F.I.C.

„ 12—Artesian Water in New South Wales, (Preliminary Notes). By Prof. T. W. Edgeworth David, B.A., F.G.S.

Dec. 2. 13—Notes on the rate of growth of some Australian trees. By H. C. Russell, B.A., C.M.G., F.R.S.

„ 14—On Kaolinite from the Hawkesbury Sandstone. By Henry G. Smith. Communicated by J. H. Maiden, F.L.S., F.C.S.

„ 15—On some New South Wales and other Minerals. (Note No. 6.) By Prof. Liversidge, M.A., F.R.S.

July 1.
Sept. 2.
Oct. 7.
Dec. 2. } 16—Some Folk-songs and Myths from Samoa, translated by the Rev. G. Pratt, with introduction and Notes by John Fraser, LL.D.

Exhibits at General Monthly Meetings:

1891.

June 3—Demonstration of a new machine for use in explaining the nature of such waves as those of sound. By Prof. Anderson Stuart, M.D.

June 3—The Tintometer. By W. A. Dixon, F.C.S., F.I.C.

July 1—Photographs of Stars and of the Moon to illustrate paper read by H. C. Russell, B.A., C.M.G., F.R.S.

Aug. 5—Prof. Anderson Stuart exhibited and described his new instrument for use in explaining the nature of such waves as those of light.

„ —A new 'Dick and Swift's' Petrological Microscope. By Rev. J. Milne Curran, F.G.S.

Sept. 2—Rapid filtration without the aid of pumps. By W. M. Hamlet, F.C.S., F.I.C.

Meetings of Sections.—Three Sections were formed last year, viz., Medical, Microscopical, and Civil Engineering.

The Medical Section held four meetings at which the following papers were read:—

1—A brief account of the histology and development of tubercle. Prof. Anderson Stuart, M.D.

2—Remarks upon the nature and treatment of diphtheria with demonstrations. By Dr. W. Camac Wilkinson.

3—Glimpses of the Past: a series of sketches with Pen and Pencil of the Medical History of Sydney. By Dr. Houison.

One of the meetings was devoted to a Medical Conversazione, and many objects of much interest were exhibited.

The Microscopical Section held five meetings at which interesting exhibits were shown and one paper was read, viz., "Notes on Slicing Rocks for Microscopical Study," by the Rev. J. Milne Curran, F.G.S.

The Civil Engineering Section held eight meetings at which the following papers were read:

1—Recent researches on the strength, elasticity and endurance of materials of construction, with especial reference to Iron and Steel. Considerations with reference to the determination of the safe working stresses in Structures. By Prof. Warren, M. Inst. C.E.

2—The bridge over Lane Cove River at the head of the navigation. By H. H. Dare, B.C.E.

3—On the Calculation of Stresses by means of Graphic Analysis. By J. I. Haycroft, M.E., A.M.I.C.E.

4—On the Tacheometer and its application to Engineering Surveys. By W. Poole, Junr.

5—On the Sewerage of Country Towns: the Separate System. By Dr. J. Ashburton Thompson.

6—Discussion upon a paper, read at a General Monthly Meeting of the Society, "On the Use, Construction and Cost of Service Reservoirs in New South Wales. By C. W. Darley, M. Inst. C.E.

Turning from these domestic matters to the scientific progress around us. The Australasian Association for the Advancement of Science held its fourth meeting at Hobart Tasmania in January last, and the gathering was a most successful one in every respect. There were six hundred members although the population is relatively small. The meetings were well attended, and no less than one hundred and thirty-five papers were read in addition to reports of committees and other business. His Excellency Sir Robert Hamilton, K.C.B., Governor of Tasmania, was President, and threw himself into the work of the Association with the good will and heartiness which characterize all he does on behalf of science. Lady Hamilton also took a very active part in the work, attended many meetings, and read one paper. Altogether the Hobart meeting was the most successful, as it was the most enjoyable the Associstion has yet held. Hospitality and kindness began at Government House and followed the Association everywhere, and we all came away with the kindliest feelings towards the good people of Hobart and their beautiful climate. The next meeting of the Association is not to take place until September or October 1893. It is to be in Adelaide, and it was considered unwise to hold a meeting there in January when the weather is very hot, and many who would like to take part in the meeting, would be kept away on that account. I have not time to refer to the work done, further than to say that so far as I could judge, the papers generally were more valuable than at previous meetings.

One of the main objects of the Association is gradually developing, and that is the formation of committees for the investigation of scientific questions. Reports of such committees in England are a mine of invaluable information on a great number of subjects, and our committees are trying to follow such a useful example. I will only refer to one of them, and I select one that has already succeeded in federating the effort to study earthquakes and kindred phenomena in all the Colonies. A most satisfactory report was brought up from this committee at the Hobart meeting, pointing clearly to certain well marked points from which earth tremors originate. One of the best defined is in Cook's Straits, and another due east of the northern part of Tasmania. A method of observing and recording earthquakes has been agreed upon, and the same form of question and record paper has been distributed. In this way all the phenomena will be traced over a large area. The active secretary of this committee, Mr. Hogben of Timaru, New Zealand has done much to help forward the work of this section. Other committees are working at their own subjects, and in this way much important scientific work is being accomplished, and the reports will become a mine of scientific wealth.

The Deputy Master of the Mint has kindly given me some most interesting data. During the past year 142,470 ounces of gold, the produce of New South Wales, and of the value of £518,249 were received at the Mint for coinage. This is more than was brought in in any year since 1881, when the amount was 145,478 ounces. A gradual decrease then set in up to 1888, when the receipts were only 82,891 ounces, which is the lowest year's production on record. The total quantity of gold raised in the Colony to the end of 1891 is estimated at 10,328,665 ounces, of the value of £38,219,327, which for the past forty-one years gives an annual average of 251,918 ounces. This is far above our present production, but it is to be hoped that the rapid recovery during the last three years will be maintained. The total quantity of gold from all the Australasian Colonies received at the Mint in 1891 was 782,804 ounces, value £2,800,803, which is considerably above the annual average, although less than that received during the two preceding years. The greatest quantity of gold coined in any one year since the opening of the Mint in 1855 was 900,475 ounces, value £3,340,473 received in 1889, and due to the large output of the Queensland mines, from which the Mint received no less than 732,447 ounces of the value of £2,722,026. It is, however, in the produce of our silver mines that very great advances have lately been made. Previous to 1884 the total export of silver was under £20,000 a year; in that year it rose to over £200,000, and has since so rapidly increased that the total value of Silver and Silver lead and ore exported in 1891 was *£3,619,589, and the total produce of the Colony for the last eight years is estimated at over *£11,000,000.

Through the courtesy of the Under-Secretary for Mines I have been furnished with a forward copy of the annual report of that Department. It is a work so full of valuable information that it is difficult to make a selection which will fairly indicate our progress in acquiring the wealth which lies hidden in the soil. The Government Geologist points out that one branch of the work—the survey and report on new localities—has during the year been somewhat hindered by the great increase in the number of applications for aid from the Prospecting Vote, which in each case had to be examined and reported on by the Geological surveyors. It is remarkable that although there has been during the year a very large increase in the total amount and value of minerals obtained, there has been a considerable falling off in the number of applications made to lease Crown lands for mining purposes. The number of applications made to lease Crown lands for mining purposes during 1891 was 2,210, being a decrease of 538 as compared with 1890. Of the 2,210 applications so made, 1,021 were for auriferous land comprising an area of 7,471 acres, and 1,189 for other mineral land comprising an area of 51,227 acres. On the other hand, the gold won was valued at £558,305, which is greater than

* These amounts include lead, as it is impossible to arrive at the value of the silver from the available returns.

that of any other year since 1880, and there is good reason to think that even this satisfactory total does not include all the the gold raised, for there are no returns of the amount of gold which goes out of the Colony associated with metalliferous ores. It is known that 5,277 ounces of gold were in this way taken from the Proprietary Mine, Broken Hill, in 1890; but for 1891 there are no returns of this item.

The value of silver and silver-lead ores won in 1891 reached the enormous sum of £3,619,589, an amount nearly a million of money greater than it was for 1890. The total value of the mineral products in New South Wales for the past year, ending 31st December, 1891, was six and a half millions, and the total value of the minerals won in New South Wales from the foundation of the Colony to the end of 1891 reaches the enormous sum of ninety-three and a half millions of money. Dividing the value of the gold won in New South Wales in the past year 1891 by the number of miners employed, it appears that the amount earned by each miner is £51 9s. 6d.. This is a very rough method of computing the earnings, because there are so many other things that ought to be taken into the account.

In coal also the out-put has been greater than it ever was before, and in value it amounts to £1,742,795, and the prospecting for new seams and new coalfields has been most satisfactory; the Government diamond drills have bored through an aggregate thickness of new coal of one hundred and thirteen feet nine and a half inches (less twenty feet bands and coal) distributed as follows: Waratah, ten feet ten and a half inches; Cessnock, twenty-two feet ten and a half inches; Nobby's, eighteen feet nine inches; Greta, twenty-two feet one inch; Cremorne, twelve feet and a half inch; Wyeé, three feet three and a half inches; Bulli, three feet ten inches. In 1891 sixteen new coal mines were opened.

Platinum.—In view of the rapidly increasing value of platinum caused by its use in electrical apparatus, the announcement that considerable quantities of this metal are in the hands of miners at Evans Head, where they have obtained it from beach sand, is important, and platinum has also been found about ten miles from Broken Hill in a lode formation, mixed with silver, copper, and other minerals. These facts are of importance, not only commercially, but also in their bearing on electrical development.

Diamonds.—At Tingha and Inverell some 1,200 carats of diamonds have been won this year.

Emeralds.—The Emerald Proprietary Company have sunk two shafts in their mine at Vegetable Creek, and about 25,000 carats have been raised during the year, which when cut and polished are worth from four to forty shillings per carat. Professor David in his report on this mine says "as far as I know this is the first well authenticated occurrence of the true emerald in New South Wales, its occurrence has frequently been reported in various places as recorded by Prof. Liversidge in his work on the Minerals and Gems of New South Wales, though as he justly remarks with regard to these reported occurrences, in some cases the beryl is probably meant." Professor David goes on to express the opinion that other deposits of emeralds will be found in that district; the report is exhaustive and deals not only with the quantity and value of the gems, but also with the geological features of the place, which induce Professor David to anticipate the finding of other deposits in the same neighbourhood.

A valuable deposit of chrome ore found at Gordonbrook, about thirty miles north-west from Grafton, was examined by Professor David, who found that 3,000 tons of chrome ore, are practically in sight—valued if delivered in England at about £5 per ton. The deposit had not been prospected fully, and there seems reason to anticipate that the yield might amount to 20,000 tons, whilst analyses show that the quality is satisfactory.

Diamond Drills and Water Augers.—The total depth bored with diamond drills during the year was 7,797 feet 9 inches, and the average cost of the work, exclusive of stores, wages, rent, and travelling expenses of the Superintendent of Drills, was 12s. 7½d. per foot, or 9d. per foot in excess of the cost of similar work in

1890. This increased cost is due to two causes, first to the rise in price of diamonds, and next to the greater wear and tear in the Cremorne bore, and in a number of holes sunk in basalt. Eight of these bores were made in basalt near Gulgong, to see if a gold lead existed under it; three of the eight bores brought up gold bearing strata, and it is hoped that the shaft to be sunk will reveal an extensive auriferous lead at a depth of one hundred and fifty feet. The great bore which was so successfully carried out at Cremorne is the deepest yet made in Australia with the diamond drill, and is one of peculiar interest to scientific men; and we cannot help reflecting what an intense pleasure it would have been to our former President, the Rev. W. B. Clarke, had he seen in this bore the confirmation of his theory in regard to the presence and depth of coal under Sydney. This bore was commenced four inches in diameter, and maintained at that up to 2,000 feet, where, owing to soft strata, the bore had to be tubed and reduced to three inches. Fully ninety.six per cent. of the core has been preserved, forming the most convincing and satisfactory section of the strata underlying Sydney. The total depth of this bore is 3,095 feet. The coal cut through measured twelve feet. The depth bored during the year with water augers was two hundred and seventy-nine feet ten inches, at a total cost per foot of £3 2s. This high rate, £1 10s. greater than in 1890, was due to defective machinery.

I read with great satisfaction the remarks of the Government Geologist, Mr. Pittman, on the valuable report of Mr. Geological Surveyor Anderson upon the possibility of finding artesian or sub-artesian water for the supply of Broken Hill. Mr. Pittman says: "Although the cretaceous rocks do not outcrop within a reasonable distance of Broken Hill, there is a considerable expanse of tertiary strata to the east and south of the Barrier Ranges, in which it may reasonably be expected that a permanent supply of artesian water would be discovered, if bores were put down sufficiently deep to penetrate to the impervious rocks, on the surface of which the water would naturally be expected to accumulate."

We have thus good reason to expect that a permanent water supply, sufficient for the wants of that prosperous community, will shortly be found, and not a moment before it is wanted, for we cannot shut our eyes to the fact that the rainfall there is far too uncertain to be depended upon. The present distress, is the outcome of little more than one year's drought, and within the past thirteen years, over which rainfall observations have been made, there have been several droughts, one of which lasted three years. In the first year, 1882, only 9·11 inches rain fell; the next year only 5·33 inches fell, and this was the driest year ever known there, and the third year, 1884, only 8·62 inches fell, the average for the three years being only 7·69 inches. Such a drought, by reason of its length and the intensity of it in the middle year, would be far more disastrous than the present one, and it is only reasonable to provide for contingencies that have happened recently, and may happen again at any time. The provision would in my opinion be better made by wells tapping the artesian waters, the existence of which there seems no reason to doubt, than by a supply from the Darling River, which when most wanted, will almost certainly be contaminated by animal, vegetable, and mineral impurities, to such an extent as to render it unfit for use.

At the end of the volume "Annual Report of the Department of Mines and Agriculture," there is a very valuable report by Mr. J. W. Boultbee, the officer in charge of the Water Conservation Branch, on the work done in the search for artesian water. It gives short notes of well-boring in the Northern hemisphere, general notes on legislation in reference to wells, regulations, etc., list of wells, public and private, in Queensland, also accounts of the work done in Victoria and South Australia. In reference to New South Wales Mr. Boultbee says: "In our own Colony the question has been for years before the Department, attention being in the first instance drawn to it by a successful well sunk on Kallara Station by Mr. David Brown, in 1879. This well was sunk in proximity to a mud spring, and at a depth of one hundred and forty feet artesian water was tapped that rose twenty-six feet above the curb, and has been flowing without intermission ever since. The first essay made by the Mines Department was in 1884, although artesian water had been previously tapped in a bore for coal near Lake Macquarie. A list of the wells bored is given, and it is pointed out that some steps should be taken, and if need be, legislation obtained, to ensure that an exact record of strata passed through in private wells or bores should be kept, and become the property of the Government, because it is of great public importance that this work should be done in a scientific manner. There can be no question that a matter of such vital importance to our Colony as a record of experience in well-boring should be carefully kept, and that in time these records will enable those charged with the duty of well-boring to do the work more economically and with better chances of success than at present, because the experience gained from wells made will point to the best places and the most economical methods of making others.

Connected with the Palæontological work of the Department under Mr. Robert Etheridge, Junr., are (1) A monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales has been published; (2) Contributions towards a catalogue of works, papers, and reports on the Anthropology, Ethnology, and Geological History of Australian Aborigines, part ii., has been completed, printed and published; (3) Part iii. of Vol. II., of the Records of the Geological Survey of New South Wales, has been published.

Mr. C. Moore the Government Botanist is now passing through the press a systematic and descriptive work of the Flora of New South Wales. This work has been in preparation for some years and is considered necessary as a corollary to the Census of the Plants of this Colony, published by Mr. Moore in 1884. Up to the present time no complete work of this kind has existed; all former descriptions of our plants having been published in a fragmentary manner, or enumerated in general floras. The main object of the book is to furnish to those who may take an interest in our flora, a ready means of determining the names and characters of all such plants which may come under their notice. Considerable pains have been taken to render the diagnosis of the genera and species as concise as possible. The work is arranged on the dichotomous system, which will be found most useful to botanical students. In addition to the descriptive parts there will be an index of technical terms, in order to give the tyro a ready means of acquiring a knowledge of technical language which in all scientific works is indispensable to a proper understanding of the subject. It is the intention of Mr. Moore to publish hereafter a full description of the plants of Lord Howe and Norfolk Islands.

In the Chemical Laboratory of the University, Professor Liversidge continues his study of the minerals of New South Wales, and in our Proceedings will be found a valuable paper by him, another addition to his work on this subject. Perhaps the most important item in it, is that referring to the auriferous haematite of the Mount Morgan Mine, Queensland. He there shows that in the specimens examined the haematite contained a skeleton or inner frame work of silica, and the gold present seems to be much more intimately connected with the silica than with the haematite. This investigation seems to render the geyser theory of the origin of the deposit doubtful. In a paper on the rusting of iron, read at the Hobart meeting of the Australasian Association for the Advancement of Scieuce, he shews that the generally accepted view of the composition of ordinary iron rust viz., that it consists of hydrated sesquioxide of iron is incorrect, as proved by the examination of a large number of specimens of rust formed under different conditions, and from iron of all sorts. He finds that in almost every instance the rust contains more or less magnetic oxide, mixed with the sesquioxide. At the same time and place he published the result of a number of experiments made to determine the amount of magnetite or magnetic particles, in certain minerals and rocks, and found that Franklinite, chrome iron and some other minerals, such as garnet and black spinet do contain particles of magnetite, thereby clearing up a point upon which doubt has existed, and is expressed in standard works on mineralogy. Bauerman in his Systematic Mineralogy for instance, says "Chrome ore, iron and Franklinite are magnetic, but it is not certainly known whether this is a special property or is caused by finely interspersed magnetite."

In the Physiological Laboratory, Professor Anderson Stuart has added materially to our knowledge of human physiology and anatomy. During the past year he has published sixteen papers on these subjects. (1.) He has demonstrated conclusively—*Proceedings Royal Society*—the presence of a membrane in front of the vitreous humour. The presence of this thin membrane has been alternately asserted and denied, and, finally, in recent years, was given up by the best anatomists. The confirmation of its presence is important from the point of view of the operator upon the eye. (2.) He has also demonstrated that the suspensory ligament of the lens of the eye is merely cemented to the capsule of the lens and to the ciliary bodies—a fact of importance in our knowledge of the development of the eye.—*Proceedings Royal Society.* (3.) Also that the suspensory ligament of the lens is really composed of two portions, with very different connections and functions—and this demonstration does much to complete our knowledge of the mode in which the eye is accommodated for focus.—*Proceedings Physiological Society.* (4.) Also that in the periphery of the vitreous body there is a ring of fibrous tissue membranes, the main septa of which spring from the ciliary region of the hyaloid membrane, and pass backwards and inwards through the vitreous tissue, so that the suspensory ligament of the lens has an attachment not merely to the hyaloid membrane but through the fibrous septa practically to the whole of the vitreous substance.—*Proceedings Anatomical Society.* He also made important contributions to the physiology of the larynx. With Dr. MacCormick he has shown, that in swallowing, the entrance to the air-passage is not closed by the epiglottis folding down as a lid.—*Journal of Anatomy and Physiology.* Also he has shown—*Proceedings Royal Society*—that the passage of the larynx is closed by the movements of the arytenoid cartilages, and the investigation has extended to all classes of animals. (5.) Contributions to the physiology of the chest—he has shown that the form of the chest in man is to be explained as the result of gravitation. Also that in forced efforts it is not necessary to close the larynx in order to make the chest rigid, since this can be accomplished by muscular effort alone.—*Proceedings Physiological Society.* He has also designed apparatus to demonstrate :—(1). The accommodation of the focus of the eye for various distances. —*Proceedings Anatomical and Physiological Society.* (2.) The hydraulic conditions of the circulation.—*Journal of Physiology.* (3.) The motion of the air particles in the transmission of sound waves through the air.—*Proceedings Physiological Society.* (4.) The transmission of light waves.—*Proceedings Physiological Society.* (5.) Some of the phenomena of double vision.—*Journal of Anatomy and Physiology.* These results are contained in the following papers published during the year just ended :—

Proceedings of the Royal Society of London—

1. On a membrane lining the fossa petellaris of the corpus vitreum.
2. On the connexion between the Suspensory Ligament of the Crystalline Lens and the Lens Capsule.
3. A simple mode of demonstrating how the Form of the Thorax is partly determined by Gravitation.
4. On the Mechanism of the Closure of the Larynx.

Journal of Anatomy and Physiology—

5. A mode of demonstrating the Gross Structure of the Eye-ball.
6. A simple means of explaining the nature of Diplopia.
7. A new method of demonstrating the relation of the two sides of the Retina to the outer World.
8. Note on a Spear Flag Indicator for Muscle-nerve Demonstrations.
9. A mode of demonstrating the Developing Membranes of the Chick.
10. A method by which accurate drawings may be made by amateurs.
11. Note on the Muscles of the Rudimentary Ear-Pendants of the Neck —in Pigs.
12. The Position of the Epiglottis in Swallowing. (With A. MacCormick, M.D.)

Journal of Physiology—

13. On some Improvements in the method of graphically recording the variations in the level of a surface of Mercury, *e.g.* in the Kymograph of Ludwig.

14. The Circulation Kymoscope, an arrangement for demonstrating many of the Physical phenomena of the Circulation.
15. The Interference Kymoscope, an apparatus for demonstrating many of the phenomena of wave-motion.

Pharmaceutical Journal—

16. On the so-called Eucalyptus Honey.
17. Report on the Koch Method of Treating Tuberculosis.

In the Physical Laboratory at the University, Professor Threlfall, aided by the Demonstrator, Mr. J. A. Pollock, and advanced students, has been engaged in making investigations most of which have occupied him at different times since 1888. One of these is the measurement of the magnetic effect of displacement currents, based on the use of a circuit of fused quartz in an alternating field. Success has not yet been secured owing to the strong diamagnetic properties of the quartz, and also for the want of sufficient means for producing strong magnetic fields. Investigations have also been made with regard to a static-gravity-meter depending on fused quartz threads, an investigation of the physical properties of which was published in the *Philosophical Magazine* for 1890 and which agreed with some results obtained by Prof. Boys and just published, though not seen by Prof. Threlfall at the time his paper was written; the Sydney results were probably the more accurate of the two, as the research was more elaborate. Since then the constants have been verified, and a very curious increase of rigidity found out; it occurs when the fibres are heated, and it is not explained by the expansion of the fibres by heat. This was worked out by the Professor and some of the students. Experiments upon nitrogen have occupied a good deal of time, as the Professor has no assistance of the kind required in this investigation. He has, however, succeeded by a partly original process, in getting a continuous flow of nitrogen in a state of purity, which it is believed has never been approached before, and he has proved that nitrogen forms a compound with mercury under the influence of the electrical discharge, and he has established the identity of this compound with one partially studied by Shönbein, and formed by acting with ammonia on mercuric oxide. The exact composition is still doubtful, but he finds that a minute trace of some impurity, besides the nitrogen and mercury is probably necessary for its formation. At present the nature of the impurity has not been determined. The Professor finds "striæ" in the purest tubes he has been able to make, but to a much smaller extent than in well purified gas, and he is now observing the gas in "endless tubes," *i.e.*, tubes which form themselves the secondary of an induction coil.

Some months were spent in trying to make the static gravity meter sensitive enough to show Lunar disturbances of gravity, but so far without success, even when using Michelson's interference method on the scale which quartz threads permitted them to give to the size of the mirrors. A fixed instrument has been made which will show a change of $\frac{1}{900000}$ "g," and efforts are being made to construct a portable gravity meter sensitive to $\frac{1}{10000}$ "g," with every prospect of success. Mr. Pollock is carrying on this work as he finds time. Important experiments on the electric properties of sulphur were begun in 1887 and are still in progress, and have led to curious results depending on the state of the sulphur. These demand a special galvanometer, which has taken a long time to make. It is required to investigate phenomena beyond the reach of ordinary instruments. Meanwhile, there is no doubt that pure sulphur is one of the best non-conductors known, and it is so far as Prof. Threfall knows at present, almost free from the phenomena of electric absorption, a property which may be of value. Mr. Brearley is assisting the Professor in this work. Experiments have been carried out on the change of temperature observed during the diffusion of gases, with results at present inexplicable. Mr. Farr is working at the magnetic elements. He observed the changes day and night for a week, and Mr. Knibbs has carefully laid down bearings with an eight-inch theodolite. The results are almost ready for publication. A marked change has taken place during the past four years. The Professor has devoted much of his time recently to the theory and practice of electro-magnetic reciprocating mechanisms and the chronograph has been applied to the study with great success. A great deal of new theory has found its way to exact expression on paper, and a successful experimental machine has been constructed as an expression of the theory. Many of the results so far obtained might have been embodied in papers, but the Professor prefers to delay publication until the investigations are complete.

Owing to enlargements and alterations, the Engineering Laboratory at the University could not be used, and Professor Warren has devoted available time to working out and preparing for press, the results of previous experiments on Australian timbers and the results will be published immediately. The new machinery is being got ready for testing timbers, building stones, cements, concrete, &c. The Professor expresses in a paper read to the Architectural Association, the results of some experiments on "Iron and Steel as applied to Building Construction," and to the Sanitary Section of the Australasian Association at Hobart, he read a paper on "Sanitary Engineering as applied to Drainage of Cities and Towns and the Disposal of Sewage." He is now engaged in writing a text-book on "Iron, Steel, and Timber, as applied to Engineering Construction," and has sent to the Institution of Civil Engineers, London, a paper on "Australian Timbers."

The Professor of Anatomy in our University, Professor Wilson, is, I believe, at present engaged in investigating the myology of the new and remarkable mammal, *Notoryctes typhlops*, recently found in South Australia. It is a gratifying indication of our scientific progress, that such work should now be carried out in Australia and in our Medical School, instead of being, as a matter of course, entrusted to English or foreign scientific observers.

The Professor of Geology in our University, Professor Edgeworth David, in his address to Section C. of the Australasian Association for the Advancement of Science meeting at Hobart, contributed to the Geology of Australia the results of his investigation of the evidences of volcanic action in Eastern Australia and Tasmania, with special reference to the relation of volcanic activity to the oscillations of the earth's crust, and to heavy sedimentations—a most important address full of carefully acquired facts bearing upon the subject. In another paper contributed to this Society, in November, 1891, on "Artesian Water in New South Wales," he discusses in a preliminary note, this important question from a geological point of view, tracing the cretaceous beds into the adjoining Colonies. To the Records of the Geological Survey of New South Wales, Vol. II., part iii., 1891 he contributed two papers, one on "The Associated Minerals and Volatility of Gold," in which he has brought together the results obtained by many workers in Australia, America, &c., on this subject in a form most convenient to those studying the formation of gold deposits, and the method of winning the gold from these deposits, indicating lines of investigation of great importance. Also a note on "Mr. J. C. H. Mingaye's Analysis of New South Wales Coals and Coke," in which he shows, that with proper care in the manufacture, Australian made coke by thorough washing the coals before coking, would form excellent coke, nearly, if not equal to, English made coke. Also, in association with Mr. William Anderson, Geological Surveyor, some valuable notes on a collection of rocks and minerals from Mount Morgan, made by the late Mr. C. S. Wilkinson. These have on important bearing on the arrangement of the gold in that mine of world-wide fame.

In the Geological Department, University of Sydney, 1891-92, the Professor has been engaged in the classifying and arranging of various collections of rocks, minerals, and fossils, and therefore, has had little time available for scientific research. The geological students, however, at the University have taken a a number of excursions, chiefly to localities in the neighbourhood of Sydney, where eruptive dykes of basalt occur in contact with sedimentary rocks. Typical collections of rocks and minerals were obtained by the students from such localities, and these are now being microscopically examined by this department. The evidence so far obtained seems to point to the conclusion that:—(1.) All the eruptive rocks in the neighbourhood of Sydney are geologically newer than the Wianamatta Shales and Hawkesbury Sandstone; (2.) That the eruptive rocks, when intruded into the sedimentary, worked their way to the surface by dissolving the overlying rocks, and absorbing the greater part of their material, instead of wedging them apart laterally. This is probably the true explanation of the great variation observable in the mineral constitution of the basaltic intrusion at neighbouring localities. All were derived in the first case probably from a magma of uniform chemical composition; but this became subsequently blended at the various points of intrusion with a variable quantity of sandstone and clay shale derived from the surrounding sedimentary rocks. An examination by Professor David and Mr. A. J. Prentice, B.A., of the Geological Fault at Lapstone Hill, proves that great disturbance in the stratification of the earth's crust to resemble a monoclinal fold rather than a fault, the strata of Hawkesbury Sandstone being bent down sharply to the east, between Lapstone Hill and Emu Plains. Until the measurements are completed, it will be impossible to state whether or not the folding culminated in an actual shearing of the strata. With the kind assistance of the Department for Mines, a new geological map has been prepared of New South Wales. A map of Australia has also been prepared in this Department, showing the area of the artesian water-bearing formations and the position of all the principal natural springs, and the artificial wells and bores.

Dr. Ramsay has kindly supplied the following list of papers published in the "*Records of the Australian Museum*" during 1891:—

On a New Species of Pteropine Bat from the New Britain Group. By E. P. Ramsay.

Notes on the Disappearance—Total or Partial—of Certain Species of Birds in the Lower Lachlan District. By K. H. Bennett.

Description of a New Fish from Lord Howe Island. By J. Douglas Ogilby.

Supplement to the Catalogue of "Nests and Eggs of Birds found breeding in Australia and Tasmania. By A. J. North.

Notes on new and little known Australian Madroporaceæ. By W. Saville-Kent, F.L.S., F.Z.S., Commissioner of Fisheries, Queensland.

Further Descriptions of Upper Silurian Fossils from the Lilydale Limestone, Upper Yarra District, Victoria. By Robt. Etheridge, Junr.

A much-thickened variety of *Bulimus bivaricosus*, Gaskoin, from Lord Howe Island. By R. Etheridge, Junr.

The Land and Fresh-water Shells of Lord Howe Island. By C. Hedley.

On the Organism Discolouring the Waters of Port Jackson. By Thomas Whitelegge.

Note on the Nidification of *Plotus novæ-hollandiæ*, Gould. By A. J. North.

On a new and peculiar Freshwater *Isopod* from Mount Kosciusko. By Chas. Chilton.

Notes on "Rock-shelters," or "Gibba-Gunyahs," at Deewhy Lagoon. By R. Etheridge, Junr.

Description of a New Pelagic Hemipteron from Port Jackson. By Frederick A. A. Skuse.

Note on the Nidification of *Edoliisoma tenuirostre*. By A. J. North.

On the Recent Discolouration of the Waters of Port Jackson. By Thomas Whitelegge.

Descriptions of three new Papuan Snakes. By J. Douglas Ogilby.

Note on the Nidification of *Turnix melanotis*, Gould. By A. J. North.

On *Hadra gulosa*, Gould. By C. Hedley.

On the occurrence of the genus *Palæaster* in the Upper Silurian Rocks of Victoria. By R. Etheridge Junr.

The Operculate Madreporaria rugosa of New South Wales. By R. Etheridge Junr.

Notes on the structure of *Pedionomus torquatus*, with regard to its systematic position. By Hans Gadow, PH.D., M.A.

List of papers read before the Linnean Society of New South Wales, 1891 :—

Jan. 28. 1—Notes on the occurrence of Stilbite in the eruptive rocks of Jamberoo, New South Wales. By B. G. Engelhardt.

Feb. 25. 2—On the anatomy of some Tasmanian Land Snails. By C. Hedley, F.L.S.

„ 3—Notes on a small collection of Hymenoptera from Narrabri, N.S. Wales. By W. W. Froggatt.

„ 4—Description of a new species of Tortricidæ. By J. Hartley Durrant, communicated by A. S. Olliff.

„ 5—Stray notes on Lepidoptera, No. 2. By A. Sidney Olliff, F.E.S.

„ 6—Notes on Australian Aboriginal Stone Weapons and Implements, Nos. 10 – 15. By R. Etheridge Junr.

Mar. 25. 7—On the Classification of Eucalypts. By Rev. W. Woolls, PH.D., F.L.S.

„ 8—On the trail of an extinct Bird. By C. W. DeVis, M.A.

„ 9—Note on an extinct Eagle. By C. W. DeVis, M.A.

„ 10—The Land Molluscan Fauna of British New Guinea. By C. Hedley, F.L.S.

Apr. 29. 11—On the occurrence of Barite (Barytes) in the Hawkesbury Sandstones near Sydney. By H. G. Smith.

„ 12—On the occurrence of a Gum in *Echinocarpus (Sloanea) australis*, Benth. By J. H. Maiden, F.L.S., F.C.S.

„ 13—Notes on Australian Economic Botany, No. 2. By J. H. Maiden, F.L.S., F.C.S.

„ 14—In confirmation of the genus Owenia, so-called. By C. W. De Vis, M.A.

„ 15—Onyx and Dipeltis, new Nematode genera ; with a note on Dorylaimus. By N. A. Cobb.

May 27. 16—A contribution to the Geology and Petrography of Bathurst, New South Wales. By Rev. J. Milne Curran, F.G.S.

May 27. 17—Remarks on Post-Tertiary Phascolomyidæ. By C. W. De Vis, M.A.

„ 18—Description of a new Marine Shell. By C. Hedley, F.L.S. and C. T. Musson, F.L.S.

Jun. 24. 19—Angophora Kino. By J. H. Maiden, F.L.S., F.C.S.

„ 20—On the Incisors of Sceparnodon. By C. W. De Vis, M.A.

„ 21—Contributions to a more exact knowledge of the Geographical distribution of Australian Batrachia No. 2; with description of a new Cystignathoid Frog. By J. J. Fletcher, M.A., B.SC.

„ 22—Description of a new Cone from the Mauritius. By J. Brazier, F.L.S.

July 29. 23—Notes on Aboriginal Stone Weapons and Implements. By R. Etheridge, Junr.

„ 24—Synonymy of *Helix (Hadra) gulosa*, Gould. By J. Brazier, F.L.S.

„ 25—The Silurian Trilobites of New South Wales, with references to those of other parts of Australia, Part i. By R. Etheridge, Junr. and John Mitchell.

„ 26—Observations on the Chloræmidæ, with special reference to some Australian forms. By Prof. W. A. Haswell, M.A., D.SC.

August meeting adjourned. No papers were read on account of the death of Mr. C. S. Wilkinson.

Sep. 30. 27—The examination of Kinos as an aid in the diagnosis of Eucalypts, Part iii. By J. H. Maiden, F.L.S., F.C.S.

„ 28—Descriptions of two new species of Carenum from West Australia, with notes on the synonymy and distribution of some previously described species. By T. G. Sloane.

„ 29—Jottings from the Biological Laboratory, Sydney University, No. 15. By Prof. W. A. Haswell, M.A., D.SC.

Sept. 30. 30—Residue of the Extinct Birds of Queensland as yet detected. By C. W. De Vis, M.A.

" 31—Observations on plants collected during Mr. J. Bradshaw's Expedition to the Prince Regent's River. By Baron von Mueller, K.C.M.G., M.D., PH.D., F.R.S.

" 32—Notes on Australian Coleoptera with descriptions of new species, Part x. By Rev. T. Blackburn, B.A.

" 33—Descriptions of some new species of Pulmonate Mollusca from Australia and the Solomon Islands. By J. C. Cox, M.D., F.L.S.

" 34—Description of a new Diphlomorpha from the New Hebrides. By W. D. Hartman, M.D.

" 35—Notes on some Land and Freshwater Mollusca obtained in Queensland during 1887. By C. Hedley, F.L.S.

" 36—Illustrations of some Australian Plants.

Oct. 28. 37—Revision of Australian Lepidoptera, Part v. By E. Meyrick, B.A., F.Z.S.

" 38—On two undescribed Exudations from the Léguminosæ. By J. H. Maiden, F.L.S. F.C.S.

Nov. 25. 39—Anatomical Supplement to the Land Molluscan Fauna of British New Guinea. By C. Hedley, F.L.S.

" 40—On a form of Womerah or Throwing-stick presumed to be undescribed. By R. Etheridge, Junr.

No papers were read in December on account of the death of Sir William Macleay.

In the Government Laboratory some matters of great interest to our members have been investigated by Mr. Hamlet, more especially those bearing upon sanitation. It is significant of serious danger when we find that in 184 samples of water used for dairy purposes from the city and suburbs, one-half of them were unfit for human consumption, and on the other hand the water supply of the city, by regular monthly analyses, is shewn to be of great purity, and that it will bear favourable comparison with the water supplied to the chief cities in the world.

The Board of Water Supply and Sewerage have in Sydney introduced a system of ventilating which has been developed by Mr. J. M. Smail, Engineer for Sewerage. It is, I understand an improvement upon any system of ventilating sewers in actual operation, in fact at this moment the sewers of Sydney are in a better sanitary condition than those of any other city in the world. And it seems fitting that in an attempt to get together a record of the applications of science, as well as pure science, that I should say a few words about a subject of such vital importance to the health of the city. The members are doubtless all familiar with Banner's system of ventilating sewers which was developed in Brighton, England, by Mr. Banner, as an attempt to get rid of sewer gases from his own house, and since 1873 has spread to so many cities ; in fact, no city with any pretentions to sanitary care is without some form of it. The principle is that the atmosphere should have free ingress to and egress from sewers at the crown of the roads, so that by oxidation it to a great extent destroys the noxious gases, and at the same time prevents the accumulation of sewer gas under pressure, and hence stops it from forcing its way into houses through the drainage pipes and traps. Before attempting to apply this system to Sydney, Mr. Smail determined to see if the upcast and downcast circulation of air and gas would go on as satisfactorily in a hot climate as it did in a cold one, and he found that it did not, and that when any wind was blowing, it became the principal factor in producing a circulation of air in the sewers. If the wind blew towards the outfall of any sewer, the air was forced up the manholes into the roadway, and although much diluted in the process, it was sufficiently noxious to cause a nuisance, especially in narrow streets, in densely populated areas; guided by these investigations the system he adopted is to close these openings in the street, and supply the sewers with fresh air by downcast pipes, and at the same time provide an upcast pipe for exhausting the air and gas from the sewer, the first stage of the process, thus providing for dilution and oxidation of the noxious gases, the work being completed by delivering this mixture above the tops of the houses.

This system is a combination of the plenum and vaccuum systems, the fresh air is forced into the sewers by means of a tall shaft fitted with an induct cowl, and considerable advantage is gained by this method, as the air is purer than if drained from a lower level, the oxydising effect of air so obtained being apparent, the sewer air becomes diluted, and the temperaature of the sewers so ventilated approximates to that of the external atmosphere. The diluted air is exhausted by tall shafts carried up the walls, and well over the roofs of the houses so that air is distributed far beyond the limits of danger. From observations made at the different shafts during the year over the lines of sewers, operated upon by the Board, which aggregates seventy-four miles of sewers of varying sizes, it was found that the average work done by the induct shafts (or air forced into sewers by wind power) varied from 1,397 to 4,554 cubic feet per hour. The results are derived from seven hundred and forty observations, the average wind velocity being 8·43 miles per hour. The total amount of work done, in withdrawing air from the sewers by the whole of the exhaust shafts erected, is equal to 1,579,656 cubic feet, or 56·41 tons of air, and the total amount of pure air passed into the sewers by the induct shafts is equal to 857,400 cubic feet, or 30·62 tons of air ; the oxydising effect of this supply of pure air is apparent when it is considered that twenty-one parts in every hundred consists of oxygen. In addition to the induct shafts, the Board have also under test a system of forcing air into the larger sewers by water sprays, so far with satisfactory results. The quantity of air introduced per cubic foot of water is equal to 1842·55 cubic feet. A proper adjustment of the grades and sizes of sewers with a good system of ventilation are necessary in order to secure the objects aimed at—even flow of the sewage, and motion and oxidation for the sewer air.

Zone time.—It is known to the members that a persistent effort has been made throughout the world for a rearrangement of time notation, and in many countries the Hour Zone system has been adopted, and is a great convenience to the travelling public, because wherever one goes in such countries the minutes and seconds of time are the same. Changes of longitude or time are made every hour (15°). For Australia the system would work most conveniently, because the fifteenth hour Zone comes through Queensland, Victoria, and New South Wales, and the change of time for either Colony would not be large, and it is understood that the Railway authorities in all the Colonies are most anxious for its adoption in the railway service. There can be no doubt that the change would be for the public convenience; but, I was obliged to point out in my report, that in an important case in the Supreme Court it was decided that "time" for legal purposes "meant local mean-time," and that if we adopted the "Hour Zone time" for common purposes, that is, a time differing from "local mean time," it would be almost impossible to carry out many legal processes without confusion, arising from the use of two "different systems" of time keeping. It is understood that the law officers of the Crown uphold the objection to the proposed change, and it is possible that a similar objection may exist in other countries.

Solar Parallax.—In the past year was published what may probably be considered the best values of the solar parallax, derived from the transits of Venus and other methods, including the velocity of light, opposition of planets, &c., and Dr. Auwers of Berlin, has at last published the result obtained from seven hundred and fifty heliometer measures made by the German Transit of Venus parties in 1874 and 1882; the resulting solar parallax for 1874 is 8·877, and for 1882, 8·879. Professor Harkness, of Washington, has published the most elaborate discussion of the many attempts made to determine the solar parallax, including all but the two just published by Professor Auwers, and as the result of his discussion he adopts 8·834 in. as the final value. Had the two Berlin results which were published after Professor Harkness' value, been known it would have been altered to 8·840 in., which makes the sun's distance ninety-two and a half millions of miles.

Some sixteen years since Sir William Thompson expressed the opinion that meteorological conditions might produce such changes in the sea level as would for the time change the direction of the earth's axis by as much as half a second of arc, and at the meeting of the Royal Society this year, he announced that he had a letter from the astronomer at Berlin, telling him that he had just received a letter from the party of astronomers which the International Geodetic Union had sent, at his suggestion, to Honolulu to observe the latitude there for a year, while similar observations were being made in Berlin with the object of comparison in order to settle the question whether the direction of the earth's axis did or did not actually change. The letter gave the result of the first three months' work, and announced that the latitude had decreased almost one-third of a second, and during the same period that of Berlin had increased by one-third of a second. Since the two places are nearly opposite each other on the earth's surface, this is the strongest evidence yet brought forward, that the earth's axis does oscillate to a small extent, but yet quite enough to effect some observations seriously. We are gradually learning. First the earth's surface acts something like that of an india-rubber ball, yielding to the changing pressure due to the tides, the atmosphere, and the moon, and now it seems we must admit that even the direction of its axis of rotation is not fixed. A preliminary examination of two years' work with the Sydney transit instrument shows that here also there is a decrease in the latitude in spring, and in autumn it increases, and members may remember that some time ago I mentioned the fact that we had at Sydney a change in the direction of the vertical amounting to 6″, due to a rain storm.

Astronomical Photography.—Since December 1891, the Sydney Observatory, in common with other Observatories taking part in the astrophotographic chart of the heavens, has been busily engaged taking the special photographs which the work demands, whenever the weather permitted, and by the way, I think we have had about the worst summer for such work I have ever known; for as a rule when heavy cloud was absent, then hazy cloud took its place, so that in four months we only had four really fine nights, however by stealing photographs between the clouds we have got one hundred and forty six taken, rather more than one-tenth of what we have to do; we could get through the whole of it in two years, that is years with a fair share of fine weather. Prior to the star chart work we succeeded in getting many invaluable photographs of nebulæ clusters and other interesting portions of the sky, and the star camera was fitted with two enlarging lenses of different powers. With these enlarged pictures of star clusters have been taken, also of the moon in various phases, and of the planet Jupiter, also of the lunar eclipses on May 24th, and the transit of Mercury on May 10th. Special experiments have also been made with ordinary photograph lenses of short focus, to see if it would be possible to take star pictures, including portions of the heavens, 50° or 60° in diameter, and substitute them for ordinary star charts, the experiments are still in progress.

Of the eighteen Observatories which originally accepted shares in the work of accurately photographing the heavens. The three in South America, Santiago, La Plata, and Rio de Janeiro have so far been unable, owing to political changes in that part of the world to begin the work, and pending the solution of their difficulties, it has been proposed that the Cape, Melbourne, and Sydney should take up the work allotted to South America. It is hoped however, that at least one new Observatory will be established in Australasia. Tasmania has a bequest of £10,000 for the foundation of a School of Astronomy, and it may be possible to combine this with the University work in such a way, that the photographic work may be taken up there. Tasmania is most favourably situated, both in regard to latitude and climate, to take a share in the work.

The comet, which is now visible in the morning sky, has, as you are aware, been photographed several times at the Sydney Observatory; and these photographs bring to light wholly unexpected phenomena in the comet's tails—phenomena which are of great scientific importance, showing, as they do, that in the camera we have an instrument for analysing light presented to us by a chemical method, which will go hand-in-hand with the spectroscopic method, for by it we may make a first analysis of the light over a large surface preparatory to the application of the spectroscope, which only tests a minute portion at a time. The members will remember that in photographs of the nebula about Eta Argus exhibited here, the camera revealed a most complex structure in parts, which, to the eye, presented a nearly uniform light, and no sign of such structure. And the same action in the sensitive plate was pointed out in photographs of coloured stars. In those of the comet the same selective action is observed, and it has brought to light no less than eight ribbon-like rays in the tail of the comet, which otherwise would have remained unknown, but for the part photography has played, for in the part of the tail visible through the telescope no sign of these rays could be seen, even when I knew from the photograph that they were there, and were photographically brighter than the hazy part near the coma. They are then features invisible to the eye, but caught by the sensitive plate—or, to put it in another way, we have a comet with coloured rays in its tail, rays which are probably blue or violet, from the fact that in comet spectra blue light prevails; and therefore, the sensitive plate, by its selective power, as well as by its power of storing up faint rays, may be used to make a preliminary analysis of cometary or nebulous light, and point the way for the more searching investigation with the spectroscope.

Ocean Currents.—For several years past the Observatory has kept up, for all who would assist in the work, a "current paper" department, and printed papers have been freely supplied to commanders of vessels and others, and quite a number of papers have been returned found upon our coast and in various parts of the world, so that now any such paper found on the coast finds its way to the Observatory; hence it was that a paper thrown over from the Austrian man-of-war *Saida*, which is of more than ordinary interest came to me. The *Saida* left Sydney on March 7th, 1891, on her way to New Zealand, and when about half way across, in latitude 40° 18′ and longitude 157° 39′, a corked bottle, sealed with pitch, and containing a paper with a memorandum written in ink to the following effect so far as it could be made out, for part of the writing had faded (which would not have been the case had it been written with lead pencil):—"Ship *Saida*, on voyage from Sydney to Auckland. All well on board. Fresh N.E. Lat. 40° 18′ south, Long. 157° 39′ east," the date is almost washed out, but appears to be March 11th, and it was found that the *Saida* left Sydney on March 7th. The interesting part of it is that this bottle found its way against a strong current, through twelve degrees of latitude and four degrees of longitude, on to the coast of Australia in lat. 28° 4′ south, two miles north of Tweed River, where it was found February 10th, 1892, just eleven months after it was thrown into the sea. From what is known of the currents, which set strongly to the south along the coast of Australia, it seems impossible that it could have travelled direct. Probably, therefore, it was carried eastward by the current, which, in latitude 35° to 40° south, sets in that direction on to the coast of New Zealand, the current then turns northwards, and probably carried the bottle on to the neighbourhood of Norfolk Island, and thence still northward towards New Caledonia, until it got into the current setting thence on to the coast of Australia. A journey without deviations, of a least 2,500 miles in three hundred and thirty-five days, or upwards of seven miles a day, and doubtless the bottle, subject to all weathers made many deviations, which made its course very much longer and therefore all the more surprising. Once before a current paper thrown from the *Marie Ogilvie* when one hundred and forty-two miles north-east of Sydney, found its way on to the coast at Little Bay, in nine days, or at the rate of sixteen miles per day.

Evaporation.—In its bearing upon a question of evaporation, which is of vital importance in Australia, I may mention that M. Hohnel, the well known botanist, has recently stated that in Europe, full grown "Poplars, Oaks, Ashes," and other large trees, transpire daily from eleven to twenty-two gallons of water, and he computes that a properly filled wood of mature beeches, two acres in extent transpires during six months of the year, June 1st to December 1st, from 500,000 to 700,000 gallons of water. If we take the mean of these two quantities as an average effect, or that an ordinary beech wood of two acres in extent transpires in the six months 600,000 gallons, it strikes one as an enormous quantity, it is in fact equal to thirteen inches of rain, and a fir wood which transpires very slowly, gives off water in six months equal to nine inches of rain.

Meteorology.—During the past summer our weather has been the cause of more than the ordinary amount of popular discussion, and it has likewise been to us who are watching it day by day of more than ordinary interest. The question most prominent is—why all this dryness inland and all the rain on the coast? With the help of Mr. Hunt, who prepares the daily weather chart, I have been watching the changes very closely, with the result that all the main features which give rise to the above mentioned weather conditions are clearly made out. For the five months of the past summer, December to March, we have had a constant succession of anti-cyclones of a peculiar type; for while the ordinary summer weather here is made up of passing anti-cyclones with well-marked low pressures between—which low pressures are distinguishing features, for they deposit rain in the Western Districts and facilitate the southerly progress of tropical rains—the recent anti-cyclones have had no effective low pressures between, and, consequently little or no rain in the Western Districts. Further, the latitude of the centres of the anti-cyclones has been greater than usual; so that when they move forward slowly or, as they sometimes do, stop south of Adelaide for several days, there is time for their distinctive wind circulation to make itself felt, and hence to produce persistent southerly to south-east winds on our coast—that is, moisture-laden winds which deposit rain on the coast and highlands. The persistence of these anti-cyclones, then has been the cause of our persistent coast rains.

The latitude has been from 35° to 40° south, and the centres of the anti-cyclones travel eastward, their average rate of motion has been four hundred miles per day—that is to say, they travel from the west to the east coast of Australia in six days, but the rate varies from two hundred and fifty to five hundred and fifty miles per day, the slowest moving anti-cyclones give most rain, and the fastest no rain at all. The reason is obvious, when the motion forward is rapid there is not time to get up the circulation which brings south-easterly winds and rain on our coast, and when it is slow these winds most prevail. If we may assume that the average daily velocity of a number of these anti-cyclones is the velocity of the motion of the atmosphere in latitude 35° to 40° and that the variations in speed are due simply to interchanges amongst the masses of air rushing about for adjustment of pressure, then it is obvious that these anti-cyclones would, if keeping the same latitude, make a circuit of the earth in about 50 days, and bring us a repetition of weather, and we should have in the open southern ocean the conditions for foretelling the weather for some weeks in advance; it is this point which has rendered the investigation specially interesting and important, but so far the results have not been very promising, because we cannot recognise the particular cyclonic centres when they return, if indeed they do return at all. But I am disposed to think from what we see of them during their two thousand mile journey over Australia, that they do not preserve special characteristics long enough to be recognised on return, after fifty days of a trip round the world. The means of forecasting the weather on this principle has been sought in the northern hemisphere; but I think Australia is the best postion in the world for testing the merits of the idea, and as I have just stated, it does not seem to hold out much promise of success.

In conclusion I thank you for the kind support you have given me in the Chair during the past year, and for the patience you have shewn in listening to this long and I fear, wearisome address. It is longer than I meant it to be, but not long enough I fear to include all the scientific work which has been done in the Colony during the past year. It now only remains for your President in vacating this chair to welcome heartily the incoming President Professor Warren, to ask for him a continuance of that kindly support which we have always given our Chairman in the past, and to express the hope that in the coming year our Society may be even more successful than it has been in the past.

ON THE IMPORTANCE AND NATURE OF THE OCEANIC LANGUAGES.

By Sidney H. Ray, Memb. Anthrop. Inst. Gt. Brit. & Ireland.

[*Read before the Royal Society of N.S. Wales, June 1, 1892.*]

I.—*The linguistic value of the Oceanic Languages.*

The languages of Oceania afford material of much value to the Ethnologist in the discussion of some of the most interesting and intricate problems of comparative Philology. Whether we regard the number and variety of dialects, their mutual relationship, origin, or influence upon each other, we find in the island region an assemblage of facts to which no other family (or families) of speech can show an exact parallel.

In America or Africa, for example, the number of languages and dialects is perhaps fully as great as in Oceania, but the phenomena presented are of a different nature. We there find languages spoken in extensive regions by large communities.

Unlimited facilities for intercourse in war and peace exist, with consequent mingling of speech and customs. In Oceania, on the other hand, the languages are those of insular populations, separated, it is true, in many cases by narrow channels, but yet so separated as to be prevented from enjoying the close intercourse to which a stream or a range of hills would be no barrier. In the continental and insular regions the languages affect one another in different ways. "Languages of a continent touch each other at their circumferences and may or may not graduate into each other. Languages of an archipelago are definitely bounded. We always know where their circumference is limited. The limit is the sea and the sea is mute."* In America or Africa the contact of languages would thus affect only the outlying portions of a large territory. The inhabitants of the central region, surrounded on all sides by people akin to themselves in speech, race and religion, may be supposed to have retained in its purest form the characteristics of the original language and race. In Oceania the tendency is in a different direction. Except on the larger islands the territory occupied by kindred tribes is small, and we may conceive the original tongue broken up into distinct portions. If another race or language varying in any degree, nay, even another dialect of the same language be introduced, it affects the *whole* of the language spoken in a particular district and not merely a portion of it. This process being repeated *ad infinitum*, the result is a mixed language differing in many respects from its neighbours and often resembling that of distant islands. Hence arises the peculiar difficulty in ascertaining the origin of any particular language of Oceania. The continuous introduction of dialects from all parts renders it well-nigh impossible to discover the original speech, or even to determine whether the languages, as now found, are superposed upon older or more primitive forms of speech.

In another respect the languages of Oceania are of importance. They afford material by which the psychologist may study the

* R. G. Latham—Comparative Philogy, p. 4.

working of the human mind in its early condition. In the eloquent words of Farrar*—"It is these (uncultivated) languages more than any others which are likely to throw a faint glimmer of light over what may be called 'that *Eocene* period of the human mind which precedes the dawn of all history'—for which, therefore, indispensable as it is for our ethnic and zoological, nay, even for our political and humanitarian speculations, all other lights are wanting. In fact, the more bizarre the method of the language, the more impoverished are its resources, the more miserable the contrivances it adopts, the more nakedly it displays the crude infantile expedients of a primitive speech, the more forcible the contrast it presents to all the languages with which we are familar, *the more entirely is it worthy of our philological examination.* For after all it is, and must necessarily be, an instrument, and an adequate instrument, for the expression of human needs, even if those needs are at their lowest; and a dim reflex of human intelligence, even if that intelligence be of the meanest and least developed type."

II.—*The stage of development in which the Oceanic tongues are found.*

A question of some interest in the discussion of the Oceanic languages relates to the stage of development in which they are now found. In most works on general philology, they are placed among languages of the agglutinating type. But if we accept the common definition of agglutination, as the placing of unaltered roots side by side, the term will only partially apply. Many words are no doubt formed in this way, but the method is not the most prevalent one in the island languages, and therefore cannot be regarded as determining the type. It would be better to adopt the classification of Steinthal and describe them as uncultivated languages of the inflectional type, expressing the modifications of meaning by prefixed particles and suffixes.* In the Australian tongues these are plainly apparent, but the practice of writing the modifying particles apart from the root in many of the other languages tends to obscure the fact of inflection, and makes the

* Farrar—Language and Languages, p. 391.

particle appear as a separate word. But when, as in Tanna and Eromanga, the formative particle is represented by a single letter and cannot be written otherwise than in combination with the root, the inflectional character of the language is apparent.

We may even compare the structure of a verbal form in Tanna with that found in the classical languages. Thus the singular imperfect indicative of the verb 'to say' is in Tanna :

1. *yak-am-ani* 2. *nuk-am-ani* 3. *t-am-ani*

and in Greek and Latin :

1. ἔ-φη-γ 2. ἔ-φη-ς 3. ϵ-φη-

1. *dic-eba-m* 2. *dic-eba-s* 3. *dic-eba-t*

Here the Tanna personal prefixes *yak*, *nuk*, *t* correspond to the Greek suffixes γ, ς, ϵ and the Latin *m*, *s*, *t*. The Tanna tense sign *am* corresponds in meaning to the Greek augment ϵ and the Latin *eba*. The only difference in the three languages is in the position of the roots *ani*, φη and *dic*. The Tanna *yak-am-ani*, *nuk-am-ani*, *t-am-ani* are equivalent to 'I, thou or he said,' without the personal pronouns *iau*, *ik*, *te (demonstrative)* being expressed, just as in the classical tongues. In all three languages however the pronouns may be used to emphasize the person.

As also the Gaelic *ba*, 'he was' shows the Latin *eba* used as a separate word, so we find the Tanna *am*, represented by *m* (with varying vowel) used in more than one language of the New Hebrides as the sign of an action combined with a pronominal idea. In Malekula *mi rij*, and Espiritu Santo (Malo) *mo viti* are equivalent to "*he* speaks."

The descriptions of the highly inflected languages of the Aryan family given by Schlegel and Bopp are equally true of the Oceanic. Schlegel's words are :—" Le merveilleux artifice de ces langues (à inflexions) est, de former une immense variété de mots, et de marquer la liaison des idées que ces mots désignent, moyennant, un assez petit nombre de syllabes qui, considérées séparément, n'ont point de signification, mais qui déterminent avec précision le sens du mot auquel elles sont jointes."*

---

* Schlegel, quoted in Bopp—Comparative Grammar, p. 101.

Bopp writes :—"There are in Sanskrit and the languages which are akin to it, two classes of roots : from the one, which is by far the more numerous, spring verbs, and nouns (substantive and adjective) which stand in fraternal connection with the verbs, not in the relation of descent from them, not begotten by them, but sprung from the same shoot with them. From the second class spring pronouns, all original prepositions, conjunctions and particles."*

It will be noted that the characteristics of the Aryan languages as here stated may be collected as follows :—

1. Roots which may be either nouns or verbs.
2. Modifying particles or syllables which have no meaning apart from the principal word.
3. One class of roots signifying things *(nouns)*, conditions *(adjectives)*, or actions *(verbs)*.
4. A second class of roots expressing relations of place *(demonstrative pronouns and adverbs)* and position *(prepositions)*.

In summing up the characteristics of the Melanesian languages Dr. Codrington uses expressions almost identical with those of Schlegel and Bopp quoted above, and his remarks may be applied to all the Oceanic languages without exception.

"There is an absence of those variations in the form of words which may distinguish the parts of speech. . . . The use of the word not its form, commonly declares its character. . . . It is evidently wrong to speak of a noun as derived from a verb, while the form is unchanged."†

"It is highly probable that words generally are in the native mind names or nouns. The thing, the action or the state, receives its name. Words thus are nouns or verbs and they receive discriminating marks, articles or verbal particles in these languages according to their use ; but there is no such distinction in the native mind between the visible object and the visible act, as to

* Bopp—Comparative Grammar, p. 96.
† Melanesian Languages, p. 102.

force them to think the name of an action a different sort of word from the name of a thing."*

"There is a class of vocables in the Melanesian languages which certainly are not now the names either of objects or actions. These are the particles which point in one direction or another, the demonstrative directive particles with which language itself gesticulates. These may be found separate as demonstrative particles, and probably as the simplest prepositions; but they are found combined in pronouns, in adverbs of place, and therefore of time, and in articles. If they are fragments of old nouns, they are now nothing but fragments of that which has been lost; they name nothing, they only point. These cannot like ordinary words, become, as the speaker is pleased to use them, nouns or verbs; they never can have an article or a verbal particle prefixed."†

In some of the Island languages, the tendency is towards analysis. This still further separates them from the agglutinate type, and confirms the analogy to the inflectional. It is mainly owing to the want of prepositions, for example, that such languages as the Fin or Turkish are denied a place with those of the inflectional type,‡ but in Oceania prepositions are commonly found. Yet, where the inflections are fullest as in Tanna and Eromanga, the prepositions are fewest. Like the Aryan prepositions, too, the Oceanic may be often shown to consist of a nominal or verbal combined with a pronominal or adverbial root. The Banks Island (Mota) '*apena*' is analogous to the English '*about it*' both in structure and signification, and literally means '*at its side*.'§ *A* is the locative particle, '*at*,' *pe* is a noun, '*side*,' *na* is a pronoun, '*its*.' The English 'about it' may be resolved into:—*a* 'at or on,' *be* 'by'; '*out*,' an adverb, and the pronoun *it*. *By* is explained as a noun meaning (a place) 'around,' the Greek ’αμφι,

§ Melanesian Languages, p. 103.

* Melanesian Languages, p. 104.

† Farrar—Language and Languages, p. 391.

‡ Melanesian Languages, p. 209.

Latin *amb.** Many similar examples of Oceanic prepositions may be found in Dr. Codrington's work.

The proof of the nominal origin of *pe* is to be found in its use as an independent noun in other languages, *e.g.*, in Leper's Island, Arag.† In the same way the Sanskrit preposition *ava* 'from,' is in the Zend a perfect and declinable pronoun, while the Zend preposition *hacha* 'out of' is in Sanskrit found as a pronoun, 'isque.'‡

It appears from the foregoing, that we may regard the Oceanic languages as being in the inflectional stage with traces of analytic forms, the evidence being of similar character to that found for the European languages. Hence it is reasonable to suppose that we may apply to them the same methods of argument and analysis which have been applied to the elucidation of other inflectional tongues. The difficulty in so doing is no doubt great, owing to the want of a literature preserving ancient forms, but the peculiar dispersion of the original population may to some extent supply the want of a literature. Here and there among the islands, we may find a few isolated remnants of an ancient people, whose dialects, from some cause or other, have retained forms which other dialects have lost. From these we may gather the true meaning of many an obscure word or particle, and perhaps in time attain some knowledge of the primitive Oceanic speech.

A word of caution is necessary, lest what has been here written should be taken to imply that the writer finds any connection between the Aryan and Oceanic tongues. There is no evidence of any such connection. To affirm it, with our present imperfect knowledge of the Oceanic would be absurd and unsafe. The analogy is to be found in structure only. A similar argument may be, and has been applied to some of the American languages.§

---

* Morris—Historical English Grammar, pp. 195, 196.

† Melanesian Languages, p. 153.

‡ Bopp—Comparative Grammar, pp. 530. 1441.

§ Hale—The development of Language, Toronto, 1888, p. 29.

III.—*A suggested Grouping of the Oceanic Languages.*

In comparing the Oceanic languages, it has been the fashion to bring forward for comparison words from all parts of the region, without any very definite result being arrived at, except that they apparently belong to one family.* Their place in that family is not very definitely pointed out. It seems desirable that some attempt should be made to condense the multiplicity of languages into certain smaller groups, and to investigate each of these separately. An enquiry into the relationship of the members of each group to one another, and also as to the evidence which each may, or may not afford as to the existence of earlier languages occupying the same regions, is more likely to prove of value to the ethnologist than a discussion of the resemblances between the words of the whole region or of their supposed affinities with some other linguistic stock.†

The following table is put forward as suggestive of a convenient nomenclature and grouping of the whole of the languages of Oceania. It does not necessarily imply that all the languages therein mentioned are of the same stock. The Australian and Papuan, for instance, may, with fuller materials for study be shown to be quite distinct from the Indonesian or Melanesian. In fact the evidence possessed for the Papuan seems at present to indicate that it forms a group of several distinct languages.

The connection of the Andaman with the Australian is argued by Von Carolsfeld. The arrangement of the other groups is that of the writer based upon a careful comparison of the grammatical forms and vocabularies.

* This is denied, however, by many, who hold that the Australian languages are distinct from those of the Malay Archipelago, Melanesia and Polynesia. The same denial is also extended to the Andaman and Nicobar languages which are here called Oceanic.

† The Oceanic tongues have been connected with all the chief linguistic families of the Old World. Bopp sought to connect the Polynesian and Indo European. Macdonald has written to prove them Semitic. Others have connected them with Indo-Chinese. The discussion of all such questions must be regarded as premature until we are in a position to declare what are the roots of the *primitive* Oceanic speech.

I.—PRINCIPAL GROUPS :

A. Australian ...1. Languages of Australia
2. Tasmanian

B. Papuan........1. Languages of the Black Frizzly-haired natives of New Guinea.

C. Melanesian...1. Southern—South New Hebrides, Loyalty Islands ; New Caledonia.
2. Central—Northern New Hebrides, Banks Islands, and Fiji.
3. Northern—Languages of the Southern Solomon Islands, Bismarck Archipelago, and South Eastern New Guinea (Port Moresby, South Cape etc.)

D. Indonesian...1. Madagascar.
2. Languages of Sumatra, Java, and Malay.
3. Languages of Borneo and Celebes, and islands to the south.
4. The languages of the Philippine Islands and Formosa.

E. Polynesian ...The languages of the Eastern Pacific—Samoan, Maori, Tonga, Hawaii, etc.

Resulting from the contact of these principal groups are found mixed languages. These may be arranged thus :—

II.—SUB-GROUPS.

a. Indo-Australian (?)—The languages of the Andaman and Nicobar Islands.

b. Indo-Papuan—The languages of Ternate, Tidor, and islands and shores of Western New Guinea.

c. Papuo-Australian—The languages of Torres Straits.

d. Melano-Papuan—Languages of the Louisiade Archipelago, and portions of Eastern New Guinea.

e. Indo-Polynesian (or Micronesian)—Languages of the Caroline Islands, Marshall and Gilbert Islands.

f. Melano-Polynesian—Languages of Aniwa and Futuna, New Hebrides, and Rotuma.

ON CERTAIN GEOMETRICAL OPERATIONS—PART I.

By G. FLEURI, Licencié ès-sciences mathematiques and
Licencié ès sciences physiques.

[With Plate I.]

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

[*Read before the Royal Society of N.S. Wales, June 1, 1892.*]

I PURPOSE to study in the present paper interesting relations which exist between a given curve and curves resulting from it by certain well known geometrical transformations. In the first part, I will show how the geometrical transformations in question can be considered as algebraical operations of a peculiar character, and I will establish the principal rules for such operations.

FIRST PART.

Let us consider in a plane a fixed circle and a curve C. We can deduce from C by well known geometrical transformations the following curves:

First, the reciprocal polar of C with regard to the circle.

Second, the inverse of C—the centre of the circle being taken as origin and the square λ^2 of its radius as power of inversion.

Third, the tangential inverse of C with regard to the same origin and same power of inversion.*

Fourth, the successive positive pedals of C, the centre of the circle being taken as origin.

---

* As this transformation is not so well known as the others I give here its defiinition:—Let m' be a tangent to C, draw op perpendicular to m', determine on op a point r such that $or \cdot op = \lambda^2$ and draw rt parallel to m. The envelope of the straight line rt is what is called the tangential inverse of C. For instance, the tangential inverse of a point is a parabola having this point for its focus and for axis the line joining this point to the origin. It is obvious that this transformation is reciprocal like that of inversion, *i.e.*, two curves being given, if the first one is the tangential inverse of the second, this second curve is also the tangential inverse of the first one.

Fifth, the successive negative pedals of C with regard to the same origin.*

There exists between the inverse, the reciprocal polar and the first positive pedal of a curve C as above defined, a relation first discovered by T. A. Hirst which can be expressed as follows :

The inverse of the reciprocal polar of a curve C is the pedal of this curve ; or

The inverse of the pedal of a curve C is the reciprocal polar of this curve.

This relation is not the only one to be found ; in fact there are, as T. A. Hirst himself has pointed out, an infinity of other similar relations which can be easily seen by examining the figure relative to the construction of the points of the transformed curve corresponding to a point of C. As these relations will be useful to us in what follows, I will show, as succintly as possible, how the points and tangents of the transformed curves corresponding to a point and tangent of C can be constructed. Let m be a point of C and m' the tangent at this point; draw op at right angles to m' —meeting m' at p ; the locus of p is by definition the pedal of C. Determine r by the relation $or.op=\lambda^2$; r is the pole of m and therefore the locus of r is the reciprocal polar of C and the locus of p is the inverse of the locus of r, that is to say :

The inverse of the reciprocal polar of a curve C is the pedal of this curve.

Draw rt parallel to m', the envelope of rt is by definition the tangential inverse of C but rt is the polar of p and therefore the envelope of rt is also the reciprocal polar of p i.e.

---

* Mathematicians differ, with regard to definition of negative pedals, as to the point of departure. Salmon (Higher plane curves) starts with the first positive pedal in such a manner that the first negative pedal of a curve C is the curve itself, and this definition is the most generally adopted. However, in view of obtaining a greater symmetry in my notations, I have taken—as Clifford and other geometers have done—the curve itself as a point of departure. Consequently what is called first negative pedal in this paper corresponds to the second negative pedal of Salmon and so on, the order of the negative pedals from Salmon's definition being greater by unity than the order of the corresponding pedals as considered in this paper.

The reciprocal polar of the pedal of a curve C is the tangential inverse of this curve.

Join om, draw ri perpendicular to om meeting om at i and draw mp_{-1} parrallel to ri. By definition, the envelope of mp_{-1} is the first negative pedal of C but because ri and mp are antiparallel* therefore :

$$oi \,.\, om = or \,.\, op = \lambda^2$$

whence the locus of the point i is the inverse of C and mp_{-1} is the polar of i, that is to say :

The reciprocal polar of the inverse of a curve C is the first negative pedal of this curve.

From the well known construction of the tangent to the inverse of a curve C which consists, being given the point m and the tangent m' of c, in drawing ia in such a manner that the triangle mai be isosceles, we can deduce the following one : Draw op_{-1} making angle iop_{-1} = angle roi (om must always be bisector of angle pop_{-1}) and ia perpendicular to op_{-1}, ia is the tangent.

Then, as the pedal C is the inverse of its reciprocal polar, we can, from this construction, deduce the following one for the tangent to the pedal. Draw op_2 making angle pop_2 = angle mop, then the perpendicular pp_2 to op_2 is the tangent to the pedal and obviously the locus of p_2 intersection of pp_2 and op_2 is the second pedal of C ; a construction identical to the preceding one will give the tangent to the second pedal and the point of the third pedal coresponding to the point m of C and so on. Making the angles $pop_2 = p_2\,op_3 = p_3\,op_4 = \ldots\ldots = p_a\,op_{a+1} = \ldots\ldots$ and drawing p_2p_3, p_3p_4, ... $p_a\,p_{a+1}$ ..... respectively perpendicular to op_3, op_4, ... op_{a+1} ..... the locus of the point of intersection of the two corresponding lines $p_a\,p_{a+1}$ and op_{a+1} *i.e.* the locus of the point p_{a+1} is the $(a+1)$th pedal of C and the line $p_{a+1}p_{a+2}$ is the tangent to this pedal at the point p_{a+1}.

An analogous construction based on the construction given above of the tangent to the inverse and on the fact that the first

* Or because the two triangles *oir* and *opm* are similar.

negative pedal of C is the reciprocal polar of its inverse will furnish us with tangents and points of successive negative pedals corresponding to tangent m' and point m of C: Make the angles $pom = mop_{-1} = p_{-1}\, op_{-2} = \ldots\ldots = p_a\, op_{-(a+1)} \ldots\ldots$ and draw mp_{-1}, $p_{-1}\, p_{-2} \ldots\ldots p_{-a}\, p_{-(a+1)} \ldots\ldots$ respectively perpendicular to om, $op_{-1} \ldots\ldots op_{-a} \ldots\ldots$; the envelope of $p_{-a}\, p_{-(a+1)}$ is the ath negative pedal of C and the point p_{-a} of intersection of $p_{-a}\, p_{-(a+1)}$ with op_{-a} is the point of tangence of this pedal on $p_{-a}\, p_{-(a+1)}$. *

The construction of the point of the tangential inverse at which the line rt is tangent to this curve is deduced from the fact that the tangential inverse of C is the reciprocal polar of its pedal by constructions analogous to the preceding ones. Make angle pop_2 = angle mop, then the point t of intersection of op_2 with rt is the point of contact sought for.

A simple glance at the figure will now enable us to write the relations of which we have spoken. I will not insist on this point. But in order to represent these relations in a convenient manner, I will adopt the following notations :

Let R denote the operation which consists in taking the reciprocal polar of a curve with regard to the fixed circle.

Let I denote the operation of inversion as above defined.

Let T denote the operation of tangential inversion as above defined.

---

* It is curious to notice that the points $m, p_1, p_2, \ldots\ldots p_a \ldots\ldots p_{-1}, p_{-2} \ldots\ldots p_{-a} \ldots\ldots$ are situated on a logarithmic spiral whose equation in polar co-ordinates ρ and ω is, with regard to o as pole and om as polar axis:

$$\rho = \lambda \cos^{\frac{\omega}{\alpha}} \alpha$$

where α represents angle mop and λ the length om. For $\omega = \alpha, 2\alpha, 3\alpha \ldots\ldots a\alpha \ldots\ldots$ we have the different points $p_1, p_2, p_3, \ldots\ldots p_a$ of the successive positive pedals and for $\omega = -\alpha, -2\alpha, 3\alpha \ldots\ldots -a\alpha \ldots\ldots$ We have the points $p_{-1}, p_{-2}, p_{-3} \ldots\ldots p_{-a} \ldots\ldots$ of the successive negative pedals, all these points corresponding to point m of C; for $\omega = o$ the spiral passes through point m itself.

Let P^a (a being a whole number) denote the operation which consists in taking the ath positive pedal with regard to the centre of the fixed circle.

Let P^{-a} denote the analagous operation of the negative pedal.

Then, considering the curve C as a unit of a certain kind, we can express conventionally the relations above mentioned by the following algebraical equalities :

$$\text{1st} \begin{cases} I\,R = P \\ I\,P = R \end{cases}$$

$$\text{2nd} \quad R\,P = T$$

$$\text{3rd} \quad R\,I = P^{-1}$$

where $I\,R$ means the inverse of the reciprocal polar of C
where P means the first positive pedal of C
where $R\,P$ means the reciprocal polar of the first positive pedal of C and so on.

With the aid of the preceding notations, I give in the following table all the relations which exist between two of the transformations R, I, T, P and P^{-1}

$R^2 = 1$	$I\,R = P$	$T\,R = P^{-1}$
$R\,I = P^{-1}$	$I^2 = 1$	$T\,I = P^2$
$R\,T = P$	$I\,T = P^{-1}$	$T^2 = 1$
$R\,P = T$	$I\,P = R$	$T\,P = P^{-1}T$

$P\,R = I$	$P^{-1}R = T$
$P\,I = I\,P^{-1}$	$P^{-1}I = R$
$P\,T = R$	$P^{-1}T = T\,P$
$P\,P = P^2$	$P^{-1}P = 1$
$P\,P^{-1} = 1$	$P^{-1}P^{-1} = P^{-2}$

Note.—All these relations are not distinct ; for instance, we already know that $I\,R = P$ and $I\,P = R$ are two relations resulting from each other. In a similar manner the relations $R\,I = P^{-1}$ and $P^{-1}I = R$ are equivalent to the two former relations, etc., etc.

The expressions such as IR, IP, RP, RI and so on bear a striking resemblance with the ordinary algebraical products of factors but the former expressions are not commutative *i.e.* the order of the letters cannot be inverted without any change in the result as it is the case for the products of factors. However one of the most important properties of the product of factors: the associativity* subsists for our expressions.

Previous to establishing this fact, I will first generalize the meaning of the notations I have adopted by taking a projection of the figure we have considered.

The circle becomes a conic, the straight line at infinity the line ij, the asymptotes of the circle the lines $o\,i$ and $o\,j$ tangents to the conic and the circular points at infinity the points of contact i and j of the tangents $o\,i$, $o\,j$.

R will then denote the operation of polar reciprocity with regard to the conic.

I the quadric inversion, or as it is sometimes called the triangular inversion.

T the tangential quadric inversion.

P^a an operation analogous to the ath pedal and which for want of any other name I will call ath quadric pedal—positive or negative according to a being positive or negative.

In order to facilitate to the reader the consideration of these operations, I will indicate—as I have previously done with regard to the former operations considered—the constructions of the points of the transformed curves and tangents thereat corresponding to a point of the primitive curve C and tangent thereat.

Let us start with the construction of the tangent to the quadric inverse.

Let l be the harmonic conjugate, with regard to the conic, of a point m of C. The locus of l is, by definition, the quadric inverse of C. As the anharmonic ratio of the pencil formed by the sides of an angle θ and the straight lines joining its vertex to the circular points at infinity is equal to $e^{2i\theta}$ (where $i = \sqrt{-1}$ e is the well known series) that is to say depends only on the value θ of the angle and on constant quantities, to the two equal

* In a product of factors, the product of any number of consecutive factors can be considered as effectuated.

angles *pom* and mop^{-1} of the preceding figure correspond on the figure projection two angles *pom* and *mok* such that $(o.ij\,pm) = (o.ijmk)$ and determining the point ι' by the condition $(ijk\iota') = -1$ we have the required tangent $\iota\iota'$. Analogous constructions will give us the other points and tangents. For instance determine op'_2 by the relation $(o.ijmp) = (o.ijpp'_2)$ and a point ϖ by the relation $(ijp'_2\varpi) = -1$, then draw ϖp. ϖp is the tangent to the quadric pedal at p and the point p_2 of intersection of this line with op'_2 gives us the corresponding point p_2 of the second quadric positive pedal. I leave it to the reader to imagine the other constructions.

This premised, let us consider any transformation whatever of the curve C; for instance let us take the *a*th positive pedal of C, then the inverse of the result, then the reciprocal polar of the result, then the *a'*th negative pedal of the result and finally the tangential inverse of the result. That is to say let us make the operation

$$T\,P^{-a'} R\,I\,P^{a}$$

We can consider, in this expression, the two letters R and I as associated; we have only to consider the curve P^{-a} instead of the curve C to see the truth of this proposition for we have shown above that, making on any curve whatever the operation $R\,I$ or making the operation P^{-1}, gives exactly the same result.

This is true for any number of letters, for let for instance be

$$P^{-a'}\,R\,I = S$$

i.e. let us suppose that the succession of operations indicated in the first member of this equality is equivalent to the transformation S, then as C represents any curve whatever, instead of C we can consider the curve P^{a} and the theorem is thus obvious; *i.e.*

The geometrical transformations considered being represented as above, any transformation whatever can be represented by an algebraical expression which is associative.

From this theorem it results at once that

$$P^{a}\,P^{b} = P^{a+b}$$

whatever be a and b* positive or negative and with the ordinary convention

$$P^{\circ} = 1$$

It is obvious that

$$R^{2a} = 1 \qquad R^{2a+1} = R$$
$$I^{2a} = 1 \qquad I^{2a+1} = I$$
$$T^{2a} = 1 \qquad T^{2a+1} = T$$

so that, if we consider any transformation whatever of C, in the representation of it the letters R, I and T need not appear at any power but the first. Moreover by considering the table I have previously given, we see that by simple transformations any two of the letters R, I and T being consecutive can be replaced by a single letter. Therefore two of the letters R, I and T need not appear consecutively. Consequently any transformation of C whatever will present itself under the form :

$$\ldots\ldots\ I P^a\ R P^b\ T P^c \ldots\ldots$$

the different powers of P being separated by one of the letters I, R or T so that we can consider the expression as being composed of different expressions of the form

$$P^a R P^b$$
$$P^a I P^b$$
$$P^a T P^b$$

We will now show that any of these expressions can be put under the three forms :

$$P^{\alpha} R,\ P^{\beta} I,\ P^{\gamma} T$$

Let for instance be $\quad P^a R P^b$

If $a > o$ and $b > o$ as $PR = I$ we have

$$P^a R P^b = P^{a-1} I P^b$$

and as $I P = R$

$$P^a R P^b = P^{a-1} R P^{b-1}$$

then obviously

$$P^a R P^b = P^{a-k} R P^{b-k} \dagger$$

and if $a > b$

$$P^a R P^b = P^{a-b} R \qquad \text{thus } \alpha = a - b$$

---

* Of course a and b are whole numbers.

† Assuming that k is smaller than the smaller of the two numbers a and b or equal to it.

but $\quad P^{a-b} R = P^{a-b} P T = P^{a-b+1} T \qquad \gamma = a-b+1$

and $\quad P^{a-b} R = P^{a-b} P^{-1} I = P^{a-b-1} I \qquad \beta = a-b-1$

If $a < b$

$$P^a R P^b = R P^{b-a}$$

and as $R P = T$ therefore

$$R P^{b-a} = T P^{b-a-1}$$

and as $T P = P^{-1} T$ thus

$$T P^{b-a-1} = P^{-1} T P^{(b-a-1)-1} = P^{-k} T P^{b-a-1-k}$$

and thus obviously

$$T P^{b-a-1} = P^{-(b-a-1)} T = P^{a-b+1} T$$

and as $P T = R$

$$P^{a-b+1} T = P^{a-b} R$$

If $a > o$ and $b < o$ as $R P^{-1} = I$

then $\quad P^a R P^b = P^a I P^{b+1}$

and as $I P^{-1} = P I$ therefore

$$P^a I P^{b+1} = P^{a+1} I P^{b+1+1} = P^{a+k} I P^{b+k+1}$$

wherefore

$$P^a I P^{b+1} = P^{a+(-b)-1} I P^{b+(-b)} = P^{a-b-1} I$$

and as $P^{-1} I = R$

$$P^{a-b-1} I = P^{a-b} R$$

And so on. These examples are sufficient to show how easily calculations of this kind can be made. In short the general formulæ are the following ones :

$$P^a R P^b = P^{a-b} R = P^{a-b-1} I = P^{a-b+1} T$$
$$P^a I P^b = P^{a-b} I = P^{a-b+1} R = P^{a-b+2} T$$
$$P^a T P^b = P^{a-b} T = P^{a-b-1} R = P^{a-b-2} I$$

a and b being whole numbers positive or negative.

From the formulæ we have established we can draw as conclusion the following theorem :

Any succession of operations as above defined performed on a curve C can be put under the three forms :

$$P^a R, \; P^{a'} I \text{ and } P^{a''} T$$

a, a', a'' being positive or negative whole numbers.

that is to say :

The study of any succession of transformations of a curve C can be replaced by the study of a transformation of the form above given.

The calculation, the method of which I have shown, offers like the multiplication of quaternions an instance of operation associative and not commutative. With regard to commutativity, any two consecutive letters can be interchanged under condition of changing the sign of the index of P which is either one of the letters or equal to the combination of the two letters. But it is not my intention to insist upon these points.

In the next part of this paper I propose to determine the degree, class, and several singularities of the transformed curve.

A DETERMINATION OF THE MAGNETIC ELEMENTS AT THE PHYSICAL LABORATORY, UNIVERSITY OF SYDNEY. Lat. 33° 53′ 14·1″ S. Long. 151° 10′ 49″ E.

By C. Coleridge Farr, B.Sc.

[With Plate II.]

[*Read before the Royal Society of N.S. Wales, June 1, 1892.*]

The object which the Author had in view when making these observations was primarily the accurate determination of the elements for use in the Laboratory, and consequently nearly all of the observations were taken in the Laboratory, in a room in which previous observations have always been made. The pipes &c. at this end of the building are all of copper, and Professor Threlfall tells me that he tested the bricks when the building was being erected. There is however a wrought iron box in the form of a 500lbs. colonial mine case, at a distance of about twenty-eight feet from the place where the values of H. (the Horizontal Intensity) were taken, and thirty-four feet from that at which the dip was observed. Its direction is about N.W. and W.N.W. from these positions and the angles of depression about 24° and 19° respectively.

The instruments used were a Kew magnetometer No. 65, by Elliott Bros., and a Dip Circle by Dover, No. 78. The Kew certificates of these instruments are preserved at the Laboratory. The method used for finding H, the horizontal intensity was that of deflections and vibrations for which the Kew instrument is constructed.

As the corrections form an important part of the investigation, it may be well to mention the following points. With regard to those adjustments which apply to the observation of the time of vibration of the needle, the first is to make sure that the axis of the swinging magnet is accurately horizontal. This was always seen to very carefully before any observation of the time of vibration was made, and the previous day's setting of the needle on its stirrup was never relied on. The temperature and induction coefficients was taken from the tables sent out with the instrument from Kew. The effect of the torsion of the suspending silk thread was determined in the usual way. The mean of six observations gave the value of one of the scale divisions engraved on the magnet 1′·782 (Kew value 1′·77) a number which I give so that others using the same instrument may be saved the trouble of finding it again. Two threads were used during the time the observations were being taken, the first one being accidentally broken on November 10. The amount of deflection of the magnet due to turning the torsion head through 90° was with the first thread 3′·47, and with the second 4′·47. No correction was applied to the observed time of vibration for clock rate as the chronometer gaining only ·5 sec. a day, so that any error produced by taking the apparent second for the time second was too small to be appreciable. The fact that the arc of vibration was not indefinitely small was taken account of.

The corrections which apply to the deflection observations are as follows: Correction for expansion of bar. This was obtained from the table sent out with the instrument from Kew, as were also those for temperature and induction, and it may be well to remark here that all observations were reduced to 0° and C G S units are used throughout. The correction for distribution was obtained by taking deflection with the deflecting magnet at (*a*) 30 cm. and (*b*) 40 cm. from the deflected magnet, this gives two value of $\frac{M}{H}$ whence a value of P, "the constant of distribution" is obtained.

The dip was measured five times inside the Laboratory and once out. It was found that the needle exhibited a tendency to stick on the agate "Knife edges," however carefully these were wiped before the observation was begun. This appeared to be due to the condensation of a thin film of moisture and it was cured by putting a little phosphorus pentoxide into the box with the magnet whilst the observation was being taken.

Observations of the declination were taken on two days and twice each day. The times adopted were at about 9·30 a.m. and 2·30 p.m., when the needle would be at its greatest western and eastern elongation respectively. I am indebted to Mr. Knibbs for giving me the azimuth of a certain fiducial mark. This mark is about one and a half miles from the Laboratory, and is just on a level with the centre of the cross wires of the magnetometer telescope when the instrument is set up over a plug on the landing at the western entrance to the Laboratory.

Besides these, hourly readings were taken of the diurnal range in declination for a week both day and night, and the curves which accompany this paper are the result. For help on this rather irksome work I am indebted to Mr. J. A. Pollock and Mr. James Cook.

In July 1890, Mr. J. W. Fell observed the horizontal force and in September 1888 Mr. C. A. Flint determined the horizontal force and the dip. These observations are shown in the table, and from them in conjunction with my own it appears that the horizontal force is at present decreasing at the rate of ·0003 C. G. S. units per annum. The inclination has also decreased very markedly, its rate being 1′ 21″ a year.

As regards the declination, without a photographic record it is difficult to arrive at any very accurate conclusion. Four observations were made of this element, which are as follows :—

	H.	M.		°	′	″
April 27, 1892, at	10	6	a.m., ...	9	39	22 E.
April 27, 1892, at	3	3	p.m., ...	9	48	7 E.
May 10, 1892, at	10	2	a.m., ...	9	36	25 E.
May 10, 1892, at	2	30	p.m., ...	9	40	45 E.

On those days when an observation of both the horizontal intensity and the dip were made, the former was always taken in the morning and the latter in the afternoon.

The value of the dip outside on April 22, 1892 was 62° 40′ 34″.

Date.	Horizontal Intensity. (a)	Horizontal Intensity. (b)	Horizontal Intensity. Mean.	Vertical Intensity.	Total force.	Dip.
October 16, 1891	0·26058	0·26062	0·26060	...	...	...
,, 19, ,,	·26105	·26114	·26109	...	...	...
,, 20, ,,	·26170	·26190	·26180	...	...	...
,, 21, ,,	·26145	·26150	·26148	...	...	° ′ ″
,, 22, ,,	·26051	·26057	·26054	0.49815	0·56218	62 23 24
,, 23, ,,	·26083	·26086	·26084	·49875	·56286	62 23 30
November 11, ,,	·26146	·26153	·26150	·49992	·56415	62 23 11
,, 12, ,,	·26048	·26053	·26051	·49824	·56223	62 23 49
,, 13, ,,	·26135	·26142	·26138	·50002	·56420	62 24 7
July, 1890* ...	...	...	·2624	...	...	...
Sept. 15, 1888† ...	...	...	·26333	...	...	...
,, 25, ,, † ...	...	...	...	...	...	62 27 55
,, 28, ,, † ...	...	...	...	...	...	62 27 26

* Observed by the late Mr. J. W. Fell. † Observed by Mr. C. A. Flint, M.A.

ANALYSES OF SOME OF THE WELL, SPRING. MINERAL, AND ARTESIAN WATERS OF NEW SOUTH WALES, AND THEIR PROBABLE VALUE FOR IRRIGATION AND OTHER PURPOSES.

By JOHN C. H. MINGAYE, F.C.S., M.A.I.M.E., Analyst and Assayer to the Department of Mines.

[With Plate III.]

[*Read before the Royal Society of N.S. Wales, June 1, 1892.*]

As little information is on record respecting the composition of the various inland waters of New South Wales, and questions having arisen at times regarding their value for irrigation, watering stock, and other purposes, I have much pleasure in bringing before the Society with the permission of the Hon. the Minister for Mines and Agriculture, the following information obtained after some years of careful work, and examinations made of various samples of water submitted to the Department of Mines for analyses and report.

In some cases, the waters were examined with a view of ascertaining whether they were suitable for drinking purposes, and the larger portion for stock and irrigation purposes. The analyses were conduced according to the information required, a few of the samples sent being insufficient for a thorough examination, though in most cases the results obtained were sufficient for all ordinary purposes. The bulk of the analyses were conducted on from one to twelve gallons, especially in waters obtained from artesian bores and mineral springs, a large quantity of the water being taken for the estimation of the various salts present in small quantities.

The analyses of artesian and well waters furnished in this paper, must not be taken as representing the average waters usually obtained by boring or well sinking, as in nearly every case the samples submitted for analyses were suspected waters; and in few cases do the waters from the fresh water bores and wells find their way to the Laboratory. It is a well known fact that a number of these bores yield water suitable for stock and irrigation purposes, while in some cases the waters are so impregnated with saline matter as to render them dangerous to stock, and useless for irrigation.

This paper comprises some fifty-three analyses, the samples being obtained from quarries, rivers, creeks, wells, artesian and mineral springs. The analyses which are returned in grains per imperial gallon, have also been calculated into parts per 1,000 in order to compare the results with other analyses published in England, Germany, and America.

Potable Waters.

Nos. 1 and 2 are very pure spring waters, obtained from the Yarrangobilly and Fish River Caves. The analyses were made with a view of ascertaining their suitability for drinking purposes. Nos. 3, 4, 5 and 6 are from Nymagee and Byerock. The first three samples were condemned as unfit for human consumption from the excessive amount of albuminoid ammonia present, and various other tests made. No. 6 taken from a Government tank at Byerock, though not a first rate water, just passes.

No. 7, Well water from Lewis Ponds near Orange was found to be so largely contaminated with organic impurities, as to render the water a dangerous one for human consumption.

No. 8, Sample of water taken from the Parramatta Water Supply. An analysis of this water was made on the 22nd June 1885, which classes it as a second class potable water.

No. 9. From the same supply, the sample being taken after the water had passed through the filter beds in January 1889, there being very heavy rains experienced during that month. The filter beds were choked up with fine clay, the filtered water being of a reddish colour and turbid—due to finely suspended clay.

The analysis made, proved the water to be seriously contaminated, and in its then state totally unfit for human consumption. These impurities were without doubt due to the heavy rains, the water having run over a large catchment area, the surrounding district consisting largely of orchard lands which at stated times are manured; the impurities being derived from the fertilizers used in enriching the soil. The water was condemned about the same time by the Government Analyst, (Mr. W. M. Hamlet, F.I.C., F.C.S.) to use his own words—"The organic, impurity which from its character on analysis is probably due to decomposing animal matter, is so excessive, and such an amount compels me to condemn this water as being absolutely unfit for human consumption either filtered or unfiltered." The water has lately greatly improved in quality, but it is not in my opinion a suitable one for a town supply, on account of the orchard lands in and around the watershed, and if at any time heavy rains are experienced the same contamination will occur.

No. 10. Spring water from Jenolan Caves (house supply). An excellent quality of water suitable for all purposes.

Analyses of Potable Waters.—

(1.) Water from Yarrangobilly Caves.

	Grains per Gallon.	In 1000 parts.
Carbonate of Lime	6·552	0·0936
Carbonate of Magnesia ...	nil	nil
Silica	·868	·0125
Alumina	trace	trace
Chloride of Sodium	1·318	·0188
Strong traces of Strontia, Nitrates and undetermined ...	·306	·0043
	9·044	·1292

Total Solid Residue dried at 220° F. = 9·044 grains per gall.
Free Ammonia... ... ... Nil per 100,000 parts.
Organic or Albuminoid Ammonia ·0026 " "

An excellent description of spring water and useful for all purposes.

(2.) Spring Water from Jenolan Caves.

	Grains per Gallon.		In 1000 parts.
Carbonate of Lime	6·888	...	0·0984
Carbonate of Magnesia ...	1·060	...	·0151
Silica	·756	...	·0108
Alumina	trace	...	trace
Chloride of Sodium	·856	...	·0122
Trace of organic matter, Nitrates, &c.	·558	...	·0079
	10·118	...	0·1444

Total Solid Residue dried at 220° F. = 10·108 grains per gall.
Free Ammonia... ... ... ·0052 pts. per 100,000 pts.
Organic or Albuminoid Ammonia ·0040 " "

An excellent description of spring water suitable for all purposes.

(3.) Water from Nymagee, used for domestic purposes.

Soluble saline matter ...	13·300	grains per gallon.
Insoluble mineral matter ...	6·300	"
Loss on ignition	4·284	"
	23·884	

Free Ammonia ... ... ·078 pts. per 100,000 pts.
Organic or Albuminoid Ammonia ·048 " "
Phosphoric Acid, strong trace.
Chlorine... ... ... 5·20 grains per gallon.

Note.—The water when heated gave off an unpleasant smell. The residue on ignition strongly darkened, emitting a foul odour, thus showing the presence of a considerable amount of organic matter. The soluble saline matter consists mainly of chloride of sodium, chloride of magnesium, with strong traces of sulphate of lime, nitrates, etc. The insoluble of clay of carbonates of lime and magnesia, silica, etc. The water was condemned as totally unfit for human consumption.

(4.) Water from Nymagee, used for domestic purposes.

Results expressed in—	Grains per Gallon.		Parts per 100,000
Appearance in two feet tube ...	Reddish-brown colour		
Odour when heated to 100° F....	slight		slight
Free Ammonia	trace		trace
Albuminoid Ammonia	·061	...	·088
Nitrogen as Nitrates	present (not determined)		
Nitrogen as Nitrites	ditto		
Oxygen absorbed in 15 minutes	·182	...	·261
Oxygen absorbed in 4 hours ...	·366	...	·524
Total solids	104·58	...	149·40
Insoluble solids	95·79	...	136·84
Soluble solids	8·79	...	12·56
Phosphoric Acid as Phosphates	strong traces		
Chlorine as Chlorides	2·60	...	5·14

Remarks.—Water of a reddish-brown colour, and extremely difficult to filter, turbid, due to finely suspended clay. On ignition the residue strongly darkened, thus showing the presence of organic matter. In its present state the water is totally unfit for human consumption.

(5.) Byerock, water from Government Tank.

Results expressed in—	Grains per Gallon.		Parts per 100,000
Appearance in two feet tube ...	Reddish-brown colour		
Odour when heated to 100° F....	slight		slight
Free Ammonia	·007	...	·010
Albuminoid Ammonia	·034	...	·049
Nitrogen as Nitrates	trace	...	trace
Nitrogen as Nitrites	trace	...	trace
Oxygen absorbed in 15 minutes	·059	...	·085
Oxygen absorbed in 4 hours ...	·115	...	·165
Total solids	11·368	...	16·240
Insoluble solids	not determined		
Soluble solids	ditto		
Phosphoric Acid as Phosphates	strong traces		
Chlorine as Chlorides	1·40	...	2·00

Remarks.—Water turbid, due to fine suspended clay. The residue strongly darkened on ignition. The total solids largely consist of clay, the soluble portions being chloride of sodium, with traces of sulphate of lime, nitrates, nitrites, etc. This water in its present state is totally unfit for human consumption. The sample was taken after the heavy rains experienced in June 1890, and the pollution is no doubt due to the water having run off a large catchment area carrying impurities from the surface into the tanks. A second sample of this water was asked to be furnished three months after, which on analysis yielded as follows:

(6.) Byerock, water taken from Government tank (second sample).

Results expressed in—	Grains per Gallon.		Parts per 100000
Appearance in two feet tube ...	Reddish-brown colour		
Odour when heated to 100° F....	nil		nil
Free Ammonia	·001	...	·002
Albuminoid Ammonia	.011	...	·016
Nitrogen as Nitrates	trace	...	trace
Nitrogen as Nitrites	trace	...	trace
Oxygen absorbed in 15 minutes	·025	...	·036
Oxygen absorbed in 4 hours ...	·081	...	·116
Total solids	13·104	...	18·720
Phosphoric Acid as Phosphates	strong traces		
Chlorine as Chlorides	·900	...	1·280
Loss on ignition...	2·128	...	3·040

Remarks.—Water of a reddish-brown colour and turbid, due to finely suspended clay. The bulk of the total solids consists of clay, the soluble saline matter being chloride of sodium, with traces of lime, magnesia, sulphuric acid, nitrates and nitrites. The water has greatly improved in quality since the previous analysis was made, the organic ammonia being only ·016 per 100,000 against ·049 per 100,000 in the previous analysis.

(7.) Well water from Lewis Ponds near Orange.

Total solid residue	93·633	grains per gallon.
Loss on ignition	27·400	,,
Chlorine	9·400	,,
Free Ammonia	0·100	parts per 100,000
Albuminoid Ammonia ...	·040	,,

REMARKS.—Water turbid, with a large amount of organic matter in suspension. Water heavily charged with sulphuretted hydrogen. The total solids were found to consist of carbonates of lime and magnesia, silica, alumina, sulphate of lime, sulphate of magnesia, chloride of sodium, and a large amount of organic matter, &c. The free and albuminoid ammonia, taken with the other constituents present in excessive quantities, renders the water totally unfit for human consumption, and it may be classed as a dangerous water.

(8.) Parramatta Water Supply (Analysis made June 22nd, 1885).

Total solid residue	11·60	grains per gallon.
Chlorine	5·90	,,
Free Ammonia	nil	parts per 100,000
Albuminoid Ammonia ...	·010	,,

REMARKS.—Water turbid, with traces of suspended matter (clay). This water may be classed as a second class potable water. As regards organic impurities it is just a trifle above the Sydney water obtained from the Botany supply, and is a fair description of water considering the period of drought we have experienced.

Analysis of total solids—

	Grains per Gallon.	Parts per 1000
Chloride of Sodium	9·74	0·1391
Oxide of Iron and Alumina...	·42	·0017
Silica	·17	·0024
Alumina	...	...
Lime (Ca.O)	·25	·0035
Magnesia (Mg.O)	·32	·0046
Sulphuric Anhydride ($S.O_3$)...	·22	·0031
Organic Matter, CO_2 etc ...	·78	·0111
	11·90	·1655

(9.) Parramatta Water Supply (Sample taken in January, 1899).

Results expressed in—	Grains per Gallon.	Parts per 100000.
Appearance in two feet tube ...	Reddish-brown colour	
Odour when heated to 100° F....	organic	organic

Results expressed in—	Grains per Gallon.	Parts per 100000.
Free Ammonia	·007 ...	·010
Organic Ammonia	·046 ..	·066
Nitrogen as Nitrates		
Nitrogen as Nitrites		
Oxygen absorbed in 15 minutes	·400 ...	·570
Oxygen absorbed in 4 hours ...	5·200 ...	7·430
Total solids	33·880 ...	48·400
Loss on ignition...	5·740 ...	8·140
Phosphoric Acid as Phosphates	trace ...	trace
Chlorine as Chlorides	3·600 ...	5·140

NOTE.—The large amount of albuminoid ammonia as well as other impurities present in this water condems it in its present state as totally unfit for human consumption.

(10.) Spring water from Jenolan Caves.

Total solid matter	7·308 grains per gallon.
Chlorine in combination ...	·700 ,,
Free Ammonia	·0040 parts per 100,000
Albuminoid Ammonia ...	·0052 ,,
Oxygen absorbed in 15 minutes	·0008 ,,
Oxygen absorbed in 4 hours	·0018 ,,

The total solids consist of carbonate of lime, with lesser quantities of carbonate of magnesia, silica, chloride of sodium, nitrates a trace, etc. An excellent sample of spring water suitable for all domestic purposes.

English Standard of purity of Potable Waters.

According to Wanklin no exception is taken to a water which contains not more than forty grains of total solids per gallon. The water as regards organic matter, etc. may be divided into three classes :—

Class I. Waters of extraordinary organic purity, yielding ·00 up to ·05 parts of albuminoid ammonia per million. This class comprises the most carefully distilled waters, deep spring waters and such waters as have been filtered through a silicated carbon filter. Waters of this class cannot be objected to organically.

Class II. Comprehends the general drinking waters yielding ·05 to ·10 parts per million of albuminoid ammonia, and any water falling into this class is organically safe.

Class III. Comprehends the dirty waters, and is characterised by yielding more than ·10 parts of albuminoid ammonia per million. Free ammonia however being absent, or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 parts per million, when it becomes a very suspicious sign, and over ·15 parts per million is sufficient to condemn a water.

The absence of chlorine, of more than one grain per gallon, is a sign that the organic impurity is of vegetable rather than of animal origin; but it would be a great mistake to allow water highly contaminated with vegetable matter to be taken for domestic use. *In the Leek Workhouse there has been for years past a general tendency to diarrhœa, which could not be accounted for until the water was examined, and shown to be loaded with vegetable matter. The water was almost free from chlorine, containing only ·5 grains per gallon. A well on Biddulph Moor a few miles from Leek, yielded ·05 grains per gallon, and ·03 "free" and ·14 of albuminoid ammonia per million. The persons who were in the habit of drinking this water suffered from diarrhœa.

Valuable as is the chemical analysis of water, the information acquired is not an unfailing test as to dangerous pollution, and the sample under analysis may be found to pass the chemical analysis, and yet may contain the germs of disease. It is probable that cholera, typhoid fever etc. are frequently contracted by drinking such waters, containing prossibly the minutest trace of the excreta of persons suffering from these diseases.

The standard of purity of waters is one which I hope will be soon taken in hand in the Colonies, as many of the waters are of a totally different character from these examined in England, and for which the basis of the standard in use is taken.

* Water Analysis—Wanklin, p. 49.

No chemist could pass such waters as the samples obtained from Nymagee, Byerock (No. 1), Lewis Ponds, or the Parramatta Water Supply (second sample), they bearing direct evidence of having been heavily polluted with organic matter.

*It is a well known fact that a large population may drink a sewage polluted water with the utmost impunity under certain conditions, and yet the death rates from fever and dysentery, and all other diseases supposed to be propagated by the water may be remarkably low, in comparison with places drinking a pure water. On the other hand the water if containing diseased germs would propagate disease, and so be as fatal as a dose of poison.—(A. Wynter Blyth.)

Analyses of water taken from various quarries and wells, etc. at Broken Hill:—

(11.) *Jenkin's Quarry.*	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	107·724 ...	1·5389
Insoluble mineral matter ...	11·220 ...	·1601
Total solids	118·944	1·6990
Analysis of total solids—		
Chloride of Sodium	61·300 ...	0·8757
Sulphate of Soda	17·850 ...	·2550
Sulphate of Lime	trace ...	trace
Sulphate of Magnesia	8·170 ...	·1167
Carbonate of Lime	6·972 ...	·0996
Carbonate of Magnesia ...	2·326 ...	·0332
Alkaline Carbonates, etc. ...	20·404 ...	·2914
Oxide of Iron	trace ...	trace
Alumina	·578 ...	·0082
Silica	1·344 ...	·0192
	118·944	1·6990

* Foods, Composition and Analysis—A Wynter Blyth.

REMARKS.—Water clear, had a strong saline taste. On ignition the residue considerably darkened giving off a foul odour somewhat resembling wool when burnt. No poisonous metals detected.

(12.) *Kidwell's Quarry.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	144·990 ...	2·0712
Insoluble mineral matter ...	15·036 ...	·2148
	160·026 ...	2·2860
Analysis of total solids—		
Chloride of Sodium	91·740 ...	1·3106
Sulphate of Soda	22·160 ...	·3165
Sulphate of Lime	trace ...	trace
Sulphate of Magnesia	11·650 ...	·1664
Carbonate of Lime	11·172 ...	·1596
Carbonate of Magnesia ...	1·652 ...	·0236
Alkaline Carbonates, etc. ...	19·440 ...	·2777
Oxide of Iron	trace ...	trace
Alumina	·728 ...	·0104
Silica	1·484 ...	·0212
Total solids	160·026	2·2860

REMARKS.—Water clear, with a small amount of suspended matter; saline to the taste. The residue considerably darkened on ignition, thus showing the presence of organic matter. No poisonous metals detected.

(13.) *Marden's Quarry.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	134·596 ...	1·9328
Insoluble mineral matter ...	19·460 ...	·2677
Total solids	154·056 ...	2·2005
Analysis of total solids—		
Chloride of Sodium	91·780 ...	1·3111
Sulphate of Soda	8·530 ...	·1218
Sulphate of Lime	2·470 ...	·0352
Sulphate of Magnesia	24·600 ...	·3514

	Grains per Gallon.	In 1000 Parts.
Carbonate of Lime	16·520 ...	·2360
Carbonate of Magnesia ...	·784 ...	·0112
Alkaline Carbonates, etc. ...	7·216 ...	·1030
Oxide of Iron	trace ...	trace
Alumina	·882 ...	·0126
Silica	1·274 ...	·0182
Total solids	154·056	2·2005

REMARKS.—This water contained a small amount of suspended matter. The residue darkened on ignition. No poisonous metals detected.

(14) *Walsh's Quarry.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	112·412 ...	1·6058
Insoluble mineral matter ...	11·880 ...	·1697
Total solids	124·292	1·7755

Analysis of total solids—

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	63·930 ...	·9133
Sulphate of Soda	23·950 ...	·3421
Sulphate of Lime	trace ...	trace
Sulphate of Magnesia	7·550 ...	·1078
Carbonate of Lime	6·300 ...	·0900
Carbonate of Magnesia ...	3·760 ...	·0537
Alkaline Carbonates, etc. ...	16·982 ...	·2426
Oxide of Iron	trace ...	trace
Alumina	·672 ...	·0096
Silica	1·148 ...	·0164
Total solids	124·292 ...	1·7755

REMARKS.—This water was clear, and contained a small amount of suspended matter. The residue considerably darkened on ignition, thereby showing the presence of organic matter. No poisonous metals detected.

The samples were received contained in spirit bottles and corked with corks which had been previously used, consequently no attempt was made to determine the organic impurities in the waters. All these samples contained a considerable amount of saline matter, which renders them very unsuitable for drinking purposes. With strangers drinking a quantity of these waters, especially that from Marden's Quarry, it would tend to act as a purgative. The quantity of water received in each case was small and insufficient for a thorough analysis.

(15.) *Water from Brewery, Broken Hill.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	123·526	1·7644
Insoluble mineral matter ...	19·246	·2750
Total solids	142·772	2·0394

Free Ammonia... ... ... ·0026 parts per 100,000 pts.
Organic or Albuminoid Ammonia ·0260 ,,

Analysis of total solids—

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	89·810	1·2830
Sulphate of Soda	6·111	·0873
Sulphate of Lime	trace	trace
Sulphate of Magnesia	15·950	·2278
Carbonate of Lime	15·036	·2148
Carbonate of Magnesia ...	3·146	·0449
Alkaline Carbonates, etc. ...	11·755	·1679
Oxide of Iron	trace	trace
Alumina	·308	·0044
Silica	·656	·0093
	142·772	2·0394

REMARKS.—Water cloudy with a small amount of matter held in suspension. This water had a very foul odour, and the residue strongly darkened on ignition. No poisonous metals detected.

(16.) *Silverthorne's Well, Broken Hill.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	101·920 ...	1·4560
Insoluble mineral matter ...	16·548 ...	·2364
	118·468	1·6924

Free Ammonia... ... ... ·010 parts per 100,000 parts
Organic or Albuminoid Ammonia ·032 „

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	74·400 ...	1·0628
Sulphate of Soda	11·180 ...	·1597
Sulphate of Magnesia	4·250 ...	·0607
Sulphate of Lime	2·172 ...	·0314
Carbonate of Lime	11·256 ...	·1607
Carbonate of Magnesia ...	4·452 ...	·0635
Alkaline Carbonates, etc. ...	9·918 ...	·1416
Oxide of Iron	... ...	trace
Alumina	·210 ...	·0030
Silica	·630 ...	·0090
	118·468	1·6924

Remarks,—This water on opening the bottle emitted a foul odour, due to free sulphuretted hydrogen being given off. The residue strongly darkened on ignition.

(17.) *Stephen's Creek, Broken Hill.*

	Grains per Gallon.
Soluble saline matter	6·496
Insoluble mineral matter ...	11·284
Loss on ignition	3·640
Total solids	21·420

Free Ammonia... ... ... nil parts per 100,000
Organic, or Albuminoid Ammonia ·066 „
Chlorine ... ... 3·8 grains per gallon

Remarks.—Water of a reddish colour due to finely divided clay held in suspension. On opening the bottles, the water emitted a foul odour, and the residue on ignition considerably darkened, and gave off a fetid smell. The insoluble matter consisted chiefly of clay, carbonates of limes and magnesia, silica, etc., and the soluble of chlorides of sodium and magnesium, with traces of sulphates of lime, alkaline nitrates and nitrites. No poisonous metals detected. The sample received for analysis being small, a more detailed analysis could not be attempted, but sufficient had been done to show that the water was totally unfit for human consumption.

(18.) *Water from Portion* 86, taken from a bore in a Limestone Quarry, Broken Hill.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	136·360	1·9335
Insoluble mineral matter ...	12·916	·1988
Total solids	149·276	2·1323
Analysis of total solids—		
Chloride of Sodium	80·410	1·1487
Sulphate of Soda	30·803	·4400
Sulphate of Magnesia	6·005	·0857
Sulphate of Lime	trace	trace
Carbonate of Lime	8·632	·1233
Carbonate of Magnesia ...	4·000	·0571
Alkaline Carbonates, etc. ...	19·278	·2754
Oxide of Iron	trace	trace
Alumina	·028	·0004
Silica	·120	·0017
	149·276	2·1323

REMARKS.—Water clear and free from suspended matter. No smell observed on heating some of the water in a closed flask at 100° F. No poisonous metals detected.

Free Ammonia...	nil	parts per 100,000
Organic, or Albuminoid Ammonia	·002	”

(19.) *Well water from Silverton, Broken Hill.*

		Grains per Gallon.
Total fixed matter	... ...	40·50
Which loses on ignition	...	1·50
Total Chlorine ...	... ...	22·40
Free Ammonia ...	... ...	·0120 pts. per 100,000 pts.
Organic, or Albuminoid Ammonia		·0130 ,,

REMARKS.—The residue from this water gave no reaction for nitrates; it contains a little sulphate of calcium in solution; but the major part of the solids are present chiefly as chlorides of sodium, potassium and magnesia. The smallness of the sample (about ½ litre) precluded a more detailed examination, but enough had been done to show that it was a fair water. Poisonous metals were not detected.

(20.) *Water from soakage, Broken Hill.*

		Grains per Gallon.
Total fixed matter	... ...	3·75
Which loses on ignition	...	1·48
Containing Chlorine ...	...	1·30
Free Ammonia..	... ...	·020 pts. per 1000,000 pts.
Organic, or Albuminoid Ammonia		·320 ,,

REMARKS.—On opening the bottle, the sample gave a faint reaction for sulphuretted hydrogen. On tasting the water it had a bad taste, and smell. Water thoroughly unfit for human consumption.

(21.) *Wilcannia*—Water from Tarella.

Analysis of total solids—	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	140·986 ...	2·0141
Sulphate of Soda	... ...	...
Sulphate of Lime	1·941 ...	·0277
Sulphate of Magnesia	42·391 ...	·6045
Carbonate of Lime	23·576 ...	·3358
Carbonate of Magnesia ...	6·370 ...	·0909
Alkaline Carbonates, etc. ...	9·008 ...	·1286

	Grains per Gallon.	In 1000 parts.
Oxide of Iron	nil ...	nil
Alumina	·448 ...	·0064
Silica	1·526 ...	·0218
Total solids	226·246 ...	3·2298

REMARKS.—The analysis of this water was chiefly undertaken with a view of ascertaining if the water was suitable for watering stock.

Miscellaneous Analyses.

(22.) *Wilcannia.*

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	876·22 ...	12·5176
Insoluble mineral matter ...	20·48 ...	·2925
Total solids	896·70	12·8101

REMARKS.—The soluble saline matter consists largely of chlorides of sodium and magnesium, sulphate of lime, sulphates of soda and potash; the insoluble, of clay, silica, carbonates of lime and magnesia, etc. Had a very foul odour due to sulphuretted hydrogen gas. The use of this water was stated to cause sickness among the cattle though the symptoms given rise to were not stated, but were probably due to the large excess of the magnesia salts present (Epsom's salts) which tend to act as a purgative. The water is unfit for stock purposes, human consumption, and for irrigation. The quantity sent (about ¼ litre) was much too small for a more complete examination.

(23). *Liverpool Plains.*—Water from Spring Ridge. From a well twenty-two feet deep in the centre of a black soil plain, about 1,100 feet above the sea level.

	Grains per Gallon.	In 1000 parts.
Chloride of Sodium	864·83 ...	12·3549
Chloride of Magnesium ...	170·25 ...	2·4322
Sulphate of Soda	54·80 ...	·7828
Carbonate of Soda	60·57 ...	·8603

	Grains per Gallon.		In 1000 parts.
Carbonate of Lime	18·15	...	·2592
Carbonate of Magnesia ...	33·25	...	·4750
Silica, Oxide of Iron and Alumina	2·10	...	·0300
Organic matter	12·90	...	·1842
	1216·85	...	17·3786

REMARKS.—Water saline to taste, of a yellow colour with a strong odour of sulphuretted hydrogen. The analysis was made with a view of ascertaining if suitable for watering stock, but the large amount of salts, and organic matter present renders it totally unfit for that purpose, of no use for irrigation purposes.

(24.) *Myall Creek.*

	Grains per Gallon.		In 1000 Parts.
Soluble saline matter	189·80	...	2·7114
Insoluble mineral matter ...	16·00	...	·2285
Total solids	205·80	...	2·9399
Chlorine	54·50	...	·7785

REMARKS.—The soluble solids consist of chlorides of sodium, and largely of magnesia combined with chlorine and sulphuric acid, alkaline carbonates, organic matter etc. The insoluble, of carbonates of lime and magnesia, silica, alumina, etc. The sample received was much too small to permit an analysis of the total solids being made.

(25.) *Nyngan.*—Water stated to be used for watering stock.

	Grains per Gallon.		In 1000 Parts.
Soluble saline matter	1473·92	...	21·1564
Insoluble mineral matter ...	79·38	...	1·1340
	1553·30	...	22·2904
Chlorine	77·20	...	1·1028

REMARKS.—The soluble saline matter consisted largely of sulphates and chlorides of sodium, potassium and magnesium, sulphate of lime, nitrates, organic matter etc. The insoluble of, carbonates of lime and magnesia, alumina, trace of oxide of iron, silica, alumina, etc. On heating, the water gave off a strong aromatic odour, somewhat resembling the essential oils yielded from the Eucalypti, also a foul smell on opening the bottle. On tasting the water it was strongly saline, and on ignition the residue strongly darkened, thereby showing the presence of a considerable amount of organic matter. The small amount of water sent precluded a more detailed analysis being made, but sufficient has been shown that the water is totally unfit for stock purposes or for irrigation.

(26.) *Rylstone.*

	Grains per Gallon.	In 1000 parts.
Soluble saline matter	652·40 ...	9·3201
Insoluble mineral matter ...	30·24 ...	·4320
Total solid matter ...	682·64 ...	9·7521
Sulphuric Anhydride (SO_3) ...	310·807 ...	4·4401
Chlorine	95·200 ...	1·3600

Remarks.—The soluble saline matter was found to consist largely of magnesia, soda, potash, lime, etc., combined with sulphuric acid and chlorine. The insoluble, of carbonates of lime and magnesia, alumina, silica, etc. The water had a peculiar harsh taste due to Epsom's salts in solution, and should possess medicinal properties. The quantity of water received was small, and precluded a more detailed analysis of the total solids being made. A larger sample of this water was asked for, but up to date has not yet been received.

(27). *Curlewis.*—Water from a well one hundred and ten feet deep, containing fifty feet of water.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	849·60 ...	12·1373
Insoluble mineral matter ...	79·20 ...	1·1314
Total solids	928·80 ...	13·2687
Chlorine	530·720	7·5818

(28.) *Wentworth.*—Water from Avoca Station.

	Grains per Gallon.	In 1000 Parts.
Total fixed matter	1504·0	21·4861
Chlorine	189·0	2 7005
Free Ammonia...	·018 parts per 100,000	
Organic, or Albuminoid Ammonia	·016 ,,	

REMARKS.—An examination of this water was made with a view of ascertaining if it was suitable for watering stock. Its taste was strongly saline, and the residue consisted largely of sodium and magnesia salts. It was reported as totally unfit for watering stock and unsuitable for irrigation purposes.

(29.) *New England.*—Water from A. Pike's well about a mile S.W. of Curlewis Station, G.N. Railway Line; twenty-five feet of water in well, one hundred and fifty feet deep. Used for steam and drinking purposes.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	48·75	·6964
Insoluble mineral matter ...	14·28	·2040
Volatile at red heat	116·20	1·6600
Total solids	179·23	1·5604

REMARKS.—The free and albuminoid ammonia were not determined, as with the large amount of organic matter present, it is a very undesirable water for steaming purposes, and quite unfit for human consumption.

(30.) *Dennison Town, near Mudgee.*—Water from well on Patrick's Station, twenty miles from Dennison Town; said to be poisonous to stock.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	73·50	1·0500
Insoluble mineral matter ...	80·92	1·1560
Volatile at red heat	129·40	1·8486
	283·82	4.0546

REMARKS.—The sample received was much too small for a proper examination. The symptoms to which this water gives rise to when supplied to cattle is not stated. It is thought however that they may be due to salts of magnesia and to the organic matter present in the water which is very high.

(31.) *Dennison Town.*—Water from a well on Patrick's Station, three miles from the above.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	15·60 ...	0·2228
Insoluble mineral matter ...	28·56 ...	·4080
Volatile at red heat	2·84 ...	·0405
	47·00	·6713
Chlorine	6·18 ...	·6713

REMARKS.—The sample received in a small medicine bottle was much too small to enable a proper examination of the total solids to be made.

(32.) *Barragan, near Mudgee.*

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	11·128 ...	0·1589
Chloride of Potassium	6·395 ...	·0913
Carbonate of Soda	13·337 ...	·1905
Carbonate of Lime	15·060 ...	·2152
Carbonate of Magnesia	3·783 ...	·0540
Nitrate of Soda	1·740 ...	·0248
Sulphate of Potash	3·001 ...	·0428
Silica	5·572 ...	·0796
Alumina	trace ...	trace
Total solids	60·016 ...	·8571

Free Ammonia ... ... ·018 pts. per 100,000 pts.
Organic, or Albuminoid Ammonia ·026 „

REMARKS.—The water when viewed through a two feet tube was of a pale green colour. It was akaline, and a minute trace of iodine and strontia were detected. The analysis was conducted on the filtered water. Suitable for irrigation and stock purposes, but not a good description of water for domestic purposes.

(33.) *Belabula River, Clifden Run.*

	Grains per Gallon.	In 1000 Parts.
Bicarbonate of Calcium... ...	21·028 ...	·3004
Bicarbonate of Magnesium ...	3·897 ...	·0556
Chloride of Sodium	1·820 ...	·0260
Sulphate of Soda	2·140 ...	·0306
Sulphate of Potash	·183 ...	·0026
Silica	·280 ...	·0040
Alumina	trace	trace
	29·348	·4192

Specific gravity of water at 60° F. = 1·00041

This water is suitable for irrigation purposes.

(34.) *Mount Hope.* Water from Holy Box Well.

Total fixed matter about (about) 370·04 grains per gallon

Chlorine (about) ... ... 173·95 „

Note.—The quantity of this sample received was very small.

Mount Hope, Mossgiel.—Water from a well at Holy Box.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	408·40 ...	5·8344
Insoluble mineral matter ...	25·20 ...	·3600
Loss on ignition	3·60 ...	·0514
Total solids	437·20	6·2458
Chlorine in combination ...	135·00 ...	1·9286
Free Ammonia...	nil	per 100,000 parts
Albuminoid Ammonia ...	·002	„

Remarks.—A water unsuitable for human consumption, also for irrigation, and not desirable for stock purposes.

(35.) *Gunnedah.*—Water from a well seventy feet deep, with twenty-eight feet of water, which is soft and potable when fresh.

	Grains per Gallon.	In 1000 Parts.
Soluble saline matter	50·14 ...	·7163
Insoluble mineral matter	8·42 ...	·1202
Total solids	58·56	·8365
Chlorine in combination	9·00 ...	·1285

Remarks.—The soluble matter was found to consist largely of sulphate and chloride of sodium and potasium, alkaline, carbonates etc. The insoluble of carbonates of lime and magnesia, silica, alumina, etc. This water may be used for watering stock, and irrigation purposes. The sample received was very small and not properly taken, consequently the organic impurities were not determined.

(36.) *Dubbo.*—Spring water obtained from the base of a high mountain near Dubbo.

Total solid matter	6·608 grains per gallon
Chlorine in combination ...	2·500 ,,
Free Ammonia	trace per 100,000 parts
Albuminoid Ammonia	·010 ,,

Remarks.—The total solids consisted mainly of chlorides of magnesium and sodium, sulphate of lime, organic matter with traces of silica, oxide of iron, and alkaline carbonates. The water when viewed through a two feet tube was of a pale green colour. A small amount of suspended matter was present, consisting of small particles of vegetable matter, which accounts for the albuminoid ammonia found. The residue darkened on ignition, thus showing the presence of organic matter. It was thought that this water might possess medicinal qualities, and may be described as an ordinary spring water having no medicinal properties, but useful for domestic, stock and irrigation purposes.

(37.) *Wellington.*—Spring water from Maryville near Wellington.

	Grains per Gallon.	In 1000 Parts.
Total solid residue at 220° F. ...	1305·248 ...	18·6467
Chlorine in combination ...	613·816 ...	8·7689
Sulphuric Acid in combination...	133·952 ...	1·9136
Free Ammonia	·012 parts per 100,000 pts.	
Albuminoid Ammonia	·008 ,,	

Taste, very saline; reaction, alkaline; odour, earthy. Colour in a two feet tube, light pale green.

Remarks.—The total solids consist largely of soda, potash, lime and magnesia combined with chlorine, sulphuric and carbonic acids, traces of alumina and silica. The water is strongly impregnated with mineral matter, a large portion of the total solids consisting of chloride of sodium (common salt) which gives it a brackish taste. Unsuitable for human consumption, and of no value for irrigation purposes. On no account should it be used for watering stock.

(38.) *Gladesville near Sydney.*—Water from a bore.

	Grains per Gallon.	In 1000 Parts.
Total fixed matter	31·40 ...	·4485
Insoluble solids	7·20 ...	·1028
Soluble solids	22·75 ...	·3250
Volatile at red heat	1·45 ...	·0207
Protoxide of Iron	1·45 ...	·0207
Chlorine	15·10 ...	·2155
Free Ammonia	nil per 100,000 parts	
Organic, or Albuminoid Ammonia	nil ,,	

Remarks.—Water fairly bright. The soluble solids were found to consist of chloride of sodium, sulphates of lime and magnesia, silica, oxide of iron, alkaline carbonates etc. The insoluble of carbonates of lime and magnesia, etc. The amount of protoxide of iron in this water is small, and it can be got rid of by exposing the water for some time when it will be precipitated. This water may be used for domestic purposes, and is useful for irrigation.

Girilambone.—Water from diamond drill bore.

		Grains per Gallon.	In 1000 Parts.
(39)	1—Total fixed matter ...	812·48 ...	11·6060
	Chlorine...	365·65 ...	5·2226
(40)	2—Total fixed matter ...	775·04 ...	11·0722
	Chlorine...	343·28 ...	4·9040
(41)	3—Total fixed matter ...	777·92 ...	11·1133
	Chlorine...	346·12 ...	4·9447

REMARKS.—The total fixed matter consists mainly of chloride of sodium, with lesser quantities of lime, magnesia, potash, etc., combined with chlorine, sulphuric and carbonic acids. The quantity sent of each was rather small, but enough has been done to show that the samples are unfit for human consumption or irrigation purposes, and not by any means desirable waters to be used for stock.

(42.) *Wilcannia.*—Water from a bore put down in a trial shaft seventeen miles from Wilcannia.

Analysis of total solids—

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	297·266 ...	4·2467
Chloride of Potassium... ...	183·558 ...	2·6234
Chloride of Magnesium ...	36·672 ...	·5239
Chloride of Ammonium ...	·185 ...	·0026
Sulphate of Lime	63·021 ...	·9003
Sulphate of Magnesia	53·247 ...	·7606
Carbonate of Lime	21·419 ...	·3059
Carbonate of Magnesia ...	13·981 ...	·1997
Total solids	669·349 ...	9·5631

REMARKS.—Water turbid, due to fine clay held in suspension. On standing for twenty-four hours the whole of the suspended matter settled, the analysis being conducted on the clear water, which was filtered before use. No silica, alumina, or oxide of iron were detected in this water. A faint reaction was given for nitrates. Zinc was detected, the amount present being 1·067 grains per gallon = $ZnCl_2$ 2·232 grains per gallon. Total matter in suspension 17·22 grains per gallon. A strongly mineralized water unfit for human consumption, irrigation, or for stock.

Analyses of Artesian Waters.

(43.) *Cuttabura.*—Water taken from bore.

	Grains per Gallon.	In 1000 Parts
Chloride of Sodium	349·040 ...	4·9863
Chloride of Potassium ...	trace ...	trace
Chloride of Calcium	27·580 ...	·3940
Chloride of Magnesium ...	4·190 ...	·0598
Chloride of Ammonium ...	·642 ...	·0092
Carbonate of Lime	6·664 ...	·0952
Carbonate of Magnesia ...	·336 ...	·0048
Silica	1·596 ...	·0238
Alumina	trace ...	trace
Protoxide of Iron	·112 ...	·0016
Alkaline Carbonates, Organic matter, strong trace of Bromine, traces of Iodine, Nitrates, etc.	6·712 ...	·0959
	396·872 ...	5·6706

Remarks.—Water clear and free from matter in suspension. To the taste strongly saline. Not suitable for domestic purposes, and useless for irrigation,

(44.) **Bourke.*—Artesian water taken from a depth of 1175 feet and flowing at the rate of 200,000 gallons per day. Temperature 102° F. (Private bore.)

	Grains per Gallon.	In 1000 Parts
Silica	4·088 ...	·0584
Carbonate of Lime	4·750 ...	·0678
Carbonate of Magnesia ...	·037 ...	·0006
Alumina	trace ...	trace
Sulphate of Potash	1·250 ...	·0178
Chloride of Sodium	9·720 ...	·1388

	Grains per Gallon.	In 1000 parts.
Carbonate of Potash	12·260 ...	·1751
Carbonate of Soda	21·663 ...	·3094
Total Solids	53·768 ...	·7679

REMARKS.—Water gave a slight acid reaction, due to carbonic acid. As the sample was contained in a stoneware jar, corked with a cork which had been previously used, the sanitary analysis of the water was not attempted.

(45.) **Bourke.*—Artesian water taken from a depth of 450 feet and flowing at the rate of 35,000 gallons per day. Temperature 102° F.

	Grains per Gallon.	In 1000 Parts
Silica	1·960 ...	·0280
Carbonate of Lime	nil ...	nil
Carbonate of Magnesia ...	trace ...	trace
Carbonate of Soda	20·941 ...	·2991
Carbonate of Potash	2·952 ...	·0421
Chloride of Sodium	8·445 ...	·1206
Organic Matter	trace ...	trace
Total solids	34·298	·4898

(46.) **Bourke.*—Artesian water from a bore at Corrella Station, No. 1 bore, depth 900 feet.

	Grains per Gallon.	In 1000 Parts
Silica	1·288 ...	·0184
Carbonate of Lime	1·000 ...	·0142
Carbonate of Magnesia ...	·336 ...	·0047
Alumina	trace ...	trace
Sulphate of Potash	nil ...	nil
Chloride of Sodium	8·733 ...	·1146
Carbonate of Potash	7·170 ...	·1024
Carbonate of Soda	27·813 ...	·3973
Organic Matter	trace ...	trace
Total solids	46·340 ...	·6516

(47.) *Water from a bore put down at Youngerrina, depth 168 feet, temperature 82° F.

	Grains per Gallon.	In 1000 Parts
Total fixed matter	32·984 ...	·4712
Soluble saline matter	31·892 ...	·4556
Insoluble mineral matter ...	1·092 ...	·0156
Chlorine in combination ...	5·100 ...	·0728
Equal to Chloride of Sodium ...	8·404 ...	·1200

The soluble saline matter consists mainly of alkaline carbonates, chloride of sodium, silica, with strong traces of lime, magnesia, sulphuric acid, etc. The insoluble matter almost entirely consists of silica, with traces of carbonates of lime and magnesia. Water clear, free from odour and matters in suspension. Before evaporation, and after, gave a strong alkaline reaction. Suitable for domestic uses, stock, and irrigation purposes.

(48.) *Water from a bore put down at Native Dog, depth 475 feet, temperature 92° F.

	Grains per Gallon.	In 1000 Parts
Total fixed matter	45·108 ...	·6440
Soluble saline matter	44·044 ...	·6292
Insoluble mineral matter ...	1·064 ...	·0152
Chlorine in combination ...	4·500 ...	·0642
Equal to Chloride of Sodium ...	7·415 ...	·1059

The soluble saline matter consists mainly of alkaline carbonates, chloride of sodium, silica, and strong traces of lime, magnesia, and sulphuric acid. The insoluble of silica, and traces of carbonate of lime and magnesia. The water gave an alkaline reaction before and after evaporation. The quantity of water received in both samples was too small to enable a more detailed analysis being made. Both these waters may be used for irrigation purposes, and are suitable for all domestic uses.

*It will be observed that the saline matter consists mainly of carbonated alkali, which are known when present in large quantities to exert a serious influence on plant life, by their corrosive action on the young roots etc. The action can to a great extent be remedied by the addition of a small quantity of gypsum to the soil prior to irrigation. The amount of alkaline carbonates present in these waters is much too small to condemn them for irrigation purposes.

(49.) *Paroo.*—Water from a bore at Mallara.

	Grains per Gallon.	In 1000 Parts
Soluble saline matter ...	133·19 ...	1·9027
Insoluble mineral matter ...	8·56 ...	·1222
	141·75 ...	2·0249
Chlorine	79·70	1·1385

The soluble solids were found to consist of soda, potash, lime and magnesia combined with chlorine and carbonic acid. The insoluble of carbonates of lime and magnesia, silica, alumina, etc. Not a suitable water for human consumption or irrigation purposes except when used with discretion.

Mineral Waters.

(50.) *Mittagong*—Chalybeate water.

	Grains per Gallon.	In 1000 parts.
Chloride of Magnesium ...	1·296 ...	·0185
Chloride of Potassium ...	2·042 ...	·0291
Chloride of Sodium	2·158 ...	·0308
Bicarbonate of Calcium ...	2·041 ...	·0291
Bicarbonate of Magnesium ...	2·243 ...	·0320
Bicarbonate of Iron	5·985 ...	·0855
Total solids... ...	15·765	·2250

Free Ammonia	nil	per 100,000 parts.
Organic, or Albuminoid Ammonia ...	nil	„
Nitrogen as Nitrates...	nil	„
Nitrogen as Nitrites	nil	„

Colour in a two feet tube, light-brown colour. Reaction, acid, due to carbonic acid gas. Taste, inky. Odour, earthy.

Remarks.—May be classed as a Chalybeate Water. Useful as a general tonic and stimulant, especially in chlorosis and anæmia.

(51.) *Jarvisville near Picton.*—Water stated to possess medicinal properties.

	Grains per Gallon.	In 1000 Parts.
Chloride of Sodium	100·620 ...	1·4374
Chloride of Magnesium ...	26·211 ...	·3744
Bicarbonate of Calcium ...	19·340 ...	·2762
Bicarbonate of Magnesium ...	50·390 ...	·7208
Sulphate of Potash	12·172 ...	·1738
Sulphate of Lime	1·985 ...	·0284
Silica and Silicates	·812 ...	·0116
Alumina	trace ...	trace
Oxide of Iron	trace ...	trace
Organic matter	trace ...	trace
	211·530	3·0226

Free Ammonia	trace	per 100,000 parts.
Albuminoid Ammonia	·012	„
Oxygen absorbed in 15 minutes	·0196	„
Oxygen absorbed in 4 hours ...	·0640	„
Nitrates and Nitrites	traces	„

Reaction, alkaline. Taste, saline. Odour when heated, organic. Colour in a two feet tube, pale green. Poisonous metals, nil.

(52.) **Ballinore, Talbragar River near Dubbo.*—Artesian.

	Grains per Gallon.	In 1000 Parts.
Bicarbonate of Sodium ...	183·10 ...	2·6157
„ Potassium ...	12·83 ...	·1833
„ Lithium ...	·05 ...	·0007
„ Calcium ...	11·38 ...	·1625
„ Magnesium ...	9·36 ...	·1337
„ Strontium ...	trace ...	trace
„ Iron	·70 ...	·0100
Chloride of Sodium	6·92 ...	·0988
Alumina	trace ...	trace
Silica	·28 ...	·0040
Total solids	224·62 ...	3·2087

Trace of Phosphoric Acid detected.

No Bromine or Iodine present.

Free Ammonia ... ... ·052 parts per 100,000

Organic, or Albuminoid Ammonia ·003 „

REMARKS.—This water had a pleasant taste, and was highly charged with carbonic acid. Obtained when boring for coal in a series of sandstone shales at a depth of 500 feet. An excellent description of table water and should command a ready sale when bottled.

(53.) **Rock-Flat Spring, near Cooma, Monara District.*

	Grains per Gallon.	In 1000 parts.
Bicarbonate of Sodium	45·29 ...	·647
„ Potassium... ...	17·15 ...	·245
„ Lithium	nil ...	nil
„ Calcium	52·08 ...	·774
„ Magnesium ...	22·40 ...	·320
„ Strontium	strong trace	
„ Iron	nil ...	nil
Chloride of Sodium	5·04 ...	·072
Nitrate of Soda	trace ...	trace
Silica	·56 ..	·008
Alumina	trace ...	trace
Total solids	142·52 ...	2·066

Waters suitable for Stock purposes.

It will be observed on comparing the analyses of many of the deep bores and well waters, that they yield a large amount of total fixed matter, the larger portion of which is saline matter. These salts consist chiefly of chloride of sodium (common salt), sulphate of soda (Glauber's salt), and sulphate of magnesia (Epsom's salt).

The medicinal action of these salts when frequently taken into the system is well known, the salts of magnesia and soda pro-

* Previously described, Proc. Aust. Assoc. Adv. Sci. for 1892, Vol. IV.

ducing a purging effect, while excessive quantities of common salt cause an increased thirst, and by their action on the kidneys impoverish the blood and hence produce debility.

It is a well known fact that stock which have been reared on a station where these saline waters exist, manage to thrive after a time, while the effect produced is often disastrous to those newly brought into contact with them. Stock are also very fond of these waters and will drink a large quantity, which must create a thirst.

These strongly saline waters therefore are very unsuitable for continually watering stock, and I have no doubt that on some occasions large numbers of stock have sickened and died through the effects of drinking large quantities, while the death of these animals have been erroneously charged to disease. In one case especially which came under my notice some seven years ago, the death of a large number of cattle were proved to be due to their continually drinking large quantities of saline water which was conserved on the run. A sample of this water yielded on analysis as follows :—Total fixed matter over 1,500 grains per gallon, the bulk of which consisted of chloride of sodium (common salt) and chloride of magnesium, and sulphates of magnesia and soda. The cattle had to be removed from the run on which this water was conserved.

In America the action of these waters on stock has received a certain amount of study. A spring water obtained from the foot-hills of the Coast Range, in Western Tulare Country, near San Francisco, said to produce disease in cattle drinking the water, yielded on analysis as follows :—

	In 1000 Parts.
Total solid residue on evaporation	...
Again soluble in water after evaporation ...	13·22
Insoluble in water after evaporation	5·11
Silica	·96
Organic matter and combined water	2·51
Total solid residue	21·80

The water was clear and odourless, with a flat brackish taste, and had a strong alkaline reaction. The soluble portion contained chiefly common salt and Glauber's salt, while the insoluble part was composed mainly of gypsum, with a little carbonate of magnesia and silica. The sample was reported as being unfit for man or beast. An analysis of a somewhat similar water is the sample obtained from Nyngan (No. 25). The total solid residue was 22·2904 parts per 1000, the amount soluble being 21·1564 parts per 1000.

*Two spring waters from Ventura Country, South America, and stated to be too strongly mineral to be used otherwise than as a purgative medicine, mitigated somewhat for the animal system by the carbonate of soda, but rendered more injurious to the soil yielded on analysis as follows :—

	No. 1. (In 1000 Parts.)	No. 2. (In 1000 Parts.)
Total solid residue on evaporation ...	5·57	6·33
Soluble part after evaporation	3·25	4·17
Insoluble part after evaporation	1·47	1·31
Chemically combined water and organic matter	·86	·85

REMARKS.—The soluble matter after evaporation consisted in the main of sulphate of soda (Glauber's salt), with some carbonate and chloride of sodium, and a little sulphate of potash. The common salt was more abundant in No. 2 than the other.—(Prof. E. W. Hilgard.)

In consequence of the many enquiries made to the Department of Mines, and the various analyses of water conducted with a view of ascertaining their suitability for watering stock, the matter being in my opinion, as to their use, more of a medical question, the opinion of Mr. Edward Stanley, M.R.C.V.S., Government Veterinarian was asked for. The following is a copy of Mr. Stanley's Report :—

* Report of Examination of Waters and Water Supply and Related Subjects during the years 1886-89 by Professor E. W. Hilgard, College of Agriculture, California.

"*Re the effects of Saline Waters on Stock.*

"For the information of the Chief Inspector of Watering Places, I have the honour to report having ascertained from some of the analyses of some of the wells in the Western District contained in the Departmental Reports, that the salts most frequently found are magnesia and soda, combined with sulphuric acid and chlorine.

"As these salines are used in veterinary medicine, their effects are well known when administered in definite medicinal quantities. Magnesia salt in doses of about 1lb. acts as a purgative for cattle, and a quarter of a pound as a purge for sheep or swine. It is not suitable for horses, as it excites too much irritation of the bowels and causes inflammation. From two to four ounces repeated daily to cattle or a proportionate quantity to sheep, would set up indigestion, dissolve the semi-fluid feces, with excited action of the kidneys, gradually reducing the animal's strength and vitality. Such water being nauseous and bitter to taste would prevent stock from drinking it, unless they are pressed by thirst. Soda salts are used, but much less frequently in purgative doses for stock. Cattle will take about 1lb, and sheep about three or four ounces. They are too violent and uncertain in their action to be used for horses. Common salt (chloride of sodium) is an essential article of food aiding digestion, it assists in the formation of the gastric juices and bile, and generally assists nutrition in quantities of one to three ounces daily for cattle, half the quantity for horses and one or two drams for sheep. Large and repeated doses of salt in drinking water causes increased thirst, excites the action of the kidneys, which excrete an excessive quantity of pale urine, and impoverish the blood of its chemical constituents, leading to loss of condition and general debility. There is no doubt that many animals located on a station can and do, accomodate themselves to saline waters, while others less robust in condition will waste away and die. It is easy to understand that starving or even thirsty travelling stock may suffer disastrously from drinking at once a large quantity of water containing a high percentage of saline matter. Horses and cattle will drink from five (5) to twelve (12) gallons a day, sheep from one (1) to two (2) gallons a day.

"Drovers could be cautioned at saline drinking places of the danger of permitting stock to drink too freely, until they have been accustomed to the medicinal properties of the water."

(Signed) EDWARD STANLEY, Govt. Veterinarian.

Value of water for Irrigating purposes.

The value of a water for irrigation purposes depends not simply on the nutrient matters in solution, but the sediment in suspension must also be taken into account. The ingredients contained in water and valuable for this purpose are mainly the nitrogen, potash, and phosphoric acid. Large quantities of alkaline salts excite a serious influence on the soil, and injure all useful vegetation, their action being a corrosive one; chiefly upon the root crowns and upper roots of plants. The alkaline carbonates, (carbonates of aoda and potash) damage the soil if present in excessive quantities, by the dissolution of the humus, which is often shown by the dark colour of the water and the black rings left were such waters have evaporated. This can to some extent be remedied when the salts consist chiefly of carbonate of soda, by the addition of small quantities of gypsum (plaster of Paris) to the soil prior to leaching, which renders the humus soluble again, and thus prevents waste. The neutral salts *i.e.*, chloride of sodium (common salt), sulphate of soda (Glauber's salts), sulphate of potash, etc., are only injurious when present in large quantities, and relief can only be obtained by washing them out of the soil by under drainage, etc.

"According to (A. Stood, Chem. Journ. Aug. 1889) water containing more than one gramme of common salt per one thousand damages vegetation, and even if the amount be only 0·5 grammes per 1000, the germination of seeds is destroyed (33%). A further action which is also detrimental to plant growth is that by the reaction of zeolites, tricalcic phosphate, etc. with chloride of sodium, the valuable constituents are rendered soluble and washed away out of the reach of plants, and this can occur when there is only 0·05 grammes per litre. Districts therefore in which salt appears either in the waters of irrigation or as underground or bottom water, cannot support plants in a healthy state; for apart from the solvent action of the common salt in warm weather, it is carried up by capillary attraction to the upper parts of the soil, becoming there concentrated and so directly inimical to life. Analyses of soils thus affected show not only a large increase of common salt, chlorine, and total ash in the residue, but a decrease in potash and sulphuric acid."—(A. Stood, Chem. Journ. Aug. 1889.)

Mr. A. N. Pearson, Government Agricultural Chemist for Victoria, in his valuable report to the Secretary for Water Supply states as follows :—" It is known that an excess of common salt and of other chlorides will diminish the productiveness of soils. Voelcker states as a result of experiment that $\frac{1}{10}$ per cent. of salt in a soil makes it absolutely barren, probably the limit varies according to many circumstances. The usual dressing of salt as an alterative to the soil is about two cwt. per acre; five cwt. is a maximum dressing, which should not be given often. Now if a water contains thirty parts of chlorine, which would represent about fifty parts of salt in 100,000 parts, one acre of that water ten inches deep would contain half a ton of salt, which as we have seen before is excessive dressing.

" It may be considered that fifteen parts of chlorine per 100,000 of water is a safe limit for general irrigation purposes; that a water containing more than this should be used sparingly; and that one containing forty or fifty should be condemned.

" These limits I have fixed upon however only on general considerations such as above given. I am putting the matter to a direct test on a laboratory scale by using solutions of different strengths for watering pot plants. It is possible that if a soil were deep drained, and occasionally flooded so that an excessive accumulation of salt in it could be washed out, a water containing a somewhat high percentage of salt may be used."—(A. N. Pearson.)

In the use of a water for irrigation purposes the following questions may arise :—

1st. As to the composition of the soil it is proposed to irrigate, also whether alkaline; as the water added for irrigation purposes if alkaline represents so much alkali added to a soil perhaps already alkaline.

2nd. The nature of the crop or vegetation it is proposed to irrigate.

3rd. The climate and temperature, also rainfall, these to a great extent determining the class of products that can be grown with a profit.

4th. The analysis of the water supply, and its freedom from excessive quantities of alkali and other injurious substances.

5th. Drainage, and thereby washing out the accumulation of salts deposited in the soil.

The benefit derived from Irrigation.

The value of irrigation in arid districts and the benefits derived therefrom, are well known in India, America and elsewhere. In the southern parts of California irrigation has transformed seeming deserts into a maze of gardens, orchards and orange groves. This is now the case in South Australia at Messrs. Chaffey Bros. Irrigation Works at Renmark and Mildura in Victoria, these districts through the energy of the Messrs. Chaffey Bros., and the help of the Government are being converted into gardens, orchards, and orange groves, thus giving employment to some thousands of the "Sons of the Soil." The entire population of the Mildura settlement last year numbered over 3,000 people, and the township will possess an Agricultural College where settlers may acquire a training in the science and art of horticulture and agriculture.

As yet little has been done in New South Wales, excepting in a small way, to utilise our waters for irrigation purposes, although it is proposed shortly to start on the large scale and form an Irrigation Colony in the Mulgoa District near Penrith; the water is to be conserved from the Nepean River and its various tributaries and will be the means of opening up a large tract of country, and thus give employment to a large number of fruit growers, who have had to contend against the great difficulty experienced, *i.e.*, want of water.

Mr. H. G. McKinney, M.E., M. Inst. C.E., in a valuable paper read before the Royal Society of New South Wales on Sept. 4th 1889, entitled "Irrigation in its relation to the Pastoral Industry of New South Wales," points out that the total area of land in New South Wales is estimated at 196,000,000 acres, that an area of 168,000,000 acres is devoted to pastoral purposes, while the extent under cultivation amounts to only 1,042,000 acres. That it is a question of great interest whether irrigation cannot be made to assist in the development of the pastoral resources of the Colony; also that in his opinion, the losses to which the pastoralists are liable through drought, can to a large extent be minimized by a proper system of irrigation. First the irrigation of extensive areas of the native grasses; second the irrigation of timber areas, of lucerne, and other fodder crops.

Mr. McKinney also points out how profitable the irrigation of the native grasses can be made when the water supply is available from river sources, the water being brought to the ground by channels, etc. How profitable irrigation of the native grasses can be made under such favourable circumstances is very clearly pointed out. With an expenditure of little over £1,200 on the Coorong Run, Mr. Gwydir succeeded in irrigating over 17,000 acres of grass land during every flood in the Lachlan. The cost of irrigating an acre, taking cost of maintenance, interest, etc., amounted to only three-seventeenths of a shilling, or slightly over two pence. Before irrigation the land barely sufficed for 4,000 sheep, after irrigation it supported 12,000 sheep and 200 horses, besides fattening 125 head of cattle.

Utah and Colorado entirely depend on irrigation. The latter State in 1883 raised in value £1,100,000 of grain and root crops, the former £700,000. In California, the Australian Eucalypti—*Eucalyptus globulus*, *E. viminalis*, and the red gum *Eucalyptus rostrata* are planted on extensive areas, some 700 to 1000 trees being set to the acre, and from them excellent supplies of firewood are obtained. Land planted with Eucalyptus which was previously valued at £2 to £5 per acre becomes worth from £20 to £80 in six or eight years, The official returns show a profit of £3 10s. per acre upon plantations which raised the value of property from £20 to £120 per acre in eleven years.

Mr. J. H. Maiden, F.L.S. &c., has pointed out the profit derived from the cultivation of the wattle barks, and I would suggest an increased value by means of irrigation where the water supply can be conserved at a small expense, say in flood time.

Value of Spring, Well, and Artesian Supplies for Irrigation.

To a large extent in various parts of the Colony, especially in the Western District where the supply from rivers and creeks are not available, we will have to rely on our artesian bores and wells. The use of these waters are largely availed of in America for the irrigation of small farms and orchards.

In the Los Angeles District and San Bernardino Countries in California, there are springs or marshes which are capable of irrigating from 20 to 400 acres each, and together supply an area of 7,000 acres of cultivated land.

At San Gabriel, California, a vineyard 1,200 acres in extent is supplied solely by artesian wells of which there are twenty-one on the estate, varying from seventy-five to one hundred feet deep.

In Santa Clara Country, Cal., there is an artesian tract yielding 2,000,000 gallons every twenty-four hours.

In California at Florin, water is raised from depths of ten to twenty feet in a steady stream by means of windmills, one of which it is stated can supply twc to three acres of land with water, the machinery costing about £25 complete.

The New River from which the London Water Supply is obtained, is partly supplied from artesian wells at Amwell and Chatfield, yielding some 4,500,000 gallons per day.

In Algeria and the Sahara, the arid districts have been fertilized with a wonderful effect by artesian irrigation.

One of the largest artesian wells in the world is situated at Huron, North Dakota. It is estimated to yield from 8,000 gallons to 10,000 gallons per minute, and throws up water to a height of 100 feet. It is stated, taken even at the lowest figure, enough water is given to furnish every man, woman, and child in the State of North Dakota with at least four gallons every four hours. The pressure is known to be considerably more than 200lbs. to the square inch.

On referring to the list given of the various wells, bores, and artesian wells in New South Wales (See Appendix A.) it will be observed that many of them yield large quantities of water, sufficient for the irrigation of some acres of land. The Native Dog artesian bore yields over 2,000,000 gallons per diem, the analysis made proving the water to be a good one for irrigation purposes. This is also the case with the artesian water at Youngerrina, though the yield per diem is smaller, being only 175,000 gallons.

As previously pointed out, the analyses furnished of a large number of the wells and bores, must not be taken as representing anything like the average water obtained by sinking and boring, as in many cases only suspected waters find their way into the Laboratory for examination. It is greatly to be regretted that no systematic analyses have been made of the various supplies, as they would prove of great value in determining their composition, and thus ascertaining their value for stock and irrigation purposes. I understand from Mr. Boultbee, the officer in charge of the Water Conservation Branch, that this matter is to be taken in hand, and an examination made of the waters of the various wells, tanks, artesian and other supplies.

The analyses of some of the typical soils in the irrigable districts would also prove of value as regards the amount of alkali present. The aeration of the artesian waters before use for irrigation is one which has received lately much attention in America.

Mineral Waters.

Mineral waters are those in which an unusually large amount of salts are held in solution, their medicinal or therapeutic properties depending largely on the composition of the waters and the amount of the constituents present. There are various classes of mineral waters, some of which constitute excellent table waters, others possess medicinal qualities and are largely used for various complaints.

The following is a description of some of the waters in use in Great Britain, the Continent, America and elsewhere :—

The Carbonated Waters, which consist largely of the so-called bicarbonates of soda, potash, lime and magnesia, are represented by the Apollinaris Water and Seltzer Waters (Germany) and the Rock Flat and Cooma Waters (N.S. Wales).

The Chalybeate Waters which contain salts of iron in solution, and impart to the waters an inky taste, such as those of the Tunbridge Well spring and the Cheltenham Waters (England), and the water described in this paper from Mittagong.

The Sulphurous Waters, sulphuretted hydrogen gas being the predominant ingredient, giving the waters a nauseous taste and smell. These waters are represented in the Harrogate Waters (England), and the Moffat Waters (America), also in a spring at Wilcannia (N.S. Wales).

Sulphated or Purgative Waters, their chief ingredients being the sulphates of magnesia (Epsom's salt) and soda (Glauber's salt), are represented by the springs at Epsom, Fredrickshall, Ofen, Hungary (Hunjadi Janos Water) and the waters obtained in various places in the Broken Hill District (N.S. Wales).

The Bromated and Iodiated Waters, which are represented by the Saratoga, Champion, and Congress Waters (New York) and others contain silica, organic matter, etc., and are said to possess medicinal properties.

Many of these springs are of a temperature higher than that of the surface of the earth where they make their appearance. At Carlsbad and Aix-la-Chapelle the temperature varies from 160° to 190° F. Such hot springs generally occur in the vicinity of volcanoes and are represented by the hot springs of New Zealand. In New Zealand some of these springs are situated at 1,200 feet above the sea, some being cold, others warm, and the rest hot, having a temperature of 117° F. In the North Island, the springs flow through probable natural artesians, coming up to the surface from a depth of some 3000 feet. The waters obtained from a bore at Youngarina and Native Dog (N.S. Wales) had a temperature of 82° and 92° F., while water taken from an artesian bore at depths of 1,175 feet and 450 feet at Bourke (N.S. Wales) gave a temperature of 102° F.

There is a large field open for the examination of our mineral waters, a number of which if thoroughly tested would no doubt be found to possess medicinal properties, and hence be of value. The districts might be made health resorts or sanatoriums, where visitors could stay and enjoy all the advantages of a club-house, and the benefit derived from the waters of the spring.

"In Queensland Mr. H. Faash has leased the Innot Hot Springs from the Government, and constructed baths and a two storied house for the convenience of patients. The water when taken is stated to have an aperient action, but patients undergoing treatment combine bathing with the drinking of the waters, two or three baths of a duration of twenty or thirty minutes being taken daily. These springs have already gained a considerable reputation for their curative virtues in chronic rheumatism, gout, liver, and kidney diseases."—(Mineral Springs of Australia, by Ludwig Bruck.)

In Victoria at some of the springs accomodation houses have been built, so as to allow persons desirous of taking a course of these waters the full benefit and comforts of a home. The best known springs in Australia as yet found are at Hepburn, Daylesford, Clifton Ballan, Stratford and Krambuk in Victoria. The Queensland springs are situated at Nestles Creek, near the Wild and Herbert Rivers (Innot Hot Springs) Tinana, Barcaldine, Eagle Farm, and other districts, some of which are highly spoken of.

Rock Flat and Cooma Mineral Springs.

The waters from the Ballinore Artesian Spring and the Cooma Natural Spring have a pleasant taste, and are strongly effervescent due to the large amount of carbonic acid gas present. In taste they resemble somewhat that of Seltzer-water. They may be described as carbonated mineral waters, and when put up into proper bottles or stored in block tin syphon drums, should command a ready sale as table waters. The spring at Cooma is held under a lease by the Government to the Australian Natural Mineral Water Company, at an annual rental of £20, and the water is retailed by the drum or per glass.

In a small book entitled "The Mineral Springs of Australia" by Mr. Ludwig Bruck, the information contained therein being reprinted from the "Australasian Medical Gazette," for January 1891, a description is given of these waters. The Ballinore Water is compared to the Vichy Waters of France, and stated to be a valuable water for gout, gravel, catarrh of the bladder, diabetes also for dyspepsia, splenic and hepatic disorders.

*" Mr. Slee, F.G.S., Superintendent of Drills, in a report to the Department of Mines states with regard to the Ballinore bore— "That at a depth of five hundred and forty feet the drill passed through a seam of coal five feet two inches thick, and while boring

* Annual Report, Department of Mines 1886, page 179.

for a second seam of coal ten feet below the first seam, artesian water commenced to flow to the surface, and it is now flowing at the rate of 1000 gallons per hour, through tubing thirty feet above the surface."

The Rock Flat Mineral Spring is situated about ten miles to the S.E. of Cooma, and occurs in close proximity to the western bank of Rock Flat Creek, in the parish of Dangelong, County of Beresford. For a description of this spring and the geological formation of the surrounding district and the geology of the immediate vicinity of the spring, I refer you to a paper by Mr. Wm. Anderson, Geological Surveyor, entitled—"On the Mineral Spring at Rock Flat Creek, near Cooma."*

The Ballinore artesian water is in my opinion the best table water of the two, and they may be both classed as excellent.

† A water similar in composition to these waters is found in a spring at Napa Country (America), the water being clear, strongly effervescent and of a pleasant taste :—

Analysis—		In 10,000 Parts.
Total solid residue after evaporation		15·080
Soluble part after evaporation		5·254
Insoluble part after evaporation		8·986
Chemically combined water, Carbonic Acid etc.		·840
Soluble part consists of—	Bicarbonate of Soda	5·648
	Sulphate of Soda	·044
	Common Salt	2·888
	Chloride of Magnesium	·408
	Potash Salts	traces
Insoluble part consists of—	Carbonate of Lime	2·950
	Carbonate of Magnesia	1·339
	Carbonate of Iron	·134
	Silica	·832

Free Carbonic Acid gas, 335 cubic inches per gallon.

* Records of the Geological Survey of N.S. Wales, Vol. I. part iii. p. 117.
† Waters and Water Supply by Prof. Hilgard, University of California.

Chalybeate Water from Mittagong.

This sample should prove useful for medicinal purposes as previously pointed out in cases of chlorosis and other complaints, where tonics are required in assisting blood formation. There are various ferruginous springs in New South Wales which are strongly impregnated with iron, and they are to be found chiefly in the Western Mountain District, and the Southern Districts at Berrima, Mittagong, Burradoo and Mereworth.

The Jarvisville water obtained from near Picton is stated to possess medicinal properties, but the amount of chloride of sodium present is high. With the exception of the Cooma and Ballinore waters, and the chalybeate water from Mittagong, I have examined no other waters which could be classed as mineral waters possessing value and saleable as table or medicinal waters. The mineralized waters of New South Wales are as a rule largely impregnated with common salt (chloride of sodium) which spoils their value for most medicinal purposes.

In appendix A. is given a list of the tanks, wells, and artesian bores in New South Wales, compiled from returns furnished by the Chief Inspector of Mines and Superintendent of Diamond Drills, also from the Officer-in-Charge of Water Conservation.

Plate III. shows the position on the map of the various wells, bores, and artesian supplies, compiled from information furnished by the Government Geologist, the Chief Inspector of Public Watering Places, and the Superintendent of Diamond Drills.

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
1	Arrawatta ...	... ...	King's Plains ...	70	5½ x 5½	65	65	Neverfailing
2	,, ...	... ...	,, ...	90	8 x 4	... ...	9	,, ...
3	,, ...	... ...	Swamp Oak ..	45	6 x 4	... ...	21	,, ...
4	,, ...	... ...	,, ...	40	6 x 4	... ...	4	,, ...
5	,, ...	... ...	Byron	21	4 x 4	20	15	,, ...
6	Macquarie ..	... ...	Cutarbat	50	8*	... ...	25	... ...
7	,, ...	... ...	Huntington ...	101	8*	... ...	71	... ...
8	Manara ...	... ...	Kilfera	189	5 x 2½	80	80	50,000
9	,, ...	... ...	,, ...	162	5 x 2½	50	60	Unlimited ..
10	Franklin ...	... ...	Moolbong	110	6 x 3	... ...	100	20,000
11	,, ...	... ...	,, ...	250	... ...	115 & 250	... ...	Unlimited
12	Windeyer ...	... ...	Buckalow	150	6 x 4	130	110	24,000
13	Taila	... ...	Malee Cliff	70	5 x 3	... ...	... ...	... ..
14	,, ...	... ..	,, ...	18	5 x 3½	15	12	3,000
15	,, ...	... ...	Bedura ...					
16	Wentworth ...	... ...	Gall Gall ...					
17, 18, 19	Taila	.. ...	O. B. Turlee					
20	Wentworth ..	... ...	Gall Gall C...	75 to 150	... ...	... ...	... ...	... ...
21, 22	,, ...	... ...	West Perengi, A.					
23 to 27	,, ...	... ...	Wamberrar ..					
28 to 34	,, ...	... ...	Outer Tapio					
35 to 37	,, ...	... ...	Octer Tilato					
38	Menindie ...	... ...	Burta	280	6 x 3	250	250	Not tested..

* Circumference.

INDEX TO WELLS—*continued.*

Number of Well.	Quality.	Nature of surrounding country.	Strata.	Remarks.
1	Brackish	N., granite ridges; E. S., and W., ridges and plain.	Black soil, granite, rotten slaty bottom.	This well is only used in time of drought.
2	"	Forest, plain, ridges, chiefly white gum timber.	Black soil, rotten granite and pipeclay.	Water stands 5′ from top in wet seasons.
3	"	N., barren ridges; E. and W. do; S. forest and ridge.	Top brown soil, then basalt to bottom.	
4	"	... ...	... ...	In a wet season overflows.
5	Slightly brackish...	Black soil plains and open forest country.	Black soil 15′, basalt 6′.	
6	Fresh and hard ...	Undulating, ridges running into rocky mountains	Black alluvial soil, pipeclay, and slate rock.	The well is believed to be down to the level of river water. The water is hard, but used for household purposes.
7	Hard...	Low ranges, with creeks running to river.	Soft slaty rock	Sunk on a low ridge, believed to be down to level of river water; used for household purposes.
8	Good stock... ..	Salt-bush plains, lignum S side.	... ...	Salt at 80′; got much better as we went deeper; last spring struck almost fresh, 100′ open shaft, 89 bore, $3\frac{1}{2}''$ diameter.
9	Salt	" "	Gypsum, sandstone, and clay.	Salt at 50′; improved slightly when bored; open shaft 100′, bore 62′.
10	Good and fresh ...	Salt and cotton bush, dark clayey soil.	Alluvial	Selection of site for well a matter of chance in some parts of Riverina. Good stock water is obtained at a depth of 100′ to 130′; in other parts two wells within one mile of each other salt water was obtained; midway between another shaft was put down and good water obtained.
11	Fresh	" "	Alluvial.	
12	Slightly brackish...	Broken plains	Alluvial, 120′ pipeclay and drift 30′.	This well is in a sandy box swamp and gives one of the best supplies in the district; other shafts have been tried in the Mulga country and failed to strike water; two of them sunk 220′.
13	... ...	S., mallee and porcupine grass; W., N., and E., black oak.	Loamy soil 15′, drift sand 55′.	
14	Slightly brackish...	Pine ridges, mallee, porcupine grass, and salt-bush.	... ...	This well is covered by the Murray water when in flood.
15 16 17, 18, 19 20 21, 22 23 to 27 28 to 34 35 to 37	Salt	Red sandy soil or clay on salt-bush plains. Red sandy soil in belar or oak scrub. Red sandhills in mallee Red clayey soil in box flats. White clay flats, with box timber.	... ...	One well on Gall Gall, C, we pumped for a considerable time in the summer, hoping the water would improve, but it did not do so. Have several soakage wells, with good stock water, all at shallow depths of not more than 20′, all sunk in the beds of dry creeks where the flood waters back up, and all within five miles of the river; the supply is not good, and are only made useful by making large chambers and drives at bottom of shaft.
38	Good stock... ...	Salt and cotton bush, light scrub, and undulating.	Hard clay, with gravel 100′, alluvial 80′, pipeclay and mica 30′, soft sandstone rock and clay 70′.	Open shaft 200′, bore 80′. This well is to be sunk to full depth of bore, when the supply is expected to increase. A Tiffen borer was used.

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
39	Windeyer ...	... ...	Mallara	64	6 x 3	64	20	Not tested..
40	Perry	... ...	Moorara	100	6 x 3	82	82	17,000
41	,, ...	... ...	Pan Ban	100	6 x 3	80	80	Unlimited
42	,, ...	... ...	North Pan Ban ...	78	6 x 3	78	75	8,000
43	Rankin... ...	... ...	Barnato	150	6 x 3	135	135	5,000
44	,, ...	... ...	,, ...	200	6 x 3	190	140	7,000
45	Woore	... ...	Fulham	175	5 x $2\frac{1}{2}$	169	168	3,296
46	,, ...	... ...	Moama	170	6 x 3	170	... ...	3,000
47	,, ...	... ...	Baden Park ...	200	6 x 3	.. ...	... ...	6,000
48	,, ...	... ...	Emerald	140	6 x 3	126	... ...	... ...
49	Booroondara ...	... ...	Paddington ...	200	8 x 4	.. ...	... ...	5,000
50	Woore	... ...	Warfield	220	6 x 3	... ...	... ...	6,000
51	Blaxland ...	... ...	Bedooba	300	... ...	300	115	... ...
52	Mouramba ..	... ...	Priory	230	8 x 4	.. ...	... ...	... ...
53	Canbeligo ...	... ...	Booroomugga ...	100	6 x $3\frac{1}{2}$	... ...	... ...	... ...
54	,, ...	... ...	Girilambone ...	$155\frac{1}{2}$	Bore ...	155	128	... ...
55	,, ...	... ...	,, ...	120	,,	116	105	... ...
56	,, ...	... ...	,, ...	100	,,	... ...	... ...	... ...
57	Rankin... ...	... ...	Donald's Plains A.	160	6 x 3	... ...	133	4,000
58	... ...	... ...	Mount Manara ...	... ...	... ...	... ...	...	... ...

INDEX TO WELLS—*continued.*

Number of Well.	Quality.	Nature of surrounding country.	Strata.	Remarks.
39	Salt and poisonous	Sandhills and oak ridges like decomposed limestone.	Pipeclay and drift ...	A good many trial shafts have been sunk on this run, salt water being struck in drift under 100′ in all of them.
40	Good stock... ...	Open salt and cotton bush plains, with oak clumps, &c.	Alluvial 82′, fine drift 18′	Have sunk fifty trial shafts on different parts of run, from 80′ to 100′; salt water struck in all; unfit for use.
41	Fair stock	Open salt-bush plains, with oak ridges, &c.	Clay throughout ...	50,000 gallons per day have been obtained, but the supply seems practically inexhaustible; slightly brackish.
42	„	„ „ „	Alluvial 20′, fine drift 58′	Cool, cloudy weather seems to increase the supply.
43	Good stock—slightly sweet...	Sandstone ridges; red clay flats; mulga pine; beefwood.	Alluvial gravel, cement and sandstone rock.	There is a 30′ drive in this well.
44	Good stock... ...	Pine sandhill; mulga and belar ridges.	Gravel and cement 100′, sandstone 60′ cement and blue clay 40′.	„ „ „
45	„	Loamy flats, rocky ridge, and mallee sandhills.	Loam, clay, and cement 167′, drift 8′	Eight miles from this well a trial shaft was sunk 188′; no water struck; half-a-mile from the above well a shaft 6′ x 3′ was sunk to a depth of 96′, then a bore 130=226′, no water being struck; boring still going on.
46	Very brackish ...	Box flats and pine sandhills.	Alluvial 100′, sandstone flags 70′, water in blue clay.	
47	Good stock... ...	Red clay flats and pine sandhills.	Cement and sandstone.	
48	„	Open mulga, with ridges of malee.	Hard sandstone 69′, chalk 1′, hard sandstone 70′.	The sandstone rock in this well required to be blasted; it is intended to put a drive in this well to increase the supply.
49	Brackish	Ironstone rises; box flats; mulga; &c.	Alluvial pipeclay, cement, and sandstone rock.	
50	Good stock... ...	Red flats and pine sandhills.	Pipeclay and cement, hard sandstone.	
51	Good and fresh ...	Undulating	Blue slate...	This well was sunk before present owners bought station. There are two long drives at bottom, not required for use.
52	Good stock... ...	Undulating barren and box flats and ironstone rises.	Cement and hard sandstone, water in sandstone.	
53	... ...	Undulating ridges; volcanic hills.	Red clay 3′, red sandy drift 4′, coarse red drift 6, red clay 7′, white sandy rock 10′, pipeclay 3′, white sandy rock 12′, fireclay 4′, white sandy rock, with occasional thin strata of fire and pipeclay 51′.	This well is not yet finished.
54	Good stock... ...	... ...	Hard sandstone, rock, cement, quartz, and gravel.	
55	Very salt	... ...	Quartz, gravel, and hard sandstone.	A shaft put down here would make 6,000 gallons per day.
56	... ...	... ...	Hard slate, quartz, and hard rock, &c.	
57	Fresh	... ...	Pipeclay and cement ...	This well is in the bed of Tiltagoona Creek.
58	... ...	... ...	... ...	Government well condemned as being unfit for stock. A well half-a-mile to the N.W. good water, supposed to be soakage.

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
59	Booroondara ...	... ...	Donald's Plains I.	90	4 x 2½	... ...	... ...	Limited ...
60	Cowper ...	... ...	Coronga Peak ...	120	6 x 3	... ...	... ...	" ...
61	Finch	... ...	Goondoobline ...	50	6 x 6	35	35	Not tested..
62	Leichhardt ...	... ...	Polly Browan ...	20	6 x 5	18	10	1,000
63	Finch	... ...	Gingie	25	7 x 7	20	20	Limited ...
64 to 78	Leichhardt ...	... ...	Euroka	45 to 68	... ...	... ...	... ...	... ...
79	Finch	... ...	Dungalear	120	... ...	100	80	... ...
80 to 88	"	... ...	"	20 to 40	... ...	... ...	... ...	... ...
89	"	... ...	Llanillo	45	6 x 4	... ...	... ...	... ...
90	"	... ...	"	45	6 x 4	... ...	... ...	... ...
91	"	... ...	"	55	6 x 4	... ...	... ...	2,000
92	"	... ...	"	45	6 x 4	... ...	... ...	... ...
93	"	... ...	"	40	... ...	... ...	... ...	1,000
94	"	... ...	"	60	... ...	... ...	... ...	1,000
95	"	... ...	"	35	6 x 4	... ...	... ...	600
96	"	... ...	"	35	6 x 4	... ...	... ...	600
97	"	... ...	"	38	4 x 3	... ...	... ...	... ...
98	"	... ...	"	60	... ...	... ...	... ...	... ...
99	"	... ...	"	50	6 x 4	... ...	... ...	... ...
100	Cowper ...	... ...	Glenariff	109	... ...	... ...	49	... ...
101	" ...	... ...	"	209	... ...	... ...	101	... ...
102	" ...	... ...	"	330	... ...	... ...	... ...	... ...
103	Killara... ...	... ...	... ...	144	... ...	... ...	Artesian	60,000
104	Landsborough	... ...	... ...	49	... ...	... ...	"	20,000

INDEX TO WELLS—*continued.*

Number of Well.	Quality.	Nature of surrounding country.	Strata.	Remarks.
59	Fresh	Cottonbush, mulga rises, and sandstone hills.	Pipeclay, cement, and layers of drift.	This well has never been used for stock purposes, owing to a 10,000 yard tank full of water in the vicinity.
60	Good stock... ...	Undulating, red, volcanic hills and mulga	... ...	Not required to be used.
61	Fresh	Sandy pine ridges, then open box flats.	Sand.	
62	Good and fresh ...	Buthar and pine timbers small clear patches of salt-bush.	White loose sand ...	This well was cleared out in the dry time, and it watered the whole of the stock on the place in the summer of 1881 and 1882.
63	Good...	Open, red and black soil.	Sand	This well is a simple sand-pocket, surrounded by clay, and catches the drainage of the adjacent hard ground; the supply is always limited, and if sunk too far salt water is struck.
64 to 78	Saline	... ...	... ...	Fifteen bores by machinery on various portions of this station struck water in each of the first sand-drifts met with; further attempts at finding fresh water abandoned.
79	Salt, unfit for stock	Very level, loamy soil	... ...	The only fresh-water wells here are small sand wells, no springs being tapped; would do for household purposes, or (say) 1,000 sheep.
80 to 88	Fresh	... ...	Sand	There are nine sandy wells, with only a limited supply of splendid clear fresh water; not sufficient to water any large number of stock; might be made available by having a receiving tank kept full for use in troughing; they are soon pumped dry, and take a considerable time to fill again; they are all in sand hollows, and fresh water is indicated by gum-trees growing in vicinity; if sunk too deep a clay bottom is struck, and continued through that for any distance salt water would be struck.
89	Fresh			
90	Salt			
91	,,			
92	,, ...	Belar and salt-bush plains, loamy and sandy soil.		
93	Fresh	Sandy basins, box, coolabar, &c.		
94	,, ...	,, ,,		
95	... ...	Pine scrub and box flats		
96	... ...	Same.		
97	... ...	Sandy soil, pine scrub, and salt-bush.		
98	Salt	Red soil, N.W. plains; S.E. pine ridges.	Drift sand.	
99	,, ...	Red soil, ridges, pine and coolabar.	... ...	There is a vein of country running from the Moonie River down to the lower Narran Lake, between the Narran and Barwon Rivers; it consists of sandy basins and low pine ridges, where water can be obtained at various depths from 20′ to 40′, in some places salt, in others fresh; on a portion of Llanillo Run there are two wells 30′ apart, one fresh wholesome water, the other barely fit for consumption; the supply is influenced by rainfall.
100	Fresh	... ...	Granite	Pumped with an Althouse windmill; waters 20,000 sheep.
101	Brackish	... ...	,, ...	Pumped 1,500 gallons per hour; mill and pump never without water.
102	Salt	... ...	Slate	Boring being continued, a Wright and Edwards' machine being used.
103	Fresh	... ...	... ...	Rises 26′ above surface in tube.
104	,,			

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
105	Mossgiel ...	... ...	... ...	360	... ...	... ...	180	... ...
106	" ...	... ...	... ...	312	... ...	... ...	... ...	... ...
107	Gunderbooka...	... ...	... ...	194	Bore ...	72′ 6″	10	... ...
108	" ...	... ...	... ...	198	" ...	198	38	... ...
109	Barrona ...	... ...	... ...	114	" ...	80	Artesian	440
110	" ...	... ...	... ...	201	" ...	192	"	... ...
111	" ...	... ...	... ...	474	" ...	427	"	... ...
112	Pottinger ...	... ...	... ...	53	" ...	40	... ...	... ...
113	" ...	... ...	... ...	25	" ...	23	... ...	... ...
114	" ...	... ...	... ...	23	" ...	23	... ...	... ...
115	" ...	... ...	... ...	41	" ...	28	... ...	... ...
116	" ..	... ...	... ...	60	" ...	57	... ...	... ...
117	" ...	... ...	... ...	41	... ...	38	... ...	... ...
118	" ...	... ...	... ...	30	Bore ...	27	... ...	... ...
119	" ...	... ...	... ...	48	" ...	38	... ...	... ...
120	" ...	... ...	... ...	34	" ...	24	... ...	... ...
121	" ...	... ...	... ...	132	" ...	70	... ...	9,600
122	Murchison ...	... ...	Bingera	80	... ...	80	... ...	... ...
123	Couralie ...	Near Moree ...	... ...	130	... ...	130	90	... ...
124	Denham ...	... ...	Gorion	174	... ...	174	78	24,000
125	" ...	... ...	"	188	... ...	164	90	576
126	Yancowinna ...	Near Silverton	... ...	40	... ...	40	... ...	... ...
127	Delalah ...	... ...	Elsinora	390	Bore ...	370	... ...	Unlimited
128	Clarence ...	... ...	... ...	184	... ...	126	... ...	... ...
129	Pottinger ...	... ...	... ...	78	... ...	... ...	54	... ...
130	" ...	... ...	... ...	82	... ...	77	62	... ...
131	" ...	... ...	... ...	81	... ...	81	4	... ...
132	" ...	... ...	... ...	90	... ...	... ...	... ...	... ...
133	" ...	... ...	... ...	136	... ...	... ...	85	... ...
134	" ...	... ...	... ...	60	... ...	... ...	35	... ...
135	" ...	... ...	... ...	40	... ...	... ...	28	... ...
136	" ...	... ...	... ...	70	... ...	... ...	60	... ...
137	" ...	... ...	... ...	71	... ...	... ...	41	... ...
138	" ...	... ...	... ...	40	... ...	... ...	... ...	... ...
139	Robinson ...	... ...	... ...	640	... ...	579	... ...	... ...

INDEX TO WELLS.

Number of Well.	Quality.	Nature of surrounding country.	Strata.	Remarks.
105	Fresh.			
106	"			
107	Salt	... ...	Sandstone 40′, clay 24′, clay and sand 130′.	Water also struck at 22′, 60′, 64′ 6″ and 69′, all salt.
108	"	... ...	Sandstone 20′ 9″, clay 39′ 3″, clay, sand, and drift 138′.	Salt water struck at 12′ and 24′. Fresh water at 31′, 32′ 6″, 45′, 53′ and 55′. Salt water struck at 198′, hard sandstone and conglomerate, and rose to 38′ very quickly.
109	Fresh	... ...	Clays 20′, mud and drift 43′, clays 20′ sandstone 31′.	Salt water struck at 20′; a large supply. Fresh water at 80′, rose 21′ over surface.
110	"	... ...	Clay and sand 82′, sandstone 105′, shale, granite, pebbles, rock, &c. 14′.	Fresh water struck at 80′, 100′ rose 8′ over surface, 80 gallons per hour; 107′ rose 8′ over surface; 122′, 6″ over surface, 600 gallons per hour; 192′ rose 10′ over surface.
111	"	... ...	... ...	Salt water struck at 110′, rose to within 23′ of surface; 349′, brackish, rose 3′ over surface; 427′ fresh water, rose to 3′ 3″ over surface.
112	"	... ...	Clay and gravel.	
113	"	... ...	Clay and sandy loam 20′, drift 5′.	Large supply.
114	"	... ...	Sandy loam and clay 20′, drift 3′.	
115	"	... ...	Clay, sand, and gravel.	
116	"	... ...	Clay & gravel 57′, rock 3′	
117	"	... ...	Sand and gravel ...	Very good water.
118	"	... ...	Loam, clay, gravel, and boulders.	
119	"	... ...	Sand, clay, and gravel.	
120	"	... ...	Clay, drift, and clay ...	Large supply.
121	"	... ...	Sand and gravel, clay and rock.	Water tapped at 32′, and at 70′; large supply.
122	"	... ...	... ...	Plentiful supply.
123	"			
124	"	... ...	Clay, sand, and drift ...	Salt water at 80′; brackish, 143′; fresh 174′.
125	"	... ...	" "	Salt water at 80′; brackish, 141′; fresh 161′.
126	"	... ...	... ...	150 gallons per day, after striking the water expected to increase to 1,000 gallons.
127	"			
128	Salt	... ...	... ...	Strong supply. Coal struck at 184′
129	Fresh	Black soil, flat... ...	Soil 18′, rock 60′ ...	Short supply.
130	"	... ...	Red soil 77′, 5′ sand ...	Water in sand inexhaustible.
131	"	Level plain	Soil 34′, sand 1′ 8″, marl 45′ 4″.	Water in gravel, good. At 80′ kangaroo bones and bivalve shells.
132	"	... ...	Pipeclay at surface. Unknown.	Overflowed once in consequence of ringbarking.
133	"	... ...	Black soil 40′, stones, &c. 10′, red soil 30′, cement 5′, gravel, &c. 51′.	
134	"	Open plain	Loam, 45′, drift 15′ ...	Good water.
135	"	"	Black soil 12, clay and gravel 16′, sand 12′.	Water abundant.
136	"	Ironbark country ...	Black soil 65′, sand 5′ ...	Supply excellent.
137	"	Black soil	Black soil 7′, rotton rock 64′.	Excellent and good supply. Came through fissure in rock.
138	"	... ...	... ...	Water supply in sand abundant.
139	"	... ...	... ...	Bore 75′ 10″ at bottom of shaft—Cobar Copper Mine. Water in slate

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
140	North'berland	Awaba ...	Teralba	568	Bore ...	197	Artesian	... ...
141	Mootwingee ...	... ...	Morden	153	,, ...	153	100	... ...
142	St. Vincent ...	... ...	.. ..	850	,, ...	... ...	Artesian	... ...
143	Cumberland ..	Gladesville ...	... ...	442	,, ...	336	8	... ...
144	,, ...	,, ...	.. ..	365	,, ...	.. ...	8	... ...
145	Young	... ...	... ...	255	,, ...	218	70	... ...
146	,, ...	... ...	.. ..	128	,, ...	121	105	1,440
147	... ...	... ...	... ...	... ...	... ...	.. ...	... ...	... ...
148	Young	... ...	... ...	35	... ...	... ...	... ...	... ...
149	,, ...	... ...	Natellie	104	... ...	.. ...	... ...	... ...
150	,, ...	... ...	... ...	135	.. ...	... ...	... ...	19,200 (150–151)
151	,, ...	... ...	... ...	135	... ...	... ...	... ...	
152	,, ...	... ...	... ...	404	... ...	... ...	... ...	720
153	Taudora ...	... ...	Glenlyon	240	... ...	... ...	... ...	20,000
154	,, ...	... ...	.. ..	40	.. ...	... ...	... ...	... ...
155	Yancowinna ...	... ...	... ...	150	... ...	... ...	... ...	... ...
156	,, ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...
157	,, ..	... ...	... ...	80	... ...	... ...	... ...	... ...
158	,, ...	Silverton ...	... ...	100	... ...	93	... ...	... ...
159	,, ...	,, ...	... ...	100	... ...	.. ...	... ...	... ...
160	,, ...	,, ...	.. ..	100	... ...	... ...	... ...	4,200
161	,, ..	,, ...	.. ..	14	.. ..	... ...	... ...	... ...
162	Waradgery ...	... ...	Mundagal	110	... ...	.. ...	65	20,000
163	,, ...	... ...	,, ...	108	.. ...	... ...	65	20,000
164	,, ...	... ...	,, ...	70	.. ...	... ...	65	40,000
165	,, ...	... ...	Illiliwah	137	... ...	137	60	... ...
166	,, ...	... ...	Ulonga	121	... ...	... ...	86	... ...
167	,, ...	... ...	,, ...	75	.. ...	... ...	65	... ...
168	,, ...	... ...	,, ...	75	... ...	... ...	65	... ...
169	,, ...	... ...	,, ...	110	... ...	.. ...	75	... ...
170	,, ...	... ...	,, ...	87	... ...	... ...	75	... ...
171	,, ...	... ...	,, ...	100	... ...	... ...	80	... ...
172	,, ...	... ...	,, ...	110	... ...	... ...	60	... ...
173	Urana	... ...	T. S. Reserve ...	141	... ...	... ...	111	7,500
174	Denison ...	... ...	,, ...	131	... ..	.. ...	112	7,500
175	Waradgery ...	... ...	,, ...	90	... ...	.. ...	75	7,500
176	Nicholson ...	... ...	,, ...	94	... ...	.. ...	67	8,000
177	Waljeers ...	... ...	,, ...	130	... ...	... ...	110	10,000
178	Mossgiel ...	... ...	,, ...	140	... ...	... ...	90	Unlimited
179	Walgiers ..	... ...	,, ...	130	... ...	.. ...	101	... ...
180	Baroona ...	... ...	Kerribee	200	.. ...	180	... ...	... ...
181	,, ...	... ...	Wanga Wana ...	400	... ...	20	... ...	... ...
182	Killara... ...	... ...	Killara	734	... ...	... ...	... ...	... ...
183	Baradine ...	Baradine Township ..	... ...	122	... ...	... ...	108	... ...
184	White	... ...	T. S. Reserve ...	76	... ...	... ...	30	14,400
185	Pottinger ...	... ...	,, ...	101	... ...	... ...	... ...	... ...

INDEX TO WELLS.

Number of Well	Quality.	Nature of surrounding country.	Strata.	Remarks.
140	Fresh	... ...	Shale, conglomerate, sandstone and coal seams.	Twenty-two feet above sea level.
141	,, ...	... ...	Turf, sandy clay, gravelly clay, loose and compact sand and chalk.	Water struck at 47′, small supply; 116′ larger supply; at 153′ abundant supply, all fresh.
142	,,			
143	,, ...	... ...	Conglomerate sandstone and shale.	Twenty-seven feet above sea level.
144	,, ...	... ...	Sandstone and shale.	Twenty-seven feet above sea level.
145	Salt	... ...	Clay, drift, and drift sand.	Water also struck at 120′; rose to 70′ at the rate of 70 gallons per hour; at 196½′ also struck, rises to 75′, small supply; at 235′ drift sand, rises 100′ in tubes.
146	Fresh	... ...	Sand, clay, and drift ...	At 111′ good stock water rose to 105′, 720 gallons per day.
147				
148	Salt.			
149	,, ...	... ...	Loam 9′, clay 30′, drift 1′ stones, clay, &c. 47′, sandstone 17′.	Well 90′, bore at bottom 14′; water poisonous.
150	Fresh	... ...	Loam, clay, sand and drift.	Good stock water.
151	,, ...	... ...	Ditto, ditto, ditto.	Good stock water.
152	,, ...	... ...	Drift 100′, rock	Shaft 236′; bore 168′.
153	,, ...	... ...	Loam, clay, stone, drift and sandstone.	
154	,, ...	... ...	... ...	Soakage water magnesian.
155	,,			
156	,, ...	... ...	Granite formation ...	Little water, but good.
157	,, ...	... ...	... ...	Will water 2,000 sheep. Fair stock water.
158	,, ...	... ...	Sandy loam and mica slate.	
159	Salt.			
160	Fresh	... ...	... ...	24′ of drives 10′ from bottom. First 600 gallons only fit for drinking
161	,, ...	... ...	... ...	Soakage water. Will water 10,000 sheep.
162	,,			
163	,,			
164	,,			
165	,, ...	... ...	... ...	Good supply; struck small supply at 60′; shaft 90′; bore 47′. Struck large supply at bottom of bore.
166	Salt.			
167	,,			
168	,,			
169	,,			
170	,,			
171	,,			
172	,, ...	... ...	... ...	Water slightly salt.
173	First-class stock.	... ...	... ...	Supply approximate.
174	,,			
175	Brackish.			
176	Salt.			
177	Sweet.			
178	Brackish			
179	First-class stock ...	... ...	... ...	Nearly completed.
180	Fair stock	... ...	... ...	Small supply.
181	Salt	... ...	... ...	Very little water struck at 20′.
182	,,			
183	Fresh.			
184	,,			
185	... ...	... ...	... ...	Not finished. No water.

APPENDIX A.—

Number of Well.	County.	Parish.	Name of Run.	Depth of Well.	Size of Well. ft. ft.	Water struck at feet from surface.	Water stands at feet from surface.	Yield per day in gallons.
186	Pottinger ...	... ...	T. S. Reserve ...	97	... ...	... ...	... ...	... ...
187	Manara ...	... ...	"	126	... ...	... ...	97	... ...
188	" ...	... ...	"	... ...	... ...	... ...	... ...	... ...
189	" ...	... ...	"	... ...	... ...	... ...	... ...	... ...
190	Young	... ...	"	... ...	... ...	... ...	... ...	... ...
191	Yungnulgra ...	... ...	"					
192	" ..	... ...	"					
193	Yantara ...	... ...	"	... ...	... ...	... ...	... ...	... ...
194	Tongowoko ...	... ...	"	... ...	... ...	... ...	... ...	... ...
195	Blaxland ...	... ...	"	167	... ...	... ...	161	Unlimited
196	" ...	... ...	"	136	... ...	... ...	118	10,000
197	Sturt	... ...	"	107	... ...	... ...	56	... ...
198	Nicholson ...	... ...	"	106	... ...	... ...	100	... ...
199	Franklin ...	... ...	"	135	.. ...	... ...	... ...	... ...

INDEX TO WELLS AND BORES—*continued.*

No.	Locality.	District.	Strata.	Remarks.
200	Youngarrina Springs	Albert	... ...	Well 6. ft deep; estimated 800 to 1,000 gallons good water per diem.
201	M'Crae's Well, Baon-gumyarra.	"	... ...	Well 27 ft. deep; 8 or 9 ft. in rock; good supply for stock; too brackish for domestic purposes.
202	Buckley's Well, Yan-tabulla.	"	Bottom on sandy drift	Well 40 ft. deep; water fairly good, but slightly impregnated with soda; daily yield about 150 gallons.
203	Rudder's Well, War-roo Station.	"	... ...	Well 20 ft. deep; water rose 10 ft.; very salt.
204	Tynganie Spring ...	"	... ...	Well 40 ft. deep; excellent water; estimated at about 10,000 gallons per diem.
205	Brindingabba, Moo-lort Block.	"	... ...	Well 94 ft. deep; watered 12,000 sheep through a drought; excellent quality
206	" "	"	... ...	Well 120 deep; water excellent; rose 90 ft. in shaft.
207	Kilfera, Kilfera Block	"	... ...	Well 150 ft. deep; supply 100 gals. per diem; good water
208	Kenmare Block ...	"	... ...	Well 38 ft. deep; bore 197 ft. water salt.
209	"	"	... ...	Well 35 ft. deep; water very salt; very bitter; no supply
210	Kilfera Block...	"	... ...	Well 100 ft. deep; said to contain powerful mineral poison.
211	Polygonum Hut ..	Darling	... ...	On road Booligal to Wilcannia.
212	Barringan Well ...	Albert	... ...	On the "Border Run."
213	Wanganilla	Murrumbidgee	... ...	On South Wanganella Block
214	Pretty Pine	"	... ...	Lower Deniliquin Run.
215	Beefwood Well, on "The Wells" Block	County Yungnulgra, Albert District.		
216	New Well, on Block Byjerk South, Paroo River.	County Landsborough, Albert District.		
217	Well	County Yungnulgra, Albert District.	Coolawundy ...	Well 157 ft. deep; good water
218	Well, Block Germano East.	County Yungnulgra.	Coparto... ...	Well 50 ft. deep; water rises to 20 ft.
219	Junction Well, Germano East.	Albert	... ...	Well 80 ft. deep; good water rises to 50 ft. of surface

INDEX TO WELLS—*continued.*

Number of Well.	Quality.	Nature of surrounding country.	Strata.	Remarks.
186	... ...	... ...	... ...	Not finished. No water.
187	Fresh	... ...	... ...	Not finished.
188	.. ..	... ...	... ...	,,
189	... ...	... ...	... ...	,,
190	... ...	... ...	... ...	,,
191	... ...	... ...	... ...	,,
192	... ...	... ...	... ...	,,
193		... ...	... ...	,,
194				
195	Fresh			
196	,,			
197	,,			
198	,,			
199	,,			

INDEX TO WELLS AND BORES—*continued.*

No.	Locality.	District.	Strata.	Remarks.
220	Danbery Well, Danbery North Block.	,, ...	... ...	Good stock water.
221	Minamithtoo Well, Dilkoorba North Block.	... ...	... ...	300 ft. deep; good water rose to 65 ft. from surface.
222	Parkungi Block ...	Albert	... ...	298 ft. deep; good water rose to 80 ft. from surface.
223	Well	... ...	Poolamacca ...	236 ft. deep; good water.
224	Thackaringa Well ...	Albert	... ...	236 ,, ,,
225	Wanga Well	,, ...	... ...	270 ,, ,,
226	North Ita Well ...	... ...	... ...	240 ,, ,,
227	Melang West Well ...	... ...	... ...	20 ,, ,,
228	Moredevil Station ...	Liverpool Plains	... ...	Artesian fresh water,
229	Myalmundi	Narromine ...	... ...	194 ft. deep; good water.
230	Gap Well (45 miles West of Cobar).	South Warrego	... ...	Salt.
231	Top Well, Newcombe	Muggare Back B Block.	... ...	70 ft. deep; good water.
232	Dungle Well (5 miles north of previous well).	... ...	... ...	70 ft. good for stock; at 75 ft. salt.
233	Walgett Wells ...	Town of Walgett	... ...	40 to 50 ft.; good water in black soil flats.
234	Triangi Well	Narromine ...	... ...	350 ft.; good water; equal to 5,000 to 6,000 gals. per day
235	Chapman's Well ...	,, ...	... ...	350 ft.; water brackish.
236	Randwick Asylum ...	Randwick ...	... ...	Fresh water.
237	Bingagong Well ...	Yanko Creek ...	... ...	120 ft. deep; fresh water rose 52 ft. in shaft.
238	Goree Well	,, ...	... ...	172 ft. deep; good water rose 105 ft.
238A	Packsaddle	Albert	Blue clay on drift.	102 ft. deep; 14,000 gals. in 24 hours, brackish.
239	,, ...	,, ...	... ...	Supply unlimited; 250 ft. dp.
240	Tarella	,, ...	Shaly clay and	250 ft. deep; water obtained by driving 10,000 gallons in twenty-four hours.
241	,, ...	,, ...	Conglomerate cement.	Untested fresh; rose 60 ft. in shaft.
242	Packsaddle	,, ...	... ...	Trial shaft 40 ft., salt, large supply.
243	Cobbham	,, ...	... ...	Supply large; fresh water.
244	Big Plain Well ...	... ...	... ...	Fresh water.
245	Bulgrandra Well ...	... ...	... ...	Fresh water.
246	Old Gunbar Well ...	... ...	... ...	Salt water.
247	Gunbar Road (13 miles from Hay).	... ...	... ...	Fresh water.

INDEX TO WELLS AND BORES—*continued.*

No.	Locality.	District.	Strata.	Remarks.
248	Gunbar Road (13 miles from Hay).	... ...	... ...	Fresh water.
249	75 miles W. of Bourke	... ...	... ...	Artesian water, 950 ft. deep.
250	101½ miles ,,	... ...	... ...	Artesian water, 952 ft. deep.
251	Tibooburra	Whillabrimah ..	Cretaceous ...	Fresh water, good supply, rose from 300 ft. to 70 ft. from surface.
252	Salisbury Downs			
253	Kallara			
254	,,			
255	Mara			
256	Buckimba	... ...	... ...	Incomplete.
257	Dunlop			
258	,,			
259	Kerrabra			
260	Beladic.			

GOVERNMENT BORES (LET).

No. on Map	Name.	Parish.	County.	Road.	Contractor.
14	Coonamble ...	Morambilla ...	Leichhardt	At Coonamble ...	Wm. Watkins
16	Warroo	Waroo ...	Irrara ...	Bourke to Hungerford	Petrolia Co.
17	Engonia	Engonia ...	Culgoa ...	Bourke-Barringun ...	,,
18	Louth (No. 2) ...	... ...	Barrona ...	Louth to Wanaaring	Wm. Pickering
19	77 M.	... ...	Ularara ...	Wanaaring to Milparinka.	,,
20	41 M.	... ...	Yantara ...	,, ,,	,,
21	25 M.	... ...	,, ...	,, ,,	,,
22	10 M.	... ...	Evelyn ...	,, ,,	,,
23	No. 1	... ...	Yantara ...	Cobham to Silverton	Petrolia Co.
24	No. 2	... ...	Mootwingee	,, ,,	,,
25	No. 3	... ...	,,	,, ,,	,,
26	No. 4	... ...	,,	,, ,,	,,
27	No. 5	... ...	Farnell ...	,, ,,	,,
28	174 M.	Makingah ...	Livingstone	Ivanhoe to Menindie	J. H. Stubbs
29	151 M.	Huco	,,	,, ,,	,,
30	130 M.	Tolarno ...	,,	,, ,,	,,
31	111 M.	Linbee ...	Manara ...	,, ,,	,,
32	21 M.	Casey... ...	,, ...	Ivanhoe	,,
33	77 M.	Pulpa... ...	Wentworth	Euston to Pooncarie	,,
34	Anumpo	Buraguy ...	,,	,, ,,	,,
35	38 M.	... ...	Taila ...	,, ,,	,,
36	19 M.	Pringle ...	,, ...	,, ,,	,,
37	33 M.	... ...	,, ...	Box Creek to Anumpo	,,
38	Willandra Well...	Whitminbah	Manara ...	Balranald to Ivanhoe	Petrolia Co.
39	Dolmoreve Well	Cubarla ...	,, ...	,, ,,	,,
40	Holy Box Well ...	Pittenweem...	Mossgiel ...	Booligal to Ivanhoe...	,,
41	Polygonum Hut...	Annan ...	Waljeers ...	,, ,, ...	,,
42	Jumping Sandhill Well.	Yarto... ...	,, ...	,, ,, ...	,,
43	Hay	... ...	Waradgery	Hay to Booligal ...	,,
44	Angledool ...	Mundoo ...	Finch ...	Collarindabri to Angledool.	Chas. Mayes
51	No. 1	Tulloona ...	Stapylton...	Moree to Bogabilla...	,,
52	No. 2	Illingrimindi	,, ...	,, ,, ...	,,

GOVERNMENT BORES (APPROVED BUT NOT LET).

No. on Map	Name.	Parish.	Country.	Road.
50	Wakool	Wombah	Caira	Balranald to Wakool.
49	Yellow Waterholes	Bama	Caddell	Deniliquin to Moama.

PRIVATE BORES, NEW SOUTH WALES.

Station.	Parish.	County.	Depth in feet.	Artesian supply in gallons per diem.	Ref. No. on Map.
Buckanbe	Wygilla	Rankin	725	Nil	1
Marra, No. 1	Balara	Killara	1,482	Nil	2
,, No. 2	...	,,	895	Nil	3
Dunumbral	...	Finch	2,070	300	4
Dunlop, No. 1	Sargorimba	Barrona	620	43	5
,, No. 2	Goolgumbla	Landsbrough	940	576,000	6
,, No. 3	Coonong	,,	860	600,000	7
,, No. 4	,,	,,	750	500,000	8
,, No. 5	Tweandah	,,	1,200	15,000	9
Nocoleche, No. 1	...	Barrona	916	140,000	10
,, No. 2	...	Ularara	1,500	Nil	11
,, No. 3	...	Barrona	1,227	700,000	12
Belalie, No. 1	...	Culgoa	1,693	600,000	13
,, No. 2	...	Irrara	1,160	In progress	14
,, No. 3	...	,,	1,600	,,	40
Yanda, No. 1	...	Cowper	750	Nil	15
,, No. 1	...	,,	1,008	Nil	16
Salisbury Downs, No. 1	...	Yantara	1,365	200	17
,, No. 2	...	,,	1,568	9,000	18
Kerribree, No. 1	...	Barrona	1,073	350,000	20
,, No. 2	Moseta	,,	1,340	1,750,000	21
Wangamana	...	,,	1,600	224,000	22
Pirillie	...	Irrara	613	No information.	23
Kallara, No. 1	Mulyee	Kallara	46	9,000	24
,, No. 2	Undelcarra	,,	140	4,000	25
,, No. 3 (Kingswell bore).	Dinpooker	,,	600	10,000	26
,, No. 4 (Toonburra bore).	Parkin	Fitzgerald	820	1,000	27
,, No. 5 (Moonooloo bore).	Moonooloo	Kallara	900	1,500	25
,, No. 6 (Box bore)	...	,,	1,411	2,000	29
,, No. 7 (Nefeenyah bore).	Tutly	,,	540	500,000	33
,, No. 8 (Paradise bore)	Calpacaira	,,	931	60,000	31
,, No. 10 (Gum Lake bore).	Paroo	,,	676	50,000	32
,, No. 11 (Tonga bore)	Mullawoolka	,,	700	7.000	33
,, No. 12 (Mungundi Lake bore)	...	,,	760	Not stated	34
Yancannia, No. 1	Cockulby	Yanbara	268	In progress	35
,, No. 2	Bingiwilpa	,,	203	480,000	36
Fort Bourke	...	Gunderbooka	1,284	Nil	37
Weilmoringle, No. 1	...	Culgoa	2,005	28,000	38
,, No. 2	...	,,	1,590	1,728,000	39
Pirillie, No. 2	...	...	803	60	43
Momba, No. 1	Charlton	Fitzgerald	1,505	Nil	44
,, No. 2	Parkingi	Yungunlgra	1,261	Nil	45

Particulars not to hand of Corella, Nos. 1 and 2, and Lissington, Nos. 1, 2, and 3, and Brindingabba bores.

LIST OF ARTESIAN WELLS IN NEW SOUTH WALES,

Governtment Wells (complete or in progress.)

No. on Map	Name.	Parish.	County.	Road.	Depth in feet.	Supply per diem in gallons.	Tem-perature.	Ap'rox Height above sea level.	Contractor.
7	121 Mile ...	... ...	Ularara	Milparinka to Wanaaring.	1,304	... ...	In pro	gress	Wm. Pickering
8	106 Mile ...	... ...	,,	,,	1,299	... ...	,,		Wm. Pickering
1	Bourke ...	East Bourke	Cowper	At Bourke	1,467	Nil ...	...	350	Petrolia Co.
12	Moongulla	Bukkulla ...	Finch...	Collarindabri to Angledool.	2,000	... ...	In pro	gress	Chas. Mayes.
13	Nyngan ...	Nyngan ...	Oxley...	At Nyngan	700	... ...	,,		Wm. Watkins.
10	Louth ...	... ...	Lands-bor'gh	Louth-Wanaaring...	810	... ...	,,		Wm. Pickering
5	Youngerina	Youngerina	Irrara ..	Bourke-Hungerford	165	175,000	82°	450	
6	Native Dog	Leila ...	Gunder-booka	Bourke-Barringun	475	2,000,000	92°	...	
15	Yantabulla	Mucruss ...	Irrara ..	Bourke-Hungerford	210	100 000	92°	...	Petrolia Co.
11	Barringun	Barringun	Culgoa	Bourke-Barringun	815	... ...	...	...	
48	Ballimore...	Murrun-gundie.	Lincoln	Near Dubbo ...	561 1/2	24,000	...	...	Put down by the Superintendent of Drills.
4	Cuttaburra	Paroo ...	Irrara ..	Bourke-Wanaaring	965 5/6	22,464	...	450	
2	Goonery ...	Goonery ...	Barrona	,,	89 1/6	24,000	...	...	
9	91 Mile ...	... ...	Ularara	Wanaaring-Milparinka.	72	Nil ...	...	...	
45	Tibooburra No. 1	... ...	Tongo-woko.	At Tibooburra ...	288	Not flow'g	...	...	
46	,, No. 2	... ...	,,	,, ...	53	,,	...	...	
47	Milparinka	... ...	Evelyn	At Milparinka ...	99 3/4	,,	...	...	
3	Tinchelooka	Wanga ...	Barrona	Bourke-Wanaaring	... ...	33,000	...	...	

SEWERAGE OF COUNTRY TOWNS: THE SEPARATE SYSTEM.*

By J. Ashburton Thompson, M.D. *Brux.*, D.P.H.,
Chief Medical Inspector of the Board of Health, N.S. Wales.

[*Read before the Engineering Section of the Royal Society of N.S. Wales, December 16, 1891.*]

I lately had occasion to visit the town of West Maitland. My advice was sought upon a question of abolishing the cess-pits with which the town area is riddled, and of substituting pail-closets for them. That proposed change would be most important to

* *Sewer*: A conduit for carrying off liquid filth—sewage. *Drain*: A conduit for carrying off rain-water, &c.

health, of course. As I have often pointed out, universal experience shows that pollution with excremental wastes of soil, subsoil and the waters held in the latter is a cause of the local prevalence or persistence of the more fatal zymotic diseases. It is also one of the most important causes of lowered vitality, in that indirect way giving opportunity to some acute and fatal diseases which either do not fall, or as yet are not recognised as falling, within the zymotic class. But the matters which would be collected and safely removed by pails are far from comprising the whole of the wastes which require removal in a careful, speedy, way on the same grounds. Much other organic matter capable of putrefaction and of causing injury to health is not excrementitious, and the pails would remove none of it. The pail-system would be but a partial improvement, therefore, and the need of sewerage to remove all wastes together would not really be much diminished by its adoption. Now, in seeking sewerage people are dominated by considerations of cost; and consequent upon the very great expense of all schemes of which they have ever heard, the people of moderate towns generally balance their desire for it by the instant reflection that to them, with their small means, it is unattainable. Something, however, they are able and willing to pay towards improvement; and it is a fair subject for discussion, after ascertaining how much they are willing to pay—say for a pail service in place of cess-pits—whether the sum is not enough to provide them with more than they expect for it; whether it be not enough, in point of fact, to provide the complete water-carriage sewerage, which all agree is the desideratum.

It will be convenient, I think, to take the case I have referred to as a basis of discussion, but I can supply scarcely any other data than the sum of money likely to be available. You know we have here no Local Government Board as they have in England, within which, in one or other sense, the Board of Health should be; so that I cannot furnish even a sketch of those conditions which so largely affect the cost of schemes of sewerage. All that I can say—and all, I believe, that it is absolutely necessary to say for the present purpose—is that the people of the town I have named, which is supplied with water, which has an area of about six square miles of alluvial soil, and a length of roads of about forty miles, are prepared to pay as follows for their new pail-system :—There are 1,600 houses; an annual charge of £1 7s. will be made for each pail, and therefore the total sum they will annually pay will be more than £2,160 (for a good many houses will require more than one pail). Now I have calculated that £2,160 a year is the sum necessary to pay four per cent. upon, and to extinguish in the course of sixty years, a loan of about £48,000. The question I propound is, therefore, this: Could not a system of sewerage be furnished to such a town for so much less than £48,000 that the annual payment of £2,160 would provide for working expenses and maintenance as well as for construction?

I believe that there is no doubt at all about this—that the scheme would fall through at once if a condition were that the combined or the partially-combined system should be adopted. The large size of the conduits necessary under either of these plans would be an insuperable obstacle on the score of cost in relation to the money conditions by which I propose the discussion should be limited. The separate system alone seems to come within that limit, and to that I wish to direct your attention. That system, as you know, is designed to carry off sewage alone. It is designed to exclude every drop of rain-water and every drop of subsoil water; and practically, in the many places where it has been successfully carried out, it does convey besides sewage only the quantity of water necessary for flushing purposes, which is supplied to the sewers from the water-mains at suitable points, in definite quantity, and at known intervals of time. The quantity of liquid that has to be carried on this system is, therefore, practically equal to the quantity of water supplied to the town. That clean water is brought in by small pipes; after it has been fouled, why should it not be carried out again by comparatively small pipes? That question indicates the view that was taken by those who designed the separate system, and who have of late years successfully applied it in so many places. Its advantages are incontestable. In the first place the quantity of sewage to be led is invariable. Having ascertained the water supply to the area to be sewered it is only necessary to calculate the size of the sewers from a datum which is the passage of the whole flow in eight hours, the pipes not to run more than half full; and upon that calculation it will be found that the size of the conduits, including the outfall sewers, is but quite small even for considerable towns. A consequence is that the whole of the conduits can be made of glazed e. w. p., so that they are of the very best form for self-cleansing. Thus that condition is fulfilled which is complementary to ventilation; for although ventilation is always necessary it will be found incapable of keeping sewers sweet unless they are of such a form that their own flow keeps them free from deposit, and passes the sewage on to the outfall before it has time to begin to putrefy. Then again, if it be necessary to pump or raise the sewage from any part of the area, the quantity to be raised and the cost of raising it are kept as low as possible; or if it be intended to treat the sewage at the outfall chemically and by filtration, its small quantity and constant composition are the important features of economical work of that kind; or if it be designed to use the flow for cultivation (as should be designed wherever cultivation is practicable), its constant quantity and constant composition are precisely the conditions which render sewage farming possible on profitable terms. All these advantages turn upon the separation of the sewage from all other flows whatever: thence also the size of the conduits can be closely calculated without the slightest fear that they will ever be unexpectedly overtaxed; thence also all those uncertain and troublesome calculations of the margin which ought to be allowed for possible rainfalls are got rid of, and with them all the expense of the immense sewers of the partially-combined system, which are never required on more than a few days of the year, which on those few days egregiously fail to answer the purpose for which alone they are built, and which all the rest of the time are eating their heads off, and are a source of stinks and difficulties, and of danger to health too. I have no doubt at all that the separate system is the most sensible, the most economical, and all ronnd the best way of sewering towns. That is a sweeping statement; but since it has been abundantly demonstrated in actual practice I do not see how anyone can doubt it, and in a new country where new towns are springing up every day I do not hesitate to express it.

Are there then no difficulties in the way? Is the whole matter quite as simple as I have represented it to be? In new towns it is; in large and long-established cities it is not. But it is not with old cities that I am now concerned, although I shall have to mention them presently. We are considering new towns built without overcrowding; and my suggestion is that for them the separate system is not only the best, but that it is the only one possible when means are small. You know what difficulty I have in mind in making those remarks. It is the alleged difficulty of excluding all surface waters from sewers. Now as to that I wish to say quite clearly that I decline to regard surface waters as sewage. My reason is simple. It is mainly this: However foul rainfall may become after sweeping over a town area, yet it so sweeps but intermittently— such storms do not happen every week, nor even very frequently; and then, foul as the first flow may be, there are but few such storms that do not last long enough for the later flow to be comparatively clean, and such as carries along with it little besides mineral matters. That is my main reason. But, after all, the foulness of such flows is relative to foulness of surface. Under reasonable scavenage the first flow should not be excessively foul, and should be very soon followed by the clean flow which would effectually cleanse the drains by which it should pass. On the other hand, if scavenging is so ill done that this is not the case, then admission of an intermittent foul-surface-flow to sewers will not at all lessen the illness that the foul surface caused when there was no rain to scavenge it; or to take another view, if the general surface is usually foul, then the construction of a few surface channels will not do the smallest appreciable extra harm to the public health, even if they should themselves be always foul—which, however, they need not be. But it is almost childish to discuss the matter in that way. Regular and effectual scavenage is as necessary to preserve the public health as any sewerage; and it should be borne in mind that scavenage and sewerage are complementary to each other—are, in fact, but diferent branches of the same business. I have long had in mind the arguments for admitting surface waters to sewers which are based upon their foulness, and at last I have come to the conclusion that it is monstrous that questions of sewerage should have remained so long complicated in that way—that such a consideration should for so long have been allowed to prevent poor towns from having any sewerage at all, and should for so long have prevented richer towns from having systems of sewerage constructed upon those principles on which alone sewage can be safely carried and profitably utilized.

But a further difficulty attaches to this matter, to which more weight must be allowed when the sewerage of established cities is under consideration. It is the difficulty of "back-yards and back-roofs." When the Western Suburbs sewerage scheme was on the point of authorization a discussion was raised—then, at the last moment, and when nothing but confusion and delay could come of it—on this very question of separate sewerage. It may possibly be within the recollection of some here present that on that occasion I allowed the fullest weight to this difficulty of back-yards, and strenuously upheld the partially combined system for the parts of Sydney then to be sewered, at a meeting of the Engineering Association of New South Wales. I did not choose then to consider what part of the Western Suburbs might fall under the conditions I am going to describe as free of all embarrassment from back yards, and to which the separate system wonld, in my opinion, be applicable. A great part of them in all probability do; but still it was not worth while to raise the point at a time when large neighbourhoods, that had long languished through a period of sanitary neglect and under a scourge of typhoid fever, were on the point of getting from Parliament the relief they urgently required. The conditions under which embarrassment arises from the source named seem to me due to the building of houses and the planning of back yards without any reference to questions of drainage. Building laws should, I think, be amongst the first sanitary laws to be enacted if only for this very reason—that for want of them houses accumulate in situations or are built in ways which prevent their surface waters from draining off naturally by the surface; and then, when the settlement has greatly increased, and when an ill-built and ill-planned city exists, its faults of this kind have to be made good at enormous expense and with great difficulty. That part of the rain-water which falls upon back yards and back roofs must be admitted to sewers, then, *whenever no other way of getting rid of it is available;* and I will even add that I am firmly of opinion that any scheme for complete separation which would involve the laying of a drain as well as a sewer from each premises is unnecessarily expensive and in fact impracticable. But in the smaller towns—comparatively new, and as to clustering of houses comparatively scattered; towns, moreover, which already are not draining either yards or roofs, be they back or front, nor any curtilage, nor their subsoil; towns which, as a matter of fact, are merely adding to their naturally clean subsoil waters the indescribably filthy and dangerous wastes of daily life: in such cases, I say that those filthy wastes should be taken care of, and that the surface waters should still be left to take care of themselves, if by observing that distinction a system of sewerage is brought within the town's means, which is entirely and ludicrously beyond them as long as it is neglected. Let the Sewerage Act for such towns—a Building Act is too much to speak of with expectation—be framed to forbid the building of houses so that back roofs and yards cannot drain to the surface, and let it contain a permissive clause to deal with the houses that have already been so improperly built whenever it shall be convenient to attend to them.

But now opponents of the separate system will be ready to point out that surface waters must be drained off inhabited areas, and if the area be considerable the streams will soon accumulate; and if they are derived from a considerable paved area that they will not run very far before they become inconvenient or dangerous by mere bulk. Well, all that is true as far as it goes; but it hardly touches the point, even in large cities. The removal of sewage is one business, to be done in one way; the removal of surface waters is another business, to be done in another way. If this distinction be lost sight of, expense, inefficiency, and general confusion result; for the kind of provision necessary for sewerage is vastly more expensive than that necessary for drainage. It hardly touches the point, I said; for Colonel Waring, although he does not press the adoption of the separate system in large cities—although he does not unconditionally urge it—has considered this point in detail, and the result of his calculations is that the length of underground drains to carry the surface waters in any place probably need never exceed one-fourth of the length of the sewers necessary in that place to carry the sewage. So, even under condition that stormwaters had to be carried underground as soon as they inconveniently accumulated, it would be cheaper to construct separate channels for them than to enlarge the sewers to carry them. But this point has very little to do with such cases as I am now contemplating. There the inhabitants have already made such provision as is actually necessary to carry off their surface waters; and as to carrying them underground in any case, even in those Western Suburbs to which I alluded a moment ago, already a part of those accumulated streams is not so carried, but in two or three neighbourhoods open channels (such as I have had opportunity of recommending officially on several occasions) are coming into use. And so the matter might be cheaply managed, and quite efficiently, very generally. Surface waters are not sewage, and therefore—I say, therefore—should not be admitted to sewers.

These surface waters become subsoil waters, except in case of storms. They should, we know, be drained off as quickly and as thoroughly as possible for reasons attaching to health; and it would be foolish not to take advantage of the opportunity which sewerage-construction affords to arrange for their thorough drainage. Nevertheless, this also is a matter quite separate from sewerage. That point is now pretty generally recognized even by engineers of the old English school; and, as a rule, they admit that all sewers should be water-tight. As for us, I hope and believe that we here are unanimous in demanding that they shall be watertight. This indeed is as important to the success of the engineer's calculations as it is to health, and that is some security that watertightness will be attempted. Subsoil waters, then, belong to the category of rainwater; they are not sewage. Often the cuts will do much to relieve the subsoil without any special work being put in to ease it. But it is possible, and when necessary it is proper, to lay a line of drain tiles in the same trench with the sewer, which drain tiles may turn aside from the sewer line at any convenient point from which an outfall to the natural surface can be got, or to an underground drain in case it has been necessary to construct one. That, I think, is enough to say of subsoil waters. A scheme of sewerage that does not provide for carrying them off (and, when necessary, for lowering the ground water too) is imperfect from the sanitary point of view. It does not cost much extra to drain them; they are not sewage, and therefore should not be admitted to the sewers.

I do not think I need say more upon the principles of the separate system and of the objections raised against it. Of the latter I have endeavoured to express my opinion clearly and forcibly so that discussion may be the easier. I do not think there is much in them at the most; they are for the most part theoretical difficulties which disappear as soon as the experimental test is applied to them; and they certainly do not weigh one grain against the system when the question is one of securing sewerage at a moderate cost for a country town in Australia.

Let me, before I sit down, recall to you the characteristics of the separate system as regards construction. Moderate size of the conduits is the first point. House drains of four inches deliver into laterals (or branch sewers) of six inches, and these are continued until the accumulated flow causes them to run half full. Then, and not until then, they are enlarged and are continued as before until the accumulated flow causes them to run half full; and so forth, until the outfall sewer of the system or of the section is reached. The calculations are very close. They can be made so with perfect safety as regards chance of surcharge because the flow is known and is constant, and because no down-comers deliver a mixture of air and water into them during rain. The second point, and a fundamental one too, is the placing of automatic flush-tanks at the head of each sewer-line, by means of which a live or scouring stream of pure water is secured once or twice or three times in the day; and you will observe that the requirement is for automatic tanks, and that hand-flushing is quite a different thing. The third point is the use of glazed e. w. p. throughout the system, and a fourth is the making of the joints both absolutely smooth inside and absolutely watertight. Then a fifth point is the possibility of getting rid of a proportion of expensive manholes, for which in many places a simple arrangement of glazed piping can be substituted; and so also are lamp holes got rid of too—for on the one hand the pleasure of being able to see through a pipe sewer is but small, I should imagine; while on the other the right-line plan of laying obliges corners to be turned upon curves of very short radius. Then a sixth point is the laying in the same trench with the sewer of a line of drain tiles wherever these may be necessary, the discharge from them being to the surface. Lastly, the seventh point is abolition of the disconnector trap; but I do not say more about that because it is debateable whether anything is gained or whether something is not lost by getting rid of it, and that question need not be entered into now. Those are the essential or characteristic points; but as e. w. p. can be economically used, I believe, up to a diameter of eighteen inches, I add that so great a diameter could seldom be necessary in such towns as I now contemplate. I will just mention a practical experiment which will serve to illustrate the small size of outfall sewer usually necessary under this system. It was in England that the use of pipe sewers, and their superiority, was first the subject of scientific enquiry and was first demonstrated and advocated in consequence; and a report by the General Board of Health dated London, 1842, has the following example among many others: The sewage from 1,200 houses was actually carried in a combined sewer which had a sectional area of fifteen square feet. For the sake of experiment a fifteen inch glazed e. w. p. was laid on the invert at a fall of one in one hundred and fifty-three, and the sewage was conducted through it. It was then found that the average flow per house was fifty-one gallons per day, and therefore that the whole flow would have passed through a five inch pipe with the fall mentioned running full bore. So that it is clear, both from this and from the presently existing results of actual practice, that an outfall of more than fifteen inches diameter could seldom be required; and back of it there would be only some comparatively short lengths of eight inch sub-main. The greater part of the system would consist of six inch laterals and four inch house connections. Now I will just repeat the question which I asked at first: "Is it not possible to furnish a country town of 1,600 houses which is already copiously supplied with water with a complete system of sewerage —to provide for construction, maintenance, and working-expenses —out of an annual payment of £2,160, which represents the annual sum required for interest and repayment within sixty years of a loan of about £48,000?"

* * * * * * *

Addendum.—It will be noticed that the above arguments are nearly those adduced in favour of what is now sometimes called the "Shone *system.*" I believe its evolution was as follows: Mr. Shone invented that very useful and successful apparatus, the ejector. It can be used and will succeed, however, only where the amount of work to be done is, within narrow limits, constant —as applied to sewerage, therefore, only when the pumping area is sewered strictly upon, or very nearly upon, the separate system. But the immense advantages of the separate systen soon impressed themselves—as they must impress themselves upon every engineer who practically adopts it on however small a scale or for whatsoever special reason: Shone's "system" was then advocated for the sewerage, not of small areas, but of town areas in general; and it was differentiated from Waring's claims and works by the suggestion that Waring's small conduits required a much greater fall to keep them clear than could generally be got uniformly over any area in the usual way, and that artificial falls must therefore be got by leading the sewage to district-centres, whence it must be pumped (or ejected) to the main outfall sewer —which latter as being larger and carrying a greater volume might have an ordinary fall. This, no doubt, entitles ejector-sewerage to a distinctive title; but it is to be observed that the alleged necessity on which it is based has never been felt in the fifty or sixty cities of America which are now sewered on the separate system.

VENTILATION OF SEWERS AND DRAINS.

By John M. Smail, M. Inst. C.E.

[With Plate IV.]

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

The ventilation of sewers and drains has in modern times been admitted to be a most important one in connection with preservation of public health. It has exercised the minds, and has been a fruitful field of speculation among scientists and others for nearly forty years.

It would be difficult to find another subject upon which so many diverse opinions have been advanced or systems patented. A review of the various systems adopted or tried in the earlier years of what might be termed modern sanitation, would indicate that very little advance had been made in sewer ventilation, beyond that known and practised by the ancients Romans. The remains of the colossal works carried out under the rule of various Roman Emperors, indicate at that remote period, that they were fully alive to the necessity of ventilation for all conduits underground as well as for the sanitary portions of the buildings. Shafts were sunk one hundred and twenty feet apart for ventilation, and to admit of workmen entering to effect repairs—some of these shafts, history informs us, remain to the present day a fitting monument to the builders. Coming to modern times, we find that sewer ventilation did not assume a practical form until the inception of the Main Drainage Works of London by the Metropolitan Board of Works, the system adopted by the engineers differed very little from that carried out by the Romans. The general principles laid down being that there should be manholes (shafts) at certain intervals opening direct into the roadways—these shafts, and in some cases lampholes were fitted with iron gratings. It will be seen by these measures, that the sewer was placed in direct communication with the external air. For a considerable time this was considered the orthodox method of dealing with the question, and for years afterwards was adopted by every town in England and elsewhere where sewerage works were carried out.

No other city in the world has expended more money in dealing or experimenting with the sewage question than London, and it is to England we must look as the cradle of sanitary science.

Notwithstanding the scientific principles adopted at the inception of the primary works, complaints arose from residents within the immediate vicinity of the open ventilators, and the minds of the various authorities were exercised as to the best means to overcome the difficulty. The sewer was voted as the root of the evil. Having a base to start from: viz., the sewer, numerous projects were advanced for overcoming the difficulty.

It is not my intention to discuss these in detail, except such as appear to have been effective in overcoming the evil, these however will be considered further on.

Atmosphere of Sewers.—A diversity of opinion exists among scientists as to the chemical composition of the atmosphere of sewers. Under certain adverse conditions it has been termed "sewer gas," and under other conditions "sewer air." The former has proved injurious, if not fatal, to life, the latter is the air of the sewer, and under favourable conditions may not greatly differ in its chemical composition from the air we breathe. Sewer gases are evolved from decomposing sewage—decomposition does not set up so rapidly where an abundant supply of water, a rapid flow, and free ventilation are available.

The following table gives the result of analyses of "sewer air" from sewers under different conditions:—

Atmosphere.	Authority.	Oxygen	Nitrogen	Carbonic Acid	Sulp. Hyd.	Marsh Gas	Ammonia
				Per	Cent.		
Bad sewage, badly decomposed air excluded ...	Letherby	...	10·187	15·89	·08	73·83	...
Choked sewer of Paris	G. de Claubry	13·79	81·21	2·01	2·99	...	...
Ordinary sewer air, over sixty analyses ...	Bucks Hygiene	19·95	79·69	0·36	traces	traces	traces
In best of these...	do.	20·79	...	0·13	traces	traces	traces
London sewers ...	Letherby	19·50	79·96	0·53	·0016		

The analyses clearly shew the necessity of ventilation. In the case of the first test, it should be noted that it was the result of a laboratory experiment and after decomposition had purposely been allowed to take place—the sewage being allowed to stand for nine weeks.

The second analysis shews the composition of gases evolved from an imperfect sewerage which had become what is termed a "sewer of deposit," *i.e.*, that by being either tide-locked or of such fall that the available velocity is insufficient to carry off the sewage, the solid matter being deposited.

The large percentage of nitrogen indicates that the "oxygen of the atmosphere had been used up in entering into combination with certain organic compounds which are present, leaving the nitrogen free. Nitrogen has not been shown to be a poisonous gas, although it will not support life."

The third analysis indicates that by improved construction and grades stagnation is not allowed to exist, the amount of oxygen being 19·95%, the composition of pure air being 20·96, the amount of nitrogen 79·69 the composition of pure air being 79·00; the amount of carbonic acid being 0·36, the composition of pure air ·04.

These results were from analyses of sewer air of London Sewers prior to any measures for purification being adopted. The fourth analysis was made from sewer air. Sewers fitted with charcoal for deodorizing the escaping gases—the results cannot be considered favourable as compared with the previous ones considering the media used for purification.

Enteric fever.—Diversity of opinion exists as to whether outbreaks of enteric fever are attributable to inhaling the air given off from the sewers, when speaking of sewer air in this case what is meant is the atmosphere of sewers constructed on modern principles. Dr. Parkes in his work on "Hygiene," states that investigations by Koch, Hesse, Frankland Haldave and others show that contrary to what might have been expected, sewer air is, under ordinary conditions, remarkably free from microbes which are capable of cultivation in solid nutrient media at ordinary temperatures, and of which alone have we any definite knowledge. Several observers have shown that sewer air may even possess a relatively less number of microbes, capable of forming colonies in cultivation, than the atmospheric air outside. The explanation appears to be that, the sides of the sewers are more or less wet, due to the fluctuation of flow, or moist from the sweating of the brick or concrete work, and that the microbes in the sewer air adhere to the damp surfaces and are thus prevented from floating about. "This reasoning is strengthened by what is already known of the presence of microbes in the atmospheric air generally, for in dry dusty weather they are found in far larger numbers than in damp weather or after rainfall.

In well made sewers the sewage is borne away from the houses in a fresh and undecomposed condition, but in old defective sewers and even in moderately good ones, when the temperature is high and the quantity of water small, putrifactive bacteria undergo enormous multiplication, fermentive changes are set up in the sewage and gases are formed which bubble up and break upon the surface of the liquid. There can be no doubt that given stagnation and putrefaction of sewage, sewer air will be found to be loaded with micro organisms of different kinds."

It is stated by authorities that the injurious effects of sewer air may be attributed to the organic matters with which it is so often laden. This is especially the case where people are exposed to escapes of sewer air into houses for a long period, the inhaling of which may not at first lead to serious results, but long continued inhalation will tend to lower the system to such an extent as to offer slight resistence to attacks of acute disease.

The experience gained from the men engaged in cleansing the city sewers show that it is only when they are employed in the old, defective, and unventilated sections they suffer, in the newer and better constructed portions no inconvenience is experienced.

Ventilation.—The necessity for ventilation of sewers and drains is demonstrated by a study of the natural forces at work within them. Before discussing the remedies for the collection of noxious gases in sewers, it will be as well to consider for a time the different forces which are brought into action in the sewers by various causes. We must divest ourselves of the notion that air or gas of any kind can be as readily pushed aside and got rid of inside of a sewer, as it can be above ground. So long as the air in our sewers is allowed free communication with the outer air at frequent intervals of space, no difference can exist between the tension of the air within and without, but the moment we obstruct such communication, various causes begin to act either separately or combined as the case may be.

Heat is one of the most powerful forces at work within our sewers, and is capable of developing a force which would be a source of danger in any unventilated system of sewer or house drains. During the day there are constant changes of temperature going on in the sewer, causing expansion and contraction of the air. Under certain conditions the temperature of a sewer has been raised from 60° to 110° by hot water being passed in from factories. The force generated by this increase of temperature can be calculated by formulæ as the pressure is inversely as the space occupied. Let V = original volume of the air of the sewer at its normal temperature. V^1 = volume of air after its increase of temperature. P the original pressure = 14·6 ℔s. per square inch, or a column of water thirty-four feet high. P^1 the pressure after the increase of temperature, we have as $V : V^1 :: P :: P^1$ in this case the volume of air at 60° is 1057·1 cubic inch, and at 110° 1159·2 cubic inches, the normal pressure being equal to 34 feet head, we have 1059·1 : 1159·2 : : 34 ft. : 37·28 a difference of head of 3·28 feet of water, equal to 1·41 ℔. on the square inch, a force no trap at present in use could withstand. It is plain that if no outlet exists for the escape of the air under pressure the seal of the nearest water traps would be broken and the house placed in direct communication with the sewer, hence the necessity for ample ventilation.

Influx of water into sewers.—The influx of water into the sewers is also a source of danger in an unventilated system where the sewers are on the combined system, in this case the area occupied by the flow of daily sewage even at its maximum is small in comparison with the whole area. A sewer running half full is suddenly charged with water up to the three-quarter flow line, it is evident that the air which occupied the upper half of sewer will be compressed into half the space it originally occupied. According to the law of Boyle and Mariotte, the pressure is inversely as the space occupied; considerable force will therefore be brought upon the traps in the vicinity of the sewer, which would unless openings are provided, be forced; this danger is however reduced by the porosity of the materials with which the sewers are constructed; the openings in the material are so minute that currents of air will pass through which may escape attention. A subsidence of the water to its normal flow will cause a reverse action. If the sewers are ventilated direct to the crown of the road the sewer air would be forced out into the street and become so diluted as not to be dangerous although unpleasant.

The fluctuation of the flow of daily sewage has the effect of compressing or dilating the air, as well as leaving the sides between maximum and minimum flow lines wet with sewage, this leads to the formation of vapour and gases. This fluctuation has been used as an agent in ventilating sewers into the roadway, it was contended that the alternate expelling and drawing in of air would set up sufficient current to provide for diluting and oxydizing the air in sewer. In other words, sufficient openings were to be made to allow the sewers to breathe.

The difference between the temperature of the sewers and the atmosphere at certain periods of the year is a powerful agent of natural ventilation. The air being at certain seasons expelled from the highest shafts and cold air drawn in at the lower ones, in other seasons the reverse action takes place. This upcast and and downcast action is due to the difference in weight of the air columns; there are some months in the year when the external and internal temperatures approach equality, at such times there is no movement in the air—except currents are set up by the air in the sewer being compressed by influx of water.

It has been found that the earth temperature controls the movement of air to some extent. Observations extending over a period of eighteen months have been made by an officer of the

Board of Water Supply and Sewerage, in connection with this matter. Observations were made at two points on a line of sewer, viz., one at a shaft ten feet deep and another fifty feet deep. The observations were taken a depth of ten and forty feet respectively. It was found during the months of June, July, August, September and October the current set steadily from the low to the higher shaft, the hourly discharge at the latter being 14,000 cubic feet—the air being drawn in at two low points. This action was reversed during the warm weather, the low points discharging, and the deep shaft acting as an induct. The diagram attached shews the results of the temperature of sewers at ten and forty feet deep, mean external temperature and mean humidity of open air.

Barometic changes also affect the amount of foul air in the sewers. The diminution in barometic pressure leads to the escape of gases which are stored in the interstices of the sewage and favour decomposition. An increase of barometric pressure enables sewer air to carry a large amount of the vapour of water and the sewage to retain a larger volume of the offensive gases due to decomposition or absorption, without parting with them.

The next force which affects the air of sewers is wind. The observations made by officers of the Sewerage Department shew that the action of the wind had great effect upon the currents in the sewers. On quick grades the current was in direction of the flow, if the force of the wind was small; on easier grades the current was reversed, so that in a line of sewer might be found currents setting in different directions according to circumstances. Observations have been made in Wimbledon, England, by Mr. Santo Crimp, A.M.I.C.E., with like results, the conclusion arrived at by that gentleman after a series of tests, being that the wind was the principal agent in controlling the air currents in a sewer—these observations were made, as in the case of the Sewerage Department, on sewers properly laid and ventilated by manholes.

Old system of sewers.—The old system of Sewerage of this City was initiated by the old City Commissioners in 1853. The sewers were constructed on the then known principles as regards form, materials, &c. ; shafts were sunk and built up at intervals, these were not carried to the surface and were therefore, as a means of ventilation, useless. An attempt was made to cut off the house drain from the main sewer by means of cast iron flap traps—these became rusted at the joints and either prevented the sewage passing from the houses, or permitted the gas to pass freely through the house drain into the houses.

The monument in Hyde Park was erected with the view of ventilating a section of the system, viz., Pitt, Castlereagh, and Elizabeth Streets sewers, these were supposed to be connected with the sewer in Bathurst Street for the purposes of circulation. It would appear that this shaft was erected as an experiment, because although other sections of the drainage works were carried out, no other shafts were erected. The shaft has been lately under observation as to the limit of effect as regards the sewers connected with it. These results are so far unsatisfactory when relying on natural forces only for creating a draught. The shaft would at certain times in the year act as an exhaust, while in others as an induct.

The only means by which the sewers appeared to be ventilated was by means of gully shafts and rainwater pipes from buildings. The gully shafts after a while became a nuisance on account of the sewer air being expelled by the forces before referred to. The gullies were then trapped, consequently greater pressure was thrown on the house drains and rainwater pipes. The outlet of the main outfalls being tide locked twice during the twenty-four hours, and a rise of temperature taking place, the result of the direct connection with houses can be imagined. The sewer gas cannot be bottled up, it will force its way somewhere. Where? Into the street, no, the shafts were closed down; through the gullies, no, they were trapped; into the dwellings, yes; because the line of least resistance in this case was the house drain. Compare the resistance of old fittings such as bell traps, D traps with the pressure brought to bear on them by a rise of temperature or surcharging of the sewer. Then again, the hopper head of the rainwater pipe finished in close proximity to an attic or other window. The window is left open on warm nights to enable the occupant to sleep in comfort, the gas escaping from the hopper head finds its way into the room and vitiates the air, this is inhaled by the sleeper, until in time if still exposed to such insanitary surroundings, his system becomes completely sapped. This is the condition of numerous dwellings in Sydney at the present day; the number however is being gradually reduced as the public are becoming alive to the fact that sewer gas is not a thing that one would like to be on intimate terms with.

In later years work has been carried out by the City Corporation on more modern principles, the house drain being cut off from the sewer and provision made for ventilation, this however the Council had no power to enforce and was only carried out in comparatively few instances.

The work of the shaft in Hyde Park from a trial extending over six hundred and forty-eight hours was 40·853 cubic feet per hour, this is due to natural ventilation only. Observations are being taken along the different sewers to determine the limit of efficiency.

New system of sewers.—The new system of sewers carried out by the Government and transferred to the Board has intercepted the older sewers at certain points, and the gases formed in them are carried by the sewage into the new system, thus complicating the work of ventilation. These however will gradually be superseded by smaller and deeper sewers which will admit of ventilation and aeration being carried out with facility. Shortly after completion of one of the main branches of the Bondi outfall some of the manholes were tested with test papers of a 10% solution of acetate of lead, and on being forwarded to the Government Analyst (Mr. Hamlet, F.I.C., F.C.S.) he reported in one case that the test paper indicated an amount of hydrogen sulphide decidedly dangerous to health ; this gentleman also fixed a comparative scale by which it could be ascertained from test papers whether the sewer air was dangerous to health or otherwise.

The main sewers and existing city system were transferred to the Board by Act of Parliament on 18th December, 1882. The Board proceeded without delay to deal with the ventilating of the sewers under their control. It was found here, as in other countries, that ventilation by open grids in the centre of the roadway was a failure, and considering the conditions of some of the suburbs, the streets being in some cases not twenty feet wide, the existence of an open grating in direct communication with the sewer could not be otherwise than dangerous to the health of the residents. Numerous complaints were received, and on investigation it was found that in almost every case the nuisance arose from a man or lamp hole. The first section operated upon was the Borough of Darlington and portion of the Borough of Redfern the population being about 10,000.

A few shafts were erected at first with the view of utilizing the man holes as inducts or air feeds, but the result was extremely unsatisfactory. It was found that owing to the spaces between the bars of grids becoming choked with horse manure, detritus, &c., the quantity of air passed through was extremely small. It appeared clear to me that if the gratings were to be used as adjuncts to ventilation it would be at a high cost for maintenance. In lieu of the gratings, specially made and tested induct cowls were attached to shafts at certain points, and a large volume of pure air was forced into the sewers. This system of aërating the sewers was tried in England with success. A description by Mr. Strachan, A.M.I.C.E., of Chelsea, appeared in the Minutes of Proceedings of the Institute of Civil Engineers; it was a small installation, but there does not appear any record whether the system has been generally adopted. The method is a combination of the "plenum" and "vacuum" systems, the advantages being purer air than that which would be obtained from surface feeds and a considerable saving in maintenance.

Where the Borough sewers join the City sewers the former are locked off by specially constructed gas check chambers, and air is thrown in or exhausted in the reverse side of the valve as required.

On the first installation by the aid of thirteen induct and thirty-five exhaust shafts, on the average about 39,000 cubic feet of air per hour was thrown in and exhausted from the sewers. The results from the shafts being so satisfactory, the system has been extended to almost every borough which has a foul water system.

The form of cowls, both induct and exhaust, has been very much improved since the inception of the works. Exhaustive tests were made at the cowl testing station at Crown Street Reservoir, the competition being very keen between the various makers. The different designs are shown by the models exhibited, representing the best forms. The system adopted in testing was at first by anemometers, but the results were so conflicting, that the efficiency of the cowl was afterwards tested by the work done in exhausting or forcing in air in proportion to the wind power. This was accomplished by sealing the bottom of the test tube and connecting a Thorp's Automatic Pressure Register with it. The instrument was started and allowed to run twenty-four hours, the clock was surrounded by a diagram upon which was registered by a pen the amount of pressure or exhaust which the cowl exerted on the instrument in inches of water. The diagrams were then forwarded to the Government Astronomer, Mr. H. C. Russell, F.R.S., who kindly supplied the wind pressures for each hour during the day. A further diagram was made from the register, and the pressures due to the cowl and those due to the wind were plotted on either side of a datum line, this represented two figures with twenty-four ordinates. As the area of the figure is clearly the base or datum line multiplied by the mean ordinate or mean pressure, it follows that the area of the figure representing the work of the cowl is proportional to the pressure exerted by the wind. The wind power was taken as the base, and the efficiency of the cowl was determined by the ratio which the work done by the latter bore to the former.

That the shafts are doing more work with the cowls than they would otherwise do, is shewn by the records of the tests made during the year. It was found that with a third class cowl on a draught of 250 feet the air exhausted was 3,387 cubic feet per hour.

Shafts without a cowl registered 1,883 cubic feet per hour, that is a difference of 1,504 cubic feet in favour of the cowl or 79%. In another case the work with a cowl exceeded the open pipe by 3,688 cubic feet per hour, or an increase of 76%. These cowls were by different makers, and each was tried simultaneously with the open pipe.

The work of the first and second class cowls considerably exceed the foregoing tests. As inspection boxes were not fixed on the first installation, a length of sewer was selected to test the aerating effect of the shafts. The distance between the induct and exhaust shaft was 990 feet. Anemometers were placed in each shaft so that the whole of the air passing into or out of the sewer would be registered.

No. 1 Return from 1st March to 28th June shewed that the air was changed on an average 2·35 times in the hour or every 25·5 minutes. Average wind velocity nine miles per hour. On one occasion the air was not changed more than once in two hours, and the test papers shewed that hydrogen sulphide was present sufficient to discolour the paper. No. 2 Return from 10th July to 2nd October 1890 the air was changed on an average 2·39 times in the hour or every twenty-five minutes, average wind velocity 8·93 miles per hour.

In a test made at an intermediate point, viz. 200 feet from the induct shaft, the anemometers shewed that at this point the aerating effect was equal to 21% of the wind force, whereas in the long length it did not exceed 13·8%, showing a loss of 7·2% due to friction and other causes. The length of the sewer was jointed with cement, but there were several houses connected without a boundary trap which would no doubt interfere with the air currents, all yard sinks were properly trapped.

The results of the trial referred to by Mr. Strachan at Chelsea are summarized as follows :—

Number of Experiments—8

Duration of Experiments in days—44

Average velocity of wind in miles per hour—12·0

Volume of air entering sewer in cubic feet per minute—140

Number of minutes taken to fill and empty sewer with air—31·5

Number of times per day sewer was filled with air—46·6

The result of tests made at shafts in Sydney and suburbs during the year is shewn by the accompanying tables, and they may be summarized as follows:—

Area of districts in which sewers are ventilated—1667 acres.

Total number of shafts erected—Induct 281, Exhust 630

Number of miles pipe sewers ventilated varying in size from 6″ to 24″ in diameter—69·16

Number of miles brick sewers ventilated of various sizes—4·67

The average work done by the induct shafts conducting air into the sewers varies from 1,397 cubic feet to 4,554 cubic feet per hour. The foregoing results have been obtained from anemometer readings placed in the inspection boxes. The time occupied in taking each observation varied from eight to twenty minutes according to circumstances. The average wind velocity during the period occupied in testing was 8·43 miles per hour. The average work done shews that 1,579,656 cubic feet or 56·41 tons of sewer air is drawn from the sewers operated upon per hour.

The quantity of air passed into the sewers, according to tests, is 857,400 cubic feet or 30·62 tons per hour. The oxydizing effect of this supply of pure air is apparent when it is considered that twenty-one parts in every hundred is composed of oxygen.

Factory shafts.—Factory shafts have been utilized for sewer ventilation with the cordial assent of the owners. The following summary will convey an idea of the aid rendered by the shafts:

	Cubic feet per hour.	Cubic feet per day.
1. Tooth's Brewery, 9″ connection ..	40,286	966,864
2. Cameron's Tobacco Factory, 6″ connection utilizing exhaust steam ...	5,369	128,856

	Cubic feet per hour.	Cubic feet per day.
3. Cornwall's Brewery, 6″ connection utilizing exhaust steam	4,522	108,528
4. New York and Brooklyn Tobacco Factory, 6″ connection	7,030	168,720
5. Shaft—Old Engine House, Crown Street Reservoir	6,857	164,568
6. Shaft—New Engine House Crown Street Pumping Station, 6″ connection	4,444	106,656
7. Shaft Hyde Park	51,424	1,234,176
	119,932	2,878,368

Shafts 1, 2, 5, 6 and 7 are connected with the old system, Nos. 3 and 4 with the new. The ventilating shafts are made of the best black iron riveted longitudinally with quarter inch rivets, with one and a half inch pitch, the gauge being for bottom lengths 16 B.W. gauge and for top lengths 20 B.W.G. The sheets are first passed through a steam power squaring and cutting machine by which all the sides are cut true to pattern, they are next passed through a multiple punching machine and punched on both sides perfectly true, they are then passed through a roller and rolled into shape, riveted, and all seams laid perfectly close. The faucets are now formed and ground out to a standard size, the pipes are afterwards placed in pickling tanks to prepare them for the galvanizing process, (these tanks contain sulphuric acid sp. gr. 1·845) when they have been sufficiently operated upon they are cleaned and passed through other tanks containing hydrochloric acid (sp. gr. 1·284) then heated very carefully in an oven, after which they are immersed in a bath of pure zinc—the surface of this bath is covered all over with a thick coating of hydrochlorate of ammonia. This ensures a complete and uniform covering. The pipes are afterwards washed and dried and having partially lost their cylindrical form they are put through various other machines until they regain their proper shape, no hammering is permitted, as it would disfigure or break the joints. The tubes are finished with an approved cowl and attached to sides or gable of buildings with neat straps &c. The tubes are coated inside with asphaltum paint and painted externally with two coats of picked colours. The first installation has been in some cases nearly two years in operation and although in very exposed situations, have withstood very heavy gales of wind which have occurred. Some of the gales were severe, the registered velocity in one case being fifty miles and in another sixty-four miles per hour, this would exert a pressure against the shaft which is unsupported above the wall of the house, of 12·5lbs. and 18lbs. per square foot.

Water sprays—Water sprays in manholes for inducing currents of air into the sewers have been tried with very successful results. The water is passed down the shaft by a three-quarter inch pipe fitted with a patent nozzle, and is spread in the form of a cone. A meter is fixed on the main to register the consumption of water. The results obtained were as follows:

Average quantity of water used per hour—213 gallons
Air passed into the sewer per hour—62,647 cubic feet
Quantity of water used per diem—5112 gallons
Quantity of air passed into the sewer per diem—1,503,528 c. ft.
The quantity of air passed into the sewer per cubic foot of water—1842 cubic feet
The cost for water per 1,000,000 cubic feet of air—3/4.

The quantity of air per cubic foot of water has been raised to 2,250 cubic feet by improving the nozzle. The sewer was tested with the spray working and stopped, the report of the inspector shewed that when the spray was working the air in the sewer was cool and free from odour, and the air currents passing up stream from the spray shaft varied from 12,000 to 6,600 lineal feet per hour, these figures would represent 115,424 and 113,190 cubic feet per hour respectively. I examined a portion of this sewer after the spray had been working some time and found that what had formerly been a very wet length was drying up considerably, the filmy coating which is generally found in large sewers where the flow fluctuates, had become dry and was scaling off like a skin. That this is due to the aerating effect of the air drawn into the sewer is beyond a doubt.

The men who have to work in the sewers quite appreciate the benefits of the supply of air, as prior to the spray being fixed, working in the sewer was not only uncomfortable, but owing to the stagnation of the air it was dangerous to keep them too long in it. The air currents were tested with the spray not working, and the results show that, although tests were made every two chains and at every manhole, there was not sufficient air movement to start the instrument; what little movement there was, was in the direction of the flow—this simply meant stagnation. When the spray was turned on, the currents registered as before stated.

The Board of Water Supply and Sewerage have lately brought this system into use on a larger scale. The water from Busby's Bore was turned into the Bondi outfall for flushing purposes and the officer in charge of the ventilating work conceived the idea of utilizing this water for ventilating purposes as well as flushing. This was done by discharging the water at a higher level through a six inch pipe with a cone at the bottom; the cone is attached to a spindle which admits of the annular aperture being adjusted to suit the pressure.

The arrangement is simple and the work done is extremely satisfactory, far exceeding my expectations. The quantity of air drawn into the sewer by the falling water was 183,458 cubic feet per hour, or 4,402,992 cubic feet per day representing 36·74 tons of oxygen passed into the sewer. The effect of this abundant supply of air is felt for nearly a mile eastwards and for some distance westwards. The power here practically costs nothing. The Board has under experiment a scheme for extracting the air from the sewers by water power, the arrangements are only of a tentative character, but the results so far shew that the work can be done efficiently and economically. I should have stated that the measured velocities of the air currents when the spray was working varied from 9,600 lineal feet per hour to

720 feet per hour; the quantities being computed at 228,186 cubic feet per hour to 22,477 cubic feet per hour, the size of the sewer at water spray being 6′ 10″ × 5′ 10″ increasing by increments to 7′ 4″ × 6′ 4″ at limit of effect. The Board have under trial a system for ventilating the sewers by means of shafts heated by gas. The system is the invention of one of the Chief Sanitary Inspectors and may be briefly described as follows:

A shaft with a base in which is fixed the apparatus for setting up the draught. Within the chamber which is the base, is placed a perforated shell, spherical in form, the shell may be made of fire clay or other material which will resist the action of intense heat its upper part being formed for a lid; a grating or perforated false bottom covers the bottom of the interior of the shell forming a chamber below the false bottom to receive a gas burner or burners. The form of burner used is an "atmospheric blow through burner," the air being supplied either from without or within the shaft; the space within the shell between the false bottom and lid is loosely packed with lump asbestos. The chamber is provided with an opening sufficiently large to introduce or remove shell. This opening is also used to apply the light to the burner. The opening is closed by fire brick or other fire proof material. In order to prevent radiation the chamber and shaft are inclosed in three inches of fire proof non-conducting material. The working is as follows: assuming that all the parts are in position, the gas is lighted through the opening which is then closed, the intense heat from the burner quickly brings the asbestos contained within the shell to an incandescent state, thereby causing a powerful up draught to ensue, and thus drawing the foul gases from the sewer. As the gases pass through and around the shell, which by this time is a ball of fire, they become disintegrated and rendered innocuous by the intense heat, and all disease germs therein consumed, the products of combustion passing up through the shaft into the atmosphere in a harmless condition. The inventor claims to be able to extract 500,000 cubic feet of air from the sewers in twenty-four hours at a cost of one shilling and eightpence. The air of one mile of nine inch sewer and two hundred and fifty house drains would be changed every twenty minutes.

The foregoing is a description of the shaft and what the inventor claims to do with it. The trial will be an important one in connection with sewer ventilation ; the results will no doubt be made public on completion.

The object to be aimed at in dealing with the question of sewer ventilation is motion, not only for the sewage but for the air, there should not be any resting place for either, and in the works carried out in connection with the sewerage system of the City and Suburbs this object is kept in view, foul gases should not be permitted to form, if the true principles of ventilation are observed, this would not take place. The introduction of currents of fresh air oxydizes the sewer air, prevents the fungoid growth on walls of sewers and tends to reduce the humidity of the air in the same.

The models shewn indicate the various forms of cowls &c. in use. A great improvement has been made, because the revolving ones although very effective are liable to and do get out of order, and in such a condition would be useless. The fixed induct does better work than the others and has not their disadvantages.

The death rate of the City and Suburbs compares very favorably with that of other cities of the world ; I see no reason why a still further reduction should not take place when the older system of house drainage is eradicated, this however can only be a work of time. The work of reconstruction is increasing yearly, old habitations are disappearing and are being replaced by large spacious warehouses and other buildings, which contributes very much to the improvement of the health of the city.

RETURN SHOWING THE EXTENT AND EFFICIENCY OF THE SEWER VENTILATION SHAFTS IN THE FOLLOWING DISTRICTS DURING 1890 AND 1891.

District.	Area.	Number of shafts		Length of Pipes.									Sewers.		Cubic Contents in Feet Full Capacity.	Average work of shaft per hour.		Times chang'd per hour.		Times chang'd per hour of 75 per cent. cubic contents.		Average No. of times changed per hour.	
		In-duct	Ex-haust.	6 in.	9 in.	12 in.	15 in.	16 in.	18 in.	20 in.	21 in.	24 in.	Size.	Length		Induct	Ex-haust.	Induct	Ex-haust.	Induct	Ex-haust.	Full capcty.	75 per cent. capcty.
Surry Hills...	94a.	45	94	...	27,989	1,927	...	152	312	...	610	...	3′ × 2′	882	20,159	2,399	1,422	5·36	6·33	7·14	8·84	6·00	7·99
Redfern ..	336a.	36	121	150	63,133	7,025	...	1,905	...	...	1,221	...	4′ 6″ × 3′ 4′ × 3′	1,350 370	56,628	2,085	1,932	1·33	4·13	1·76	5·50	2·73	3·63
Lacrozia Ck..	77a.	27	63	163	7,437	8,906	...	740	283	470	295	230	3·77′ × 2·916′ 3·52′ × 2·54′	878 358	24,174	1,869	1,669	2·09	4·35	2·78	5·80	3·17	4·29
Waterloo ..	89a.	15	44	...	20,308	1,210	...	1,305	980	...	1,020	...	3′ × 2′ 3′ 3″ × 2′ 2″	300 1,360	58,544	4,316	2,468	1·10	1·85	1·47	2·47	1·47	1·97
Alexandria ...	20a.	7	13	...	3,570	1,210	...	...	...	...	...	...	...	...	2,551	4,554	3,019	12·50	15·38	16·66	20·52	13·94	18·59
Paddington ...	250a.	37	86	...	59,261	3,735	...	...	...	...	810	644	3·259′ × 2·521′ 3 77′ × 2·916′ 3′ 6″ × 2′	360 440 420	41,579	3,486	1,818	3·10	3·76	4 14	5·01	3·43	4·57
Woollahra ...	77a.	14	21	...	17,560	...	...	...	...	...	...	...	...	...	7,757	1,397	1,629	2 52	4·40	3·36	5·88	3·46	4·62
Strawberry Hills	250a.	46	95	...	...	45,889	...	2,458	2,240	...	...	...	3′ 3′ 6″ 4′ 6″ 6′	878 1,340 826 1,500	91,847	2,626	2,164	1·32	2·24	1·75	2·97	1·78	2·36
Blackfriars and Pyrmont	346a.	54	93	1,420	41,622	19,748	255	7,470	1,680	...	150	60	3′ × 2′ 6″ 3′ × 2′ 3′ 6″ 4′ 6″ 4′ × 2′ 8″ 5′ × 4′ 6′ 7′	497 1,940 570 5,750 2,620 80 1,280 630	186,730	3,457	2,410	1·00	1·20	1·33	1·60	1·10	1·47
	1,539	281	630	1,733	240,880	89,680	255	14,030	5,495	470	4,106	934		24,659									

Discussion.

Mr. J. L. Bruce—I think, sir, it will be mostly admitted that the papers which after all are of most solid value to the general community are those wherein mere theorizing is reduced to a minimum, and where practical experimental tests, necessarily of course suggested in the first instance by untried theory, form the bulk of the communication. Such facts form a firm and immovable foundation for the obvious conclusions which flow from actual tests, and so give the data for formulæ, resting as all formulæ should, on good and true "practical work" in the form of carefully conducted experimental trials. The paper under discussion is emphatically of this class, and that very fact, which renders it all the more worthy of careful and thoughtful study, to a large extent disarms criticism, or rather renders it in many directions impossible. Experimental facts are of course undeniable, and all that remains for discussion is the method in which they have been arrived at, and the conclusions drawn from them together with any theoretical suggestions for future investigations thereby indicated.

As my classes at the Technical College prevent my attendance at the Society's meetings, I was deprived of the advantage of hearing the paper read, and was dependent for information on the print sent to members and which I received only yesterday afternoon. I therefore had but scant time to consider the matter, but as a few points have occurred to me I venture to lay them before the Society, for the most part more as suggestions for future investigations than as absolute conclusions.

First as to sewer temperatures as influenced by earth temperatures. This is a point to which too little heed has hitherto been given, and Mr. Smail has as yet only opened an investigation which if continued and widened, will have an immense influence on questions of warming, cooling, and ventilation, far outside the field of mere drain ventilation. Sufficient has already been done by Mr. Smail to show the very direct bearing of this influence on the direction and motion of air currents in underground channels. The valuable series of observations on this subject of earth temperatures conducted for some years past by Mr. Russell at the Observatory here, show that nineteen feet below the surface the annual range of temperatures has been as little as 3·8° with a surface shade range of 60·1° and that the maximum observed range at that depth seems to have been 5·9°. From this it becomes evident that here we have an influence which cannot but make itself felt in underground channels, such as sewers. As perhaps making this matter clearer, taking the earth's temperature at Mr. Smail's quoted level of ten feet below the surface, we find from Mr. Russell's tables for 1889 that in December the mean temperature ten feet underground was 64·5° with a range for the month of 2°, (the maximum being 65·6) on the surface in the shade it was 72·2° mean temperature and a maximum of 99·5° with a range of 38·2°. Under such conditions we would naturally expect that the air passing into the sewers would be at once cooled and of course contracted and rendered denser so gravitating with the fall of the drain, and this Mr. Smail's admirable tests actually prove. On the other hand in July of the same year the ten feet underground mean temperature was 61·2° with a minimum of 59·8° and a range of 2·5°, while on the surface the shade mean was 52·5 with a minimum of 41·6° and a range of 22·8°. These data would lead us to expect, what Mr. Smail's experiments now prove, that under these conditions the cold surface air passing into the sewers is warmed by the higher earth temperature and so caused to rise even against the flow of liquid matter in the sewers. In a climate such as ours, when for many purposes coolness is a necessity in summer time, such a power as that furnished by the natural earth temperature, and one so easily availed of, is surely well worth more attention than it has hitherto received. I have already urged the importance of this matter in the course of public lectures here as far back as 1887, but with the exception of a few dairies to which it has been applied this vast store house of power is as yet unopened. What is still wanted in the direction of rendering this power intelligently available is that a series of experiments should be initiated to determine the heat conducting power of our local subsoils, for it is very clear that as the heating or cooling of air is entirely a matter of the extent of surface in contact with it, the heat emitting or heat absorbing power of a unit surface of underground channel must depend entirely on the rapidity with which the heat can be transferred to or from the general mass of the surrounding material.

By observation of the sewer wall temperatures in the different strata relatively to the temperature and velocity of the air current passing through, and the depth below the surface, much light might be thrown on this subject, and Mr. Smail would confer further benefit on sanitary science if he would include this in the very valuable series of experimental investigations now in progress under his direction.

I fear I have occupied rather too much time on this point, but would like to refer to one other before concluding, namely as to the action of the various ventilators in their influence on dangerous or offensive matters arising with sewer air. In an article entitled London Fogs, in the *Spectator* of January 9th of this year, a matter is suggested which has aroused much speculation and discussion, namely whether the opening up of sewers to ventilating air currents has not really rendered the atmosphere of large cities (especially cities subject to fogs) more dangerous and unhealthy. This certainly interests us here, but, fortunately we are as yet under very different conditions as to fogs from London, Glasgow, or Manchester. These cities are in the first place more unfavourably located than we are, and there the smoke nuisance has assumed practically unmanageable proportions, partly owing to the vast extent of ground closely covered with buildings, and in many cases because of sheer carelessness or parsimony on the part of manufacturers. I speak of the matter advisedly because I acted for some time as consulting engineer to the Glasgow City authorities in smoke nuisance cases, and I do not hesitate to say that in 90% of the cases submitted to me, the nuisance was caused either by simple carelessness in firing or by forcing boilers or chimneys to do work far beyond their power.

Smoke particles as is well known aggravate, sometimes actually cause fog, and the fog practically stops all efficient circulation of air, consequently sewer air from the sewer ventilators cannot diffuse as it does under more favourable conditions, but is retained near the surface of the ground, and in the opinion of the writer in the *Spectator*, effects a poisonous action on suffering humanity. That under such conditions sewer air, in common with respired air, combustion gases, and all the other aerial ashes of civilized life, will be retained more or less in the neighbourhood of their inception we can hardly deny, but in view of the enormous extension of London, annually, and considering that sewer air forms but a fractional part of the "aerial sewage" arising from habitation, it is clearly absurd to charge the increasingly poisonous nature of the fogs of rapidly extending cities entirely to sewer ventilation. On the face of it, it must be infinitely safer so to dilute the sewer gases and constantly sweep them out into the air where they can be harmlessly and readily dissipated throughout the atmosphere all the year round excepting on a comparatively few foggy days, rather than store them up in increasingly compacted or concentrated form to be intermittently delivered into the houses under the constantly recurring conditions pointed out by Mr. Smail. Ventilation of sewers is clearly a necessity in some direction, but at the same time it has not been clearly shown that under certain conditions ventilation without disinfection is free from danger.

It is now a pretty generally accepted dictum that organised poisons do not find their way into the air from water surfaces, but that the danger from these arises when the margins become dry and so enable these poisons to be borne by the air currents in the form of dust and so scattered throughout the atmosphere, as for example the malaria so commonly following the partial drying up of swampy lands. If this is correct it is quite possible to conceive that the very drying up of our sewers caused by the ventilation currents as described by Mr. Smail, may furnish an element of danger by carrying freely into the open air organized poisons, which would otherwise have remained in the sewers adhering to the damp walls till washed away by the next storm or by flushing water. Remember, I am not decrying ventilation, on the contrary I warmly advocate it, because it does good in preventing offence and danger to health in other directions, but that does not affect the point that the drying effect of ventilation with all its advantages may add this danger in its train. If so, it is better it should be recognised and the ventilation so arranged that this action may be guarded against. Clearly the ordinary vacuum plenum system with perfectly open educts cannot influence the matter—a return to no ventilation at all is not to be thought of, and we are consequently brought to consider the action in this respect of the two other systems referred to by Mr. Smail in his paper, viz., McKenzie's heat current method, and the water spray. To effect the purpose aimed at, the action clearly must take place at the educt. McKenzie's system acts in this way namely on the vacuum system and all that remains to be proved in his case is that the organisms passing out through his furnace shaft, or destructor ventilator are really passed so closely over the highly heated surfaces of his motive power as to be destroyed as living organisms, and that the furnace or burner is so constructed that perfect combustion takes place within it, so that no poisonous carbonic oxide gas, (CO) is thrown into the air, but only the comparatively harmless carbonic acid (Co_2) and water vapour. If McKenzie's system ensures this it is unquestionably the more efficient of the two from a health point of view, because while it is, I believe, quite possible to prevent all organized matters, and in addition all dust also from passing into the air by means of the water spray applied to sewer ventilation, yet, the water spray cannot absolutely destroy the life of living organisms as fire can, hence the difference. Of course the water spray if used in this way would require to be applied as an exhaust instead of an induct, but this presents no difficulty and so used the sewer air would be washed and separated from its dust which would again be transferred to the flowing water of the sewer and so away to the land to be consumed by the earth microbes of which we have been recently informed, or to the sea to furnish food possibly to some of its myriad inhabitants..

The matter is pre-eminently one calling for experimental test. The sugar of lead papers of course furnish an indication of the state of the sewer air as to sulphuretted hydrogen and sulphuretted hydrogen is not only a deadly poison in itself, but usually keeps bad company, so that this test is of unquestioned importance as far as it goes. But we must not lose sight of the fact that organized poisons (our most terrible enemies in sewer air) appear to be found when sulphuretted hydrogen is absent entirely, and so being odourless themselves, and unaccompanied by any odour and also invisible to the naked eye, some other means must be taken with regard to them. Fortunately the biological or cultivation test is available to give further insight into these conditions, and its application in regard to the three methods of ventilation namely, the plenum vacuum with open pipes, the McKenzie, and the water spray educt, would, I believe furnish the only reliable data on which to judge the matter effectually.

In this connection another point has occurred to me as following out a remark of Mr. Smail's paper to the effect that the mass of oxygen thrown into the sewers with the ventilation currents must have a very marked influence in the way of purifying by oxidization. That such an influence is a real one, no one with a knowledge of the subject can doubt but it would be of great value if the actual extent of the action could be ascertained and an analysis of the air as to its proportions of oxygen at the induct and at the educt, conducted with that accuracy possible to modern chemical work, would I should expect throw much light on this subject. I fear I have taken up rather much of your time but trust that these hastily written notes may at least suggest some lines of discussion or of investigation in the direction noted, and in which I should be very glad to assist.

Mr. J. M. Smail—Mr. Bruce's remarks form a valuable addition to the literature of the section, and indicates how the field of research in connection with the temperature of the earth and its bearing on air currents in sewers can be extended and broadened. This matter alone would occupy the attention of one person, but as the practical work of a department has to be carried on, investigations on these lines can only be carried out in connection with others as time permits. The question is too important to be allowed to remain uninvestigated. With regard to the possible danger of the air becoming charged with germs from the sewer ventilating shafts and being entangled with vapour during fogs as mentioned in connection with London and other British cities, I think the danger *re* fogs is so remote, considering the different climatic conditions of this city as compared with the ones referred to—the other question is however one for consideration. If the shafts were attached to sewers badly constructed, and were what is termed "sewers of deposit," no doubt the gases from such ducts would be inimical to public health, but if on the other hand the sewers, notwithstanding constructive defects in some cases, are flushed and the deposit of solid filth prevented in addition to being air-swept by pure air being passed into the sewer, it will I think be admitted that the danger to public health is reduced to a minimum. Stagnation of the sewage and air in sewers leads to serious results, and the object of a sanitary authority should be to substitute motion for stagnation to both. The drying of the sewer walls by the currents of air passed into the sewers being likely to be a source of danger, is a question which can only be settled in any way satisfactorily by bacteriological investigation. So much has this matter impressed me that the Board on my suggestion, intend having the matter scientifically investigated. There can be no doubt as to the purifying effect of the quantity of oxygen which is passed into the different systems annually, and as the exhaust shafts are carried well up above the living zone, the danger of vitiating the atmosphere appears to me to be remote. There is not the slightest doubt that to cremate the gases passing from a sewer would place the question of danger beyond all doubt —this matter is under trial and results will shortly be known. The temperature maintained in the shaft is, according to scientific authorities, sufficiently high to destroy all germs likely to be injurious to health. If this object aimed at is attained by present investigations, I feel sure that the ventilation of the Sydney sewers will leave very little room for complaint.

FLYING-MACHINE WORK AND THE $\frac{1}{6}$I. H.P. STEAM MOTOR WEIGHING $3\frac{1}{4}$℔s.

By Lawrence Hargrave.

[With Plates V. to XIII. inclusive.]

[*Read before the Royal Society of N.S. Wales, August 3, 1892.*]

Since July 1st, 1891, a quantity of experimental work has been done that will be of interest to those who see the near approach of the successful navigation of the air.

No. 15 motor may be passed over with the statement that it was intended to drive two screws in opposite directions by bands from a turbine. The turbine to be worked by the products of the combustion of nitrate of ammonia, charcoal and sulphur. A considerable expenditure of time resulted in the turbine remaining stationary.

After long delay some pure aluminium was procured with a view to ascertaining whether the receivers for the compressed air could be made out of it lighter than the tinned iron plate ones. A receiver was made $23\frac{3}{8}$ ins. long and 5·5 ins. diam. of aluminium plate ·02 ins. thick. $\frac{3}{8}$ ins. x $\frac{1}{8}$ in. rivetting strips were insufficient to make tight joints; it weighed twenty-six ounces, and 80 ℔s. per square inch water pressure blew out one of the ends; the fracture took place at the bend of the flange, not along the line of the rivets.

No. 16, another compressed air driven machine, Plates v., vi., has had a most varied experience: no less than twelve trials are recorded. Trial ten was the successful one. On that occasion it flew three hundred and forty-three feet in twenty-three seconds, with fifty-four and a-half double vibrations of the engine; the machine had a decided slope upwards, possibly 10°; it had 25·1% of the area in advance of the centre of gravity. Supposing the efficiency of the engine to be ·29, the same as No. 14, and the reduced pressure 60 lbs. per square inch, seven hundred and forty-two foot-pounds of work drove it at 10·1 miles per hour. The bi-plane was fitted to No. 16 for the first trial, the forward section was 52 ins. x 18 ins., and the after one 64 ins. x 18 ins., leaving a distance of five feet between. The engine was twenty-six inches from the bow. This form is very stable, and, from the cross-bow models that were previously tried, the tendency to turn upward is much reduced. A trussed body-plane 10 ft. 2½ ins. x 28½ ins. was also tried, but it is difficult to balance.

A piece of drawing-paper was curved by suitable cross bars and battens, Plate vii., fig. 1, and attached to one of the cross-bow models, to see if any additional support could be obtained, but its erratic flight showed that complications would ensue from its adoption at the present stage of the experiments.

The facts elicited by the action of this segment of a hollow cylinder cannot be generally known, therefore as concise a statement as possible is given.

1. With the leading edge tangential to the direction of impulse, Plate vii., fig. 1, two or three back summersaults are made before the apparatus falls to the ground.
2. If the segment is detached from the cross-bow model and dropped from a horizontal position convex side down, it falls vertically.
3. If the segment is rotated on its longest axis, on being released it will fall at an angle of 45° towards the side that is ascending. Plate vii., fig. 2.

4. If a thread is tied to one end of the longer axis, and the segment held by the thread in the wind, if slightly rotated it will take up a position at a right angle to the direction the wind is blowing, and continue rotating. Plate VIII., fig. 1.
5. If the segment is mounted on its longitudinal axis it will remain stationary if the wind is blowing on either the concave or convex surfaces. Plate VIII., fig. 2, Case 1.
6. If the segment is placed in the positions shown in Cases 2, 3, Plate VIII., it will begin and continue rotating.
7. If a finger is placed as in Case 4, the segment reciprocates.
8. If the segment is plano-convex or semicircular in section, it will rotate under the same conditions.
9. If two segments are substituted for the two opposite sails of a windmill, Plate VIII., fig. 3, the two rotating segments will balance the two windmill sails when set at 45° pitch angle.

Plate IX. shows the detail of the air pump.

It was now thought desirable to see what could be done with the available appliances towards making a steam motor. The conditions being that it should be lighter than the compressed air apparatus, have a uniform boiler pressure, and flap the wings of the standard size as fast as the compressed air engine did and for a longer time.

The steam generator was at once recognized to be the main difficulty; and the Serpollet boiler was singled out as the germ to be developed. Steel pipe is not to be got in Sydney, so copper of ordinary trade sizes was procured. By the way, an English correspondent says that the "Credenda" Seamless Steel Tube Co., Ld. is the only English firm which makes seemless tubes, but there is another in France whose productions up to one inch diameter are simply wonderful, for they can make a tube $\frac{1}{32}$ inch diameter with a hole $\frac{1}{64}$ inch diameter in the centre, ten feet long, all solid and seamless.

Quite a number of coiled, flattened coils and corrugated boilers were made and rejected. The one drawn, Plate X., is a two stranded coil and can easily be improved.

Methylated spirits of wine, commercially pure, was decided to be the cleanest and most reliable fuel obtainable, and its receptacles were placed on the top of, inside and underneath the coil, the vapourized spirit mixed with various quantities of air spurting into the furnace: the whole being encased in asbestos card. As much as 6·9 cubic inches of water has been evaporated by 1·7 cubic inches of spirit in eighty seconds making one hundred and eighty-two double vibrations of the wings which have the same dimensions as those of Nos. 14 and 16. The spirit holder and burner have undergone many changes, and in larger engines the spirit will have to be pumped by the engine instead of the whole amount of fuel being put on at once.

No. 17 Engine (steam) Plates x., xi., is of the usual vibrating type with the addition of the feed pump, 5·2 m. in diameter, which is single acting.* A cock is provided for reducing the quantity of water pumped, but it has not been used; if all the water is not evaporated it cannot endanger the cylinder covers as the valve does not cut off appreciably for compression and expansion. All the springs and catches about the valve are abolished. The valve cylinder ends are reduced in area to the size of the steam passages by caps, so that the reaction of the exhaust steam forces the valve to the end of its cylinder directly the port opens. Possibly the caps are unnecessary, if so, they serve to limit the travel of the valve. The valve cylinder has four port holes at each end with an annular space outside. There is a difficulty in grinding in the valve if there is only one port for each passage. The main piston and cylinder are made of brass and there are no packing rings.

The relation between the cylinder capacity and boiler is :—

Cylinder	2·2 cubic inches.
Steam and water space of boiler ...	2·8 ,,
External surface of boiler	113 square inches.
Internal surface of boiler	71 ,,

Sundry chronograms have been taken showing that 1·66 double vibrations per second are made with fifty-five pounds steam

* Plate x. has the feed pump ram marked 4·2 m. instea o 5· m.

pressure, and 1·8 per second with seventy-five pounds. At a speed of 2·46 per second the pen marks are illegible, this is when using the indicator delineated in last year's Proceedings.

A thrust diagram shows that—

2·2	double vibrations per second	produce	a thrust of	·75 lbs.
2·3	,,	,,	,,	·9 ,,
2·44	,,	,,	,,	1·1 ,,
2·5	,,	,,	,,	1·25,,

It is noteworthy that a slight increase of engine speed makes a large increase of thrust.

The total weight of the apparatus is 64·5 ounces which includes 12¾ ounces for the strut and body-plane and five ounces for spirit and water; and by putting on the indicator, Plate XII., it is found that ·169 H.P. is developed when 2·35 double vibrations are made per second. Plate XI. With 2·5 double vibrations per second there would be a corresponding increase of work done. It is inconvenient to attach the indicator cord to the cross head. Fastening it to the wing arm moving in an arc of 112° must produce a slight distortion of the indigram near the ends of the stroke.

If we load the machine with ten ounces more spirit and water to bring it to the same weight as No. 12, which flew three hundred and forty-three feet* with thirty-eight double vibrations, it will be seen that five hundred and forty-six double vibrations can be made by No. 17 which will give a possible range of one thousand six hundred and forty yards.

On starting, the boiler is empty, and warmed up by a Bunsen burner: then the spirit holder is heated till the flame ignites, it is kept alight by a few shreds of asbestos put into the coil. When the flame is fairly underway, part of the boiler gets red hot in a few seconds. Then the wings are moved up and down a few times by hand squirting about a teaspoonful of water into the boiler and

* The best flights of Nos. 12 and 16 were each three hundred and forty-three feet.

nothing further is needed but attention to the chronograph and indicator.

Plate XIII. shows a three cylinder engine designed to rotate two wings through 360° of arc in exactly the same time without the interposition of bevel gearing. From the drawing it will be seen that the cylinders are attached to one wing and the crank shaft to the other; the cylinders are free to rotate in the opposite direction to the crank-pin. Uniformity of motion is got by two eccentrics, one on the cylinder face and one on the valve. The two eccentrics are between one pair of guides. Should one eccentric try to go faster than the other, owing to the difference of the frictions of the two sets of moving parts, it is checked by the guides which at the same time add a slight impetus to the other eccentric.

The ram for the spirit pump delivers one volume of spirit for two reciprocations of each of the three steam pistons. The feed pump is double acting. The engine is estimated to give out at least one horse power and to weigh about two and a half pounds.

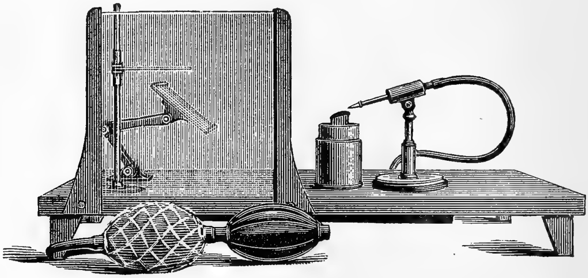
A word of protest may not be out of place here against the repeated connection of the flying-machine with dynamite missiles. It is natural for the military man to view it as a possible means of destroying the enemy from a secure position, but we are not all intent on the wholesale destruction of human life; and there is no doubt in the writer's mind that the flying-machine will tend to bring peace and goodwill to all, that it will throw light on the few unexplored corners of the earth, and will herald the downfall of all restrictions to the free intercourse of nations.

ON A NEW BLOWPIPE ARRANGEMENT.

By William M. Hamlet, F.I.C., Government Analyst, N.S.W.

[*Exhibited before the Royal Society of N.S. Wales, August 3, 1892.*]

The blowpipe consists of the usual fine platinum jet, fastened to a brass tube jointed on to a sliding rod, inserted into a brass stand shown in the wood-cut, by which means the jet may be inclined to any desired angle.



The air-blast is urged by means of one of the ordinary caoutchouc spray producing balls obtainable at any pharmacy, these balls are attached to a piece of capillary lead-glass tube, over one end of which a piece of oiled silk is tightly tied, thus forming a valve that only opens inwards and prevents any back flow of air: the valve is passed through a cork and inserted into the inlet of an air-tight chamber made of tin plate, and measuring 10″ × 8″ × 1″, this air chamber is placed out of sight by screwing on to the underside of the blowpipe table, which measures 18″ × 10″, and stands on four legs 1½″ high.

To the left of the front is an upright frame made to hold a sheet of glass six inches square; into the groove made in the frame, ruby, violet, green and colourless glasses may be inserted as wanted. At a point 2″ from the left edge is a brass rod 6″ high which serves to hold a glass tube bearing a fine platinum wire for flame reactions.

The lamp may be any one of the many varieties of paraffin or grease lamps having a flat wick. In my own case I employ the lamp found in Letcher's blowpipe outfit, using solid paraffin as fuel. On the extreme left just midway across the board is a brass plate 2″ × 1″ hard-soldered on to a universal joint. This forms a convenient support, when protected by a piece of asbestos mill-board, for charcoal pellets or cubes, as well as for plaster slabs and aluminium plates. An upright prism of porcelain is used for cupelling. On the right is embedded into the table a flat steel anvil and agate mortar.

Such a blowpipe becomes a valuable adjunct to the laboratory equipment, and instead of the blowpipe being despised and consigned to the drawer or box of odds and ends it finds a useful place on the working bench. With such a piece of apparatus one can get a very clearly defined reduction or oxidation flame, and when the jet slopes down on to the wick at the proper angle it is easy to produce a flame four inches long and so steady that I have actually cupelled off a lead button as perfectly as it could have been done in the muffle. Such a thing is sometimes stated in books, but I never saw it accomplished until I actually did it myself with the apparatus I now describe.

Using the flame colouration and a blue screen it is quite possible to see the potassium flame amid the abundance of sodium salts in urine. Conversely, the presence of sodium salts in potassium compounds may be recognised by using the green tinted screen. Altogether it is the most efficient and the most easily handled blowpipe arrangement I know of, and I made good use of it during my recent visit to the Broken Hill Silver-Lead mines. With the steady flame obtained, Von Kobell's reaction for bismuth compounds gives most brilliant results on a slab of plaster of Paris; and with dry thiosulphate all the reactions may be instantly obtained in the dry way, that are usually given in the wet way with sulphuretted hydrogen.

On the EFFECT which SETTLEMENT in AUSTRALIA has produced upon INDIGENOUS VEGETATION.

By Alex. G. Hamilton.

[*Read before the Royal Society of N.S. Wales, September 7, 1892.*]

In considering this object, the first point to be noted is the state of the indigenous vegetation at the time of first settlement. This we can only arrive at by analogy. Australia being for so long a period practically isolated from the other continents, and the conditions of the animal and vegetable life having been for so long a time constant and uniform, the vegetation then must have been in a state of balance, or, if any changes were taking place, they were very small in amount and slow in action.

The balance above spoken of was then, and is still being, disturbed in the following ways by settlement:

Division I.—By the direct action in destroying forests and herbage by clearing the land for cultivation and settlement; in clearing roads, railways and telegraph-lines; procuring timber for building, fencing and fuel, and for mining purposes; and ringbarking tracts of land to improve the grazing capacity. Under this head too, comes the checking of bushfires, although as will be seen when this subject is treated of, this has perhaps only an indirect action.

Division II.—The introduction of a new fauna altering the flora; and the destruction of the native fauna modifying it.

Division III.—The introduction of a new flora, and consequent modification of the indigenous flora through competition.

It is necessary to examine each of these causes in detail, to arrive at an understanding as to how, and to what amount each of them acts.

Division I.

Destruction of forests and herbage, and checking bushfires.

In all newly settled countries this is the first cause, and for a considerable period the principal cause of alteration in the flora. On the arrival of the first fleet in 1788, the first thing done was the clearing of land for the erection of buildings, and for cultivation. It is difficult to say the exact area of forest-clad lands in Australia at that time.

The only colonies for which I have been able to make any estimate are New South Wales and Victoria. Mr. R. Brough Smyth*gives the following as an estimate of the approximate area occupied by forest trees and scrubs in Victoria, on the authority of the State Forest Commissioners :

Stringy-bark and messmate	30,000	square miles.
Mallee scrub	18,000	,,
Eucalypti of small size	14,000	,,
Large white gums	5,000	,,
Red gum *(E. rostrata)*	3,000	,,
Lightwood	1,000	,,
Oak and Murray pine	500	,,
Iron bark	500	,,
Honeysuckle, etc.	500	,,
Sassafras, etc., in mountain gullies ...	300	,,
Tea-tree scrub...	200	,,
Total forest clad lands ...	73,000	,,
Extent of open country ...	13,831	,,
Total area	86,831	,,

This, however, does not give us the area of forest land in Victoria at the time of first settlement.

In New South Wales it is probably safe to assume that the whole of the coast district, the table lands and mountains, and a

* Goldfields and Mineral Districts of Victoria, Melbourne 1869, p. 26.

narrow fringe of the plains were forest-clad, and that the major portion of the plains was treeless. Now this tree-covered part is probably not less than one-third of the total surface, that is to say, 103,000 square miles, or 65,920,000 acres of forest. The area cleared for, or under cultivation in 1890 was 2,688,486 acres; and that ringbarked and partially cleared was 21,823,690 acres, making a total of 23,512,176 acres upon which the forest has been destroyed. The amount cleared for procuring timber for mining and other purposes is probably partly included in this. But to show the enormous amount of timber that has been used in coal-mining, I may say that mining managers calculate the cost of timber used in coal mines at one penny per ton of coal raised; the timber averages £1 per 100 props, etc. These are of different sizes, but they average about half a cubic foot each. The total amount of coal raised in New South Wales up to the end of 1891 is given in the Report of the Mines Department for that year as 49,864,849 tons, which at one penny per ton for timber would be £207,770, from which we find the total timber to be 10,385,500 cubic feet. Taking 200 cubic feet as the amount yielded by one tree, this would give us 51,942 trees destroyed for coal mining alone. In Victoria, the value of props, cap pieces, laths, slabs, sawn timber and firewood in 1867 was £561,123.*

The total of land cleared in New South Wales quoted above does not, I presume include that cleared for townships, roads, telegraph-lines and railways, which would make a considerable addition, when it is considered that there are 32,000 miles of roads in New South Wales; 9,554 miles of railway in the Australian Colonies, (exclusive of private and colliery lines) and 38,082 miles of telegraph lines in Australia, which includes 11,497 miles erected in New South Wales.

On the whole, it is probably within the mark to say that in New South Wales alone, probably one third of the total forests have been swept away since the colony was founded. Of course

* R. B. Smyth, *op. cit.*, p. 29.

there is some amount of reforesting going on, but up till the present time, the area can only be small, and may be left out of consideration. We may hope however, that under the present policy of the Government on the subject of forests, that the re-forestation of various districts will proceed with vigour.

The next point to be considered under this division, is the method of action; and this may be classified in two subdivisions, Direct, the actual destruction of the flora; and Indirect, which includes the effects of clearing on (*a*) the forest flora; (*b*) the surface reacting on the flora; (*c*) the climate reacting on the flora; (*d*) the fauna reacting on the flora; and (*e*) the effects of the checking of bush fires.

1. *Direct action. Actual destruction of the flora.*

The plants that are absolutely destroyed are of all genera and species. In clearing for cultivation, the trees are of course the first to suffer. Then during burning off the timber, where that course is resorted to, all the undergrowth and herbaceous plants are entirely exterminated; ploughing the ground completes the destruction, and the tract thus cleared never thoroughly recovers, even if no crop be put in, and the ground left fallow to produce what it can. An example of this may be seen at Heathcote on the Illawarra Railway Line, where large tracts of the National Park were cleared and dug by the unemployed some years ago. Even from the train in passing it is easy to see the vast difference between this piece of country and the adjoining uncleared bush. And a closer inspection will show that a very large percentage of native plants have disappeared completely, and that even the undisturbed state of the land for some years has failed to reproduce that which was destroyed.

In clearing land for building townships, for roads, railways and for telegraph lines where such do not go along road or rail, the devastation is equally complete. In the latter case the land must be cleared of all trees, shrubs and undergrowth for a distance of thirty feet on each side. In this case, of course, the herbaceous and low growing plants suffer least, but the amount of damage done to forests may be computed when it is considered that there are in New South Wales 11,497 miles of telegraph line, and in the Australian Colonies 38,082 miles.

In timber getting, whether for building, fencing, mining, or fuel, the chief damage is done to forest, although of course the smaller plants suffer in the carting or dragging the timber away.

The trees that are most destroyed are naturally those that afford the best timber for the purposes, and are different in different districts. But the principal of them are the various species of Eucalyptus. And of these perhaps none have had such havoc wrought among them as the ironbarks—*Eucalyptus crebra, E. leucoxylon, E. melanophloia, E. paniculata*, and *E. siderophloia*, which are so highly valued as building timbers, for heavy beams in bridge and wharf construction, and for railway sleepers. In some districts the ironbarks have been almost exterminated, and from the slow growth of these trees this loss is greater than that caused by killing many gums which are comparatively rapid in growth.

Many other species of Eucalypts have become, or are becoming scarce on account of their excellence as timber or fuel. In West Australia a vast quantity of the Jarrah—*Eucalyptus marginata*, is annually exported to other colonies and to England. In the closely allied genus Syncarpia, the turpentine (*S. laurifolia*) has become rare in many parts. Being proof against the terrible Teredo, it is of great value for piles in constructing wharfs and jetties, and consequently in the Illawarra district, where this tree once abounded, it is very seldom that a trunk of any size is seen, immense quantities having been used in constructing the many coal jetties along the coast from Clifton to Port Kembla.

Another tree rapidly being extirpated is the red cedar (*Cedrela australis*). Mr. J. Ednie Brown says, "owing to its very great value, the indigenous forests of *Cedrela australis* have been largely worked upon, and owing entirely to inadequate regulations and supervision by the State, they have been to a very large extent ruthlessly destroyed; and although not beyond the means of renovation both by natural regeneration and planting, it will be a matter of very careful and special application for a considerable number of years before their previous original excellence can be attained."* And again, "From my own observation in that part of the country, there are, comparatively speaking very few natural matured trees of the species still standing, and with the exception of along the rivers and creeks, the natural reproduction of the tree is in a general sense not so prolific as one could wish."†

So far back as 1871, it became apparent that the supplies of this valuable timber were lessening on account of the reckless way in which timber-getters destroyed it, and the Government at last were compelled to take action to regulate the trade. In 1879 the system of timber licenses was introduced, and from that time till 1890 the sum of £163,671 has been derived from timber licenses, royalties, etc. At the same time a schedule was issued prescribing the minimum girth of trees allowed to be felled, that for cedar being nine feet. Licenses to cut timber were issued at the rate of £6 per annum for timbers in Reserves, Class A; £9 in Class B; and in Class C the license was fixed at £6 with a royalty varying from 3d to 1/6 per 100 superficial feet. Besides this, on ordinary crown lands, a license is required to cut timber at the rate of £3 per annum. That these regulations came not any too soon may be gathered from the fact that the red cedar was once a common tree in the Illawarra brush-forests, while now it would be difficult to find a tree of four and a half feet in girth—half the prescribed minimum. It is a noteworthy sign of how this wood is diminishing in quantity that the price has been rising steadily for some years. At present it is higher than it ever has been—6d. per square foot.

The palm-trees, *Ptychosperma Cunninghamii*—the Bangalow, and *Livistona australis*—the Cabbage-tree, are also diminishing rapidly in numbers in some districts, their tall straight trunks

* Annual Forest Report for N.S. Wales, 1890, p. 28.

† Ib. loc. cit.

when split enabling fences to be rapidly erected, as they can be split in such great lengths. And as they decay quickly and are replaced again and again, the trees are gradually becoming fewer. This applies more particularly to the Bangalow, which is now very rare in the Illawarra district.

Tree-ferns too, do not escape, their trunks being exported largely to Europe and to America for gardening and for ornamental pedestals, etc. The loss to the native flora in the palms and ferns is perhaps more irreparable than that of other trees on account of their slow growth. Indeed it is to be feared that another half century will see them extinct except in those ravines which are inaccessible to timber-getter's teams.

The indiscriminate ravages of bark-strippers among the wattle-trees is another instance of injury to the indigenous vegetation. In their greed for large returns, the strippers spared neither large nor small trees, and in consequence the wattle-bark industry is now defunct in many districts once famed for a large output of bark. This is to some extent being remedied by the enlightened policy of the State Forests Conservancy Branch, and a few years will see a steady inflow of revenue from the wattle plantations established in many districts.

At present the value of the timber of the majority of the Australian trees is unknown, but experiments are being made to determine it, and we may expect that when their qualities are discovered, large numbers of others will be drawn upon, and as time goes on, only those of little use for fuel and timber will escape. It is therefore manifestly a wise policy to establish State nurseries, as has already been done at Gosford, for rearing valuable trees and distributing them to suitable localities, and the proclamation of extensive forest reserves is another safe-guard against the extinction of our most valued trees.

What cultivation does for a native flora may be summed up in the following quotations from Professor Moseley: "The island of St. Thomas itself, as well as its outliers, is covered with a wild bush growth, which at first sight might perhaps be taken for original vegetation, but which is composed of plants which have overrun the deserted sugar plantations. It is only in a few remote parts of the island that any original forest exists and in small streaks of broken ground bordering the watercourses."* And again, "It is only in the highest part of the island of Madeira that anything is to be seen of the true indigenous vegetation. Below, cultivation has destroyed the native plants."†

We now arrive at the indirect injury caused by settlement.

(a.) *Indirect injury to the flora from forest clearing.*

The damage done to the indigenous plants by clearing does not stop with the mere killing of the forest trees. The plants beneath them having grown up under their shade, and being adapted for life under such conditions, suffer immediately when the shade is withdrawn. A good instance of this may often be seen when the rich brush country in Illawarra is cleared. In these forests the only undergrowth consists of saplings of the prevalent trees, and ferns of the following genera: *Trichomanes*, *Hymenophyllum*, *Alsophila*, *Adiantum*, *Pteris*, *Lomaria*, *Blechnum*, *Asplenium*, *Polypodium*, and on the tree trunks *Platycerium*. Immediately the land is cleared, the majority of these die off, the earliest to suffer being the first two genera; and those which are not killed by exposure to the sun, merely keep alive, and make no headway. If the cleared land be let stand idle, other plants, both indigenous and introduced, suited for the new conditions, invade the space, and in a short time there is a new growth, partly consisting of the old plants, but chiefly of introduced plants and indigenous plants not previously found here.

That a new indigenous flora sometimes springs up in cleared lands is well authenticated. Wallace says: "It is a known fact that when forests are destroyed, trees of a different kind usually occupy the ground."‡ Again, "Denmark has at present forests

---

* Notes of a Naturalist on the Challenger, p. 11.
† Op. cit., p. 40.
‡ Geographical Distribution of Plants, first edition, Vol. I., p. 43.

mostly composed of beech trees, and a few oaks or pines. But at the time of the pre-historic man who formed the kitchen-middens, the pine covered the most of the country. In the peat bogs too, oaks are found embedded, and, at a greater depth pines."* And H. O. Forbes says of Sumatran primeval forests: "When, however, this ancient forest is devastated to any great extent, either by natural means or by the wood-cutter's axe, the trees that arise belong to a different lineage, the new wood is in great bulk of different species, which, strange to say, were but rarely found in the old forest." . . . . "In every clearing, trees from their gigantic size have here and there escaped the axe, and have been allowed to stand unmolested. One cannot resist a feeling of pity for the solitude of these towering monarchs, whose grandeur, concealed as they stood amid the multitude of their peers, can now be seen in all its stateliness. They look the very picture of strength and immobility, yet though they have withstood in the company of their fellows the storm and sun of centuries, they survive their solitude but a very few seasons, getting feebler year by year, one great limb after another dying and dropping off, till all life ceases, when some lightning flash or sudden blast measures their noble stems on the ground."† The latter part of this quotation is a vivid picture of what occurs in Australia when solitary trees are left in clearing a forest.

As illustrating the effect which shade may have in determining the existence of trees, Wallace gives the following account of the struggle between trees in the forests of Denmark, from the researches of M. Hansten-Blangsted: "The chief combatants are the beech and the birch, the former being everywhere successful in its invasions, Forests composed wholly of birch are now found only in sterile, sandy tracts; everywhere else the trees are mixed and wherever the soil is favourable the beech rapidly drives out the birch, The latter loses its branches at the touch of the beech, and devotes all its strength to the upper part where it towers

* Op. cit., p. 43.

† Naturalist's Wanderings in the Eastern Archipelago, 1st ed., p. 132.

above the beech. It may live long in this way, but it succumbs ultimately in the fight—of old age if of nothing else, for the life of the birch in Denmark is shorter than that of the beech. The writer believes that light (or rather shade) is the cause of the superiority of the latter, for it has a greater development of its branches than the birch, which is more open, and thus allows the rays of the sun to pass through to the soil below, while the tufted bushy tops of the beech preserves a deep shade at its base. Hardly any young plants can grow under the shade of the beech except its own shoots; and while the beech can flourish under the shade of the birch, the latter dies immediately under the beech."* He goes on to show that the order of succession of trees in Danish forests has been aspen, birch, fir, oak and beech.

Something of the same kind is going on in our own land on the slopes of Mount Kembla. There may be seen a thick undergrowth of *Acacia*, *Eugenia*, and many other brush plants, while towering above them are huge blackbutts *(Eucalyptus pilularis)*, dead to the smallest twigs. Twenty years ago there were many of the blackbutts distributed about among the brush, and the smaller trees have all been cut down and converted into mining timber, but the big trees, left untouched on account of their unwieldiness, have not survived the destruction of their companions. Probably the clearing away of the forest trees, which before allowed a certain amount of light and heat to reach the soil, has permitted the scrubby growth to spring up thickly, and this cuts off the light from the soil and so causes it to become colder and wetter. The gums left then suffer from this, and gradually die off as described by Forbes in the passage before quoted. I cannot account for the deaths of these giants in any other way.

These passages all tend to show that a new flora arises when land is deforested. So far, the subject has not been thoroughly investigated in Australia, but there is evidence that something of the kind does take place. In the Mudgee district for example,

---

* Darwinism, Cheap Ed., p. 20, *et seq.*

when the low river hills covered with eucalypts interspersed with a few pines *(Callitris verrucosa)* are cleared, a thick scrub of pines springs up immediately, among which no other trees are able to survive, as they are smothered in youth by the dense growth of the young pines. And in the Western parts of the Colony the extension of the pine scrub is a matter for serious consideration to the pastoralists.

Dr. R. v. Lendenfeldt says, "In 1863 there was little or no pine scrub *(Callitris)* in the Lachlan district. In 1883 the pine had taken possession of the district, and was rapidly superseding the angiosperm trees, which previously formed the forest in that district. It appeared to be only a question of time when the forest would be converted into a pine forest. In 1885, when engaged in collecting timber specimens, Mr. Ridstone could not obtain a single sound tree of any size with the exception of the pine. I myself visited the Mooramba district at the beginning of 1885 and found there a prevalence of pine, which was, according to the statements of old residents, a new acquisition in that district."* Dr. von Lendenfeldt ascribes this to change of climate, a statement which I shall discuss later on under that head.

We are all familiar with the fact that in the coast district and table-lands, when the land is cleared and seedling trees spring up, the wattles of one or more species usually outnumber all others in the proportion of two to one. In a piece of ground which I dug up during the past year, and which had lain fallow for years, seedlings of *Acacia binervata* came up in hundreds, and I did not observe any other species of tree, except one solitary seedling of *Commersonia Fraseri.* That seeds may lie for a long time dormant in the ground is well known. Darwin says, "Out of one small portion of earth thus completely enclosed in the roots of an oak about fifty years old, three dicotyledonous plants germinated: I am certain of the accuracy of this observation."† And there have been many well authenticated instances of a crop of plants new to a

---

* Proc. Linn. Soc. of N. S. Wales, Vol. x., p. 721.
† Origin of Species, 6th Edit., p. 326.

district springing up in soil from a considerable depth when it was exposed to sun and air.* It may be in this manner that pines and wattles succeed other trees in Australia when the land is cleared. But I think it will be manifest that that is not the case in Danish or Sumatran forests.

In the beginning of 1887 a road was cleared through virgin brush-land over the side of Mount Kembla. The prevailing trees were palms, gums, giant-nettles, *Omolanthus*, *Elæocarpus*, *Diploglottis, and Pennantia*, with very rarely plants of *Commersonia*, *Panax elegans*, and *Asterotriche.* In October of the same year, I walked up the road, and on each side, cutting off the road from the brush, was a dense hedge composed of nothing but *Commersonia Fraseri*, *Asterotriche floccosa*, and *Panax elegans.* At present (1892) the majority of the smaller plants have been killed off in the struggle for existence, but there is a row of fair-sized trees of these three species—the first predominating—on each side, to the exclusion of all other trees. Here we see the mere fact of an opening in the forest gave these plants an advantage over others which they made the most of.

(b.) *Indirect injury to vegetation caused by alteration of surface.*

In clearing land and during the progress of settlement, the surface of the ground is injured in many ways; in the formation of paths and roads; and in ploughing the ground. When the surface is broken on a slope, no matter how gentle, the protection afforded by the grasses and herbaceous plants to the soil is removed and the surface drainage is altered. Small runlets of water begin to travel along the line of disturbance and to cut channels which become deeper and deeper. The amount of earth cut away of course depends greatly on the slope, the nature of the soil and the amount of rainfall, being greatest in light soils and on steep slopes. In a light sandy soil I have seen on a very slight slope, channels nine feet deep and twelve or fourteen feet wide cut in a single wet winter. If the channel cut passes through forest land, the roots

* *Vide* Wallace in "Island Life," p. 513, *et. seq.*

of the trees are laid bare, and some fall through being deprived of support, while those which do not fall have to suffer from the summer's heat and the winter's cold acting on their roots; they become unhealthy and gradually die, their deaths being accelerated by the attacks of various parasitic enemies, fungoid or insect, which find a suitable habitat in the diseased plants. When steep hillsides have been cleared, the roots left in the ground decay, and the binding together of the particles of mould which they effected is lost; when a wet season comes, the upper soil resting on rock or on a stiff sub-soil, becomes saturated with water till it is in a viscous state and moves down the hillsides slowly; an unusually heavy downpour of rain when it is in this condition, precipitates landslips down the hillsides, and considerable areas slide down, overwhelming the herbage which grew on them and that on the level ground at the bottom in one common destruction. A notable example of this kind was to be seen on the Illawarra Line near Clifton, when whole hillslopes moved down during the wet winters of 1889 and 1890. On the sides of Mounts Kembla and Keira too, the same occurred, but to a less extent.

The late Professor Moseley has on this subject: "Griesbach* in his account of the vegetation of Australia, dwells on the close relation of interdependence which exists between the tree vegetation and the coating of grass which covers the earth beneath it, and remarks that the amount of light allowed by the trees to reach the ground beneath them is rendered more than usually great by the vertical position in which their leaves grow. Hence the growth of grass beneath is aided."† "It may be that this permitting of the growth of other plants beneath them and the consequent protection of the soil from losing its moisture, besides other advantages to be derived, is the principal reason why, as is familiarly known, two widely different groups of Australian trees, viz., the Eucalypti and Acacias, have arrived at a vertical position of their leaves by two different methods." After pointing out

---

* Veg der Erde, p. 216.

† Notes of a Naturalist on the Challenger, p. 264.

that the Acacias do this by flattening their leafstalks into phyllodia and the Eucalypts by twisting the leafstalk, he goes on to say: "In support of this conclusion, I was told when at Melbourne, that when native vegetation was cleared away from under gum trees, they ceased to thrive, and after a time perished. I was shown a number of gum trees not far from the city, scattered over some public land covered only with short turf, which seemed to be mostly in a dying condition."* I scarcely agree with this conclusion. Griesbach expressly says " The growth of grass beneath is aided" and Moseley says that under the dying trees the turf was still present, but short. He would therefore seem to say that it is the undergrowth other than grass which is of advantage to the trees. But everyone knows that as a rule Eucalyptus forests are singularly free from undergrowth. And I have known large areas of land which were cleared of all but the trees and the grass, and had been so for years, and yet the trees were perfectly healthy and flourished as well as the primeval forests on the hill-sides within a mile. R. Brough Smyth remarks: "In the camping places of the cattle you see many stately trees destroyed. The grass is beaten down and the long roots of the trees exposed to the intense heat of the sun, and the frosts of winter. When the roots are protected by litter or earth, the trees quickly recover and spread their branches with a luxuriance not observable even in the natural forest."† This I quite agree with. The benefit derived from the grass is merely mechanical, and could the trees have an even firm coating of soil without grass they would be just as healthy. The destruction of the grass affects the trees because it permits the water to tear away the protecting soil from the roots.

The making of roads causes a great alteration of surface drainage. Everyone who has travelled much on bush roads must have seen deep gullies cut along the road sides by the rush of water in the drainage channels on each side, and this of course acts in the same way as above.

---

* Loc. cit.

† Goldfields &c., p. 28.

The injury done by the alteration of surface caused by settlement is then : *first*, Actual destruction of forests on the land affected ; *second*, the alteration of surface drainage which renders the plants adjacent to the altered area more or less unhealthy, the water being carried off that formerly lay in the ground and supplied moisture to the roots, and the plants being affected by the exposure of their roots to heat, cold and winds.

(c.) *Indirect injury caused by the alteration of climate effected by clearing.*

Whether rainfall is affected by deforesting is a very vexed question among scientific men, and an imposing array of authorities may be marshalled on either side. It is hard to come to any definite conclusion on the subject, for meteorological observations, except in one or two instances, have scarcely been long enough accumulated.

Trees are said to temper climate and to increase rainfall. For example : "With regard to the influence of forests on rain and snow-fall, there is as yet only a single series of observations supplying comparative statistics, and extending over a sufficiently long period. These were taken in the neighbourhood of Nancy, and they show an important influence of forests on rain in the climate of Central Europe in increasing the rainfall. It might appear that the effects of forest on rain in the climate of Central Europe in winter would be small, for the difference between the temperature and humidity of the forests and open air is very little, and the quantity of moisture in the atmosphere is small. But the observations show that it is at this time of the year that forests get much more rain. This the writer attributes to the clouds being lower, the resistance which the forest offers to the movement of the air, and the moist west wind. Forests retain rain by the undergrowths of grass, moss, etc., much better than the open ground, and let water off superficially only after a heavy rainfall; the moisture filters up slowly, and much of it is used for the evaporation of the trees."*

* Peterman's Mittheilungen, quoted by E. Pollitzer in Sydney Quarterly Magazine, Vol. VII., p. 7.

"The fall of rain in any district increases with the increase of vegetation, and especially of forest growth. Trees and forests contribute to the formation of springs and watercourses, not only by means of the humidity which they produce, and the condensation of vapours by refrigeration, but also by reason of the obstacles which they present to the evaporation of the water in the soil itself, and by means of the roots which, by dividing the soil like so many perforations, render it more permeable and facilitate filtration. The clearing of forests and the consequent drying up or draining of marshes and bogs, have caused a material alteration, not only in the entire face of the country, but in the supply of water to the rivers, formerly derived from these resources, and in the periodical amount of rainfall and the regularity of its distribution. In Germany it is considered that, in order to secure a regular and sufficient rainfall in agricultural districts, the proportion of forest or woodland shall not be less than twenty per cent."*

Humboldt too, who first broached the theory, was of opinion that forests influence rainfall. Buff says: "The Canary Islands, when they were first discovered, were clothed with thick forests, and overgrown with the richest verdure. Great part of these woods were destroyed and burned by the first settlers; the result has been the lessening of their rains, and the dwindling away of their springs and brooks." Thus the rooting up or even the mere thinning of forests always exerts a striking influence on the moisture of a country. Many districts, which in former times were known for their rich fruitfulness, have lost, together with their forests, much of their flourishing condition, and have even been changed in part into desert. But you will also see that, by gradually planting trees, many regions of our earth, which have been hitherto waste and barren, may be rendered fit for tillage and the dwelling of man."†

Speaking of the Vindhya Range, Sir J. D. Hooker says: "The climate of the whole neighbourhood has of late changed materially;

* Prof. J. Scott quoted by S. Pollitzer—Sydney Quarterly Magazine, Vol. VII., p. 7.

† Physics of the Earth.

and the fall of rain has much diminished, consequent on felling the forests; even within six years, the hailstorms have been far less frequent and violent."* He then goes on to say: "The air on the hills is highly electrical, owing no doubt to the dryness of the atmosphere, and to this the frequent recurrence of hailstorms may be due." Here the author seems to contradict himself. He first says that hailstorms have been far *less* frequent and violent, and then that their frequent occurrence is due to dryness of the atmosphere. This, however, may be due to a misprint of "less" for "more" in the first passage quoted; and the important point is the opinion of so distinguished a scientific man, that deforesting lessens rainfall. But I am of opinion that such a statement unless upheld by meteorological records showing a progressive diminution of rainfall, is not to be depended upon as evidence that destruction of forests lessens humidity.

Mr. J. Ednie Brown says, "Scientific observation and research have, in the course of a century, proved beyond the question of doubt, that large tracts of forest country have a direct, a lasting, and a beneficial effect upon the climate; that a wise process of reforestation not only increases but equalises the rainfall, purifies the atmosphere, subdues aridity, prevents sudden floods, and as a natural consequence greatly tends to encourage increased settlement."* And he quotes Dr. J. C. Brown's work on "Forests and Moisture" as follows: "It will generally be found that the temperature, both of the earth and of the atmosphere, is lower amidst abundant vegetation than in a barren, sterile, stony district; probably the heat being absorbed and retained in a latent form by the process of vegetation in the one case, while in the other it is reflected unchanged. In consequence of this, if a wind in any degree hotter blow over a district covered with trees, this wind is cooled down; its power of holding water in a state of vapour is thereby diminished in a geometrical ratio with every fall of temperature, and a large deposit of moisture may follow in the form

* Himalayan Journal.

† Report of State Forest Administration for 1890, p. 2.

of dew, mist, or rain."* Again, "There can no longer be any doubt in the minds of those who have taken the trouble to study the subject, that large forests do really attract the rain-clouds. It is beyond the question of a doubt—it is a well ascertained fact."†

Dr. Ross says: "The practice of wholesale ringbarking I feel sure exercises a very deleterious influence on the growth of vegetation. Not only are the grasses, deprived of the protecting shade of the trees, scorched and withered by the unintercepted rays of the sun, but the radiation and reflection of the solar heat is far greater on the surface of uncovered mountains and treeless plains than from forests. The superincumbent air therefore becomes hotter; its capacity for sustaining vapour in suspension is decreased and the probability of rainfall is lessened."‡

In a paper on "The Effects of Forest Vegetation on Climate," by the late Rev. W. B. Clarke§ the author takes the same stand. In a resumed discussion of the paper, "Mr. C. Moore restated the points he had previously advanced as follows:—1. That the dense jungle vegetation, which of all others is supposed to attract and hold moisture, and which for about four hundred miles was so general within the coast range has been almost wholly destroyed during the same period. 2. That in addition to this, millions of acres of more open forest have been destroyed during the same period. 3. That notwithstanding this tremendous destruction no drier climatic effect has been experienced. 4. So far as my knowledge extends, the only observable effect has been that in some districts in which the forest has been destroyed small rivulets usually contained water, but in many instances are now dry. 5. That now the larger rivers of the Colony show no diminution in breadth or depth. 6. That the rainfall, instead of decreasing as might have been expected from the destruction of so much forest, has been of late years more regular and greater than formerly."

---

* *Id.* p. 3. † *Id.* p. 5.

‡ On the effect of Climate, etc. on Wool—Journ. Roy. Soc. of N. S. Wales, Vol. xvi., p. 237.

§ Journ. Roy. Soc. of N.S. Wales, Vol. x., pp. 179 - 228.

Many observers competent to form an opinion on the subject, agree with Mr. Moore that deforesting does *not* lessen rainfall. The New South Wales Government Astronomer, Mr. H. C. Russell, who has devoted much attention to the subject, and is certainly specially qualified to form an opinion thinks that the trees are the result of rain, and not the rain the result of the trees. Mr. Russell gives a comparison between the records of a gauge in densely timbered country, and of a number in a circle in open conntry round about. His summary is as follows:—"In 1887, therefore, the forest station had 6·26 inches less than the average for the district; in 1888, again 3·79 inches less than the average for the district; and in 1889, again 2·24 inches less; again in 1890 it was 3·03 inches less than the average for the district."*

Although a single set of observations like this cannot be taken as conclusive, yet it adds greatly to the probability of the theory that forests do not increase rainfall.

Dr. Draper in an article on the subject in the *Scientific American* supplement for January 3rd, 1880, is satisfied that deforesting does not lessen the fall of rain. He bases his opinion on the records of rainfall in the Eastern States of America (an area probably more cleared than any other in the world) and demonstrates that there has been no alteration of any moment in either the annual amount of rain or in temperature. And he corroborates this evidence by a consideration of the meteorological records of Paris, which show a slight increase in the amount of rain, but with oscillations either way. These records embraced at that time a period of one hundred and ninety years, and are probably the most extended series of observations in existence. It is rather strange that an opinion exactly opposite should be based on the same set of records—I take them to be the same—in the passage before quoted from Petermann's Mittheilungen.

Mr. W. E. Abbott, in a paper which I shall have further occasion to quote, remarks, "Indeed it is hard to understand how any

* On Results of Rain, River and Evaporation Observations made in New South Wales during 1890, [1892] p. 4.

forest could come into existence if the amount of rainfall were influenced mainly by the forest growth, as the forest would have to precede the rainfall and yet could not grow without."* Again "American observations show that the magnificent forests which extend from Minnesota to Maine have a rainfall identical with that of the nearly treeless plains which extend westward of Chicago";† and again, "The Government Astronomer of this Colony points to the rain records of England from 1762 to 1882—to those of France extending back to 1688—to those of the United States of America for a period of sixty-six years, and to those of this Colony for forty-six years—all of which show an increase not a decrease in the rainfall, notwithstanding the enormous amount of forest destruction which has taken place.‡

For my own part, I am satisfied that deforesting has not the effect of diminishing rainfall, and I quite coincide with the latter opinions. Further, I think, that since in little over one hundred years one-third of our forests have been destroyed, and that the destruction is still actively proceeding, the decrease of rainfall should be very marked, and would continue from year to year. But our records do not show this to be so. An examination of them seems to me to show that the rainfall follows the rise and fall of an undulating curve on either side of the mean, in obedience to a law which has yet to be discovered.

Dr. Lendenfeldt in the paper before referred to, on the spread of pine scrub in the interior attributes this to the occurrence of a dry period. But as he bases that theory on the occurrence of a dry period at the same time in Sydney and not on records taken in the places where the pine is spreading, I think we may safely consider the evidence as not conclusive enough to satisfy all reasonable demands as to probability.

---

* Ringbarking and its Effects—Journ. Roy. Soc. of N.S. Wales, Vol. XIV., pp. 97-102.

† First Report of Roy. Comm. on Conservation of Water, Abridged Ed., p. 15.

‡ *Ibid.*, p. 15.

But when the effect of tempering climate is taken into consideration, there is a general consensus of opinion that forests have a most decided effect, and also that they prevent the flow of surface water. Trees take up heat more slowly than the ground, the amount of evaporation from their leaves keeping their temperature down; the air and soil reach their maximum about four o'clock in the afternoon, but the trees go on heating till sunset, and then begin to part with the heat again, thus lowering the temperature in the daytime and raising it at night.

"While there appears ample proof that forests have no appreciable effect on the rainfall, it is beyond question that they have a moderating effect on the temperature. This is well illustrated in the case of two places in the Punjaub Plains, situated at a distance of eighteen miles apart, one in open country, and the other in dense forest. It is found that in the hot season, the temperature at the latter is generally 6° or 8° lower than at the former."*

Mr. J. Ednie Brown also points out in his report for 1890, that "Practical experience has shown wherever the experiment has been tried, the planting of belts of timber through the dry open country of Australia has been that the hot winds, which at present are the very scourge of such country, so far as their effect on vegetation is concerned, have very often been subdued altogether, but more often so softened and moderated by contact with the cooler atmosphere arising from the damper surface of the ground shaded by trees, as to pass almost harmlessly over the country."†

One effect of forests and an important one where the rainfall is light, is that slight showers of short duration do not reach the ground at all, the water clinging to the leaves, and after the shower being evaporated almost immediately.

The effect of ringbarking and deforesting on the surface flow is considered by Mr. W. E. Abbott in a paper before quoted, and his conclusion is that the flow of water in the creeks is increased

* First Report of Roy. Comm. on Water Conservation, Abr. Ed., p. 16.

† Op. cit., p. 3.

by ringbarking and he gives the measurements and outflow of these creeks in corroboration. In this I am able from personal observation to support him. I have had many opportunities of seeing that the amount of water in creeks is increased by clearing, although not always to so great an extent as mentioned by him.

The following quotations supply what he considers to be the reasons of such increased outflow. "First, the roots of the trees decaying may act as a sort of subsoil drainage, leading the water down into the subsoil and afterwards allowing it to drain off slowly into the watercourses. If this is the only cause, one of the greatest advantages of ringbarking will be but temporary. The other explanation—and the one which seems to me most probable—is, that when timber is dead the large proportion of the rainfall which was formerly taken up by the roots of the growing trees and evaporated from their leaves is allowed to find its way to the creeks and rivers. The fact that the Eucalyptus is perhaps the most vigorous growing tree known, and that it has been used successfully to dry up swampy land in other parts of the world, seems to support this explanation."*

It is the former action of ringbarking above alluded to that causes the improvement in grass land, which that operation is so well known to effect. The moisture lying in the ground being drained off, the sourer grasses and herbs have no longer a suitable habitat and die off to give place to sweeter and better feed. I have seen a paddock formerly clothed principally with Apple trees *(Angophora intermedia)* and covered with rushes, sedges, sour grasses, mosses and hepaticæ, and in the course of a few years after ringbarking, all the worthless plants had disappeared and the paddock was covered with sound sweet feed. Further, from being a very boggy piece of land in wet weather, it changed into solid enough ground.

The conclusions I arrive at therefore are (1) that deforesting and ringbarking do not dimimish rainfall; (2) that these operations dry the air, and render the effects of hot winds more felt;

---

* Op. cit., pp. 100 – 101.

(3) that they also cause the water to drain more readily out of the soil and so render it drier. (4) That these effects being wrought, there is a very decided modification of the flora caused by deforesting, etc.

(d) *The effect of clearing on the fauna reacting on the flora.*

This is most decidedly a potent factor in the alteration of the native flora. For instance the destruction of shelter for the smaller marsupials leads them to flock to the forests left and become more abundant there. But their natural enemies being diminished by the settlement of the country, the damage or benefit they cause to plants, directly or indirectly, will increase in those places and the flora will be modified accordingly. This subject, however, will be better considered in the second division of the paper.

(e) *The effect of checking bush fires on the vegetation.*

Previous to the settlement of Australia, bush fires undoubtedly played an important part in causing the changes—great or small —which then went on in the native flora. The aborigines were in the habit of setting fire to grassy tracts of country in order that the animals on which they lived might fall an easier prey to them ; and also in some cases, that the sweet fresh feed which springs up after a fire might attract kangaroos and wallabies. And doubtless too, they were as careless with their fires as white men so often are, and so accidental conflagrations took place. Either through lack of means or of inclination, they did not usually attempt to check the fires, which spread over vast tracts of country and in this way many plants must have been destroyed locally, and the flora so modified. And although at the present time (and still more in older days) the settlers burn off long dry grass so that their stock may have the fresh, young feed which so soon appears, yet on the whole it has been their aim to fight the fires and keep them down.

Most of us know the great alteration which a bush fire makes in the tract burnt. The coarser undergrowth is destroyed and does not reappear for a long period of time, and the annual and herbaceous plants have a better chance of flourishing in such an area the next spring. Then, too, the bulbous-rooted plants, although their leaves and stems are destroyed, come up with renewed vigour after the next rain, and also have some amount of advantage given them in the struggle for existence by the destruction of their coarser and stronger competitors which before cut off so much of the light and air from them. As a rule, a burnt tract of country is notable for the show of terrestrial orchids and liliaceous plants it makes the following spring; indeed some orchids are actually shy of blooming excepting after a fire. The late Mr. R. D. Fitzgerald remarks that *Lyperanthus nigricans* flowers as a rule only after a fire;* and I have observed the same thing myself. Wishing to get some flowers from a cluster of plants which I had known not to have blossomed for some years, I heaped some dry leaves on them and burnt them off, and was rewarded the next year by several spikes of flowers. And I have recently seen large numbers of plants of *L. Burnetti* in bloom on a burnt tract where for five years previously I had not seen a single flower.

Among plants which are undoubtedly benefited, as far as propagating their species goes, are the wattles. Their seeds have a coating of an extreme, almost stony, hardness, and will lie on or beneath the soil for an indefinite time without germinating. But let a fire sweep over a spot where wattles grow, and although it may destroy hundreds of mature trees, yet it will burst the hard testa of the seeds and the result will be myriads of young and healthy plants. On this account writers on the subject of wattle culture recommend the seeds to be placed in boiling water or scattered in the glowing embers of a fire of twigs, and then when sown they will quickly germinate.† The prevalence of young wattles after a bush fire is a fact that must have struck the most unobservant in the bush.

In a paper by the late Rev. R. Collie, "On the Influence of Bushfires in the distribution of Species,"‡ he gives an account of

---

* Australian Orchids, Vol. I., Pt. iv.
† *Vide* J. H. Maiden—Wattles and Wattle Culture.
‡ Journ. Roy. Soc. of N.S. Wales, Vol. XIV., p. 103, *et seq.*

a tract of land traversed by a bushfire (judging by its flora, it must have been on the Hawkesbury Sandstone formation, as the the plants are very characteristic of that soil) where the majority of plants covering the ground before the fire did not reappear, their places being taken by allied species and many distinct ones. He gives a list of one hundred and twenty one species collected on the burnt space, and on examination of the list, I find that seventy nine are either herbaceous or small shrubs, fourteen being terrestrial orchids, which bears out what I said above as to annual and herbaceous plants being advantaged.

Mr. A. W. Howitt, F.G.S., in a paper on the Eucalypts of Gippsland,* remarks that the annual bushfires tended to keep the forest open, and prevented open country from being overgrown; that they also acted as a check to insect life destroying among others those that prey on Eucalypts, and that therefore any cause lessening the number and force of bushfires alters the balance materially and thus produces new and unexpected results. He points out that parts of the Snowy River valley once open and free from forests, at present show whole tracts of country covered with sapling forests of *Eucalyptus hemiphloia*, *E. pauciflora*, *E. viminalis*, *E. amygdalina*, and *E. stellulata*, and he also mentions other localities where the same has taken place.

As Mr. Howitt points out, bushfires have an indirect effect on vegetation, since they destroy multitudes of insects, some of which may have been fitted to fertilise certain flowers. In this way plants at a distance might be put at a disadvantage through a fire; or insects preying on plants being destroyed, the plants concerned would be benefited. Again, insectivorous animals of small size are overtaken and burnt, and here again a mesh of the network between the animal and vegetable kingdoms would be affected for both injurious and beneficial insects would be less liable to destruction by their natural enemies and many plants would in consequence suffer or benefit. But in the present state of know-

* Trans. Roy. Soc. of Victoria, Vol. II., p. 81.

ledge of such subjects in Australia, no more can be done than indicate how modification, other than direct, might occur.

The alteration in the mechanical and chemical structure of the soil is a point that must not be lost sight of. The burning of quantities of vegetable matter must add potash to the soil, while the great heat chars some of the organic constituents of the soil, and alters the clays and stiff soils mechanically. Such changes must benefit some plants more than others, and here again another cause of change occurs.

Again after a bushfire, the surface of the ground having lost its protecting investment of grass, etc., would be more liable to erosion in a wet season and consequently alterations of surface drainage would take place, with consequences to plants that have already been pointed out, and will be alluded to again in Division II.

Since then bushfires have so great an influence, direct and indirect, on the flora, it must be regarded as proved that the checking of the fires results in as great an effect in the opposite direction.

But besides all the effects indicated above, there is still another though obscure one, which must be touched upon: the destruction or modification of a flora reacts on the animal kingdom, and that acts again on the flora. The complex network of relations between organisms is such that any disturbance of any part, alters the balance in all parts, just as a stone thrown into a quiet pool produces waves which not only proceed to all parts of the shore, but are reflected back again in all directions and thus produce most complex wave systems by interference with each other. It is difficult, if not impossible to say what effects may have been produced in this way, but that there are such effects is a point beyond all dispute. The sweeping away of whole groups of plants must necessarily destroy the means of subsistence of groups of insects which live on these plants. But as many insects fertilise plants (and usually different species to those on which their larvæ live) some flowers would remain partly or entirely unfertilized, which would be a disadvantage to them in the struggle for existence, and they would to some extent drop out of the race. Again, the surface disturbances would destroy other insects and the same would occur here, while on the other hand, the accumulation of dead timber would favour wood-boring insects and these if specialised to fertilise any particular plants, would give an advantage to those plants in competition with others not so favoured. It is easy to see then, how destruction of forest and other flora might react on the native fauna, and cause scarcity or extinction, or increase to a large extent in various groups of the animal kingdom, and this increase or extinction would have a very important effect on the flora.

Division II.

Introduction of a new fauna altering the flora; and the destruction of the native fauna modifying it.

This may be divided into two subdivisions: first, The introduction of a new fauna, and second the destruction of the native fauna—altering indigenous vegetation. These may be examined under the following heads :—

First Subdivision—

(*a*) Direct destruction of flora caused by introduced fauna.
(*b*) Alteration of drainage caused by introduced fauna.
(*c*) Alteration of soil caused by introduced fauna.
(*d*) Spreading new plants by introduced fauna.

Second Subdivision—

(*a*) Direct destruction of native fauna and its effects on plants.
(*b*) Indirect modification of native fauna and its effects.

First Subdivision—*Introduction of a new fauna.*

The introduced fauna is fairly large and comprises animals of many natural orders. The vertebrates comprise dogs, foxes, cats, rabbits, hares, rats, mice, cows, buffaloes, sheep, goats, deer, camels, swine, horses, birds, particularly the domestic fowls, pigeons and sparrows. Among the invertebrates are planarian worms, earthworms, various ento- and ecto-parasites, insects and mollusca.

The mischief done to the flora by dogs and foxes is indirect and may be better considered under Subdivision 2.

Rabbits and hares, were, I believe, introduced for sporting purposes, but it was never imagined that their new home would be so suitable a habitat for them. Indeed, in some parts of the country they were a long time getting a footing. I knew a station where rabbits became wild through escaping from domestication, and took up their quarters in the stock-yard. They became plentiful for a while, but the continued attentions of the station cats and dogs at last cleared them out. Now, however, the same place is infested with rabbits which have arrived from other places where they did succeed in getting a footing.

The number of rabbits in the Colonies now is astounding, and one can form a good idea of how they have increased by perusing the returns of numbers destroyed. In the *Daily Telegraph* of March 21st, 1892, the following is given as the number destroyed at fifteen stations in the western interior during the summer of 1891-2:—Billella, 150,000; Morara, 300,000; Cuthero, 150,000; Nettly, 300,000; Outer Netallie, 80,000; Momba, 1,000,000; Kilfera, 1,250,000; Marfield, 147,000; Mount Manara, 150,000; Baden Park, 30,000; Fulham, 70,000; Kew, 69,000; Tilcha, 250,000; Forty-eight Mile Tank, Booligal Road, 17,400; Thirty-five Mile Tank, Booligal Road, 40,000; Twenty-six Mile Tank, Booligal Road, 73,500; making in all a grand total of 4,086,500. Again in the same paper for April 7th, 1892, Outer Netallie is given as 120,000, being 40,000 more and Mooriba 2,000,000. The Rabbit Inspector, Mr. A. R. Torrens, who sent in the report to the Minister for Mines, believes that for every one destroyed, at least thirty died. These returns only refer to holdings on the south side of the Darling on the boundaries of the Cobar and Balranald land districts. These being the numbers destroyed in a part only of the Colony, what must the rabbit population be of the whole of the infested Colonies?

Estimates are, I believe, sent in quarterly or annually by the Stock Inspectors, of the number of rabbits, hares, marsupials, etc., in their respective districts. But these statements are too loose to have any value in a scientific point of view, while the returns of killed have this value, being statements of actual facts which have come under observation.

The damage done to indigenous vegetation by introduced rats and mice is probably small, certainly nothing to be compared to that wrought by the immense hordes of indigenous rats and mice which at times cross the interior plains.

When we consider the animals grouped under the name of stock however, the case is very different. In Australian Statistics for 1890,* I find the following numbers given for the Australian Colonies (in all these figures, as in those for roads, railways and telegraphs, I have omitted New Zealand):—Sheep, 97,878,619; Cattle, 9,903,692; Horses, 1,509,669; Swine, 889,333. The significance of these figures will be better appreciated if we take the number to each square mile in Victoria and New South Wales

	New South Wales.	Victoria.
Sheep,	180·19	144·92
Cattle,	6·14	20·29
Horses,	1·43	4·97
Swine,	·91	3·21

Making 188·67 animals to each square mile in New South Wales, and 173·39 in Victoria.

When we consider that all these animals are introduced and have been spread over a new country, where the native fauna as regards individuals was very scanty, it is not difficult to see how much they must have injured the native vegetation.

With regard to the birds—the domestic fowls, pigeons, the sparrow and a few others, I am not aware of any statistics of their numbers.

Among invertebrates the most noticeable groups are insects, of which the Phylloxera, the Codlin Moth, some destructive weevils and an American butterfly (not however an introduction of settle-

* T. A. Coghlan—Govt. Printer, Sydney, 1891.

ment) are the most prominent. Of the Mollusca twenty-four* species of foreign snails and slugs have been introduced, a list of which is given by Mr. C. Musson.†

There are several introduced earthworms, which certainly have an effect in loosening and fertilising soil, but in view of the very large number of indigenous species and individuals of these animals found in Australia, their work need not be considered. It is remarkable however, how widely they have spread, introduced earthworms have been collected far beyond Bourke.

(a) *Direct destruction of flora by introduced animals.*

Taking rabbits and hares first, there can be no question but that they destroy immense quantities of plants. In an ordinary season when grass is fairly plentiful, their ravages are chiefly confined to that, and they do little harm in that way. But when a dry season comes, and food is scarce, hunger drives them to courses they do not ordinarily take. Their habits change under the pressure of starvation, which bears out what has been said by Chas. Darwin of the innate plasticity of constitution in organisms becoming active when they are removed to new habitats and surroundings. They have been accused (I am not prepared to say with how much truth) of swimming rivers and climbing over wire-net fences in their migrations in search of food. It is certain that in the western plains, the scrub over large areas has been killed by their gnawing the bark off (a habit which has been taken advantage of in killing them, poisoned twigs being scattered about their haunts) and it is well known that they climb bushes to get at leaves, young twigs and bark, an addition to their powers since they reached Australia, as a climbing rabbit was never heard of in England. In numerous localities, areas of many square miles have been denuded of all grasses and herbaceous plants, the roots dug up and devoured, and the bushes killed as above mentioned. In the report before quoted, Mr. Torrens says, "In the driest spots

* Since writing the above, Mr. Hedley has been good enough to look carefully into this question and he raises the number to twenty-six.

† Proc. Linn. Soc. of N.S. Wales, 2nd Series, Vol. v., p. 883.

a small thriving colony of rabbits may be met with, living principally on a watery yam something after the nature of a radish. . . . . Very serious damage has been done by the rabbits to the scrub country. Four species of trees have been found to be unbarked by the rabbits, and while the rabbits have killed some useless bushes, and prepared country for the growth of grass, still the carrying capacity of the land is much affected by the pest."

Destruction of this kind done in a dry year is never got over thoroughly. What the rabbits begin, the drought finishes and the pasture land is never again the same. Of course myriads of the animals perish in such a season, but the rapid breeding of the survivors soon brings the numbers up again, when a good season comes, and then the next drought advances the destruction another stage. Large amounts of money have been spent by South Australia, Victoria, Tasmania, New Zealand, and New South Wales, and by private individuals in endeavouring to exterminate the pest.

In an article in *Scribner's Magazine* for February, 1892, on "Station life in Australia," by Mr. Sydney Dickenson, the writer gives, on the authority of Mr. Black, Chief Inspector under the Vermin Destruction Act, Victoria Lands Department, the following figures: "Expenditure in connection with the destruction of rabbits in Australia for the seven years ending 30th December, 1890—Victoria, £190,000; New South Wales, £820,000; South Australia, £250,000; and expended by land owners in same period and approximate losses of crops and grass, £2,700,000. During five years prior to 1889, New Zealand, Queensland, and Tasmania, spent £150,000 in the same way, and the personal expenditure and losses of the owners for that period in these three colonies is estimated at £750,000. This would make a grand total of £4,860,000."

A reward of £25,000 offered by the New South Wales Government for a method of destroying the rabbits, brought out a multitude of plans, the chief being Pasteur's method of inoculating with chicken cholera, but no certain remedy has been hit on yet.

So far, the most promising seems to be fencing off the water with wire netting and then when the rabbits in dry weather congregate round the enclosure, supplying them with water poisoned with arsenic. Poisoned sticks, grain, and jam have also been much used and are very effectual. It seems to me however that the rabbit plague is rapidly reaching that stage when it will prove its own remedy. Unfortunately it is scarcely practicable to wait for this, for before the effects of overcrowding became severe, all the live stock in the West would probably be dead of starvation. I am inclined to think that if Pasteur's virus of chicken cholera would do the work, it would be worth trying. But unfortunately Dr. Katz's experiments at Rodd Island seem to show that it is incapable of standing the high summer temperature experienced in the Western Interior, which at once destroys all hope in that direction.

With regard to hares, their ravages, although very serious, as yet bear no comparison to those of their cousins the rabbits. Indeed from a personal knowledge of their habits, I should say that their mischief was chiefly done to farmers' green crops and to trees, both fruit and ornamental, which have been introduced. They do not seem to have wandered into the inland dry country very much, or if they have, the damage done is lost sight of in the greater destruction wrought by rabbits. Pastoralists complain of the rabbits, farmers of the hares.

The pasturing of sheep and cattle damages the indigenous flora in much the same way as the rabbits do. Given a few good seasons and owners let their flocks and herds increase to the verge of the carrying capabilities of their holdings. When drought comes, the starving animals devour every vestige of green herbage, pull the roots out of the ground and eat them, and even lick the seeds off the surface. I remember once expressing surprise to the owner of a river frontage near Mudgee at the good condition of his stock in a dry season. He told me that in the spring there had been an unexampled growth of trefoil (*Mendicago denticulata*) on the river banks which had produced a very large quantity of seed, and this lying on the ground was licked up by the stock when the herbage failed and so they kept up their condition till the rains came and brought succulent green feed again. This I was able to confirm by personal observation subsequently. The same thing occurs also with native plants. What chance have plants to succeed when they are eaten off root and branch and the very seeds licked up off the ground?

The most valuable of the native forage plants in the West are the saltbushes of various species. But through overstocking and droughts many of the best species, especially the "Old man saltbush" *(Rhagodia parabolica)* are rapidly failing under the severe conditions to which they are subjected. Dr. Ross in a paper on the "Effect of Climate etc., on Wool,"* states his opinion that the best native grasses and forage plants die down as they are eaten back again and again and so are destroyed while worthless weeds are left. This is particularly the case when a wet winter and spring are succeeded by a dry summer, for in a wet time more of the seeds shed the previous autumn will germinate, and less will be left dormant in the ground.

Many forest trees too, have been cut down for the purpose of feeding stock with the leaves in drought. To such an extent was this done during droughts, that the cattle would gather at the sound of the axe. There is now however, legislation which forbids the destruction of trees useful for fodder—they may be lopped and the branches fed to the stock, but the trunk must be left. This particularly applies to the Sandal-wood of the Murray River and the Currajong (*Brachychiton populneum*) the mucilaginous leaves of which are much relished by cattle. It seems a marvellous thing that people should have to be protected from themselves by Act of Parliament, but so it is.

There is a very obvious remedy for this state of things, *i.e.*, to avoid overstocking, but it is one that is not always taken, owners often preferring to risk a bad season coming. There is another

* Journn. Roy. Soc. of N.S. Wales, Vol. XVI., p. 237.

remedy as yet taken only by a few, whose number however is quickly increasing. On most runs, even if fully stocked, there is a superabundance of feed of all kinds in a good season, and the stock do not diminish it greatly. Hundreds of thousands of acres of good pasture are allowed to stand uneaten in a drooping season, till it dries up and is either set fire to accidentally or purposely; or till it blows away in dry straw. But if taken at the right stage enormous masses of hay could be made with the expenditure of a little trouble and less money. A mowing machine and a horse rake would be the means of conserving enough fodder in a good season to tide many an owner over a drought. And still better while the fodder was young and green, it could be made into juicy silage, far more fattening and palatable to stock than even bush hay. These methods of conservation would still leave the plants alive and with a chance to survive the drought when it came.

But as things are at present, our forage plants (and they are our most valuable plants, since our chief wealth lies in our sheep and cattle) are likely, if not to become extinct, at least to get scarcer and scarcer every year. All practical and experienced men are agreed that during the past twenty years the plains have diminished in stock bearing capability twenty or thirty per cent., and that the diminution continues year by year.

The above remarks apply more particularly to the plains, where the pressure of dry seasons is felt more severely than in either the coast district or the table-lands. But even in these districts many fodder plants are becoming rarer, and numerous settlers have felt the necessity of laying down artificial pastures with foreign grasses to make up for the diminished grazing capabilities of their holdings.

Another remedy has been suggested, *i.e.*, the conservation of rainfall with a view to irrigation. Where irrigation has been experimented with on the plains, the combination of heat and moisture has caused a phenomenal growth in herbage.

In 1886 the Royal Commission on Conservation of Water estimated that the carrying capability of the Colony of New South Wales was 55,000,000 of sheep if irrigation were carried out; but in 1890 the Government Statistician gave the number in the Colony as 55,986,431—nearly a million over the Royal Commission's estimate under irrigation. I think it is not too high an estimate to say that New South Wales is capable of carrying at least 100,000,000 if the two last courses were resorted to viz. :—converting on overplus of feed into hay and silage, and conserving the rainfall for irrigation. If, as we have been told, he who makes two blades of grass grow where one grew before, is a benefactor to his species, what could be said of a plan which would do that over most of the vast area of Australia, and so double the wealth of our land?

Before leaving the subject of the effect of pasturing stock, I may quote the following passages from Wallace :—"We know for example that the introduction of goats into St. Helena utterly destroyed a whole flora of forest-trees"; and "Cattle will in many districts prevent the growth of trees."* And again Charles Darwin says: "But how important an element enclosure is I plainly saw near Farnham in Surrey. Here there were extensive heaths, with a few clumps of old Scotch firs on the distant hilltops: within the last ten years large spaces have been enclosed, and self-sown firs are now springing up in multitudes so close that all cannot live. When I ascertained that these young trees had not been sown or planted, I was so much surprised at their numbers that I went to several points of view whence I could examine hundreds of acres of the unenclosed heath, and literally I could not see a single Scotch fir, except the old planted clumps. But on looking closely between the stems of the heath, I found a multitude of seedlings and small trees which had been perpetually browsed down by the cattle. In one square yard, I counted thirty-two little trees; and one of them with twenty-six rings of growth had, during many years tried to raise its head above the stems of

* Geographical Distribution of Plants, 1st Ed., Vol. I., p. 44.

the heath, and had failed. No wonder that, as soon as the land was enclosed, it became thickly clothed with vigorously growing young firs. Yet the heath was so extremely barren, and so extensive, that no one would ever have imagined that cattle would have so closely and effectually searched it for food."*

(b) *Alteration of drainage caused by the introduction of a new fauna.*

It has already been shown in Division I. how alterations in surface drainage may affect the plants of a country. It now remains to be seen how drainage is altered by stock.

A very good description of how the damage is done is given by Mr. R. B. Smyth in the following passages:—"Quite extensive tracts of forest lands have lately deteriorated by the decay of belts of trees. Numerous theories have been started to account for the destruction of the timber on these once flourishing areas. Many suppose that insects have attacked the tender buds, and destroyed them, or the roots, and prevented their growth. Others suggest that the extraordinary increase of the smaller marsupialia, now that their natural enemy, the dingo is, in inhabited parts, almost extinct, has caused the mischief. But after examining many tracts where the trees have decayed both in the level country and in the high lands, I am inclined to think that, in most cases, the trees are killed by the changes effected on the surface by cattle and sheep which have been introduced by the settler. The tracks made by these animals carry off the rain water, and, when there is a slight incline, these tracks deepen into gullies, and drain the land so effectually as completely to destroy the conditions which in the natural state of the ground were favourable to the growth of the gums. In the camping places of the cattle, you see many trees destroyed. The grass is beaten down and the soil broken and the long roots of the trees exposed to the intense heat of the sun, and the frosts of winter. When the roots are protected by litter or earth, the trees quickly recover and spread their branches with a luxuriance not observable even in the natural forests."†

* Origin of Species, 6th Edit., p. 56.
† Goldfields and Mineral Districts of Victoria, p. 28.

"Here in Australia we may observe the surface as nature has formed it. The aborigines have not spoiled it nor improved it, nor scarcely at all altered it, but where the cattle of the settler cross a well-grassed slope in any part which is naturally moist, immediate changes are effected. The surface waters begin their work at some small hole made by the hoof of an ox, and gradually enlarge and deepen it, (always working backward towards the hill) until a dry channel several feet in depth is excavated. In this way thousands of cubic feet of soil are carried into the low-lying valleys by streams in places where for ages there has been no current or denudation."

"Large swamps which in the memory of settlers have been dry lands for several years in succession, have by tillage and drainage of the adjacent slopes, been converted into lakes which have in a brief period increased in depth and area, and inundated large tracts of fertile land. Lake Learmonth, Lake Burrambeet, and notably Lake Modewarre are notable instances of this kind of action."*

Any one familiar with sheep runs in hilly country will remember the net work of paths on the hillsides; and by the formation of these tracks, drainage is largely affected. Cattle do even more damage in this respect, and many landslips occurring on steep hillsides can be seen to have had as a starting point a cattle track. There is a very curious damage done by cows to the surface on the steep slopes of the Illawarra Range. Along the hillsides are to be seen tracks composed of alternate grassed lumps and hollows between, bare of grass, and in wet weather full of mud. They look like the impression of a huge cog-wheel on the soil, and where they go directly down the hill form regular flights of steps. I cannot say with certainty how they are formed, but believe that the cows all tread on the same spot day after day and so cut the hollows. These hollows, small as they are, are often the origin of landslips; besides which they invariably hold water a considerable time after rain, and become centres of little colonies of rushes and sedges which soon begin to spread over the pasture.

* *Op. cit.*, p. 206.

The amount of hurt done to the surface of a hillside by a herd of cattle rushing down in very wet weather, must be seen to be appreciated. The soil is cut away and poached into mud, and large quantities of herbage destroyed. A heavy downpour of rain coming soon after will convert the place into something resembling the bed of a mountain torrent more than a hillside pasture.

As to what effect the surface alterations have upon the vegetation, I have already spoken in Division I.

(c) *Alteration in soil caused by pasturing stock.*

This occurs in two ways : first, by taking constituents from the soil; and second, by adding other substances to it.

With regard to sheep, the enormous quantity of wool yearly taken from the soil, and in lieu of which nothing is added but the droppings of the animals, must result in a change in the composition of the soil such as will render it less suited for the growth of the original vegetation. And with cattle and sheep alike, the same is the case with regard to the flesh consumed by the inhabitants of the colony (and indeed many outside of it) and the skins, etc., exported. In the case of the native animals, most of the substances removed from the ground are returned to it again in their excreta, or in the bodies of the animals themselves at their death. But now, taking wool into consideration, we have some hundreds of millions of pounds of wool sent out of Australia annually. For instance Mr. T. A. Coghlan gives 306,308,699 lbs. as the total export of wool for 1890 for the six colonies. And this goes on, and increases year after year, while little or nothing is added to replace the valuable constituents which in the economy of the animal are converted into wool.

I have not the figures showing the amount of flesh consumed, but taking the population of Australia as 4,000,000, and the amount consumed as averaging 1lb. per week (manifestly a very low estimate) we have 208,000,000 lbs. of flesh taken from the soil every year (omitting consideration of horns, hoofs, hides, bones, and offal) for which again there is little or no return. This enormous drain cannot go on without affecting the plant bearing capacity of the soil.

With regard to the second head—the substances added to the soil, they consist mainly of excreta and the dead bodies. Human excreta and bodies as at present treated may be considered as making no addition, and those of animals very little, the latter being as a rule scattered over wide spaces. But even so, a greater proportion of the droppings of sheep reach the soil now as compared with the old days when the animals were shut up in yards ten or twelve hours out of every twenty-four. Then nearly half the manure accumulated in the yards; and people who recall the system must have a lively recollection of the state of these sheepfolds when used for a long period. Certainly some of the manure, dissolved by rains and carried away in surface water by the fall of the ground, did reach the vegetation again, but only to a limited extent, and on a restricted area.

The amount of change produced in the local flora by the addition of substances derived from the excreta, or dead bodies of introduced animals may fairly be regarded as so small as not to be worthy of consideration.

(c) *Spreading new plants by the introduction of new animals.*

This is a very potent factor in the alteration of the native vegetation but will be best considered in Division III.

Second Subdivision—*The destruction of native fauna or its modification altering vegetation.*

(a) *Direct destruction of the native fauna and its effects.*

The amount of destruction wrought among the native animals by settlement has undoubtedly been very great. Many animals and birds have become very scarce, and are only to be found in sequestered spots. And we may expect from the experience of other countries, that in time, a portion of our fauna will become extinct. As cases in point the buffalo in North America, the dodo and solitaire in Mauritius, and nearer home, the Nestor parrot of

Phillip Island, will occur to every one. And many examples of local extinction have already occurred. The brush-turkey, was I believe found in the Illawarra district, but none are found there now. And only the shy and retiring habits of the lyre bird have kept it from sharing the same fate, it is so hunted and persecuted by people, who, when they get a specimen, cut the tail off and throw the rest of the bird away. Animals good for food or for other purposes, or noxious from their destroying domestic animals, grass, or cultivated crops, will naturally be the first exterminated.

In the first group of animals, the dingo is the one most destroyed. The destruction which even one dingo will work among a flock of sheep is so great, that it is very desirable that they should be destroyed and in most parts of the Colony a reward of £1 is given for the scalp and tail of each dingo killed. This has had the result of making them very scarce in all but the most inaccessible parts of New South Wales.

Among the second class the kangaroo family is pre-eminent. These animals not only destroy grass which should support valuable stock, but their skins are a marketable commodity and fetch a good price, and so it is doubly profitable to destroy them. The kangaroo-hunter gets a bounty for the scalp of each and is able to sell the skins at a high figure. So far indeed, the process of extermination has not begun to lessen their numbers very greatly, but the time will come when kangaroos will be, if not extinct, at least very rare.

The destruction of the native fauna must have a very marked effect on the plants. For example, the extinction of the Entomophagous group of marsupials might result in the increased numbers of certain insects on which they chiefly lived, and these insects might be hurtful to plants as eating them either in the larvæ or imago state; or beneficial as fertilisers of some plants which would naturally produce larger quantities of seed, and thus gain an advantage over their compeers. Or the destruction of the Sarcophagous marsupials and birds of prey would allow the Entomophagus group to increase, and in this case the insects would suffer and the plants be correspondingly benefited or injured. That this is no far-fetched theory, Darwin's well-known instance of the influence of cats on the yield of red clover shows.*

There can be no doubt that the extermination of the aboriginals, the native dog and other enemies of the Poephagous marsupials has resulted in an enormous increase of the latter, and that plants have been affected thereby to no small extent. In the same way the extinction of certain Meliphagidæ and honey-eating paraquets, would cause trees habitually fertilised by them to become more or less barren. Many of our eucalypts are fertilised by paraquets. Indeed some naturalists have gone so far as to express an opinion that certain puzzling species of this genus which systematists find hard to place or even to separate, are really hybrids made by birds of this kind in their search for honey. Be this as it may, there is no doubt that any such alterations in a flora would be brought about with extreme slowness, although the extinction of animals and insects, or their increase, might have taken place at a very rapid rate. Furthermore it would be a change which would be difficult to detect, and there can be no doubt but that it would be modified by the action of the principle of Natural Selection. For when we consider the vast amount of variation which takes place in every species (on this subject *vide* Wallace's Darwinism, Chap. III.) it is hard to avoid the conclusion that some individuals would vary in a direction giving them a better chance of survival under the changed conditions, and slowly but surely such individuals would establish themselves, first as a dominant race, and at length a species fitted for the new opening in the organic network.

Darwin gives an instance "Showing how complex and unexpected are the checks and relations between organic beings which have to struggle together in the same country. . . . . In Staffordshire, on the estate of a relation, where I had ample means of investigation, there was a large and extremely barren heath, which had never been touched by the hand of man; but several

* Origin of Species, 6th Edit., p. 57.

hundred acres of exactly the same nature had been enclosed twenty-five years previously and planted with Scotch fir. The change in the native vegetation of the planted part of the heath was most remarkable, more than is generally seen in passing from one quite different soil to another; not only the proportional number of the heath plants were wholly changed, but twelve species of plants (not counting grasses and carices) flourished in the plantations, which could not be found on the heath. The effect on the insects must have been still greater, for six insectivorous birds were very common in the plantations which were not to be seen on the heath; and the heath was frequented by two or three distinct insectivorous birds. Here we see how potent has been the effect of the introduction of a single tree, nothing whatever else having been done, with the exception of the land having been enclosed so that cattle could not enter,"* And again: "In several parts of the world insects determine the existence of cattle. Perhaps Paraguay offers the most curious instance of this; for here neither cattle nor horses, nor dogs have ever run wild, though they swarm southward and northward in a feral state; and Azara and Rengger have shown that this is caused by the greater number in Paraguay of a certain fly which lays its eggs on the navels of these animals when first born. The increase of these flies, numerous as they are, must be habitually checked by some means, probably by other parasitic insects. Hence if certain insectivorous birds were to decrease in Paraguay, the parasitic insects would probably increase; and this would lessen the number of navel-frequenting flies—then cattle and horses would become feral, and this would certainly alter (as indeed I have observed in South America) the vegetation: this again would largely affect the insects; and this, as we have just seen in Staffordshire, the insectivorous birds, and so on in ever-increasing circles of complexity."†

Another instance of insects determining the existence of mammals occurs in the Tse-tse districts of Africa, where horses and

* Origin of Species, 6th Edit., p. 55 *et seq.*
† *Ib.* p. 56, *et seq.*

cattle cannot be kept domesticated, much less run wild, through the bites of a small fly.

Again, the effect of the presence or absence of certain mammals on the vegetation is well shown in the oft-quoted fact—(before referred to) that the success of red clover in seed-bearing, depends largely on the presence of cats in the neighbourhood, which keep the field-mice down, and so allow the humble-bees to increase, (the latter being preyed on by field-mice) and as humble-bees are supposed to be indispensable to the fertilisation of the red clover, the yield of seed would naturally increase with the presence of cats. For this reason humble-bees were acclimatised in New Zealand, and the red clover has become thoroughly naturalized there; attempts are being made to bring about the same state of affairs in New South Wales by importing the humble-bee from New Zealand. I have seen, however, that red clover is quite fertile at Mt. Wilson in the Blue Mountains, and is spreading there rapidly. My friend Mr. J. D. Cox, called my attention to the fact that every head was full of seed, which shows that either the plant has learned to fertilise itself in its new habitat, or that some suitable insect has found it out. This latter I am disposed to think the true state of the case from the fact that it so uniformly produces seed and that it has only recently been introduced there. We were not able, however, to discover any insect actually at work on it. On mentioning this fact to Mr. F. Turner, Botanist to the Agricultural Department, he informed me that he knew of the plant seeding in other localities of New South Wales.

(b) *Indirect modification of the native fauna and its effects on the flora.*

A good deal of the foregoing applies to this heading also. The destruction or protection of one group of animals has a corresponding effect on other groups, and from them it is transmitted to the flora. For example, the destruction of birds of prey, and dingoes has caused a great increase in the numbers of some of the smaller marsupials, *e.g.*, opossums and bandicoots. These latter in the neighbourhood of farms do much damage to potatoes and root crops in general. From the amount of destruction wrought in this way, we are able to gauge the amount done to native plants whose roots they feed on. I have seen in a single night, a paddock of one acre completely rooted up by bandicoots. Kangaroo rats, too, generally increase in new settlements and must have an effect on the flora.

Within the past few years, there have been many instances of Australian forests decaying, discussed by various authors. Mr. R. B. Smyth has already been quoted on the subject, his opinion being that the alteration of surface drainage and consequent erosion of the ground is responsible for most of the damage. But while I am convinced that much damage is done in this way, I have seen some instances where this could not have been the cause, and where it must be attributed to an undue increase of some animals caused by the alteration of conditions following in the wake of settlement. As the following will show, I am not alone in this opinion. In a paper by the late Sir William Macleay, an account was given of the amazing numbers of Phasmidæ found on Eucalypts at Binda (now Jenolan) Caves by the late Mr. C. S. Wilkinson, Government Geologist. The insects were described as lying in heaps under the trees, which were completely denuded of leaves by them. Such an enormous increase in number of these insects must have had some cause, perhaps the decrease of the various birds—*Podargus*, *Dacelo*, etc., preying on them.* Mr. A. W. Howitt gives an instance of a belt of red gums (*Eucalyptus rostrata*) destroyed by the larvæ of *Urubra lugens*, which ate the epidermis of the leaves and thus asphyxiated the trees,† and he is also quoted by Sir William Macleay on the subject of a caterpillar very destructive to *Eucalyptus tereticornis*, the larva being that of a species of *Orygia.*‡ Further, in a paper on "Some causes of decay of Australian forests" the late Rev. Peter Macpherson, summarises the alleged causes as (1) Flat wet lands, (2) Seasons

* Proc. Linn. Soc. of N.S. Wales, Vol. VI., p. 536.

† Trans. Roy. Soc. of Victoria, Vol. II., p. 81.

‡ Proc. Linn. Soc. of N.S. Wales, Vol. VII., p. 344.

of drought, (3) Bushfires, (4) Difference of soil, (5) Sheep manure, (6) White ants, (7) Caterpillars destroying bark, (8) the blacks' opinion—the ravages of opossums, with which last he coincides and adduces strong evidence in favour of that view. The increased number of opossums arises from the destruction of their natural enemies, the blacks, dingoes, eagle hawks, and lace lizards.

The seventh theory advanced, viz., caterpillars destroying bark, of course fits in well with what was mentioned before. Insects indubitably do work great destruction among gum-trees. I have seen a forest of gums near Home Rule dead from, as far as I could notice, the effects of their being infected with *Coccidæ*. The beetles of the genus *Anoplognathus* at times swarm in trees like bees, and completely strip every leaf off, and if this does not kill them, it at least renders them unhealthy. In the discussion on Mr. Macpherson's paper, Professor Liversidge thought the decay of the trees might proceed from exhaustion of the soil.*

Another theory advanced was that on the death of an aboriginal, certain ceremonies were gone through, including the killing of a tree, but this would account for very few, and indeed in many parts where forests are dying there have been no blacks for the last half century.

Mr. K. H. Bennett in a paper on the subject is strongly of opinion that gum-trees, especially *Eucalyptus rostrata* and *E. melliodora*, are killed by opossums, and attributes their great increase to the passing away of the blacks.†

During the past few years the southern parts of the Colony of New South Wales has been visited by immense hordes of grasshoppers and also Hemipterous insects. The former destroyed all kinds of crops and trees, and the latter were very destructive to the vines. Now such a visitation is without doubt due to some disturbance of the balance of nature, whereby these insects were not so much preyed on by their natural enemies.

* Journ. of Roy. Soc. of N.S. Wales, 1885, p. 83.
† Proc. of Linn. Soc. of N.S. Wales, Vol. x., p. 453.

All the foregoing tends to show how direct or indirect modification of the fauna of a country must react beneficially or injuriously on the flora.

As another example of how these causes react on a flora the following may be of interest: "We know for example that drainage will affect the distribution of the butterfly-orchis, because it affects the insects which alone can fertilise this peculiar kind of flower."* Again: "And it is a remarkable fact that the smoke and chemical odours which surcharge the atmosphere of such of our large towns as Manchester, Leeds, and Derby, by causing certain kinds of insects to keep away, have indirectly but positively made it impossible for numbers of wild plants, formerly included in local floras, to perpetuate themselves now."

Division III.

Introduction of a new flora, and consequent modification of the indigenous flora.

This is a very important source of modification of the vegetation of any new country. It may be considered under the following heads:—

(*a*) Manner of introduction and spread.
(*b*) Action on local flora.
(*c*) Introduction of indigenous plants to new localities.
(*d*) The plants introduced.

(a) *Manner of introduction and spread.*

The plants which have become naturalised in Australia, naturally come under two headings, viz., those purposely introduced for use, ornament or sentiment, and those which accidentally found their way here.

Of those introduced for use or for ornamental purposes, a large number do not spread to any extent: they are children of civilisation and show no tendency to become feral. Many hardy annual garden flowers come up self-sown in gardens year after

* J. E. Taylor—Flowers, their origin, shapes, etc., p. 19.

year and yet never gain a footing outside. Others again, which have the power of spreading rapidly, are never able to do so, as they are succulent feed, and cattle take care that they never multiply. Such are oats and other grains. Wheat never seems to spread at all away from the fields in which it is cultivated. But still there are numbers of useful plants which are able to hold their own and more. Among these may be mentioned the lemon, peach, Cape gooseberry, tomato, and passion fruit, all of which are wild in many parts of the Illawarra district, and continue to bear fruit. Another species of passion flower (*Passiflora alba*?) is common there and is even more plentiful than the edible species. It is bitter and nauseous, but has spread over large tracts of bush country, converting them into tangle of the densest description. The common bramble or blackberry has been introduced for the sake of its fruit, and is now beginning to be a troublesome tenant of unoccupied lands in the cooler parts of the Colony. It reaches a development far exceeding that attained in its native land.

Sweet-briar and Scotch thistles are said to have been introduced for the sake of the associations clustered round the plants in the mother country. The latter plant is reported to have been introduced into Tasmania by a patriotic Scotchman desirous of having his national plant growing near his new home. He appears, by all accounts to have succeeded only too well.

But with regard to most introduced plants, there is much difficulty in discovering the method of introduction. The plants which habitually flourish in European cornfields are certainly easily accounted for—they came in the seeds imported to the Colonies. Such are corn marigold, corn spurrey, and many of the Caryophylleæ, the cornfield poppy and numerous others which will occur to every one. Then again, many noxious weeds growing among grain, were introduced to Australia in straw in packing cases. Such are the Centaureas and others. As an example of this I may note that *Bupleurum rotundifolium* first appeared in the Mudgee District in a yard where a box from England was unpacked.

But with many plants introduced, we can only reason by analogy as to the manner of their introduction. In an article on the weeds of Europe in the *Cornhill Magazine*, an anonymous writer states that a common English weed was introduced into an Antarctic island by the use of a spade which had some mould attached to the blade, and the plant has now spread all over the island. Darwin gives instances of seeds being found in balls of clay attached to the feet of birds, and even to the elytra of beetles. Still, the method of introduction of many foreign weeds must in the nature of things always remain more or less of a mystery. Many aliens have arrived in the colony attached to the wool of sheep or the hair of other animals as in the case of the Bathurst Burr—a species of vegetable stowaway.

As to the methods of spreading, they are various. Cultivation of the soil brings the weeds in its wake, and they manage to spread some how. Some have specially constructed seeds to float through the air—anyone who has seen thistle infested country on a windy day will have a good idea how thistles spread. The Composites are especially rich in plants adopting this contrivance. Others stick to the wool and hair of animals by hooks, barbed hairs, or sticky glands. Others again have seeds so minute that a high wind will carry them, although they are not furnished with special apparatus for the purpose.

Railways and roads are active helpers in the dissemination of aliens, especially the former. The land being fenced in is protected from the depredations of stock, and thus protected the weeds flourish and spread rapidly. In 1887 I remember noticing on the Mudgee Railway near Lue that there were miles of the embankments one tangled mass of *Meliotus parviflorus.* And in the neighbourhood of Bowenfels the railway line enclosures are thickly covered with a species of *Hypochœris*: it is pretty plentiful outside but inside the land is a golden sheet of the yellow flowers. Rivers also act in the same way, and especially carry weeds when in flood and deposit them on the flooded lands. I first noticed *Ranunculus* *muricatus* and Fool's parsley on the river banks at Mudgee. The following year they had reached Cullenbone, and the next year had got as far as Guntawang, a distance of seventeen miles by road but at least twenty-five or thirty by the river. A curious instance of the spread of a plant from one locality to another was afforded me in 1886 and 1887. During a journey from Guntawang to Wellington, a distance of forty-two miles, I noticed at Wellington, on the river banks, great quantities of *Cassia sophora.* At that time none of the plant was found in the Mudgee District, but in the same year a mail coach commenced running from Wellington to Gulgong passing through Guntawang. The following year, two plants of the *Cassia* appeared at Guntawang, and soon after it began to be common in the district. The Rev. Dr. Woolls, at a meeting of the Linnean Society of N.S. Wales, in September 1890 exhibited plants of *Calotis scapigera* and *C. hispidula* from Concord and Burwood. These are strictly denizens of the interior and were probably brought down by sheep travelling to the sale yards. Indeed I feel pretty sure that an examination in the neighbourhood of the Homebush sale yards would show that many western plants are brought down by the sheep, etc. In collecting introduced plants, I have always been most successful by roadsides, riverbanks, and railway enclosures, and there can be no doubt but that they are the principal lines of travel for these plants.

The plants which have edible fruits containing indigestible seeds are for the most part dispersed by birds and mammals which eat the fruit and void the seeds in new localities. In this way passion fruit, blackberries, *Phytolacca*, tomatoes, solanums, cape gooseberries, and many others are distributed.

It is a significant fact that horehound—*Marrubrium*—is always plentiful in the vicinity of a sheep station. Two other plants commonly found in the same situations are the introduced nettles, *Urtica urens* and *U. dioica*, whether from the plants being eaten by the sheep and the undigested seeds voided, or because that in sheep-manured land they find a congenial soil, I am unable to say.

(b) *Action on local flora.*

As already pointed out, Australian plants from their long isolation, and their having little competition of a severe kind, settled down into a state of balance or rather of slight oscillation, governed by a few causes, which themselves varied but little. In the older continents, however, from the intercommunication of the various nations, and from the fact that men continually add to their stock of cultivated plants, there is severe competition; the struggle for existence goes on continually and aided by natural selection and domestication some plants gain an advantage. Among other useful habits acquired by plants under competition is a certain plasticity of constitution which enables them to bear changes to different climates with equanimity. On this account the old world weeds when brought to Australia are able to beat the native plants. They are mostly plain dwellers, and as such accustomed to the heat of the sun in the open, and the bitter blasts of the winter, better than forest plants. When forests are cleared and brought under cultivation, the weeds soon beat the former occupants out of the field. Again many old world weeds are plants of wide range, and on this account have an advantage over those of more restricted habitat. "Widely varying species abounding in individuals which have already triumphed over many competitors in their own widely extended homes, will have the best chance of seizing on new places when they spread into new countries. In their new homes they will be exposed to new conditions, and will frequently undergo further modification and improvement; and thus they will become still further victorious and produce groups of modified descendants."* As before remarked their success in competition implies a plasticity of organism which is an advantage to them also; on this subject Darwin says, "If a number of species, after having long competed with each other in their old home, were to migrate in a body into a new and afterwards isolated country, they would be little liable to modification or variation; for neither migration nor isolation in themselves

* Origin of Species, 6th Ed. p. 319.

effect anything,"* The isolated productions of Australia on the other hand, have had uniform conditions and comparatively small range and so they cannot make way against those that have had such competition and range.

"In the same manner at the present day, we see that very many European productions cover the ground in La Plata, New Zealand and to a lesser extent in Australia and have beaten the natives, whereas extremely few southern forms have come to be naturalised in any part of the northern hemisphere, though hides, wool and other objects likely to carry seeds have been largely imported into Europe during the last two or three centuries from La Plata, and during the last forty or fifty years from Australia."† Wallace says, "There is good reason to believe that the most effective agent in the extinction of species is the pressure of other species, whether as enemies or merely as competitors."‡

It is well known that few Australian plants have found a footing in Europe notwithstanding the many facilities which commerce offers for their introduction, and the few American weeds which have found their way to Europe do well only in the Mediterranean region. Even in New Zealand but a few Australian plants have become naturalised as is shown by Mr. T. F. Cheeseman's paper on the naturalised plants of Auckland (read before the Auckland Institute, November 1882).

In America, the majority of introduced weeds are European, though at first they completely beat the natives, it is noteworthy that now the natives are holding their own, and even beating the strangers, thus showing that competition has gone on long enough for some advantage to be gained by the natives. It is remarkable too that the plants of Eastern America immigrated westward with man, and conquered the western plants at first; but from a consideration of the facts the great American botanist Prof. Asa Gray was led to prophesy a return wave of western plants, and that is now actually coming.

---

* *Op. cit.*, p. 319. † *Op. cit.*, p. 340.
‡ Island Life, p. 63.

The theory that insulated floras are less able to resist the influx of foreign plants is supported by the fact that only in the Neilgherrie Mountains in India have Australian plants been able to compete with others to any extent. It is, I believe, considered that that part of India long existed as an insular region. Therefore we see that the Australian flora, which though isolated, had a large range, is able to get an advantage over the Neilgherrie flora which was for so long developed in a small centrum.

One cause of the power of spreading of what are commonly called weeds, is that they are usually plants with inconspicuous flowers, and as such are generally self-fertilised and so can get along without specialised insects to fertilise them. It is manifest that in a new country where the local insect fauna is being destroyed to some extent, the plants which have not to depend on insects for fertilisation will be the more likely to win. And even cross-fertilised plants seem to manage sometimes to find insects to perform that office for them. Moseley points out an instance in the following passage: "The orange, lemon and lime, which grow wild all over Tahiti do not appear to deteriorate at all in quality or quantity of fruit, although in the ferine condition. The fruit almost appears finer for running wild. . . . . Some native insect must have adapted itself completely to the blossoms of the orange tribe as fertiliser, so abundant is the fruit."* The same is the case in Australia, for although the orange does not seem to grow wild to any extent, lemons have made themselves at home in the Illawarra District. The flowers of the lemon and the native plant *Synoum glandulosum* are much alike in structure, and it may be that the same insect or insects fertilise them. These plants would be on equal terms in this respect, but the lemon from its wide cultivation has gained a power of bearing diverse conditions which gives it a better footing. I may remark that *Synoum* is a common plant in Illawarra.

Among wind-fertilised plants are the grasses. The introduced species so far are not beating the natives. They are equal as far

* Notes of a Naturalist on the Challenger, p. 524.

as regards fertilisation, but most introduced species are from cool temperate regions, and so the Australian species being warm temperate, are able to hold their own. The dying out of some Australian grasses is attributable to over stocking and close feeding and not to competition.

In considering the introduction of weeds in Australia there is a great difficulty, viz., that it is hard in some cases to say whether certain plants are indigenous or alien. It is considered a safe rule to take all plants common in the Colony in Robert Brown's time as truly indigenous, but as Brown only collected in the neighbourhood of Port Jackson, that course leaves some difficulty still. On this subject, Baron von Mueller says in the preface to his "Census of Australian Plants," (1st Edit. 1882)—"The lines of demarcation between truly indigenous and recently immigrated can no longer in all cases be drawn with precision; but whereas *Alchemilla vulgaris*, and *Veronica serpillifolia* were found along with several European *Carices* in untrodden parts of the Australian Alps during the author's earliest explorations, *Alchemilla arvensis* and *Veronica peregrina* were at first only noticed near settlements. The occurrence of *Arabis glabra*, *Geum umbrosum*, *Agrimonia eupatoria*, *Eupatorium cannabinum*, *Carpesium cernuum*, and some others will readily be disputed as indigenous and some questions concerning the nativity of various of our plants will probably remain for ever involved in doubts." As will be seen from this, the origin of some plants will and must remain more or less a matter of personal opinion. And on referring to lists of plants of the various colonies it will be found that their authors differ in their placing of these doubtful plants. If we critically examine the Census of New South Wales plants by Mr. C. Moore, of Queensland plants by Mr. F. M. Bailey, of Victorian by Baron von Mueller, and of New South Wales by Dr. Woolls, we shall find abundant evidence of diversity of views in this respect. But very many weeds present no difficulty at all, although the record of their plentiful occurrence in very early days may well surprise us. The Rev. J. E. Tenison-Woods† remarks that Leichhardt

† Proc. Linn. Soc. of N.S. Wales, Vol. IV., p. 133.

found *Verbena bonariensis* so plentiful in the neighbourhood of Darling Downs, then only five or six years settled, that he named the place Vervain Plains.

The injury done by introduced weeds will be almost entirely by competition, but it is possible that in time, the Australian plants may begin to hold their own and even to some extent drive out the others. This will be more especially the case with the group of plants which are found on the barren and sandy tracts wherever the Hawkesbury Sandstone formation occurs. In such land few aliens get a footing. On the sandstone about Sydney as a rule, and in the Blue Mountains where the same soil occurs, the foreign weeds have no chance. But wherever the soil is fairly good, or where it has been broken up, there they triumph and exclude the indigenes.

To some extent however, the weeds will work their own destruction. They increase so rapidly that competition is most severe, not between them and the natives, but between individuals of the same alien species, or between distinct alien species. *Sisymbrium officinale* was once a pest near Mudgee, the fallow and unoccupied land being covered with a thick mass of it; but after the lapse of a few years it became quite rare, and *Erigeron canadense* took its place. I think that in some cases the fact of a heavy crop of weeds occurring in a locality one or more years is a reason for expecting its scarcity in the following years. The soil becomes exhausted of the particular constituents demanded by the plants, and they fail in consequence. I had often read doleful prophecies of the damage that might be expected when the Cape weed (*Cryptostemma calendulaceum*) became common. When I first saw it appear in Illawarra, I was therefore prepared to see much land infested by it in a short time. It spread to a great extent in certain spots for a couple of years and then almost disappeared. In my garden half-a-dozen vigorous plants came up, and as I left them for the purpose of observation, they flowered and seeded plentifully. I fully expected a large crop the following year, but to my surprise not a single plant was to be found, nor has there been one since.

Mr. T. Kirk, in a paper on the naturalised plants of Port Nicholson, N.Z., says:—" At length a turning point is reached, the invaders lose a portion of their vigour, and become less encroaching, while the indigenous plants find the struggle less severe and gradually recover a portion of their lost ground, the result being the gradual amalgamation of those kinds best adapted to hold their own in the struggle for existence with the introduced forms, and the restriction of those less favourably adapted to habitats which afford them special advantages."* And Mr. T. F. Cheeseman, from whose paper on the " Naturalised plants of the Auckland District" I have quoted the above, coincides with this opinion to some extent and says, " Speaking generally I am inclined to believe that the struggle between the naturalised and the native floras will result in a limitation of the range of the native species rather than in their actual extermination. We must be prepared to see many plants once common become comparatively rare, and possibly a limited number—I should not estimate it at more than a score or two—may altogether disappear, to be only known to us in the future by the dried specimens in our museums."† If this is likely to be the case in a territory so limited as New Zealand how much more is it probable in Australia with the vast extent of area, diversified surface, and various climates from tropical to cold temperate.

append a list of plants alien to Australia collected by myself, or named as occurring in the various Colonies by the authorities mentioned:—Queensland: Mr. F. M. Bailey ; New South Wales: Mr. C. Moore, Rev. Dr. Woolls, Mr. F. Turner, Mr. E. Betche; Victoria: Baron Ferd. von Mueller ; South Australia: the late Dr. Schomburgk ; Tasmania: the late Rev. W. Spicer. There is as yet no list published for West Australia, and the few in my

* Trans. N. Z. Inst., Vol. x., p. 363.

† Paper read before Auckland Institute, November 1882.

list were kindly supplied me by Baron von Mueller from Mr. Drummond's collection.

It will be noticed that there are several Australian plants included in the alien list. These are plants which through the influence of settlement have migrated or been introduced into new localities. For instance *Paspalum distichum* is not a Victorian plant, but it has appeared there, how, I do not know. *Sida retusa* is another of these Australian weeds. It is certainly the commonest weed in Illawarra, but it is a native of the northern parts of the Colony, as well as of tropical regions generally.

Summing up the foregoing, I am of opinion that the chief causes of destruction of the native flora are:—(1) The destruction of forests for timber, and cultivating the soil, or improving pastures; (2) by alteration of surface drainage by the surface being broken, either designedly or by cattle ; (3) by the overstocking and feeding down of the natural pastures without any means being resorted to for renovating them ; and that the destruction or modification of the flora by climatic alteration, the checking of bushfires, the destruction or modification of native fauna and the introduction of a new flora, while they certainly must result in some amount of alteration, yet cannot do so great an amount of damage as the first group of causes. Further, in the first group the causes numbered one and three are to a great extent capable of being remedied, as indicated in the body of this paper, while the second of the first group, and all of the second group are almost out of our power to alter or modify.

Appendix.

List of naturalised plants well established and spreading to a greater or less extent, with their distribution in the Australian Colonies.

	Q.	N. S. W.	Victoria.	S Aust.	Tas.	W. Aust.
RANUNCULACEÆ						
Ranunculus muricatus, L.		*	*		*	

APPENDIX—*continued.*

	Q.	N. S. W.	Victoria.	S. Aust.	Tas.	W. Aust.
PAPAVERACÆ						
Fumaria officinalis, L.		*	*	*		
CRUCIFERÆ						
Sisymbrium officinale, Scop. ...	*	*	*	*	*	
Sinapsis arvensis, L.	*	*	*	*	*	*
Nasturtium officinale, R. Br. ...	*	*	*	*	*	
,, *amphibium*, R. Br. ...		*				
Capsella bursa-pastoris, Moenh. ...	*	*				
CARYOPHYLLEÆ						
Silene gallica, L.	*	*	*	*	*	*
Cerastium vulgatum, L.	*	*	*	*	*	*
Stellaria media, L.		*	*			*
MALVACEÆ						
Malva rotundiflora, L.	*	*	*	*	*	
Modiola carolinianum, L.	*	*	*			
GERANIACEÆ						
Erodium moschatum, L'Her. ...		*	*	*		
,, *circutarium*, L'Her. ...		*	*	*	*	*
LEGUMINOSÆ						
Ulex europæus, L.		*	*	*	*	
Medicago denticulata, Willd. ...	*	*	*	*	*	
,, *lupulina*, L.		*	*		*	
,, *minima*, Willd.		*				
,, *sativa*, L.		*	*	*	*	
Meliotus parviflora, Desroux. ...	*	*	*	*	*	
,, *alba*, Desroux.		*				
Trifolium arvense, L.	*	*	*	*	*	*
,, *repens*, Riv.	*	*	*	*	*	
,, *pratense*, L.		*	*			
,, *procumbens*, L.			*		*	
Vicia sativa, L.				*		
Cæsalpinia sepiaria, Roxb... ...	*	*				
Cassia lævigata, Willd.	*	*				
,, *occidentalis*, L.	*					
ROSACEÆ						
Rosa rubiginosa, L....		*	*		*	
Rubus fruticosus, L...		*				
ONAGRARIEÆ						
Œnothera biennis, L.	*	*	*			
PASSIFLOREÆ						
Passiflora edulis, Sm.	*	*				
,, *alba*, L. & Q.	*	*				
,, *cærulea*, Willd.		*				

APPENDIX—*continued.*

	Q.	N. S. W.	Victoria.	S. Aust.	Tas.	W. Aust.
CACTACEÆ						
Opuntia vulgaris, Mill.	*	*				
,, *tuna*, Mill....		*				
,, *ficus-indica*, Ham... ...		*				
,, *Braziliensis*, Willd. ...		*				
,, *Dillenii*, Haw.			*			
RUBIACEÆ						
Sherardia arvensis, L.		*	*		*	
Richardsonia humistrata, Cham. ...		*				
Galium aparine, L.		*	*			
COMPOSITÆ						
Erigeron canadensis, L.		*		*		
,, *linifolius*, Willd.	*	*	*	*	*	
Ambrosia maritima, L.	*					
Anthemis cotula, L.		*	*	*		
Cryptostemma calendulaceum, Br. ...	*	*	*	*		*
Aster dumosus, Willd		*				
Centaurea melitensis, L.	*	*	*	*		
,, *solstitialis*, L.	*	*	*	*		
,, *calcitrapa*, L.		*	*	*	*	
Carduus lanceolatus, L.		*	*		*	
,, *marianus*, L.		*	*	*		
,, *arvensis*, L.		*	*		*	
Cirsium acaule, All...				*		
,, *palustre*, Scop.				*		
Onopordon acanthium, L.		*	*	*	*	
Kentrophyllum lanatum, Cand. ...		*	*	*		
Picris hieracoides, L.	*	*	*	*	*	*
Hypochæris radicata, L.	*	*	*		*	
,, *glabra*, L.		*	*		*	*
Lactuca saligna, L.			*	*		
,, *scariola*, L....	*					
Sonchus oleraceus, L...	*	*	*	*	*	*
Trapogon porriflolius, L.		*		*	*	
Senecio vulgaris, L....		*		*	*	
,, *scandens*, L....		*				
Xanthium spinosum, L.	*	*	*	*	*	
,, *strumarium*, L.	*					
Tagetes glandulifera, Schr.... ...	*	*				
Chrysanthemum leucantheum, L. ...		*				
Tanacetum vulgare, Scop.		*				
Inula graveolens, Jacq.				*		
Taraxacum officinale, Wigg... ...	*	*	*	*	*	*
Leontodon hirtus, L...		*				

APPENDIX—*continued.*

	Q.	N. S. W.	Victoria.	S. Aust.	Tas.	W. Aust.
ASCLEPIADEÆ						
Asclepias currassavica, L.	*	*				
Gomphocarpus fruticosus, R. Br.		*	*	*		
BORAGINEÆ						
Lithospermum arvense, L.	*	*	*	*	*	
CONVOLVULACEÆ						
Cuscuta epithymum, L.	*	*				
,, var. *trifolii*, L.		*				
,, *Europœa*, L.	*					
SOLANACEÆ						
Nicandra physaloides, Gært.	*	*				
Datura stramonium, L.	*	*	*	*		
SCROPHULARINEÆ						
Verbascum Blattaria, L.		*				
,, *thapsus*, L.		*				
Linaria elatine, Mill.		*		*		
PEDALINEÆ						
Martynia diandra, L.	*					
VERBENACEÆ						
Lantana camara, L.	*	*	*			
Verbena Bonariensis, L.	*	*	*	*	*	
LABIATEÆ						
Salvia verbenacea, L.		*				
,, *pratense*, L.		*				
Mentha viridis, L.		*				
,, *pulegium*, L.			*			
Marrubium vulgare, L'Ecluse.	*	*	*	*	*	
Stachys arvensis, L.	*	*		*	*	
Nepeta cetaria, L.			*	*		
Leonotis leonurus, R. Br.		*				
PLANTAGINEÆ						
Plantago major, Cam.	*	*	*	*	*	
,, *lanceolatus*, L.	*	*	*	*	*	
,, *coronopus*, L.			*	*		
AMARANTACEÆ						
Amarantus paniculatus, L.		*				
,, *blitus*, L.		*				
,, *viridis*, L.		*				
,, *græcizans*, Willd.		*				
,, *albus*, L.			*			
,, *spinosus*, L.		*				
CHENOPODIACEÆ						
Chenopodium murale, L.	*	*	*	*	*	

APPENDIX—*continued.*

	Q.	N. S. W.	Victoria.	S. Aust.	Tas.	W. Aust.
CHENOPODIACEÆ						
Chenopodium album, L.	*	*	*	*	*	
" *ambrosioides*, L. ...	*	*	*	*		
" *glaucum*, L.	*	*	*	*	*	
Atriplex patulum, L...	*	*	*	*	*	
" *hortensis*, L.		*				
PHYTOLACCACEÆ						
Phytolacca octandra, L.	*	*				
" *decandra*, L.	*					
POLYGONACEÆ						
Polygonum aviculare, L.	*	*	*	*	*	
" *convolvulus*, L.		*		*		
Rumex crispus, L.		*	*	*	*	
" *conglomeratus*, Mur... ...	*	*	*	*		
" *acetosella*, L...	*	*	*	*	*	
" *pulcher*, L.				*		
EUPHORBIACEÆ						
Euphorbia peplus, L.		*	*		*	*
" *helioscopa*, L.		*	*	*	*	
Ricinus communis, L.	*	*	*			
URTICACEÆ						
Urtica urens, Ray.	*	*	*	*	*	
" *dioica*, L.		*	*	*	*	
AMENTACEÆ						
Salix babylonica, L...		*				
" *alba*, L...		*				
SCITAMINEÆ						
Canna indica, Ken....		*				
IRIDEÆ						
Sisyrhynchum Bermudianum, L. ...		*	*			
" *micranthum*, Cuv. ...		*	*			
HYDROCHARIDEÆ						
Elodea Canadensis, Mich.		*	*	*	*	
AMARYLLIDEÆ						
Agave Americana, Kerr.		*				
LILIACEÆ						
Allium fragrans, Vent.		*			*	
AROIDÆ						
Richardia Africana, Kunth. ...		*				
GRAMINEÆ						
Panicum colonum, L.		*				
" *maximum*, L.	*					
" *teneriffæ*, R. Br.	*					
var. *rosea*	*					

	Q.	N. S. W.	Victoria.	S. Aust.	Tas.	W. Aust.
GRAMINEÆ						
Pennisetum longistylum, Hat. ...		*				
Coix lachryma, L.	*					
Euchlæna luxurians, Asch... ...	*					
Alopecurus agrestris, L.		*	*		*	
,, *pratensis*, L.		*	*		*	
Sorghum halepense, Pers.	*	*	*			
Holcus lanatus, L.	*	*	*	*	*	
,, *mollis*, L.			*			
Avena fatua, L.	*	*	*	*		
Kœleria phlœoides, Pers.		*	*	*		
,, *cristata*, Pers.		*	*		*	
Dactylis glomerata, L.	*	*	*	*	*	
Briza minor, L.	*	*	*	*	*	
Poa annua, L.	*	*	*	*	*	
Agrostis palustris, Hud.			*			
,, *vulgaris*, L....					*	
,, *canina*, L.					*	
Aira caryophyllea L.		*	*			
Festuca bromoides, L.	*	*	*	*		*
,, *ovina*, L.					*	
,, *rigida*, M. & K.		*				
Bromus sterilis, Ger.	*	*	*	*	*	
,, *uniloides*, Hunb.	*	*	*		*	
,, *mollis*, L.		*	*	*	*	
Lolium perenne, *L*.	*	*	*	*	*	
,, *temulentum*, L.	*	*	*	*	*	
Hordeum murinum, Cæsp.		*	*	*		
,, *nodosum*, L.		*	*			

The above list of one hundred and sixty-five species and two varieties well established in Australia, are distributed in the Colonies as follows:—Queensland, seventy-three; New South Wales, one hundred and thirty-eight; Victoria, ninety-five; South Australia, seventy-nine; Tasmania, sixty-four; West Australia, thirteen.

An examination of the orders represented most fully shows the following proportions:—Graminæ, thirty-two species; Compositæ, thirty-three; Leguminosæ, fifteen; Labiatæ, eight; Amarantaceæ six; Chenopodiaceæ, six; Polygonaceæ, six; Cactaceæ, five; Cruciferæ, five. These nine orders contain one hundred and sixteen of the total number of species, or nearly seventy per cent. of the whole. The grasses probably owe their wide spread to their being freely sown for fodder, and being wind-fertilised plants, they are able to more than hold their own against native flowering plants which are insect-fertilised, while they are themselves the products of severe competition in the older continents, and so have an advantage over the native grasses. This more especially holds good in the moist coast district, and they do not so readily spread on the dry inland plains where the conditions are more or less adverse to them.

The Composites probably owe their success to, first, their being capable of fertilisation by any insects ; second, to the large quantities of seed they produce ; and third, to the fact that many of them possess special apparatus for the dissemination of their seeds.

The Leguminous plants spread partly because they are freely sown on account of their value as fodder, and partly because the undigested seeds are scattered far and wide by stock feeding on the plants.

The Labiates seed very freely, and some possess special means of spreading in their fruits.

The Amarantaceæ, Chenopodiaceæ, and Polygonaceæ seed very freely, are self-fertilised, and have their seeds scattered by passing through the digestive canal of stock uninjured. They are also spread by ants which collect the seeds as food. The last of these three orders too, possesses fruits furnished with hooklets which cling to passing animals.

The Cacti have edible fruits which birds eat and void the seeds in new localities; their spines too, help them by protecting them from herbivorous mammals.

THE VENOM OF THE AUSTRALIAN BLACK SNAKE, (*Pseudechis porphyriacus*).

By C. J. MARTIN, M.B., B.Sc. *Lond.*, Demonstrator of Physiology in the University of Sydney, and J. McGARVIE SMITH.

[*Read before the Royal Society of N.S. Wales, August 3, 1892.*]

THE literature of the chemistry of Australian snake poison is very scanty, and with the exception of a few stray observations, which will be mentioned later, there has been no investigation from a chemical standpoint.

This paucity of literature is not surprising, when one considers that those who have interested themselves in the subject of snake poison, have almost exclusively, been gentlemen engaged in the practice of medicine, having neither time nor opportunity for chemical work, but who have used their best endeavours to find a successful method of treatment in cases of snake bite.

A complete investigation into the subject of snake poison must attempt to answer three questions :

(1) What is the poison ?

(2) What is its exact physiological action ?

(3) How can one best prevent or counteract this action ?

We venture to suggest that the majority of previous workers have begun at the wrong end, for out of about four hundred references which we have consulted on the subject of snake poison over three hundred are to papers in which the author answers to his own satisfaction this third question, and describes the beneficial results following the administration of some such potent drug as ash-tea, or human saliva, and the utter and entire futility of the whiskey or any other treatment.

A chemical investigation into the poison of Australian snakes is beset with even greater difficulties than is the case elsewhere, which no doubt accounts for the fact that whereas the venom of American and Indian species have received the attention of many observers the chemistry of Australian snake poison is almost an unopened book.

There is the initial difficulty of obtaining the snakes in sufficient number and of sufficient size. Further one is unable here to command the services of a professional snake catcher to manipulate the creatures, so that it is necessary to overcome that dislike and dread of the serpent which is instilled into the youthful intelligence at an early age in every Christian land.

Again, the quantity voided at one time by the Black snake is insignificant compared with that obtained from a decent-sized Cobra or Rattle-snake, which latter discharges at a single bite five to ten times the amount of venom that we have been able to procure at any one time, under the most favourable circumstances, from the largest of our specimens, a snake six feet long.

But although the yield of poison is so small, we find that the virulence of our Black snake compares very favourably with that of the Cobra. That is to say, the minimal fatal dose per pound weight is in our hands considerably less than that given for the Cobra by the Indian Snake Commission, and not very considerably greater as has been previously stated.* Some idea of this virulence may be gathered from the fact that $\frac{1}{1000}$ grain invariably kills a rabbit of 5 lbs. weight, when injected into a vein, in about one hundred seconds.

The following experiments illustrate the toxic power of the poison :—

$\frac{1}{10}$ grain of the dried Black snake poison was dissolved in 5 c. cm. of 1% Na Cl solution, 0·05 c. cm. would accordingly equal $\frac{1}{1000}$ of a grain.

Four rabbits, each weighing 5 lbs., were taken and the poison injected into the median vein of the ear. The first two received

* Sidney Martin—Proc. Royal Soc. Lond., Vol. XLVI. Halliburton—Text Book of Chem. Physiol. pp. 138, and Rep. Comm. Med. Soc. Vict. on Snake Poison, 1876. The Australian snake mentioned is the Tiger snake.

0·1 c. cm. of the solution ($=\frac{1}{500}$ grain) and died in 90 seconds and 91 seconds after the withdrawal of the syringe.

Two others received 0·05 c. cm. of the solution ($=\frac{1}{1000}$ grain) and succumbed in 97 and 98 seconds respectively.

Similar experiments were performed with a solution of the venom from the Tiger snake (*Hoplocephalus curtis*) prepared in a similar manner, so that 0·05 c. cm. equalled $\frac{1}{1000}$ grain.

The two rabbits which received 0·1 c. cm. ($=\frac{1}{500}$ grain) died in 92 and 101 seconds, and those which had 0·05 c. cm. ($=\frac{1}{1000}$ grain) in 104 and 105 seconds respectively. All four rabbits weighed over 5lbs.

The above experiments show a marked uniformity between the toxic power of these two venoms.

In the Proceedings of the Royal Society, London, for 1889, Dr. Sidney Martin gives a table purporting to represent the relative toxicity of the venoms from snakes of different species and from different countries which appears to us to be extremely untrustworthy, as there is no guarantee that the poison was procured in an equally pure state, nor that the method of introduction into the system was the same in all cases. When a snake bites, often twice as much saliva escapes from the mouth as venom, and unless this be prevented from passing into the receptacle by some such arrangement as was used by us, it would be dried and estimated as poison. Again, whether the poison be introduced intravenously or subcutaneously makes a difference of at least a decimal place in the lethal dose.

And further, the kind of animal experimented on, influences the result to a marked degree, rabbits being seven times as sensitive to Black snake poison as guinea-pigs, weight for weight. It should be noted too that the quotation made by Dr. Sidney Martin from the Victorian Medical Society's Proceedings, refers to fresh, that is wet poison, whereas that from the late Mr. Vincent Richard's "Landmarks of Snake-poison Literature," obviously refers to poison in a dried condition. Lastly, we have consulted the data given in this little book just referred to, and fear that Dr. Martin has made a mistake of one decimal place in favour of the Cobra, in his calculation, and that the venom of this snake is really less powerful than he would lead us to believe, but in a matter of arithmetic we are anxious not to insist too strongly.

A short historical resumé of the chemical work on the poisons of snakes from other countries is necessary, in order that the point from which we start may be appreciated and our results compared with those obtained by the various observers working with other species.

In this resumé we shall not include the historically interesting but otherwise unimportant views as to the composition of snake venom, held by those pioneers in the subject, Francesco Redi, Dr. Mead, Charas, and the Abbé Fontana. Some account of these early workers and their contentions is given by Mr. Vincent Richards, Chairman of the late Indian Snake Commission, in the Landmarks of Snake-poison Literature."*

The first investigation into the chemistry of snake poisons of any importance was by Prince Lucien Bonaparte on the poison of an adder *(Pelias berus)* in 1843. An interesting account of this is given by Sir Joseph Fayrer in a paper in the Proc. Med. Soc. Lond. 1884. Bonaparte found that the activity of the poison was associated with that portion precipitated by alcohol, and he gave the name of echidnine or viperine to this precipitate. The result of his analysis is stated in the table below—†

(1) Echidnine or viperine (the active principle)
(2) A yellow colouring matter
(3) A substance soluble in alcohol
(4) Albumen or mucus
(5) Fat
(6) Chlorides and phosphates

* Landmarks of Snake-poison Literature, Madras, 1886.

† For this table we are indebted to a paper by Badaloni—Lancet, 1883, Vol. I.

After Bonaparte the subject appears to have had no investigation until about 1860, when Dr. Weir Mitchell turned his attention to the subject. This accomplished author is essentially the founder of our present knowledge on the subject, though conclusions drawn at the time when animal chemistry was in its infancy, have very naturally had to be modified as knowledge of the chemistry of proteids has advanced.

The following analysis of the venom of the Rattle-snake was published by Mitchell in 1861 :*

(1) An albuminoid active principle (Crotalin)
(2) An albumen (coagulable by heat)
(3) Colouring matter
(4) A trace of fat
(5) Chlorides and phosphates

The parallelism between this and the analysis of Bonaparte is striking. The great advance made by Mitchell was the determination of the proteid nature of the active principle. These researches left the study of venoms in as satisfactory a position as could be gained with the laboratory facilities of 1843 – 1861.

In 1861, this author published some more observations on the subject† and then in 1883, in conjunction with Reichert published a preliminary report of some very extensive researches they had been carrying on for some years, on the chemistry and physiological action of the poisons of the North American snakes; a complete account of which was published by the Smithsonian Institute in 1886.‡

In these papers the authors establish the proteid nature of the venom of the American snakes, and ascribe poisonous properties

---

* "On the treatment of Rattle-snake bites, with experimental criticisms upon the various remedies now in use."—N. Am. M. Chir. Rev. V. 269.

† Prelim. Report on the Venoms of Poisonous Serpents."—Med. News, Philadelphia 1883.

‡ "Researches upon the Venoms of Poisonous Serpents."—Smithsonian Contributions to Knowledge, 1886. This paper contains an exhaustive bibliography on the subject of Snake Poison up to 1885.

to a peptone, and three varieties of globulins which they separate by "appropriate processes." The reactions given by their so-called peptone are characteristic of those bodies which we know now as albumoses, and a mixture of the primary albumoses is capable of behaving in many respects as their "globulins."

In India the subject has received the attention of many observers. About 1871 Brunton and Fayrer* began an extensive series of experiments with the venoms of the Cobra, Kraits, and Indian viper *(Daboia russellii)*. Their valuable work however hardly deals with the chemical aspect of the question.

In the first volume of the Analyst, Winter Blyth† published a paper, the contents of which, coming from an analyst of such acknowledged experience, attracted considerable attention. In this paper Blyth stated that he had discovered in Cobra venom a highly poisonous crystalline body, to which he gave the name "cobric acid," and that this cobric acid was the sole poisonous constituent.

We have consulted his methods and are convinced that he is not justified in coming to any such conclusion. Blyth's conclusions were criticised by Wolfenden,‡ who maintained that the crystals figured by him were sulphate of lime (!) derived from the water in which the poison was dissolved.

In 1878 Professor Pedler§ of Calcutta published an account of his investigations. He made an ultimate analysis of the dried poison, and showed that in percentage composition it corresponded fairly with that of albuminous bodies generally. He also claimed to have separated a "semi-crystalline" body of an alkaloidal nature to which he ascribed the potency of Cobra venom.

* Rep. on San. Improve. in India, 1873; ditto, 1874. Rep. on San. Meas. in India, 1874. Proc. Roy. Soc., 1872-3; 1873-4; 1875 and 1878. "Thauatophidia of India," Lond. 1872, by Sir Joseph Fayrer, and numerous papers by F. in Edin. Med. J. and Ind. Med. Gaz. between the years 1868 and 1874.

† "Analyst," 1876, Vol. I.

‡ "On 'Cobric Acid,' a so called constituent of Cobra venom," by Norris Wolfenden—Journ. Physiol. Vol. II.

§ "On Cobra Poison," Proc. Roy. Soc., Lond. 1878.

Armstrong, and still earlier Dumas, had previously made ultimate analyses of the poison with somewhat similar results. Dr. Armstrong's analysis was appended to the Snake Commission Report, 1874.

In 1883 Wall* published his interesting book "Indian Snake-poisons their nature and effect," which contains two facts of especial importance from a chemical point of view, viz.,

(1) That the whole of the poisonous properties reside in the coagulum by absolute alcohol, and that if the alcohol be absolute, the filtrate is quite innocuous.

(2) That the poisonous principle is taken up by distilled water from the precipitate by alcohol, and that the solution so obtained possesses all the toxic properties of Cobra poison.

Dr. Wolfenden's† valuable contributions to the subject appeared in 1886. In these papers the author establishes the proteid nature of the poison, and excludes the possibility of alkaloids, ptomaines, germs, and any body of the nature of Blyth's "Cobric acid." He claims to have separated an albumen, an albuminate, and a globulin, to all of which he ascribes poisonous properties. This author does not appear to have been aware of Wall's results, for all of these bodies, would be rendered insoluble by absolute alcohol.

When Wolfenden's work is read by the light of recent developments in proteid chemistry his conclusions do not by any means necessarily follow.

In the last number of the Journal of Physiology for May of this year, is a paper by Kanthack,‡ in which he shows that Cobra poison contains a proto-albumose which is capable of producing all the symptoms of the fresh venom. This paper is especially interesting as the methods used were similar to those employed by us, and his results as far as they go point to a close analogy between the composition of the venom of the Cobra and that of Australian snakes.

* "Indian Snake Poisons, their nature and effect."

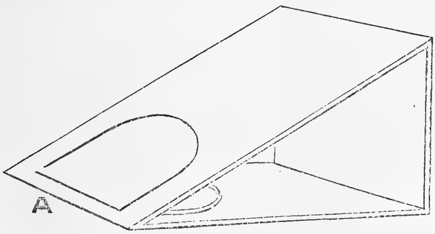
† "On the nature and action of the Venom of Poisonous Snakes"—Journ. Physiol., Vol. VII.

‡ The nature of Cobra Poison—Journ. Physiol., Vol. XIII., Nos. 3 and 4.

In this paper we have endeavoured to give as complete an account of the composition of the venom of our Black snake, as our supply of material would allow. The particular species was chosen because we had the largest supply of this kind of poison.

Method of obtaining the poison.

Our method is a modification of that adopted by the Indian snake-men, who employ a mussel-shell covered with a plantain leaf to catch the poison. The snake is firmly grasped immediately behind the head and as a result of this and previous manipulation he generally opens his mouth. The shell is thrust between the jaws so that when the creature bites, the fangs penetrate the leaf and the poison trickles into the receptacle below. We follow a like procedure, only instead of a mussel-shell and plantain leaf, we use a hollow framework of wood in the shape of an inclined plane, and in both planes of which holes are cut near the sharp angle A. (See figure.)



The upper hole is covered with thin rubber sheeting such as is used by dentists in the stopping of teeth, and the edges of the lower are bevelled so as to hold a small watch-glass, which is kept in position by a pair of clips. The ingenious idea of using rubber is due to Mr. Bray a naturalist of this city.

By this device we obtain the poison free from all secretion from the mouth. It flows direct from the fang into a watch-glass the weight of which is known. The glass is removed and reweighed with contents, then placed in a desiccator over calcium chloride, and when dry, again weighed. From these data it is easy to calculate the percentage of solids in the sample of poison obtained.

This has been done in every case, so that we have a long series of observations showing how this percentage varies under different circumstances, such as previous discharge of poison, feeding, time of year &c.

The variation in the percentage of solids (which means variation in the toxic strength of the venom) is very extensive. We have obtained poison containing as much as 67% of solids and as little as 12%. These results which we hope to communicate in detail at some future period are interesting and important, as they show that one is not justified in dealing with the fresh (*i.e.* wet) snake poison as a constant factor.

This error vitiates all the experiments of the committee appointed to enquire into the subject of snake poison by the Medical Society of Victoria in 1875-6.

Nicholson* notes variations in the proportion of solids in cobra venom of nearly as great a range as ours.

The poison thus obtained is a clear straw coloured fluid of varying viscosity and strongly acid reaction. On drying at about 16° C. in a desiccator it forms clear glistening scales, behaving just in the manner of white of egg under similar circumstances. It will keep for six months (probably any length of time) in this condition, and retains its virulence unimpaired. At the end of this time it dissolves up completely in a small quantity of distilled water or weak salt solution (1 to 10%) forming a perfectly clear solution. The poison though strongly acid when received direct from the fangs, loses its acidity by drying, so that the solution formed afterwards is neutral or very faintly acid. The acid is volatile and by drying except at low temperatures is driven off.

In recent times the effects following the injection of snake poison, have been ascribed by various authors to five different classes of bodies, which according to these authors are present in venom, viz.:

(1) Germs.

---

* Indian Snakes, Madras, 1874.

(2) Some body of the nature of a digestive ferment.
(3) Alkaloids or ptomaines.
(4) A crystalline acid.
(5) Proteids.

Although grave doubt has been thrown even upon the existence in venom of the majority of the above list, and although it has further been shown that the active properties of the Indian and North American snakes are resident in the proteid constituents of these venoms, facts which afford a basis *a priori*, for inferring that the poisonous qualities of Australian snakes are due to similar substances, we yet thought it advisable to exclude the possibility of the presence of any poison of another nature. The results of our observations and experiments in reference to each of these alleged poisonous bodies may now be discussed seriatim.

(1.) In 1878 Dr. Jean Baptist de Lacerda* of Rio, announced his discovery that the effects of snake poison were due to germs contained in the venom. To test this statement, snake poison was allowed to drop from the fang directly upon a slide, means being taken to prevent contamination by saliva. The drop of poison was then dried and stained with methyl violet and examined for micro-organisms, but with negative result.

We have also inoculated tubes of nutrient beef broth and gelatine, and of nutrient snake broth and gelatine, with the poison and have kept them at 20° C., again with negative result.

Lacerda does not say how he collected his poison, most probably it was contaminated with saliva, which in snakes under some circumstances teems with bacteria. When a snake swallows another animal, frequently almost as large as itself, the creature swallowed undergoes putrefaction as well as digestion, and judging from the appearance and smell of the gastric contents in snakes we have opened some few days after a meal, one would say that the former process was in excess. With such a decomposing mass in the stomach it is not surprising that the mouth should be swarming

* Compt. Rend. Acad. d Sc., Paris, LXXXVII.

with bacteria, and from the negative results of our observations we are in a position to state—that snake poison as discharged from the fangs does not under normal circumstances contain any micro-organisms.

(2.) The second suggestion that the poison contains a ferment analogous to a digestive ferment has suggested itself to many, owing no doubt to the fact that the venom gland is the homologue of the parotid salivary gland. Prof. Halford* stated as his theory of the action of snake poison that it digested or dissolved the fibrinous elements in the blood and so prevented it from clotting, and he considered all other symptoms as secondary to this primary effect on the blood.

In 1881 we find Lacerda, who had in the mean time wearied of his former hypothesis, advancing a similar view. He states† that the poison is a digestive juice comparable to pancreatic secretion but much stronger.

Recently too, some observations appeared in one of our daily papers to the effect that snake poison was capable of digesting pieces of flesh, and hard boiled egg. To ascertain whether our snake poison really possessed any such digestive activity, we performed the following experiments :—

Eight test-tubes were taken and divided into two groups. Four were half filled with 0·2% H.Cl., and the remaining four with 1% Na_2 CO_3 solution, in order to test whether the poison might be capable of digesting in an acid or alkaline medium. To two tubes in each group was added a small piece of clean, fresh fibrin, and to the other two in each group an addition of 1 c.c. of dog's serum was made. Thus we had four pairs of tubes, the pairs being exactly alike in every respect. To one tube in each pair a small quantity of snake poison was added and the whole eight tubes were placed in an incubator at 40° C. for forty-eight hours, a small crystal of thymol having been added to those containing

---

* Brit. Med. Journn. 1867, II.

† Compt. Rend. Acad. Sc., Paris, XCIII.

Na_2CO_3 to prevent putrefaction. In none of the tubes was the fibrin dissolved nor the serum affected. We may therefore conclude that there is no reason to ascribe the effects of Black snake poison to any digestive action.

(3.) Gautier stated* that he had extracted two ptomaines from the venom of the Cobra. Wolfenden† however was unable to confirm this, and Prof. Walcott Gibbs‡ who examined the venom of the Rattlesnake at the request of Dr. Weir Mitchell, was unable to discover the presence of any body of this nature.

The possibility of the presence of ptomaines adherent to the proteid constituents of snake poison demands careful attention. In the breaking up of proteids under the digesting influence of micro-organisms (*e.g.* Anthrax bacilli) it has been shown by Dr. Sidney Martin,§ that alkaloids or ptomaines are frequently found as part-end-products in addition to albumoses. Similar results were obtained with tubercle bacilli by Crookshank and Herroun, || Hunter,** and Hankin.†† Brieger ‡‡ also in his monograph on Animal Alkaloids, has shown that a ptomaine "pepto-toxine" is formed during artificial gastric digestion.

Accordingly we carefully examined a small quantity of poison by Brieger's§§ modification of the Stas-Otto process for the separation of alkaloids. The extract which should contain any body of this nature, was quite harmless when injected into the peritoneal cavity of a small guinea-pig.

We therefore conclude that such bodies are absent from Black snake poison.

---

* Bull, Acad. de Med., Paris 1881.

† Loc. cit.

‡ Smithsonian Contribution to Science, 1886.

§ Rep. of Med. Off. to Local Govt. Board, 1889 and 1890. Brit. Med. Journ., March 1892. Journ. Pathol. 1892.

|| Proc. Physiol. Soc., Feb. 1891.

**Brit. Med. Journ. July, 1891. †† Brit. Med. Journ., 1891. ‡‡'Ueber Ptomaine,' Berlin, 1885.

§§ Loc. cit. et Text Book of Chem. Physiol.—Halliburton.

(4.) Blyth* is the only author who claims to have derived a crystalline acid body from snake venom and his statements have, to say the least not been confirmed. As we mentioned earlier the acid present in Black snake venom, at any rate in the quantities which we have been able to experiment with, produces when injected into an animal, no obvious physiological effect.

(5.) As it has been conclusively shown that the albuminous bodies in the venom of Cobra and Rattle-snake do actually possess toxic qualities, we naturally look to the proteids of Black snake poison, as the active agents. This venom we find to be a strong solution of proteids in which we can discover nought else but the volatile acid and a small amount of inorganic salts, of which sodium chloride forms the major portion. All reagents which precipitate the proteids from a solution of venom deprive it of its toxic powers and submission to those conditions which are capable of decomposing or altering proteids in solution—*e.g.* prolonged boiling, either alone or with diluted acids or alkalies, convert this virulent solution into an innocent liquid. Reagents such as $Ag\ NO_3$ which precipitate proteids in an insoluble form, render both the precipitate and filtrate perfectly harmless. We therefore conclude that there is no poisonous body present in the venom other than proteids.

The proteids present in the venom.

A two per cent. solution of Black snake poison in one per cent. NaCl behaves in the following manner with the undermentioned reagents :

(1) Warming with nitric acid and the subsequent addition of ammonia—orange colouration (Xantho-proteic).

(2) Millon's reagent—usual proteid reaction.

(3) Heating—turbidity between 80 – 86° C., which settles as a precipitate.

The filtrate from this solution still contains proteid and gives the following reactions :

* Loc. cit.

(4) Caustic potash and trace of $Cu SO_4$—brilliant biuret reaction.

(5) Nitric acid—a precipitate soluble on heating but returning on cooling. (This precipitate is increased in presence of more $Na Cl$).

(6) Picric acid—precipitate disappearing on heating, returning on cooling.

(7) Saturated with $Na Cl$—precipitate.

(8) Saturated with $Mg SO_4$—precipitate.

(9) Saturated with Am_2SO_4—precipitate.

(10) Dropping the fresh solution into distilled water produces a cloud.

(11) $Cu SO_4$ 5% solution—precipitate.

(12) Alcohol—precipitate.

From the above reactions it is obvious that the poison contains:

(*a*) A proteid coagulable by heat, viz. albumin or globulin.

(*b*) Some proteid or proteids not thrown out of solution by this treatment, which might include albuminates (acid albumin), albumoses, or peptone.

A solution of the fresh poison gives no precipitate when neutralized by 1 in 5,000 KHO, thus excluding the presence of acid albumin. Peptone also is absent, for the solution was acidulated with a drop of 5% H_2SO_4* and shaken with Am_2SO_4 crystals for twenty-four hours. After this thorough saturation the filtrate was proteid-free.

The albumoses present are hetero-albumose, proto-albumose, and possibly deutero-albumose in small quantity, these were separated in the following manner :—

A solution of the original poison was heated to 90° C. and filtered. The filtrate was saturated with $Mg SO_4$ and shaken for twelve hours. By this means a flocculent precipitate was produced. The whole was then thrown on to a filter and thoroughly washed with a saturated solution of $Mg SO_4$.

* Vide Neumeister "Ueber-Albumosen und peptonen," Zeitschrift f. Bidl. Bd. xxvi., 1890.

The filtrate was dialysed for twenty-four hours in running water and two days in distilled water, and then concentrated by dialysis against absolute alcohol. We thus obtained a few c.c. of fluid, containing a small quantity of proteid in solution.

The proteids which alone could be present in this solution after the above manipulations are, proto-albumose (traces), deutero-albumose and peptone. The last we have previously shown is not present in the venom.

Neumeister has shown that it is impossible by saturation with neutral salts, to absolutely precipitate all proto-albumose from solution,* and as the filtrate became cloudy on the addition of a few drops of 5% $Cu\ SO_4$, some proto-albumose was present in the filtrate. Whether deutero-albumose was also present we were unable to determine, as we are not acquainted with any method by means of which traces of this proteid may be determined in the presence of proto-albumose.

The contents of the filter (*i.e.* the precipitate thrown down by saturation with $Mg\ SO_4$) were all washed through by means of distilled water, and the solution freed from $Mg\ SO_4$ by dialysis as in the previous case.

At the end of three days there was a considerable precipitate on the dialyser. The contents of the dialyser were emptied into a test-tube and centrifugalised. In a few minutes the precipitate was deposited at the bottom of the tube.

The supernatant fluid was pipetted off and concentrated by dialysis against absolute alcohol and evaporated to dryness at a gentle heat (40° C.). The precipitate was thoroughly washed with a large volume of distilled water, by means of the centrifuge, and then dried over chloride of calcium.

In this way we obtained two albumoses, both precipitable by saturation with $Mg\ SO_4$ and therefore belonging to the class of primary albumoses, one of which was soluble in distilled water, the other insoluble, but readily soluble in dilute solutions of

* Neumeister, Zeitschrift f. Biologie, Bd. XXIII.

neutral salts. The names given to similar bodies formed in the gastric digestion of proteids* are respectively, proto-albumose and hetero-albumose.

We next allowed some venom to remain under a large volume of absolute alcohol for several weeks, by which means proteids other than albumoses or peptones are rendered permanently insoluble in water or dilute saline solutions, whereas proto-albumose is unaltered and hetero-albumose only to a certain extent, some portion of it being changed into dys-albumose and therefore no longer capable of being dissolved by these media. The results obtained by this treatment were confirmatory of those detailed above.

After the sojourn under alcohol the precipitate was extracted with 5% Na Cl solution. The extract so obtained was very virulent and contained proto- and a small amount of hetero-albumose, which were separated in the following manner. The precipitate was digested with the salt solution for twenty-four hours and filtered. The filtrate was dialysed against distilled water, which was frequently changed, for forty-eight hours. At the end of this time there was a slight flocculent precipitate on the membrane. The whole contents of the dialyser were then decanted into a test-tube, the deposition of the precipitate hastened by means of the centrifuge and the supernatant fluid carefully pipetted off.

The small precipitate was then thoroughly washed with an abundance of distilled water and then the tube again placed in the centrifuge, and in a few moments the precipitate was deposited at the bottom of the tube, and the excess of fluid could now be easily removed. The sediment was dried at a gentle heat. The fluid contents of the dialyser were concentrated by a further dialysis against absolute alcohol and evaporated to dryness at 40° C.

In this way we again obtained two bodies (albumoses) the one insoluble in distilled water and therefore precipitated by dialysis,

* Kuhne & Chittenden—" Ueber Albumosen," Zeitsch. f. Biol. 1884.

the other soluble. These two albumoses gave the same chemical and physiological reaction as those separated by our first method.

We now turned our attention to the proteid coagulated by heating.

On dialysing the fresh poison, after some days there is a precipitate on the membrane. This might be either a globulin or hetero-albumose, but from the fact that dilute solutions of this precipitate in 1% Na Cl gave no obvious precipitate on heating, we are of the opinion that the former of these bodies (globulin) is absent.

The venom of this snake contains a small and variable amount of albumen. The temperatures of coagulation were determined by an arrangement similar to that suggested by Prof. Schäfer and described by Professor Halliburton.* This apparatus was so modified as to enable us to work with very small quantities of fluid (*viz.*, 2 c.c.), and the tube was viewed by reflected light against a black back-ground in order that the slightest turbidity should be visible. The solutions used contained 2% of the dry venom. We noticed an extraordinary sensitiveness on the part of the albumen to the acidity of the solution. The slightest excess of acetic acid prevented coagulation, the albumen being converted into acid albumen, as on neutralizing the boiled solution carefully with 1 in 10,000 KHO it was precipitated.

Some idea of this sensitiveness can be drawn from the fact that if a glass rod 2 m.m. in diameter moistened with 0·05% acetic acid were used to stir the 2 c.c. of solution, too much was added, and unless the rod had been previously shaken to remove all excess, coagulation was prevented. If, on the other hand, the fluid were alkaline or even sometimes neutral, no coagulation occurred until it was acidified. Having ascertained the necessary degree of acidity, we found that there were two temperatures at which definite flocculi were formed, separated from each other by about 4° C. That is to say, if the first formed coagulum were filtered off, and the filtrate reacidified, on further heating, the solution

* Journ. of Physiol., Vol. v.

again became turbid and a second precipitate was formed. This occurred whether the fluid were reacidified or not, but under the latter circumstances happened at a few degrees lower than if the second acidification had not taken place. The mean temperatures at which these two coagulations took place in eight experiments were 82° C., and on raising the temperature to 95° C. no further precipitate occurred. After saturation with Mg. SO_4 and ridding the filtrate from excess of the salt by dialysis, in the one experiment in which this was done, flocculi appeared between 83° C. and 84° C., and again at 90° C.

The virulence or innocence of these albumins is a point which is very difficult to determine. Albumin in a soluble condition and unaltered is very hard to separate from a solution containing proto- and deutero-albumose. We have tried various neutral salts and saturation with combination of salts, but in every case in which albumin was thereby precipitated, deutero-albumose came down also.

It is not only impossible to separate the albumin from deutero-albumose, but also from traces of proto-albumose by the saturation methods. For though it is true Mg. So_4 solution precipitates proto-albumose and does not affect albumin—it is impossible to precipitate the whole of the proto-albumose by this method, unless acetic acid be added at the same time.* Unfortunately this addition of acetic acid to a solution saturated with Mg. SO_4 brings down at the same time any albumin.

Owing to the virulence of the albumoses present in the venom it is essential that any albumin separated, be absolutely free from these former bodies, in order to determine whether the albumin itself may possess any toxic powers.

To separate the albumen in an uncoagulated condition we were obliged to resort to dialysis. ·5 gramme of dried venom was dissolved in 25 c. cm. of distilled water, and placed in a specially prepared dialysing tube made from the muscular coat of a rabbit's

* Neumeister, *loc. cit.*

intestine. This membrane was much thinner than the sausage skins made of sheep's-gut or vegetable parchment, and hence allowed diffusion to proceed at a more rapid rate.

The skin containing the solution of venom and a crystal of thymol was suspended in a vessel through which a gentle stream of distilled water passed. After twenty-four hours the contents of the skin had become turbid, and at the end of forty-eight hours a sticky precipitate adhered to the inside of the tube. The contents were then turned into a test-tube and centrifugalized, the supernatant clear fluid pippetted off and placed in a new dialysing tube of the same material, together with a crystal of thymol. The contents of this second tube were dialysed in distilled water for between three and four weeks. At the end of this time, a few drops gave no cloudiness when allowed to stand over $Mg. SO_4$ crystals for twenty-four hours. The dialyser, however, contained a small quantity of proteid in solution, which coagulated on heating.

The whole of the remaining solution was concentrated to 3 c.c. by warming at 40° C., 2·5 c.c. of which was injected into the jugular vein of a small guinea-pig, and the remainder soaked up by a small piece of sponge which was placed in the abdominal wall, in the manner described below. The solution produced neither local nor general effect. These experiments point to the innocence of the contained albumens.

To sum up, we find Black snake venom contains the following proteids—albumin in small quantity : hetero-albumose and proto-albumose in considerable amount: with perhaps a trace of deutero-albumose.

Note.—In every case of dialysis a crystal of thymol was added to the fluid to prevent decomposition. The various filtrations were much facilitated by the adoption of the method of Fessenden* by whose arrangement of folding the paper, not only does one dispense with a funnel, but in no part is the paper double or triple, so that the whole surface of the filter paper is utilised.

* Chem. News, Vol. LX., pp. 166.

We now come to the consideration of the question as to which of these separated proteids possess toxic properties?

The results of the introduction of any poison into the system can be divided into (1) local, (2) general effects. To test the former it is necessary to have an extremely small dose of the poison acting continuously. For a very excellent method of accomplishing this we are indebted to the suggestion of Mr. C. J. Pound, who also performed and took charge of the majority of the experiments to test the local effect of our various solutions.

A guinea-pig was taken and the belly shaved, and washed with a solution of $Hg\,Cl_2$ 1 in 1,000, the rectal temperature having been previously taken. Then two small pieces of sterilized sponge (2 m.m. cube) one of which had been soaked in the proteid solution concerning the local action of which we desired information, were aseptically introduced into the inter-muscular planes of the abdominal wall, one on each side. The one not previously treated with the supposed poison acted as a control. The small incision which was one inch distant from the situation of the sponge, was brought together with a horse-hair suture, and covered with collodion. In this way we obtained the maximum of local with the minimum of general symptoms.

Dilute solutions of our albumoses inserted in this manner, produced œdema spreading over the whole of the same side of the abdomen in from six to eight hours. In no case was there any exudation around the control sponges.

To test the general effect, the solutions were introduced either into a vein or into the peritoneal cavity. The proto- and hetero-albumose killed in a few hours. We therefore conclude that the active principles of this venom are, proto-albumose, and hetero-albumose.

Action of heat on a solution of the venom.

Boiling does not destroy the activity of Black snake poison, unless this be continued for some hours, and momentary heating to 100° C. did not appear to cause any diminution in the virulence of the solution, until we repeated our experiments under circumstances in which much greater accuracy was possible, viz., by using the minimal fatal dose and direct introduction into the venous circulation.

The following experiments illustrate this diminution in toxic power:—Six guinea-pigs of nearly equal weight were taken and the minimal fatal dose of the poison was ascertained by injecting into the jugular vein of the first $\frac{1}{2000}$ grain, into the second $\frac{1}{1000}$ grain. Both these animals suffered from convulsive movements which gradually decreased in severity and they recovered in four to five hours. The third guinea pig received $\frac{1}{750}$ grain, which caused death in sixty seconds.

The three remaining pigs each received an intra-venous injection of a solution of the poison which had been momentarilly raised to 100° C. One of these latter received an amount of the solution $= \frac{1}{1000}$ grain, and two others $= \frac{1}{750}$ grain. All three suffered from some twitching, but none died, in fact in three hours one could not detect anything wrong with them.

We have been unable to detect any chemical change in the solution on heating to 100° C. with the exception of the coagulation of the albumin, which we have reason to believe is not possessed of poisonous properties, and cannot therefore attribute the diminution in toxic strength of the solution to this cause. The boiled solution even when boiled for several days, by placing in a small flask with a little vertical condenser attached to it, and surrounding the flask by a water bath, still contains proteids in solution which possess the same chemical characters as before, though it has lost its physiological importance. This effect of heat on Black snake venom, is similar to the results obtained by authors for the venoms of American and Indian snakes.

Mitchell and Reichert found that heating the solution produced a continued impairment in its toxic power even after the separation of the "globulin" by coagulation, which occurred below 75° C., and attributed this to the action of heat on the solution of their "venom-peptone" (albumose). Wall showed that heating to 100° C. lessened the virulence of Cobra venom. Kanthack denies that boiling ordinary Cobra poison diluted with water momentarily diminishes its toxic power and gives three experiments to prove this, and remarks "These three examples may suffice." As three experiments performed in the same manner with Black snake venom gave a similar result, but on repeating with the more accurate method previously mentioned, showed a marked deterioration in power, we cannot help thinking that if Dr. Kanthack repeated his experiments with similar precautions he might obtain the same result as Dr. Wall. The effect of raising the temperature of the venom of the Indian viper to 100° C. entirely does away with the direct effect of that poison on the nervous system, as Wall has shown.

Dr. Sidney Martin's results with abrus-albumose and the albumoses produced by "Anthrax-digestion" are exactly analogous, the former being especially sensitive, so that raising the solution to 85° C. rendered a lethal dose harmless, while at the same time no chemical change could be detected.

The action of caustic potash appears to be very much the same on Black snake venom as that observed by Weir Mitchell, Wall, and Vincent Richards with Crotalus, and Cobra venoms. When the poison is mixed with twice its weight of caustic potash dissolved in a few drops of distilled water, and then injected subcutaneously, a fatal dose fails to produce any effect. If however the mixture be introduced into the vascular system a fatal result follows, but the time which elapses before death is immensely increased. A few experiments illustrate these points.

$\frac{1}{10}$ grain dried Black snake poison was dissolved in ·5 c. cm. of a 1% solution of Na. Cl. and injected subcutaneously into the thigh of a rabbit. This animal died in four hours, twelve minutes.

$\frac{1}{10}$ grain Black snake poison and $\frac{2}{10}$ grain KHO dissolved in ·5 c. cm. 1% Na. Cl. solution injected into thigh of a rabbit as in previous experiment. No effects followed.

$\frac{1}{10}$ grain of Black snake poison dissolved in ·5 c. cm. 1% Na.Cl. introduced into the marginal vein of the ear of a rabbit. Dead in ten seconds.

$\frac{1}{10}$ grain Black snake poison and $\frac{2}{10}$ grain KHO dissolved in ·5 c. cm. 1% Na. Cl. introduced into a vein of the ear of a rabbit. Dead in one hour fifteen minutes.

Our conclusions that albumoses are the active agents in Black snake poison are interesting when compared with similar results obtained by Sidney Martin,* Hunter,* Hankin, and Crookshank and Herroun,* with the poisons produced by the bacilli of anthrax diphtheria, and tubercle. Albumoses are the products of the hydration of albumins, and this hydration can be accomplished in many ways, for instance by boiling solutions of albumin at high pressure, by gastric or pancreatic digestion, or by the vital influence direct or indirect of cells. In the case of gastric or pancreatic digestion the result is brought about in an indirect manner, *i.e.*, the gland cell manufactures a ferment, pepsin or trypsin, which, under suitable conditions, hydrate the albumins, forming albumoses &c. In the case of digestion by the diphtheria bacillus, Martin* has shown that the bacilli, grown either in the juices of the body or in culture-media outside it, produce by their activity a ferment which is capable of forming albumoses from the proteids. These albumoses formed by such bacilli are highly poisonous, much more so than those produced during gastric digestion, and give rise to the pathological conditions which we recognise as the disease diphtheria. Anthrax bacilli do not give rise to any ferment but are capable of directly digesting albumins, producing poisonous, but different albumoses. The same is the case with tubercle bacilli.

In all these processes of hydration some of the albumin is further broken up, giving rise to some nitrogenous body of the ammonia type. In the case of gastric digestion we have a ptomaine peptotoxin.† In pancreatic digestion we have leucin and tyrosin, in

* Loc. cit.

† Brieger, "Ueber Ptomaine," loc. cit.

anthrax and tubercle digestion we have an alkaloid. In diphtheria no alkaloid is formed, but an organic acid, and the question whether this be nitrogenous, is as yet undetermined.

The following table taken, and somewhat altered from Sidney Martin's Goulstonian Lectures to the Royal College of Physicians, London, illustrates this analogy, to which we have added our results with snake poison for comparison :—

Table illustrating the analogy between various processes of hydration due to vital activity.

Primary Agent.	Ferment.	Products.	
		Albuminous.	Nitrogenous.
Epithelial cell of gland (Stomach).	pepsin	hetero, proto, and deutero-albumoses, peptone.	pepto-toxine (in artificial digestion)
Epithelial cell of gland (pancreas).	trypsin	globulin like body peptone	leucin tyrosin
Bacillus anthracis ...	(none)	hetero, proto, and deutero-albumoses, peptone.	leucin tyrosin anthrax alkaloid
			? Nitrogenous.
Bacillus diphtheriæ ...	ferment	proto and deutero-albumose.	organic acid
Epithelial cell of gland (venom-gland snake)	(none)	hetero-, proto-, deutero- } albumoses ...	organic acid

Our conception of the formation of these albumoses in the venom-gland of the snake is the following:—The cell, by a vital process directly exercises an hydrating influence on the albumins supplied to it by the blood, the results of which influence are the albumoses, which we find in venom. The differences between this process and the digestion by pepsin or by anthrax bacilli, is that in the case of the gland cells of the venom gland the hydration stops short at the albumose stage, and is not continued so as to form peptone, as is the case with the others mentioned. That the protoplasm of gland epithelium is capable of exercising such an hydrating influence, we will instance the conversion of glycogen into sugar by the liver.

It must be borne in mind that although the proto-albumose, hetero-albumose, and deutero-albumose which are formed by these various agencies, have so far not been chemically differentiated, they are not identical. And when submitted to that infinitely more sensitive test, the physiological one—produce vastly different results.

In view however of the essential chemical identity which does nevertheless underlie such physiological differences, we may be permitted to express our conviction that the discovery of a method of antagonising those effects which follow the administration of snake poison, would be a highly important contribution towards the solution of the problem of dealing with the effects of the virulent products in zymotic diseases.

In conclusion we wish to express our gratitude to Mr. C. J. Pound for invaluable help with the various experiments, the results of which are recorded in this paper.

SOME FOLK-SONGS AND MYTHS FROM SAMOA.

Translated by the Rev. G. Pratt.

With Introduction and Notes by John Fraser, LL.D.

[*Read before the Royal Society, N.S. Wales, November 2, 1892.*]

XXXI.—Losi and Malae-Lā—*A 'Tala.'*

The war of the gods and the giants.

(Three Versions, Nos. xxxi., xxxii., xxxiii.)

—o—

Introduction.—The classical scholars who are here to-night will be interested to learn that the Sāmoans have a myth which is a local version of the Grecian story of the war of the gods and the giants. I was myself surprised when, on turning over a bundle of old manuscripts, I found one written by a Samoan hand and headed with the words 'ia le malaga na alu i le lagi,' 'about the expedition which went up to the heavens.' When translated, it was found to be the description of a contest between the sons of Tangaloa-in-the-heavens and a band of earth-born giants. This myth accordingly raises many curious questions; but, first, let me present to you a sketch of the myth, and then we shall be the better able to consider the questions which arise from it.

The Samoan cosmogony has eight heavens, and a ninth, in which sits, calm and peaceful, in his 'Bright-house,' the supreme Tangaloa, the creator of the heavens and the earth. The upper heavens are ruled by representatives, or rather emanations, of Tagaloa-i-le-lagi, all of these being called Tangaloa; but the regions of the sky nearest the earth are occupied by Night and Day, and the Sun and Moon, and other regents, and their progeny; these persons are called Sā-Tagaloa, 'the family of Tangaloa.' The messengers of the gods are two girls, Tuli and Longonoa; the name Tuli is also applied to a bird common enough in all Polynesia, and supposed to be the emblem of Tangaloa. The Sā-Tangaloa, occupying the lowest heavens, are of inferior rank, and have many of the appetites and passions of mortals; they like fish, and certain fishes of the ocean are sacred to them, especially the 'bonito' of the South Seas; hence, in many of the islands there, 'a fish for Rongo' is the cry, when the worshippers are about to kill a man and lay his body as an offering before their god.

Now, on earth below, there were then many giants; one account says that at least one hundred of them engaged in this war. One of these, Losi, the fisherman of the gods, was indirectly the cause of the war. They were really giants; for one of them was named Tele, which, translated into the vernacular of our streets, would be the "Big Un"; another could stand firm in the midst of a swollen river; another could swallow a whole oven-full of food, along with the shoulder-pole and baskets which brought the food. There were certainly giants there in those days.

The war arose in this way. The Sā-Tangaloa wanted to have some fish, and so they sent down their messengers to ask Losi to get some for them. Losi obeyed orders, caught a lot, and took them up to the heavens; but, being of a tricksome mind, like many giants, and fond of fun, he laid a fish during the night at the door of each of the young men there, who, when they came out in the early morning, slipped on them and fell, much to their own damage and to Losi's amusement.

That practical joke produced no serious consequences; for we next find Losi quietly looking on while the Sā-Tangaloa are preparing an oven of 'taro,' in order to offer him the usual hospitality of food. Coveting this kind of food, of which there was none on earth below, Losi secreted on his person a small piece of it, fit for planting. The Sā-Tangaloa suspected him and searched him, but could find nothing; they, however, searched him so unceremoniously that he felt himself insulted; and, when he returned to his home and had planted the bit of 'taro,' which grew well, he cried to his relatives and especially to his mother Earth for a war of revenge. The best of Earth's warriors assembled, and went up to the heavens, as if on a friendly visit. But the Sā-Tangaloa knew their secret purpose, and tried to get the better of them by stratagem. And first, as their duty was, they prepared food to offer to their visitors, but 'there was death in the pot,' or at least in the plot; for the young gods intended to attack them when they were all busy eating, and kill them. The giants, however, outwitted them; for they prepared a meal for themselves apart, and sent two of their own number to the place where was the food offered; to the astonishment of the Sā-Tangaloa, these brothers ate it all up, with the yoke and baskets as well. Hence they were justly called the 'Big-eaters.'

Next day brought another device. One of the Sā-Tangaloa came along to try their skill in club-play, expecting to master every one of them; for he had 'eight livers' of courage, and, strange to say, they were somehow attached to his body outside! But Moso, one of the giants, encounted him, and forthwith made him sue for ransom to save his life.

Next day another device. The Sā-Tangaloa caused a fresh in the river, and challenged their visitors to plunge in after them, and battle with the stream. But one of the giants had placed himself in the middle of the river; and, when the bands of the Sā-Tangaloa came sweeping past, he seized them and held their heads under water till they were drowned; but, when any of his own friends came by, he lifted him out and set him on the bank.

Next day the Sā-Tangaloa had another scheme for the destruction of their visitors. The rain-makers brought down heavy torrents of rain, expecting to paralyse them with the force of the rain-drops and the cold; for the Polynesians shiver when exposed to rain, and run from it if they can find shelter. One of the giants, however, had furnished himself with wings and the feathers of birds; and, under these, like a huge mother-hen, he gathered his men and they were safe, while many of the Sā-Tangaloa themselves were killed by the rain.

It was now evident that plotting was of no avail against the giants; so the Sā-Tangaloa resolved to try a pitched battle. But in it the giant Le-Fanonga, 'Destruction,' encountered the whole host, and, as might be expected, he conquered and destroyed them. So the giants came off victorious in the strife and carried down to earth, for their own use, the trees and roots good for food, that the celestials possessed. So far our Samoan myth.

The Grecian story of the war of the gods and the giants is first given in full by Hesiod, who lived about 700 B.C. It runs thus:—In the beginning uprose Chaos, and next broad-bosomed Earth. First, Earth produced the starry Heaven, and the barren Sea, and the deep-eddying Ocean, and the Sun (Hyperion), and the Moon (Phœbe) with golden coronet; but the youngest son was the savage and wily Kronos. These were all known as Titans; they correspond with our Samoan Sā-Tangaloa, being ranked as gods. Next, from the union of Heaven (Ouranos) and Earth (Gaia), arose the three Cyclops,—Brontes, Steropes and Arges—Cyclōpes their name,

> "For that one circular eye was broad infixed
> In the mid-forehead; strength was theirs, and force,
> And craft of various toil."

Then came three giants great and mighty, who were also earth-born, —Kottus, Briareus and Gyges by name—each of whom had a hundred arms and fifty heads; they had also monstrous strength and vast size.

The story goes on to say that Kronos mutilated and dethroned Ouranos, and, with the aid of the Titans, set up a new monarchy, for which grave act vengeance was not long in coming on them. For when Zeus, a younger son of Earth, had grown to man's estate, he secured the assistance of his half-brothers the Cyclops and the Giants against the Titans, who occupied the heights of Mt. Othrys, while Jove and his party had possession of Olympus. For ten years the opposing parties fought, their battle-field being the plains of Thessaly between. At last, weary with the strife, the mighty Jove drew his forces together, and prepared to put forth all his stores of thunder and lightning. In battle the Titans were now driven from heaven, and thenceforth Jove reigned supreme. So far the Greek myth.

The Giants figure also in the mythology of the Norse nations; for there, the very first earth-being is a frost-giant, the mighty 'Ymer'; he was killed by the gods, and from the maggots generated in his dead body came the Dwarfs of the northern myths—powerful and energetic, notwithstanding their diminutive size. As these giants are a prominent feature in the Scandinavian mythology, I will give here some account* of them, thus:—In the beginning, there were two worlds; in the far north a world of mist and ice-cold, Nifl-heim, and in the far south was Muspelheim, the fire world; between them was a yawning gulf. The blasts of heat passing across this gulf melted the frozen vapours in drops, which

* Abridged and adapted from an article in Chambers's Cyclopædia.

by the might of Surt, the heat-sender, produced a giant man, Ymer, the first of the evil race of giants. In a similar manner appeared a cow, which gave milk to Ymer. This cow, by licking the salt from the ice-rocks, produced first the hair of a man's head, then the head, and in the evening a perfect man, Bure; his son Bor, married the giantess Best-la, and she bore three sons—Spirit (Odin), Will (Vile), and Holiness (Ve); these three slew Ymer; out of his body they made the world; for, his flesh became the land, his blood the ocean, his bones the rocks, his hair the forests; his skull became the vault of the sky, and in it they set red-hot flakes from Muspel-heim to be the sun, moon, and stars. Odin himself became the father of the gods who rule heaven and earth. One day, as three of the gods were walking by the sea shore, they found there two trees, an ash and an elm; the first god, Odin, gave to the trees breath, Hœner gave them feeling, and Loder gave them blood and the image of the gods; and thus these trees became a man and a woman, Ask and Embla—the progenitors of the human race.

These Scandinavian gods and goddesses dwell in Asgard, but each has a separate location there. From his seat on high, Odin looks down on the nine worlds, and in his bright hall, Valhal, he assembles all men who have died in battle. In Asgard is the sacred fountain of Urd ('the Past'), to which the gods repair daily over the rainbow bridge, 'Bifrost'; everything placed in this fountain becomes white as the film of an egg-shell.

At the time when Ymer was slain, only two of his race escaped—a man and a woman. From them came the later giants, who carried on constant warfare against the gods. The chief of these giants is Loke, at one time a foster-brother of Odin. One of his three children is Hel, the goddess of death; her domain is in the lower world; it has nine abodes, one below another; and in the lowest is her palace called 'Anguish.' All who die a straw death—of sickness or old age—go to her.

The brightest and most beautiful of all the gods is Balder; he dwells in a mansion called 'Broad-shining-splendour' (Breid-ablik), into which no unclean thing can ever enter. Him Loke hates and at last kills by fraud. For this deed Loke was bound to a rock, and was tortured by the venom from a serpent's mouth falling on his face. This causes him to shriek with pain, and then the writhing of his body shakes the earth.

Balder's death brought on a terrible war between the gods and the giants, in which war of Ragnarok gods, men, and giants all perished; thereafter appeared a new and better world, a new earth, a new sea, a new sun, with brightness, peace, and beauty over all. There came also a new heaven, Gimle, in the highest empyrean—more brilliant than the sun—a realm of joy where the virtuous dwell for ever. So far the substance of the myth in the Edda.

Now, in this Norse legend we have two mythologies of which the later is much coloured by Christian influences; but to the older Edda belongs the antagonism of the giants to the gods and the general conflict which ensued; to it also belongs the proto-giant Ymer, of whom the Edda thus speaks:—

> "It was Time's morning, when Ymer lived;
> There was no sand, no sea, no cooling billows;
> Earth there was none; no lofty heaven;
> No spot of living green; only a deep profound."

And so everywhere in Aryan mythology these giants appear, sometimes in one dress, sometimes in another; but everywhere also they are represented as of huge size, and fierce countenances; they eat and drink prodigiously; they are good-natured and peaceable, but, when roused, they use their stupendous strength; therefore in the Titanic war, they

> "Successive thrice a hundred rocks in air
> Hurled from their sinewy grasp, with missile storm
> The Titan host o'er shadowing; them they drove,
> All haughty as they were, with hands of strength
> O'ercoming them, beneath the expanse of earth,
> And bound with galling chains."

Strong though they are, the giants of all countries can easily be outwitted by men; and so the hero of the Odyssey escapes from the Cyclops by a simple stratagem, and in our own nursery tales Jack-the-Giant-killer always outwits the giant.

Some mythologists are incredulous as to the existence of giants, and will tell you that these are merely personifications of the volcanic and other terrestrial forces in nature; they assert that the war with the gods, the climbing up into heaven, and the hurling of huge rocks in battle, are only a poet's way of saying that the mountain tops burst into flame, and that stones and dust and liquid fire were thrown into the sky. But it is evident that giants did exist in the olden times, for the tradition of them is found everywhere; and, in Genesis xiv. 5 and elsewhere, there is testimony that early Canaan had races of gigantic stature.

Now, if we turn to our Samoan myth, the first curious question that I ask is this: How did these Samoan myth-makers come to know any thing about giants? for there are no races of giants in their islands; and I suppose there never were. The only satisfactory answer must be that the first Polynesian settlers brought these tales with them from their ancestral home, and the whole cast of the present myth leads me to think that that home was in Asia and among an Aryan people; for our myth ends by saying that the Sā-Tangaloa—the heavenly race—*were conquered* by the giants and driven out; and that is exactly the fate of the heavenly Titans in Hesiod's account of the war. It is true that the later Grecian traditions, and to some extent Homer also, tell a different tale, when they narrate how the giants "waged war on heaven with vain attempt," piling Pelion on Ossa in their efforts to capture Olympus and its gods; and that Jove at last scattered and quelled them with his thunderbolts. Our myth knows nothing of such a war; but it agrees with Hesiod in recognising the giants as earth-born and as overcoming the host of inferior gods and expelling them from heaven; in no other respect does it agree with the Norse Edda except in this that there was a war between the gods and the giants. Now, South-eastern Asia is the only locality from which the ancestors of the brown Polynesians can have come, and in that locality there are only two main races, the Mongolians and the Caucasians of India, the remnants of the black race being a negligeable quantity in this connection. The Mongolians may also be dismissed from consideration, for the Polynesian physique and character show nothing Mongolian. I therefore argue from this myth that, in some way and at some time, the founders of the Polynesian race must have been in contact with the Caucasians of India, and got from them the original tales about the giants and their wars. I do not know enough about the Vedas and the Purānas of the Sanskrit-reading Brahmins to be able to say how far this myth corresponds with any incidents they tell about the *devas* of their pantheon; but, in examining a dictionary of the Pâli language of India—the sacred language of the Buddhists—I find there are in it many things which bear a close resemblance to the Samoan ideas of a cosmogony. And so, if the progenitors of the brown Polynesians came from India, that race is allied to the Caucasians, and not to the Malays, who are essentially Mongolian.

The next curious thing in our myth is the mode by which the giants ascended to heaven. They climbed up by a huge *fau* or 'hibiscus' tree. This at once reminds one of Jack-and-the-bean-stalk and other folk-lore tales among many nations.

Then the Sā-Tangaloa, seeing so many strong men arrive, and suspecting their intentions to be hostile, prepared to offer them the usual hospitality of food, but intended to set upon them and kill them when their weapons were laid aside at the feast. This agrees with similar devices in all ages. Apparently, these young men of the heavens do not respect the protection which the laws of hospitality afford. But the plot did not succeed; for the rest of the giants ate apart, and two of their number came and devoured the whole of the offering of food. In a similar way our nursery tales tell us of the enormous voracity of giants.

The Sā-Tangaloa now have recourse to stratagems. They try a clubbing-match, swimming on the bosom of the swollen river, and exposure to heavy rain. These are all thoroughly Polynesian; and so they prove that, wherever the Polynesian forefathers got the frame-work of the myth, it has since been filled in with local incidents. The same thing is apparent in the whole setting of the Norse tales also, in which frost and ice are a conspicuous feature. That portion of our myth which speaks of Losi and his doings is also purely Polynesian.

From these snares the giants deliver themselves by their superior strength and cunning, and ultimately, in open combat, they conquer the Sā-Tangaloa and spoil them of their goods. And thus ends the war. But the whole conflict arose at the first from the tricksomeness of Losi, who corresponds in this respect with the Robin Goodfellow of our English tales.

It must be confessed here that this Samoan myth ends tamely enough; for, in addition to the expulsion of the Sā-Tangaloa, the only result of the war is the gaining of 'taro' roots, and cocoa-nut trees, and banyans and the like, for the inhabitants of earth. We almost regret that there is not here some grand catastrophe; as when, in the classic tale, the vanquished are thrust down to earth and Tartarus, and thenceforth restrained by chains on their limbs, or such an island as Sicily cast upon the prostrate body of a Typhōeus, his mouth under Etna, from which in his struggles to be free he vomits flames. But such as the Samoans made the myth to be and such as I found it, I have given it to you.

Then again, in eastern lands also, another and an important parallel to this Samoan myth of ours is found in the *Râmâyana*, the famous Sanskrit epic, which details the adventures of the Indian hero Râmâ, and also in the Boma-kăvya of Java which tells of Boma, an earth-born hero, who fought with the inferior gods and vanquished them. Allow me a few words as to these two poems.

The popular belief in India makes Brahma, Vishnu, and Siva to be the supreme gods, occupying the higher and invisible firmament. But of the subordinate gods—the *devas*—dwelling in the lower sky, the chief is Indra, who is the visible heavens, and wields the lightnings and the thunderbolt. Others of the *devas* are Varuna, the god of the ocean; Yama, the god of the south and of Hades; Agni, the god of fire. These and others are visible representatives of the higher gods, and do their will; they therefore correspond with the 'dii minorum gentium' of the Romans; they are not themselves immortal or invincible; for they use the celestial nectar, 'amrita,' to keep them alive, and they are often in jeopardy at the hands of giants; they are also represented as youths. All this agrees well with the Samoan notions about such things; for the Sā-Tangaloa are young men, placed in authority in the lower heavens by the appointment of the supreme Tangaloa; there they feast on the celestial 'taro' and drink the celestial 'kava' cup, and in our present myth they are vanquished both in cunning and skill, and in prowess also, by the earth-born giants of Losi's expedition.

Both of these poems acknowledge the power of the giants. The Boma-kavya, that is 'Boma-song,' is written in the Kawi language of Java, but is of Indian origin. Boma (Bhâuma) is the son of Vishnu and Prithivī ('Earth'), and, as earth-born, he is a 'dânava' or demon, both in form and disposition. Along with other 'dânavas' he wages war on Indra, conquers him and reduces him to dire distress; in this extremity one of the higher gods interposes; but he has to lift Boma bodily from mother-earth in order to be able to kill him; for as often as Boma's body touched the earth, his strength was renewed.

So also in the Râmâyana, Râvana, the giant king of Ceylon overpowers Indra. But he himself is afterwards conquered and killed by Râmâ, an incarnation of Vishnu. Râmâ, to accomplish this, became the son of an Indian king of the Solar dynasty, but still had half the nature of Vishnu. While yet a stripling, he assisted in routing a war band of the Rakshasas, a race of demons, and he, soon after, succeeded in bending a wonderful bow, and thus obtained the beautiful princess, Sīta, in marriage. But the jealousy of his step-mother drove him into exile; and, while they were living in hiding in the forest, Sīta was carried off by this same Râvana of Ceylon, himself a Rakshasa. Râmâ now makes an alliance with a monkey-king in India, whose son, Hanuman, discovers the place in Ceylon to which Sīta had been carried. With an army of monkey warriors, Râma miraculously crosses the straits, and, entering Ceylon, conquers Râvana and his demons, cuts off Râvana's head, recovers Sīta, returns to his native dominions, and is made king there. As a reward for his assistance, the monkey-king and his people got the tableland of India, the Dekkan, to possess.

This story of Râma has not much bearing on our myth, but there are three ethnological analogies in it which deserve notice.

(1) Râma's wife is Sita, and, all through the poem and in India to this day, she is regarded as a pattern of wife-like devotedness and fidelity. Similarly, in our myths everywhere, the hero's wife is called Sina, and Sina is a very popular name for women in Polynesia. In Sanskrit, Sīta means 'white,' 'a handsome woman'; in Polynesia, Sina means 'white,' is a name for women, and as such is applied to 'the moon.' Is it possible that the Polynesians brought this name with them from Asia? As to their form, the two names are radically the same. (2) The other two analogies bear on the origin of our Australian blacks. In the story of Râma, there are traces of three races in India at the time when the Râmâyana was composed. The white race gives us Sita, 'the fair one,' and Râma himself, who is of the Solar kings. At war with him are Râvana and his demons in Ceylon, whom I consider the remnants of the first black race which we know to have occupied India in the earliest times; their position in the remote island of Ceylon shows that these Rakshasas had passed thither from the mainland of India, probably driven thither by an invading race; and the name 'demons' is often applied by conquerors to a fierce people when subdued, especially if they are of a different colour. The monkey-king got the Dekkan; and that portion of India is still occupied by diverse tribes of blacks. Of course the monkey warriors were men, and are, in the poem, called monkeys because of their features, as compared with the shapely faces of the fair Caucasians. It is rather odd, as a coincidence, to know that the Mantras, a black race in Malacca, say that they are all descended from two monkeys.

To my mind therefore, these original inhabitants of Ceylon—not the present Singhalese—represent the primitive inhabitants of India; Râma's allies of the Dekkan represent a mixed black race which came in afterwards, and Râma himself is a white Caucasian. But the incoming of Râma's kindred had already driven the other two black races far a-field, and continued to drive them until at last they found refuge in our island, Australia. Such at least, is my view of the matter.

And now, in summing up, I may add that to some of you this may seem a long introduction to so small a matter as a Samoan myth, but discussions of this kind have a distinct and sometimes an important value to the ethnologist. Let me just show you how it may be so in this case. The ethnic origin of the brown or eastern Polynesians is still undetermined. One long-established opinion is that these Polynesians are a branch of the Malay race; hence they are often called Malay-Polynesians; this would ally them with the Mongolians, for the Malays are largely Mongolian. Another opinion is that these Polynesians are not in any sense Malays, but, on the contrary, are Caucasian and came from India and south-eastern Asia, long before the Mongolian race and the Malays established themselves in these parts. A third opinion is that the Polynesians in the islands have come from an admixture of a conquering white race with a conquered black race previously there.

Now our present Samoan myth supports the second of these two opinions and, indirectly, to some extent the third also. For, so far as I know, the story of the war of the gods and the giants does not exist in Mongolian or Malay lands, and is the exclusive property of the Aryan languages and race in India, in Greece, in Scandinavia, as I have shown. If it should be proved that the Mongolian-Malay race has not this tale at all, or has it in an essentially different form, then it is clear that the Samoans did not get it from the Malays, and therefore they are not of Malay origin. But if the myth is entirely Aryan, then it follows that the ancestors of the Samoans must have been at one time in close contact with the Aryans, and are probably, in some way, an offshoot of that Indo-Germanic race. And it is because of the ethnological aspect of it that I have dwelt so long on this simple Samoan myth.

Mr. Powell's Summary.—1. Sā-Tangaloa in the heavens desired to eat fish. Losi, at that time, had charge of the sea and was the fisherman of the gods. Accordingly, two female messengers, Tuli and Longonoa, were sent down to him with a request for fish. Losi obeyed orders, went and caught some very large fish, tied them by their tails to a long rope, and then told the messengers to come and take the fish. They came, but the fish dragged them hither and thither, and they had to call to Losi for help. He said, "You go on first, and I will take up the fish." So he went up with one hundred large fish; he took so many, because the large house in heaven, where the single young men lived, had a hundred doors. When he arrived there, Losi, placed a fish, during the night, on the threshold of each door; and, in the early dawn, when the young men came out, each stepped upon the slippery thing and fell down; one got a broken arm, another a wounded head, and so on. This took away all their enjoyment of the fish; hence the proverb, "Ua lē poa le ta'e a Losi," which means 'Losi's fish (*lit.* 'dirt') has no savour,'—applied to any favour or service the enjoyment of which is marred by painful circumstances attending it.

2. Hospitality, however, required that the young men should prepare an oven of food for their guest, and Losi went to look at its preparation. In those days there was no 'taro,' or breadfruit, or yams on the earth below. Losi, therefore, secreted one of the 'taro' eyes about his person under his girdle. The young men observed his movements, and, suspecting what he had done, they laid hold of him, and, in searching him, they most indecently exposed his person. But they did not find his treasure. He

went off in great indignation at the disgrace. On earth below, he planted the 'taro' eye; it became very productive, and he got from it a fine crop. Some time after, the young men came down to earth, and, seeing his plantation of 'taro,' they said, "After all, he did bring down the things of heaven." And so they carried off all his fruit. This incensed him still more, and from this arose the war in which they were subdued.

3. Mr. Powell adds, "Tauānuʻu tells me that a hundred heroes and more were engaged in this war. Among them he mentions, Fai-malie and Fai-tāmai; Pava-tai and Pava-uta; Le Fanonga, 'Destruction'; in battle he carries everything before him; Le-Sā, 'the sacred one,' the son of Fatu and Le-ʻEleʻele; Tiʻe-tiʻe, the adopted son of Ulu-le-papa; he fought with the 'eight-livered' giant; Moso-ma-fufulu; he stretched out his wings and covered his comrades from the rain; Lavei-fulu-fulu-i-tolo, a hero; and Ali-ngalu, the wife of Le Fanonga."

The 'Tala.'

4. Malae-Lā was the husband of Pulou-lou-tele, 'the big bonnetted,' who was the daughter of Fatu and Le-ʻEleʻele and mother of Losi.

5. Two girls went down from the heavens, the children of Tangaloa, to borrow fish from Losi. Losi said, "Have a sleep first." Then he went to spear fish. He got fish. He tied the fish with a rope; he tied them with *fue-fue-luea* rope, on the sea side of Mutia-tele. Losi said to the girls, "Take your fish, you two." They went there but the fish were fierce. The girls shouted to Losi. He said, "Go on ahead, you two, and I will bring them." Then the girls went on ahead to the sky. Losi went up and placed them all along in the doorways of the house. When the men came out, they trode on the fish; the fish wriggled about; the men fell; they were angry; they abused Losi and said thus—"The dung of Losi is not like the fragrant yam"!

6. Losi remained, and the Sā-Tangaloa made an oven of food for him. There was no 'taro' down there in those days. Losi took up of the scrapings of the taro a little piece, and secreted it under his girdle. Sā-Tangaloa suspected him of the theft. They searched him without ceremony, but found nothing. Losi was angry at this. He cried to his father for war, but his father was unwilling,

for he had none to fight a battle. "But you go to your mother," said he. Then he came to his mother, and to Tui-Manu'a and Taū. He cried to them for war, to bring punishment for the insult to him.

7. Then were appointed Pulou-lou and Taū, Le-Sā, Moso-ma-fŭfulu, Lávĕi-fulu-fulu-i-tolo, Ti'e-ti'e, Le Fanonga. These went up into the heavens to fight the Sā-Tangaloa. They went as a travelling party [but not ostensibly for war]. The gods laid a snare for them in the offering of food; for they took food to the travelling party, but they earnestly desired to kill them before [the feast] was over. But Le-Sā ate up all the food. Then they had a clubbing match. Le-ate-valu, 'The-eight-livered,' encountered Ti'e-ti'e with clubs. One blow and he died; the Sā-Tangaloa were thus overcome. In the morning they sported in the fresh in the river. Then Ti'e-ti'e went with the men of the Sā-Tangaloa. Then Ti'e-ti'e was lifted up by Lavei-fulu-fulu-i-tolo, and the Sā-Tangaloa were carried away and drowned.

8. Then they had a day-song; they made it outside and it rained; the Sā-Tangaloa were killed by the rain, but the travelling party was sheltered by Moso-ma-fufulu, 'Moso-of-many-feathers.' Then they fought a battle; the Sā-Tangaloa were driven back; for Le-Fanonga stood up and smote the Sā-Tangaloa. Then they went down [*sc.*, to earth], as they were conquerors. They took down also 'taro,' and cocoa-nut, and bread-fruit, and the 'kava' circle, and a hundred 'kava' bowls.

Notes to No. XXXI.

Par. 1. *Sā-Tagaloa*, 'the family of Tangaloa'; these are the younger and inferior gods who occupy the lower heavens. Their place of assembly for council and sport is Malae-Lā, the 'village-of-the-Sun'; strictly the *malae* (*marae*) in all Polynesia is *an open space* in the village where the people assemble on public occasions, but the word is often used as part of a village-name, like the Latin *Forum* and the English *Market*. The title of this myth shows that these Sā-Tangaloa were sun-gods; thus they correspond to the Indian *devas*.

To eat fish; one fish, *atu*, 'the bonito,' was an especial favourite with the Polynesian gods; and here their desire 'to eat fish' shows that the

Sā-Tangaloa are regarded as having the same appetites and passions as men.

Losi, fisherman; losi, as a common noun, means 'emulation.' In the classic mythology, the sea is under the rule of Neptune, a brother of highest Jove, and the dolphin is his favourite. In the Hindu pantheon, Varuna, in one of his aspects, is god of the ocean; but here, in Polynesia, Losi is only an earth-born giant, and obeys the gods above.

Female messengers; things in the Polynesian heaven resemble social arrangements on earth; in the Samoan myth of Creation, the denizens of the lower sky are created male and female, and in pairs.

Tuli and Longonoa; these two are specially mentioned in the Samoan account of Creation (*q.v.*).

Their tails; in the world-myths, the giants are often set forth as merry, tricksome fellows.

One hundred; in many myths, this number is the *ne plus ultra;* so Thebes had a hundred gates, Crete had a hundred cities, and Briareus had a hundred hands.

Large house, where the single men lived; this is a common arrangement in various parts of Oceania.

Losi's fish; the story about Losi must be very old, for this incident has established itself as a proverb.

2. *Hospitality;* invariably food is offered to a visitor.

In those days; see also the story of Mafui'e and Ti'e-ti'e.

The earth below; lalo-lagi, 'under the sky.'

Secreted; heavenly possessions are coveted by men; Prometheus *stole* fire from heaven.

3. *Fai-malie, &c.;* for these names see the '*Solo*' and the '*Sufi*' on the same subject.

Fatu and *Le-'ele-'ele;* see the Myth of Creation.

Eight-livered giant; see the 'Tala,' No. XXXII., 3.

Le-Fanonga; see Introduction to Myth No. IX.

4. *Mother of Losi;* Losi is thus Earth-born.

5. *Two girls;* Tuli and Longonoa.

Children, borrow; the Samoan words here are 'fanau' and 'no.'

To spear fish; so'a-so'a; see the third line of each verse of the 'Sufi.'

Fue-fue; this is a creeping vine, much used for tying.

Go on ahead; 'mua-mua'; mua means 'first.'

When the men came out; men, 'tagata'; these Sā-Tangaloa are not *aitu,* 'spirits,' much less *atua,* 'gods.'

Said then; 'fa'apea.'

6. *An oven of food;* 'umu fono.'

Those days; ia ona po, *lit.,* 'on those nights.'

Losi took up &c.; 'ua tago ai e Losi pa'u talo [valuga] se mea iti-iti'; here *pa'u* is 'skin,' 'rind,' and *valu* is 'to scrape'; '*se mea iti-iti*' is 'one very little thing.'

Under his girdle; 'i le mea masoa'; here *masoa* is 'filthy,' and *mea* is a 'thing.'

Cried for war; tagi-tau. 'Malae-Lā' is here called *his father;* but this must be a mistake; for Malae-Lā is the name of a place, as above.

None to fight a battle; 'e leai ni e tau ai se taua.'

Punishment, insult; sala is 'punishment,' 'a fine,' 'to cut off'; *faiga* is any 'abuse' which causes pain.

7. *Snare* is here 'mailei,' 'a trap'; *offering,* tāulaga, 'a sacred offering'; *travelling party,* malaga; *food, lit.,* 'something to eat.'

Clubbing-match; 'aigofie'; there is no open war here; it is all sport and trials of skill, as in our own nursery tales.

The-eight-livered; the next 'Tala' tells how these livers are placed on his body. The number 'eight' here is peculiar; it is not seven nor nine, and yet it seems to indicate a perfect number. I take it to be used for 'twice-four,' and four in the Indian languages has an indefinite sense, equivalent to our 'a considerable number.'

In the morning &c.; 'ua taeao, na faia lo latou fa'a-tāfega'; 'carried away,' tāfea; the 'fa'a-tāfega' is a kind of sport and trial of strength, as is the 'aigofie'; 'drowned,' oti, *lit.,* 'died.'

8. *Day-song;* ausoa.

It rained; the Polynesians dislike rain very much; it is so cold on their bare bodies.

Sheltered; 'fa'a-paolo'; *paolo* is 'shade,' 'protection.' For the manner of Moso's protection, see the 'Sufi.'

A battle; 'taua'; it is now a fight for victory, no longer in sport.

Taro &c.; these are the spoils of victory; 'kava circle,' alofi. For the 'kava" see Nos. IX. - XIV.

[Another Version.]

XXXII.—Le Malaga na alu i le lagi—*A 'Tala.'*

" The Expedition that went to the heavens."

1. These are the men that went on the expedition, Moso-a-le-alofi, Lau-tolo, Tele, Losi, Ti'e-ti'e, Fai-malie and Fai-tāma'i, Tui. There are two opinions about the way the party got up. The one of them says that there is, at Aleipata, a 'fau' tree by which they got up; but the other is that Sangana is the place where the 'fau' was, because there is there a spot called Fau-i-lalau, 'the *fau* of the many leaves.' [At all events], they went to the heavens.

2. But the Sā-Tangaloa determined to [make a plot against] them. Then Tui said, "Don't let our party say a word about it; when to-morrow comes, an offering of food will be brought to us; we shall not have finished eating, when our party will be killed." Then Fai-malie and Fai-tāma'i said, "Leave that business to us two; when they bring the offering, do you prepare some food for yourselves to eat, and leave it in the court for sports." Then the offering of food was placed before them, and the young bread-fruit was fully ripe. And Tui ran and went round their portion. There was also one of them whose name was Tui-tele-vave, 'Tui-of-great-quickness.' But it was Tui-le-i'ite, 'Tui-the-prophet,' that separated their portion. And they put the whole of it in the court. Then went Fai-tāma'i and Fai-malie and ate up all the offering, along with the yoke-sticks on which it had been brought and the baskets; not a thing was left. Great distress of mind came upon the Sā-Tangaloa.

3. Again Tui-the-prophet said, "Don't let our party utter a word about it; to-morrow the Sā-Tangaloa come for their sports; do you determine whether it will be profitable [to take part] in them." Then said Moso-a-le-alofi, "Leave that to me." Then at once the Sā-Tangaloa came along hastily. They of the expedition looked, and, lo! Tangaloa-of-the-eight-livers approached. This was a chief about whose body hung his livers. Then Moso rushed on him; the two joined in a [hand to hand] combat with clubs, he and Tangaloa the-eight-livered; they lifted up their blows and the-eight-livered got a gash; one of his livers was cut off; again another blow struck him and another liver was cut off; the eight-livered became weak. Then came the troop of the Lava-sii to pay his ransom.

4. A fine mat was laid across [Moso's] shoulder [and fixed as a shoulder belt]; it was put on quickly, and not allowed to touch the ground, for it was sacred; it was brought with water to sprinkle on it. That is the band that began [the use of] the water of sprinkling, with the privilege of sitting beside the chief; because

the sitting by the side of the Lava-sii is a sacred thing. Here began also the 'tafa'i-paia.'

5. Tui-the-prophet said again, "Don't let our party say a word; to-morrow comes the sport of floating on the bosom of the river." Then Lau-tolo said, "Leave that to me also; if they engage in this sport, let our party rush down one by one, but let the Sā-Tangaloa come down by hundreds; I will stand in the midst of the water; if one of our men is washed down, then I will take hold of him and bring him up above the water; but if any one of the Sā-Tangaloa is swept down by the flood, I will thrust him down to hell."

6. Then came on the sport of floating on the river, which was done as I have just described. Then the Tangaloa said, "Stop up the water; no doubt the whole of our visitors are dead." Then the Sā-Tangaloa looked, and, behold! the party were all shaking the water out of their hair, and no harm had come to anyone of them. Hence sprang the proverb, 'They were delivered by the hairiness of Tolo.'

7. Again, Tui-the-prophet said, "Don't let our party say a word; to-morrow we shall be exposed to torrents of rain; but do you decide whether any one of us will be useful for that." Then again said Moso-a-le-alofi, "Leave that business to me." Then came along the band of rain-makers; but Moso went and took off the wings of birds and the feathers of all birds, and made with them wings for himself; and his party hid themselves away under them when the rain came down in great quantities. But Tui-the-prophet went and remained by himself in the rain, and was not cold. Then another name was given to him—Tui-laga-ua, 'the Prince that is superior to rain.'

8. Then the Tangaloa said, "Let the heavens be shut up; doubtless our visitors are all dead." Then the heavens were shut, and when the Sā-Tangaloa looked down, lo! the party had got no harm; but the most part of the Sā-Tangaloa were killed; no evil had hurt the party of visitors. And the names next to the

greatest were these—Tui-laga-ua, Tui-le-i'ite, 'Prince-the-prophet,' Tui-tele-vave, 'Prince-great-in-quickness,' Tui-lulu'u, 'the Prince-with-the-water-of-sprinkling,' Tui-mua-i-'ava, 'the-Prince-that-first-receives-the-kava.' Each one of all the visiting men was good for something; but there was no use for 'Big' (Tele), the chief; only for eating was he useful; hence his by-name, 'Great-in-eating' (Tele-i-'ai).

Notes to No. XXXII.

Par. 1. *Expedition;* malaga, 'a travelling party'; for variety I have translated this word as 'expedition,' 'visitors,' 'our party'; but in all parts of the tale it is the same word, 'malaga.'

Men; these are the giants who made the expedition to the heavens against the Sā-Tagaloa, 'the family of Tangaloa,' the supreme god. The meanings of their names are—Moso-a-le-alofi, 'Moso-of-the-circle-of-chiefs,' Lau-tolo, 'leaf-of-sugar-cane,' Tele, 'big' or 'large,' Losi, 'emulation,' 'jealousy,' (see his story No. XXXI.); Ti'e-ti'e, 'perching upon,' (see his story No. VIII.); Fai-malie, 'making pleasant,' Fai-tāma'i, 'making good fortune'; Tui, 'a prince.'

Got up; ui ai. *Fau* is the 'hibiscus' tree.

Aleipata; a place in Tutuila; *Sangana* is another place there.

2. *Determined;* 'pulea,' to make a decree of death; hence, to plot destruction.

Don't let our party &c.; 'aua le talanoa vale lo tatou malaga'; 'talanoa vale' means, to 'chat together foolishly,' 'to engage in idle chatter.' This formula of words comes up again and again in the story. By this, Tui enjoins his comrades not to let their plans be known. Tui, who is the directing genius of his party, means to countermine every plot of the Sā-Tangaloa; just as Jack the Giant-killer always outwits the giant.

Offering of food; 'taalolo,' see Note XXXI., 2; taalolo means 'the taking of food to visitors by several villages at once.'

Court of sports; 'malae i le taalo'; that is the open spaces where the Sā-Tangaloa were to hold their sports. The giants are to place a supply of food for themselves in reserve there, because the offering to be brought by the Sā-Tangaloa was intended as a snare.

Went round &c.; 'taamilo lana to'; *to* means 'to plant,' 'to separate,' 'to come upon as a calamity.' The *to*, used as a noun, must mean here the food that was intended to do them harm; and Tui 'went round' it (taamilo) to indicate their acceptance and separation of it as a gift.

Ate up all; this exhibition of power and voracity was enough to cause *atu-atu-vale*, 'great distress of mind; *atu*, 'to be perplexed,' *atu-atu* (plural) is intensive, and *vale*, 'foolish,' is also used as an intensive.

Eight-livered; 'ate-valu'; *ate* is 'the liver' and is here the seat of courage; in Hebrew and in Greek the 'liver' means the 'mind.' *Eight;* see Note XXXI., 7.

Combat; fe-tā-iga; *fe,* a reciprocal; *tā*, 'to beat.'

Got a gash; soni, 'to chop'; was *cut off,* motusia; *was cut off,* tipia; *ransom,* 'togi-ola'; *togi,* 'to cast,' *ola,* 'alive.'

4. *A fine mat;* 'lava,' 'an ornament worn over the shoulders.' This fourth paragraph describes the mode of investing Moso with the ensigns of victory. In Rome the gaining of the *spolia opima* was attended with peculiar honour and ceremony.

Water of sprinkling; 'vai-lulu'u'; *vai* is 'fresh-water'; *lulu'u* means 'to take up a handful.' This act of sprinkling removed the *tabu* or sacredness of a thing so as to let it be applied to a common use. It is curious to find such an observance as this in Samoa.

Tafāi is 'those privileged to sit on the right hand and the left hand of a titled chief.' This privilege seems to have come from these Lava-si[i] who paid the ransom, 'the redeemers'; *pa'ia,* 'sacred,' is a term applied to a titled chief. *Sii* is 'to lift,' 'to levy a fine'; for '*lava*' see above.

5. *Sport of floating;* 'fa'a-tafega'; this is another amusement and test of strength among the celestial Sā-Tangaloa; *cf.* the occupations of the 'einheriar' of Valhalla. The river is in fresh, and the test of strength is to hold out against the current.

In the midst of the water; this proves his strength and his stature.

The flood; u, 'to roar as the waves'; 'hell' is fafā, the Samoan Hades.

6. *Shaking the water &c.;* lialia'i, 'to shake the head,' as a dog shakes himself when he comes out of the water.

No harm; lē afa-ina, 'they were not hurt *or* injured,' from *afā*, 'a storm.'

The proverb; 'o le upu,' *lit.*, 'the word'; 'hairiness' is a reference to *tolo,* 'the sugar cane,' which is a tall stalk, somewhat hairy, and has a shaggy head.

7. *Rain-makers;* fa'a-ua-ga; *fa'a,* 'make'; *ua,* 'rain'; this craft is found everywhere, either to make rain or to drive it away.

Was not cold; this shows his power and endurance; for the Samoans dislike rain on their naked bodies; see a previous note.

Superior; laga, 'to raise up,' as a conqueror may do.

8. *Names;* these are—Tui, 'Prince,' the leader of the party, called here Tui-mua-i-'ava; for the 'kava' cup was always handed first to the chief highest in rank of those present; the other names are explained in the text.

[A Poetical Version.]

XXXIII.—Ia le Malaga—*A 'Sufi.'*

"*About the Expedition.*"

[*Note.*—A 'Sufi' is a kind of song which gives an explanation of ancient words. The subject of this 'Sufi' is the same as in the story of Losi and the War of the Giants. "This," says Mr. Powell, "I got from an old man named Lau-afia, living at Fangali'i, on the north side of Tutuila."]

I.

1. [Here is] a canoe-load of sufies; how many? [this is] one.

The messengers thus address Losi—

2. Be quick [to catch] the evening tide; the dawn is near.
3. Scrape your spear of the 'asi' wood;
4. With it to pierce for us (two) a fish—an 'ali';
5. The 'ali' is our fish; the fish that goes up to the heavens.

The narrator now speaks—

6. It was the fish of Le-Moso and Fulu-fulu-Tolo,
7. And Tui-a'i and Tui-a'a,
8. And Pava-uta and Pava-a-tai,
9. And Fai-malie and Fai-tāma'i.

Losi now speaks—

10. You girls there come to the allotting of food—
11. The thick 'taro,' and the water-side 'taro,'
12. And the spreading 'taro,' and the new plantation 'taro,'
13. And 'taro' both whole and sliced, with the squeezed 'vi,'
14. And swamp 'taro,' and the black-branched 'taro,' with [the sweet 'vaisalo' dish.

Refrain to verses I. - IX.

II.

15. A canoe-load of sufies; how many? the second.
16. Be quick to catch the evening tide; the dawn is near.
17. Scrape your spear of 'pua' wood;
18. With it to pierce for us a fish—an 'ulua';
19. The 'ulua' is our fish; the fish that goes up to the heavens.

Add here the *Refrain* (lines 6 – 14).

III.

20. A canoe-load of sufies; how many? the third.
21. Be quick to catch the evening tide; the dawn is near.
22. Scrape your spear of 'nonu' wood;
23. With it to pierce for us a fish—a 'nofu';

24. The 'nofu' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

IV.

25. A canoe-load of sufies; how many? the fourth.
26. Be quick to catch the evening tide; the dawn is near.
27. Scrape your spear of 'lalapa' wood;
28. With it to pierce for us a fish—a 'sa'ulā';
29. The 'sa'ulā' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

V.

30. A canoe-load of sufies; how many? the fifth.
31. Be quick to catch the evening tide; the dawn is near.
32. Scrape your spear of 'maosina' wood;
33. With it to pierce for us a fish—an 'i'a-sina';
34. The 'i'a-sina' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

VI.

35. A canoe-load of sufies; how many? the sixth.
36. Be quick to catch the evening tide; the dawn is near.
37. Scrape your spear of 'papaono' wood;
38. With it to pierce for us a fish—a 'maono';
39. The 'maono' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

VII.

40. A canoe-load of sufies; how many? the seventh.
41. Be quick to catch the evening tide; the dawn is near.
42. Scrape your spear of 'olapito' wood;
43. With it to pierce for us a fish—a 'lavaga-ifo';
44. The 'lavaga-ifo' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

VIII.

45. A canoe-load of sufies; how many? the eighth.
46. Be quick to catch the evening tide; the dawn is near.
47. Scrape your spear of 'talafu' wood;
48. With it to pierce for us a fish—an 'atu';

49. The 'atu' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

IX.

50. A canoe-load of sufies; how many? the ninth.
51. Be quick to catch the evening tide; the dawn is near.
52. Scrape your spear of 'ola-sina' wood;
53. With it pierce for us a fish—an 'uisila';
54. The 'uisila' is our fish; the fish that goes up to the heavens.
Add here the *Refrain* (lines 6 - 14).

Losi's two fishermen go out to fish—

55. Shaking the rattle, darting the spear, Fangaena and Matamuti'e
56. Pole their canoes to the extreme corner of the north, and the [land of the sun;
57. That is Niuē; it is far to the east;
58. [And so] Niuē has much daylight.

Losi addresses his attendants—

59. Sweep together the red mullet and carry them into the house;
60. And put them in a basket as my offering to the Sun.
61. Catch hold of the fish and prepare the fire;
62. Broil them tied up; the fire stands [ready] there.

The reciter now addresses Losi—

63. Tell us, [O Losi,] where did [these fishes] grow up
64. For the basket and the net; where did they come from?

Losi, in reply, enumerates the islands of his domain—

65. From the islands of Ofu and Olosenga, from Tutuila,
66. From the small freshwater lands, and Manu'a, and Fanua-tapu;
67. From my group of Sapai and Tonga and Niua and Tafasi,
68. And beautiful Fiji, and black Atafu, and reddish-brown Atafu;
69. Manu'a and Papatea are seen
70. And the island of Nu'u is going to float, and foreign lands;

The reciter speaks again—

71. Losi and Mau and Tui hurry on the 'sufi,'
72. And Ti'e-ti'e-a-Talanga and Fai-malie and Fai-tāma'i;
73. To them belongs the 'sufi,' who went up to the heavens.

---

74. Scrape the spear of 'manunu' wood;
75. To pierce with it for us a fish, a 'tautu';
76. And that is the last word from the lips of those who make [this tale. O!

Another version

gives the catalogue of Losi's domain differently; thus:—

65. From Upolu, and Uēa, and Savai'i, and my group of Sapai;
66. From my group of lands which are at the ends of the sea,—
67. Lautara and Pulotu, Vuia and Raepa,
68. Long Tonga, like the wing of a bat—
69. The land [that] stank, for the 'funga' plant slept there.
70. Seaward is my group of Vou, [that is] Vou and Vou,
71. Eh! my group of Fiji is my group Vou;
72. My group of Tonga is my group Vou;
73. My group of Nuu is my group Vou.
74. Lefē is a land of women;
75. [For] the men there are [like] the roots of the 'fasa' tree; [for]
76. They maintained themselves by the offerings made to them.
77. Fuaena is my Tanapa group where the day breaks on the in- [land side of the road;
78. Its people are lying down [to die]; they sleep on; they wake not.
79. Luvai is the land of Luvai;
80. My group of lands do not eat;
81. They do not know how to talk together;
82. The children do not go early in the morning to the water,
83. To bathe, and to take up the mats to sleep on them.
84. Pulotu has grassy eyes; Tulia's cocoa-nut tree stands on the [beach;
85. Its dry leaves are not washed away, are not gathered.
86. There are the spirit-hosts of Tui-Pulotu, the prince of Fafanga;
87. Their comrades stand there at the water; in front is To'elau;
88. They are still praising thy tree; where is the prince of To'elau?
89. About lower Fiji, upper Fiji, and short Fiji [I may say that]
90. Fiji is a peculiar land; they sleep in war and wake up languid.

91. Fiji is carrying the bier; why groan, Luuluu and prickly Fiji?
92. Fiji, [you are] a funny land, your road lies through smoke;
93. [For] the bananas were baked with the man; the bananas [were cooked, but the man was alive.
94. Beautiful Fiji groaned at it; for Sa-fulu-sou was delivered up.
95. Far off Tonga turns its face to it—
96. A group of lands—and my group of Sapai.
97. My group of lands is next—
98. Atafu-'uli, Atafu-mea;
99. Atafu is the land which has no houses;
100. It rains on them there and yet they sleep.
101. The 'fetau' tree and the red-eyed [wood]
102. Go down to the land of Savea.
103. Lua-ā is that land, the land of the sun.
104. Under the 'pua' tree is the standing place of the sun.
105. And the land of Sisia-le-fafā,
106. And the land of Alo-alo-o-le-Lā—
107. [The one is] the land that is shone upon by the sun,
108. [The other is] the land that is not shone upon by the sun.
109. There lived Lua-ui and Lua-maa, the children of Lu-faingā,
110. Who broke down the daily sacrifice to the Sun.
111. There is the land of Sioa,
112. And the land of Vale-vale-noa,
113. And the land of Tupu-sao-noa.
114. Sioa is the land of Sioa; Maioa is the land of Maioa;
115. There are the lands of Pola-taia, Pola-saia,
116. Pola-suena, Pola-piitia; but as to Pola-ta-olo-valu
117. And Fatu-tā, they are lands that are not watered.
118. Tapataia is the land of the 'pua' tree, the land of the 'velota' [bird,
119. And the land of many birds;
120. Towards the sea is the beach on which they alight;
121. Inland is the beach round which they wheel;
122. Towards the east is the land of Sina;
123. Towards the sea is the land of fish.
124. Far at sea is the fresh water of Malai;

125. It is drawn up by the trade winds.
126. Ofu and Olosenga are soon passed by,
127. Tutuila and the Si-mangalo lands,—
128. Those two lands—and the great lands,
129. Manu'a and Fanua-tapu.
130. We soon pass by my group of Samoa;
131. And if you thread them together, I will go on.
132. The land of Manu-manu now comes into sight,
133. With the land of Talinga-mai-Valu,
134. And the land of high Fiji and low Fiji.

---

135. O Losi, the 'sufi' is about to fail;
136. But do you consider in your heart, [and take heed]
137. Lest any group of lands should be overlooked.
138. The eastern groups and the Sinango land,
139. Sina-sengiina, and the land that does not budge;
140. The 'malauli' fish glides along there,
141. But the 'tafuti' fish airs itself in the breeze,
142. And the 'pusi' family stands up;
143. The 'pasa-pasa' splashes in the water;
144. Its ears are deaf and its eyes are closed.
145. And the land that is like a long house;
146. And the land of Atu—not wise to make plantations of 'vase';
147. But living men are sent there.

---

148. [Losi,] is that all thy groups of islands in the midst of the sea,
149. Together with the foreign groups?
150. Let not one land be forgotten, lest they be angry.
151. All the groups of lands are now finished,
152. But the land of Ula remains.
153. I suppose thy groups of Fiji are complete,
154. And also complete is thy group of Tonga,
155. And the groups to the west are finished.

The narative of the expedition is now resumed—

156. But [while other warriors] hastened to the heavens
157. The sons of Pili remained quiet.

158. [At first] the Sā-Tangaloa were about to flee,
159. But they rallied at the Malae-a-toto'a.

The speaker interrupts the narrative to say—

160. But let us [first] strike up our own dance.
161. The answer of the speaker is
162. Drive, drive on.

But now resumes—

163. Sā-Tangaloa are about to break up the rally of the angry [heavens,
164. [Whence] the thunders are threatening.
165. Mafui'e goes towards it;
166. Then the heavens were raised aloft, and you fell.
167. Drive, drive on.

The speaker reverts to the origin of the war—

168. I stood before the opening in the reef,
169. With that spear of mine, the 'afa' tree;
170. With it I pierced the bonito; that offering I left lying there—
171. The fish that I left there as a snare,
172. That gave no delight to the Sā-Tangaloa—
173. [The fish] that were not put in a basket.
174. [So] Tangaloa the talker got his head broken,
175. And Tangaloa the vengeful was knocked down.
176. O Sā-Tangaloa, cease to speak of getting the first kava [cup].
177. Tangaloa-sioa, cease to speak of getting the first kava [cup].
178. Tangaloa-maioa, cease to speak of getting the first kava [cup].
179. Tangaloa-lē-fuli, cease to speak of getting the first kava [cup].
180. Tangaloa-uatea, cease to speak of getting the first kava [cup].
181. Tangaloa-ua-o-po, cease to speak of getting the first kava [cup].
182. Stop that talk, for you are now in a bad [case];
183. The women have their heads broken, and so have the men.
184. [Even] Masina cried out with pain,
185. And a shout was raised on the tenth night.
186. Eat your mouthfuls of food with your broken heads.

The speaker winds up—

187. And our spear is of a 'futu' tree;
188. We pierced with it the 'tautu.'

189. [Moso's] feathers were raised,
190. And then the pursuit of the people went on.
191. Drive, drive on.

O!

Notes to No. XXXIII.

1. *Canoe load;* the 'sufies' are so numerous that they are here called poetically *tautaga,* 'a canoe-load.'

2. *Be quick;* the two girl-messengers thus address Losi and bid him make haste, for the space between nightfall and dawn is the best time for fishing; and perhaps they must ascend before daybreak.

3. *Scrape;* 'valu-valusia'; scrape, that is, get ready for use.

3, 4, 5. *Asi wood &c.;* the nine sufies mention the different kinds of wood used for fish spears, and the different kinds of fish caught for the two girls to take up to the heavens with them.

6 – 9. *Le-Moso &c.;* these are some of the giants who engaged in the war. Tolo means 'sugar-cane' and fulu-fulu is a plural form meaning 'hairy'; Tui-a'i is the 'prince of eating' or 'of eaters'; Tui-a'a, is the 'prince of the family.' The other names are explained elsewhere.

10. *Allotting of food;* lagi, 'to call out the different portions of food and the person for whom each is intended.

11 – 14. *The thick 'taro' &c.;* the 'taro' root is much used as food in the South Seas; it is cooked and eaten with the fish. The good kinds of 'taro' are enumerated in the lines thus:—11. Talo-tua-tua; talo auvai. 12. O talo pasai, ma talo mālai. 13. O talo tetele, ma malepe-lepe. 14. Talo fusi, maga-uli; vaisalo magalo. The 'vi' is a much esteemed fruit like a plum; the outer skin has to be *gape,* 'broken' or squeezed off.

55. *Shaking the rattle &c.;* 'o lulutu, o vevelo.' Losi sends off his two attendants, Fangaena and Mata-muti'e, to catch the fish; they shake a rattle to attract the fish and then they spear them.

56. *The north;* here expressed by Lua-o, Lua-vai, who are the regents of the north; see the 'Myth of Creation,' No. XXX.

57. *The east;* here expressed by 'the land of the Sun,' and further explained to be Niuē, which cannot be the island now known by that name, but some other far to the east.

58. *Daylight;* the word here is 'ao-ao,' which seems to me to be an intensive form of ao, 'daylight.' The line is—'Niuē ua tau ao-ao.'

59 – 62. *Sweep together;* I take these lines to describe Losi's own propitiatory offering to the Sun, and so the fish here are mullet and of a red colour, 'aua ula.'

60. *And put them, &c.;* this seems to be the meaning of this line—'Ma faotaga mā'u monotaga ia le La.' Is 'faotaga'=faa'atoga,?

62. *Broil them;* 'lagi,' for 'lalagi,' a chief's word; *tied up,* 'lili'; the fish are swathed in banana leaves or the like, when put in the oven.

64. *For the basket and the net;* 'ia fao ma uamea.' This translation is not certain, for the manuscript is indistinct here.

Where did they come from? This question gives the poet an opportunity to bring in the names of the islands known to the Samoans, and this catalogue may be interesting, although many of the names in it are not known to modern geography. Its horizon extends from Fiji on the west to Bora (Pola) in Tahiti on the east.

66. *Small fresh-water lands;* 'nu'u si-magalo.' These are the small islands of the Samoan group; they have springs and streams of fresh water. *Fanua tapu* means 'holy land'; I suppose it is the island of Taū. Ofu and Olosenga, Manono, Apolima are the other small islands of the group. Tutuila, Upolu, Savai'i are the large islands.

67. *My group;* as Losi is the supposed speaker, he claims these islands as his own—'*my* group.' And so with all the other groups in the sequel.

69 *bis. Fūnga;* this plant emits a fetid odour, especially at night.

70. *Foreign lands;* 'papalagi,' meaning 'far off.'

70 – 73 *bis. Vou;* thus in our MS.; but as an island Vou is unknown to us. In Samoan *vou-vou,* as an adjective, means 'disobedient.'

71. *Hurry on;* these giants who went up to the heavens are said to *hurry on* the 'sufi'; for it is coming to a close.

74 *bis. Lefe;* I do not know what island this is, but it has a bad name here for cowardice and indolence; the men are women, and they live on the presents of food made to them by others.

76. *Last word &c.* The text reads, 'O si'u-si'u ai lau-gutu o le nu'u fai 'upu,' *lit.,* 'being the extremity of the lips of the people who are making words.' 'Laugutu' is a vulgar word which the speakers would not apply to any but themselves; 'si'u-si'u' is 'the point *or* extremity of anything'; 'upu' is 'a word.'

77. *Tanapa* is not a proper name in the manuscript, but we cannot tell what the word means nor what is the reference in this line and the next.

80. *Do not eat;* 'e lē a'ai'; we do not know what this line means, nor the next. But Luvai may be a fairy land like Atafu, 'which has no houses,' (line 99).

82. *Children,* 'livai'; water, 'vai,' that is, fresh-water.

83. *Mats,* 'fala,' fine mats to sleep on.

84. *Pulotu;* this is the Samoan name for Hades; *'has grassy eyes'*—the manuscript has here the word 'mavematamuti'a'; the meaning we give to the word is a conjecture founded on the parts of it *mata* and *mutia. Mave* is not known to be a Samoan word, but in Tahiti it means 'streaming as hair in the wind'; *Mata,* besides 'an eye' means also 'the top of anything.' The epithet *mave-mata-muti'a* may thus mean, 'where the surface of the grass sways to and fro in the wind.'

Tulia's cocoa-nut tree; this stands on the road to Hades and the ghosts dash their heads against it. Its leaves lie there undisturbed; for there is no tide there to sweep them away, nor are they gathered as fuel.

Tulia, as a participle, means 'driven'; they say that at the north-west corner of the island of Savai'i there is a huge cocoa-nut tree, near the entrance to Hades there, and, when the ghosts of the departing are being driven along this way by the spirits, if any one of them strike against this tree, that dying man recovers.

86. *Tui-Pulotu;* 'prince of Hades'; *Fafanga* may be only another form of the word *fafā,* which means 'hell' or Hades.

87. *Water;* vai, 'fresh-water'; 'trade wind,' to'elau. We do not know the meaning of the lines which are—87. O loo tu i le vai soā, o loo lumanai e le To'elau. 88. Tau fa'alupe lau laau, o i fea le tui o To'elau? But it is possible that '*the comrades*' are those that have been brought to life again by striking against 'thy tree.'

90. *Peculiar;* 'faigā'; peculiar in this that they go to sleep, &c. This has happened; for on one occasion, in Savai'i, a band of men lay down to rest after a battle, and, while they slept, the enemy came on them and killed them all.

91 – 94. *Carrying the bier &c.;* these doubtless were well known incidents in the history of Fiji, but we know nothing about them.

99. *Atafu;* see line 68; also Myths No. II. and No. XV.

101. *Red-eyed;* 'mata-memea.' This word also means the planet Mars.

104. *Standing place;* tulā, 'a perch, a prop to stand on.' For this and the 'fetau' tree and the 'pua,' see Myths No. XV. and No. XVI.

107-8. *Shone upon;* 'sulu-ia'; as if 'be-torched,' for *sulu* is a 'torch.'

109. *Lua-ma'a;* for him and Ui and their doings, see Myth No. XV.

112. *Vale-vale-noa;* 'beautiful.' For *Sioa* and *Maioa,* see lines 177-8.

116. *Pola;* this seems to be Bora-bora in Tahiti.

120. *Alight;* tipa, 'glide down.'

124. *Fresh-water, far at sea;* at Safotu on Savai'i, in Samoa, when the tide is low, a spring of fresh-water bursts up on the reef half a mile out; on another very small island there is a lagoon of fresh-water.

125. *Drawn up;* 'utufia'; *utu* means 'to draw up water from a lagoon or a well'; 'to fill a bottle.'

131. *Thread them;* 'su'i fa'asolo'; the meaning is—Thread their names together as beads on a string, without enumerating them separately.

135. *Fail;* fano, 'fade away to an end.'

139. *Budge;* alo, 'to get out of the way of a superior.'

141. *The 'tafuti'* evidently has the habit of the flying-fish; the '*pusi*' family are all of the 'muraena' kind.

145. *Long house;* 'a folau papata'; we have not translated *papata;* it may mean 'lumpy.'

146. *Vase* is a fine kind of 'taro'; what this line and the next refer to, we do not know.

150. *Angry;* to'atamai, 'chief's anger.' In Samoa it is a grievous insult to a chief to omit his name from a list.

151. *Finished, complete;* 'uma.'

157. *Quiet;* toto'a. For Malae-a-toto'a, see the 'Solo o le Va.'

161. *Speaker;* 'to'oto'o'; *lit.*, the official staff which the orator holds in his hand when he is making a speech; to hold *that* is equivalent to our English expression 'to be in possession of the chair.'

164. *Threatening;* the angry gods threaten an assault; but Mafui'e, the giant of earthquakes encounters them, tosses up the heavens, and the Sā-Tangaloa are thrown to the ground and thus discomfited.

170. *Lying there; a snare;* these must refer to Losi's trick in laying the fish at their doors.

174 - 182. *Tangaloa; tau-tala,* 'the talker'; *mana-mana,* 'mindful' in a bad sense; *sioa,* 'languid'; *uatea,* 'rain in sunshine'; *ua o po,* 'who went by night; *lē-fuli,* 'immoveable'; he should not be in this list, for he is one of the high gods; see the 'Myth of Creation.'

183. *Women, men;* male and female among the Sā-Tangaloa, but apparently not among the high gods. Masina, 'the moon,' in the next line is a woman—and she is wounded.

185. *Tenth night;* the Samoans have a special name for that—fa'a-sagafulu, *lit.*, 'tenth.'

186. *Eat &c.;* this is spoken by the conquerors and is a terrible outrage to the vanquished.

189. *Feathers;* alluding to Moso's device to protect his comrades from the torrents of rain; *raised,* that is, when the rain ceased, the warriors came out and continued the pursuit of the Sā-Tangaloa.

XXXIV.—The history of Tangaloa-a-Ui, Ali'a-matua, and Ali'a-tama, Kings of Manu'a.

—o—

Introduction.—This history is given here more in detail than in Nos. XIX., XX., XXI., and differently in some respects. From a comparison of this version with those three previously given, the reader may be able to select the common features which seem to be historically true. It is certain that the Rarotongans trace their ancestry to the Manu'a group, and their kings to this Ali'a family; see No. XIX.

[Note.—Under date 6 Feb., 1871, Mr. Powell's MS. have this entry:—"I received to-day the following particulars from Taua-nu'u, tradition keeper, which modifies the account which I received from Fofo. This of Taua-nu'u seems the more consecutive."]

1. Ta'e-o-Tangaloa, the child of Tangaloa-a-Ui and Sinǎ-a-Sa'u-mani, named Sina-tauata, had two wives; the one named Laulau-a-Le-Folasa, the daughter of Le-Folasa; the other named Sina, the daughter of Tao-toai-se-Aua-luma. These two wives became pregnant at the same time.

2. Ta'e-o-Tangaloa was at Le-Fanga when this Laulau-a-le-Folasa gave birth to her child; she, or rather her family, immediately shouted that a king was born there, *'o le Tui-Manu'a*, 'the king of Manu'a.' Her husband was displeased at her haste to declare her child king. He went up to Aua-luma, where he found that his other wife, Sina, had given birth to a son at the very time of the birth of the other son. Sina said to him, "Come now; your other wife has given birth to a son, and she has proclaimed him king; go therefore and live with her; let me decide what is to be the name of this child; and leave me."

3. He answered, "Do I consent to that child's being king—that child of haste? that child of the hasty one? don't be angry; come bring your child, and let him be proclaimed king; let his name be Fa'a-ea-nu'u, 'exalter of the people,' and let him be Tui-Manu'a; *the kingly power* is associated with men; men will stand up to speak in the palace of Tui-Manu'a."

4. He was the first *man* to whom the dignity of king was given; that was previously considered the prerogative of heaven; for Tae-o-Tangaloa was Tui-Manu'a, but he was regarded as a god rather than a man. Of the child of Laulau-a-le-Folasa, he said, "Let that child at the east be named Ati-i-lagi, 'addressing-speeches-to-the-heavens'; let him direct his addresses to heaven to Tangaloa, in his 'fale-ula' palace; let him be associated with the gods."

5. In accordance with this appointment the chief or priest of Fiti-uta used to sit cross-legged, leaning on the handle of his *fu'e* or 'fly-flopper,' and thus offer prayer and make speeches.

6. When the children had become men, Ta'e-o-Tangaloa said to his brother Le-Fanonga, "You stop here in the east and be the

war-god of Fiti-uta, but I will go and be the war-god of Le-fale-tolu; if my sons fight, you watch the war and side with the weaker party, and I will come to help, if needful; let not the attacking party conquer; if Fiti-uta come to attack Fale-tolu, you will unite with me to repel them.'

7. Ta'e-o-Tangaloa then went to his sons and gave them formally their appointments, which he had mentioned at the time of their birth. To Fa'a-ea-nu'u he said, "Let the imperial dignity abide with thee; through thee, let it be associated with men; let them stand up and make their council-speeches in thy palace, 'O king of Manu'a and all Samoa.' To his brother he said, "Be thou named Ati-i-lagi; let the royal dignity be associated with the inferior, human gods through thee; sit thou in thy palace and speak to the heavens."

8. He then warned them both against going to war with each other, because they were brothers. "Break your spears in two; when unwilling to fight, cover up your battle-ground; your battle ground is Ava-tele; if you," addressing Ati-i-lagi, "if you cross the battle-ground and come to One-uli, your land will become desolate" [*lit.*, will be overrun with creeping plants ('fue-fue')]; "but if you," addressing Fa'a-ea-nuu, "cross the boundary to Tapu-tapu, your land will in the same way become desolate."

9. It was probably between the childhood and the manhood of these two boys that Ta'e-o-Tangaloa undertook the visit to Fiti, since the name he there and then obtained for his land, Fiti-uta, is mentioned in his final appointment of Fa'a-ea-nu'u and Ati-i-lagi, but not at their birth.

10. Fa'a-ea-nu'u took a wife named O-malu-o-le-Taū. By her he had several sons, all named Sao, but distinguished from each other by different terminations to their names, viz., Sao-'io-'io-manu, Sao-loa, Sao-puu, Sao-le-tupua, Sao-tupe-soa, Sao-le-folauga.

11. Fa'a-ea-nu'u, becoming old, retired from his official position and appointed his eldest son his successor. But this son, Sao-'io-'io-manu, was unwilling to accept the restraints which the dignity

imposed, and he therefore made a voyage to the eastern groups without designating a regent or successor to take his place. A consultation was therefore held at Aua-luma to appoint a king in his stead. Sao-loa was chosen to receive the dignity and title of Tui-Manu'a. He refused to accept it, lest calamity should come upon him if he did so, as his brother had not made any such appointment. He therefore fled and became a chief on Savai'i. There was thus an interregnum; for none of the other brothers was asked.

12. Sao-'io-'io arrived at a place in the eastern groups, the king of which was named Tapu-longo-longo. This king had a daughter named Sina-felo-le-sámă, who became the wife of Sao-'io-'io-manu, and by her he had three sons, 'O-le-lolonga-tele, 'O-le-lolonga-loa, 'O-le-lolonga-pu'u. When the boys were grown up to manhood, their father gave his appointment, saying to his sons:—"You younger boys, remain with me, to attend on me and take care of me; but you, Le-lolonga-tele, go you to my people who have no king; for my brother feared to accept the dignity; and be thou their king in my stead."

13. Le-lolonga-tele therefore came to Samoa, where his uncle, Sao-le-folauga, was still alive. He landed at Aua-luma where his uncle still was. The family immediately held a council and declared Le-lolonga-tele the king of Manu'a. They also consulted about a wife for him, and it was resolved to seek for him a lady named Soa-le-tele, the daughter of a chief named Le-ula. The suit was accepted and she became his wife. After her, he sought and obtained a second wife named Sina, the daughter of Tao-toai-se-Aua-luma. Then he took a third wife named Ana-moa-tele, daughter of Tangaloa, a chief who lived at Fangali'i of Aua-luma. He then sought and obtained a fourth wife, the daughter of Taua-lunga, belonging to Fiti-uta; her name was Sina. For a fifth wife he obtained the daughter of Lenga; her name was Tele-i-le-vao; and, lastly, he had a sixth wife; for her he came to Le-fale-tolu; her name was Moe-talā-luma; she was the daughter of Pua of Siufanga.

14. By each of these wives he had a son. After the birth of the sixth son, and when they were all of adult age, as he was infirm, he wished to abdicate in favour of one of them; and so he assembled them in his palace at Aua-luma, and gave them their official names and appointments, as follows:—

15. The child of Soa-le-tele he named Satoa and he appointed him to be the 'virgin' of Manu'a; that is, he was to act the part of mediator in case of war, to get peace made, and to bury those killed in battle.

16. The child of Sina, daughter of Tao-toai-se-Aua-luma he named Tui-sali'a, and appointed him to attend on the king, pitch his tent, and get the drink and food which the king might leave after feasting.

17. The child of Ana-moa-tele he named Le-Folasa-Aua-luma, and gave him the title of Tangaloa, chief of Aua-luma.

18. The child of Sina-i-gagá'ĕ he named Le-Folasa-i-gagá'ĕ, and appointed him peace-maker for Fiti-uta (*lit.*, for gagá'ĕ), to walk among the dead and to be pure water for his own district.

19. The child of Tele-i-le-vao he named Ali'a-matua and the sixth child, that of Moe-talā-luma, he named Ali'a-tama. To them he said, "I will throw down the royal dignity ('ao') between you two chiefs; you must settle between you whose it shall be; for I am afraid of the influential parties inland; I am also afraid of the chiefs of the Fale-tolu." Hereupon Ali'a-matua said, "What dignity can that youth assume, while I am here who am the elder; let me have the dignity; let me be Tui-Manu'a."

20. To this the younger agreed, and he became the king's attendant. This arrangement, however, did not accord with the prevailing idea of what was right. Ali'a-tama was considered of higher dignity, on the mother's side, than his elder brother, and therefore ought to have had the kingly power. However, Ali'a-matua wore the crown—a turban of white cloth ('fau'). But the matter did not rest here. The chiefs of Aua-luma counselled the young chief to endeavour to seize and carry off the crown. They

advised him to pretend to have sore feet, and to make that an excuse for not bathing when he went with his brother to the bathing place, and to watch his opportunity to run off with the crown while the latter was bathing, since he would, of course, lay aside his turban while he performed his ablutions. Ali'a-tama did not make the attempt on the occasion suggested, because he feared his brother might pursue and overtake him, if he then attempted to run off with the 'fau,' the emblem of royalty, while he was in the water. He therefore waited for a more favourable opportunity. This he was not long in getting. One day, when they went to bathe, he proposed that they should cleanse their heads with detergent, made of the expressed oily juice of old cocoa-nuts. When this ointment had been prepared, a contention arose as to which of them should use it first. Ali'a-matua urged that his younger brother should use it first, lest if he, the king, dipped his head in first, and thus rendered the preparation sacred, it should cause the death of his brother. To this Ali'a-tama replied, "No; you dip in first, lest you die if I dip first." This idea the other resented, and urged his brother to dip first. He accordingly did so, and then went to the water to bathe. Ali'a-matua then dipped in his head, and immediately fell down into the pool. stupefied. When his brother returned, he found the king in this condition; he rolled him out of the pool, but found him still insensible; he roused him a little, and said to him, "Did I not warn you of the consequences of my dipping my head in first"? And then he prayed to Tangaloa, and said, "O Tangaloa, if thou hast given me this secret power ('mana'), let my brother immediately revive." At once the king came to, and got up, and walked, They went away together, but the king was envious of the power of his brother; and, being weak, when they came to a place called 'O-le-Luu, he wished for a cocoa-nut to drink. Ali'a-tama excused himself from going up the tree by saying that his feet, which were bandaged, were sore, and that he had heard their father say that it was not forbidden ('sa') to a king to ascend a cocoa-nut tree. The king therefore hung his crown on a branch of a 'fau' tree that was near, and began to climb the cocoa-nut tree with only his native cloth ('siapo') wrapped round him. His brother then said, "Why should you encumber yourself with this cloth. I have heard our father say that it is not forbidden for you to ascend the tree, naked like a common man." The king acting on this suggestion, disrobed himself, and went up the tree. No sooner was he up, than Ali'a-tama seized the robe and the crown, and ran off to Le-fale-tolu shouting as he ran, "My crown! my kingdom! I have got my crown."

21. Ali'a-matua returned home in disgrace, without robe and crown. He immediately collected his forces, and prepared to seek to regain his lost dignity. Le-fale-tolu also prepared their forces to fight for their kinsman and king. The armies met; they fought at a place called 'Ele-'ele-uli, but Ali'a-matua was killed at Pala-pala. This settled the matter. Ali'a-tama had now the sole right to the kingly title, and the succession was swept away from the family of Ali'a-matua.

22. The next king after Ali'a-tama was Pui-pui-po; then Fa'a-ea-nu'u, and then Sili'a-i-vao. To Sili'a-i-vao succeeded Tiālingo; that is the king of peace ('ligo'); there was no war in his time, although his kingdom was very extensive, and distant lands brought tribute (called *le umiti*) to him.

23. The succession of Kings of Manu'a stands thus:—

'O Tangaloa-a-Ui

1. 'O Ta'e-o-Tangaloa	6. 'O Ali'a-tama
2. 'O Fa'a-ea-nu'u	7. 'O Pui-pui-po
3. 'O Sao-'io-'io-manu	8. 'O Fa'a-ea-nu'u
4. 'O Le-Lolonga	9. 'O Sili'a-i-vao
5. 'O Ali'a-matua	10. 'O Tiālingo

NOTES TO No. XXXIV.

PAR. 1. *Ta'e-o-Tangaloa, Tangaloa-a-Ui, Sa'umani;* see the Summary of No. IX.

Pregnant at the same time; 'to-masaga'; *to,* 'to be with child'; *masaga,* 'twins.'

3. *Child of haste;* 'le tama fai lise'; *child of the hasty one,* 'le tama a le fai lise.'

Associated with men &c.; 'ua tautagata le ao ia te ia.'

Palace; 'fale'ula,' *lit.*, 'bright-house.' This name is also given to a big house in which the dancers and singers of the town meet and councils are held.

4. *Let that child at the east;* the text here is—'A o lela tama i gagae ina igoa o ia ia Ati-i-lagi; ia ati i lagi i Tagaloa; e tauaitu i lona fale'ula ia te ia (le ao).'

Associated with gods; 'tau-aitu.'

Tau-tagata, tau-aitu; the meaning of these phrases is that men are associated with Tui-Manua and that spirits are associated with Fiti-uta. Thus, the imperial dignity is associated exclusively with men through Tui-Manu'a, but with gods, that is, the 'aitu' or inferior gods, through the prayers ('ati-i-lagi') of Fiti-uta; and Tui-Manu'a has the divine prerogative of king among men, while the chief of Fiti-uta has the privilege of communication with spirits or gods. The one is the head of the temporal realm, the other of the spiritual; man is connected with heaven through Tui-Manu'a; spirits are connected with earth through 'Ati-i-lagi.'

5. *Prayer and speeches;* 'ati.'

6. *Le-Fanonga,* 'Destruction'; *war god,* 'aitu-tau.'

7. *Be thou named;* the text here is—"Igoa ia oe ia Ati-i-lagi; ia tau-aitu ia te oe; ati i lagi i lou fale'ula. Tauaitu ia Fiti-uta; ia nofo ma ati i lou faleula."

8. *Break your spears in two;* the text here is—"Ma oulua tao gaulua, a lua musu i tau, ufi la oulua tafa; lua tafa lea Avatele; aua le sopoia. A ē Ati-i-lagi sopoia atu i le Oneuli, ua saua oe i le au fuefue. A ē sopoia atu i Taputapu, ua saua foi oe i le au fue-fue."

Mr. Powell's manuscript here adds this note:—"The following are the words taken down on Feb. 28, 1871, but the narrators by no means keep to the same *form* of expression; they express the meaning in various words. "Tagata taa aitu. Ati-i-lagi, *i.e.*, ati i lagi lou faleula. Tau-aitu i le Fiti-uta nofo ma ati. A o lea tama e tautagata i ao i Aualuma ma le Faletolu e ati ma tu. E te'a lava oe ina tautagata le ao ia te oe o *Tui-Manua ma Samoa-toa*; laulautu i lou fale'ula. Ma oulua tao gaulua; a lua musu i tau, ufi la oulua tafa; oulua tafa lea o Avatele, aua le sopoia. A ē sopoia atu i Taputapu, ua saua foi oe i le au fuefue."

One-'uli; 'black sand,' a place in the west side of the battle ground.

Tapu-tapu; 'very sacred'; a place on the east side.

10. *Several sons*; 'io-'io-manu means 'a young chicken bird,' loa, 'long,' pu'u, 'short,' tupua, 'an image,' soa, 'a companion,' folauga, 'a voyaging,' malu, 'a shadow.'

11. *Retired &c.*; na gafua Fa'a-ea-nu'u, 'F. had his sacredness taken off.'

Appointed; 'e'e,' to pay respect to, to reverence.

12. *Le-atu-sasae*; 'the eastern group'; *Lolonga*, 'rain,' *tele*, 'great,' *loa*, long, *pu'u*, 'short.'

13. *Council*; 'fono'; *it was resolved, &c.*; the text here is—'Ua filifili se tamaitai e ave i ai le afiafii o le ali'i,—'They chose a lady to take to her the evening present of the chief.'

Ana-moa-tele; 'a great lot of fowls'; *Taualunga*, 'the ridge pole'; *Tele-i-le-vao*, 'great in the bush'; *Moe-tala-luma*, 'sleep in the front part of the house.'

15. *Virgin*; 'taupou'; *to get peace made &c.*; 'e fa'aola taua, ma tanumia tama'i a le tau.'

16. *Pitch his tent &c.*; 'ina toia le fale, ma 'ai mea paia.'

17. *The title of Tangaloa &c.*; 'ina igoa ia ai Tagaloa e fai, ma ali'i o Aualuma.'

18. *Peace maker &c.*; 'ina vae toto e pupulu, ma tanumia tama'i; o le vai magalo ia o gagae'; *lit.*, 'goes to divide between blood, and bury the dead; he is the fresh-water of Gagae' (the east); *fresh-water*, figuratively.

Fiti-uta; a dying chief of A'ana made his appointment thus:—He broke his *to'o-to'o* ('sceptre') in two, and gave a half to each of his two sons, appointing the one to rule over the district to seaward (Fasi-too-tai) and the other to rule over the district toward the centre (Fasi-too-uta) of Upolu, not necessarily inland (*uta*), but nearer the centre.

19. *I will throw down &c.*; 'o lea ou lafo le ao i va i ali'i.'

Influential parties inland; 'le ao lemu i fale auta,'

What dignity &c.; 'Se ā le ao e nofo ai le tama, a o au o nofo atu ua matua.'

20. *A turban*; does the *white* cloth denote the *priestly* character of the king? The bark of the *hibiscus* ('fau') is white.

Detergent; frequent sea bathing and other causes make this very necessary; for this purpose the Samoans use the pulp of the wild orange ('moli') as a soap or lather.

The preparation sacred; observe here the sacredness of the person of a king; any violation of this is *desecration*, and is punished immediately in some supernatural manner.

My crown; *my kingdom &c.*; 'lo'u ao e! ua o'u auaua o'u ao'!

21. '*Ele-'ele-'uli*; 'black earth.'

Ali'a-tama had now &c.; ua tafatasi ai le ao ia Ali'a-tama; ua tafea le utu a le alii o Ali'a-matua'; *lit.*, 'the title remained solely with Ali'a-tama; the right of succession was swept away from Ali'a-matua the chief.'

PRELIMINARY NOTE ON LIMESTONE OCCURRING NEAR SYDNEY.

By Henry G. Smith, Laboratory Assistant,
Technological Museum, Sydney.

Communicated by J. H. Maiden, F.C.S., F.L.S.

[*Read before the Royal Society of N.S. Wales, November 2, 1892.*]

The Hawkesbury sandstones and the Wainamatta shales, being almost devoid of lime, it may be interesting to record the presence of an argillaceous Limestone occurring at Duck Creek, Auburn, and also near Homebush, both near Sydney. The exact locality where this limestone is opened out, is about a quarter of a mile south of the intersection of Cheswick Road and Duck Creek, Auburn.

When I visited the locality, men were at work quarrying the limestone, this being used by a neighbouring municipality for road-making. When first broken, it is of a blue-grey colour, not much unlike basalt; it was spoken of as "blue metal" by the quarrymen, who no doubt consider it identical with the igneous rock bearing the same name. On weathering, the limestone becomes lighter grey in colour.

The deposit is a sedimentary one, and is interspersed with small bands of carbonaceous shale, and thin bands of coal. It runs horizontal for some distance along the creek, this being nearly north and south, but where opened out, it is very irregularly deposited. There is about six feet of surface soil, under this about two feet of shale, very much carbonised, interspersed with small bands of good clay, nodules of ferruginous clay, and small bands of ironstone. The bed now being worked is six or seven feet thick. Under this, nodules of clay-ironstone are found; a qualitative analysis of these nodules shows that lime is present in very small quantities; they contain a large quantity of carbonate of iron, and the clay appears to be the same as that contained in the limestone. Time did not permit a quantitative analysis to be made of these nodules, and other material, but I hope to complete this later. I was informed that under these nodules the limestone continues, but I was unable to ascertain the fact, as it is the bed of the creek where the quarry is situated. If this is so, probably it is a fissure filled with the material. The fissures filled with clay, found in the Hawkesbury Sandstones, (one of which has been opened out at Kogarah to a good depth, and the whole width) contain clay of a very good quality, and which consistently shows absence of lime, with but a trace of magnesia. Now the clay left on removing the substances soluble in hydrochloric acid from the limestone, is qualitatively identical with that of Kogarah and other like deposits, lime being absent, but a trace of iron, and a small quantity of magnesia, in fact, almost pure silicate of alumina.

Favouring this idea of a fissure, is, that at the locality near Homebush, where I obtained a specimen of limestone almost identical with that from Duck Creek, the material has been quarried for a good distance along what appears to have been a fissure, and used for road making. This locality is perhaps two miles distant from Duck Creek at Auburn.

The following is an analysis of the limestone from Duck Creek:

$Ca\ CO_3$ = ...	39·673	per cent.
Clay = ...	39·416	,,
$Fe_2\ O_3$ = ...	2·686	,,
$Fe\ CO_3$ = ...	13·480	,,
$Mn\ CO_3$ = ...	·425	,,
$Mg\ CO_3$ = ...	1·625	,,
Alkalies present as chlorides = ...	·679	,,
Water = ...	2·260	,,
	100·244	

This may be considered as an hydraulic limestone, but it is doubtful if it could be obtained in sufficient quantities for commercial purposes. The carbonaceous shales overlying the limestone contain iron pyrites and barytes in small scales.

In the crevices of the clay-ironstone nodules, almost pure carbonate of lime has been deposited.

No signs of organic structure can be detected in the limestone. A slide was cut with fair success, and under the microscope but a few particles of quartz can be seen, the remainder being principally composed of semi-opaque granules and grains of calcite.

I am indebted to Mr. W. M. Thomas, of Auburn, for information in reference to this deposit.

OBSERVATIONS ON SHELL-HEAPS AND SHELL-BEDS.

Significance and Importance of the Record they afford.

By E. J. Statham, Assoc. Inst. C.E.

[With Plates XIV. and XV.]

[*Read before the Royal Society of N.S. Wales, December 7, 1892.*]

A paper lately contributed to the Linnean Society by Mr. C. W. Darley, gives a description of some remarkable shell-heaps at North Creek, on the Richmond River; and the last report of the Mines Department, contains a contribution on the same question.

Believing that the subject is by no means exhausted; and that far greater importance and interest are attached to it, than may at first sight be supposed; I request to be allowed to bring under notice the information and observations, which, for several years, I have been enabled to collect.

My attention was first directed to these shell deposits many years since, by the very prosaic and practical consideration of the want of a suitable material for road making, in the stoneless and swampy deltas of the Clarence, Richmond, and Brunswick Rivers; where, consequently, this material has been extensively used to ballast the roads. Vast quantities of the same have also been utilised for lime-burning since the settlement of the districts referred to; and, considering the extent of the deposits still remaining above tide level, it scarcely seems probable that their origin is wholly attributable to the aborigines, as is usually the explanation afforded by that great authority, the "oldest inhabitant." In this connection, I may mention that on one occasion, whilst examining an excavation from which approximately a thousand cubic yards of shell had been obtained, one of the old residents who was present remarked, "The blacks must have been very numerous at one time to have piled up all this shell." "Yes," I replied, "and it must have been a long time ago," pointing to a giant fig-tree which had taken up a selection on the deposit, and the roots of which had stopped further progress of the excavation. I have noticed many instances where the older vegetation covered deposits of this description, going to show that they are prehistoric, and that the testimony of the oldest inhabitant must be taken with a certain amount of caution; the assertions of some being very positive as to the agency of the aborigines, others of long experience affirm that the deposits have not been materially added to since they have known them.

Bearing in mind this conflict of opinion, I have observed somewhat closely the ascertainable camping-places of the existing race of blacks, where shell-fish are at present abundant, and fail to discover any accumulations at all resembling these older ones; in fact, the characteristics are essentially different, the residual shell being small in quantity, and scattered, with a more noticeable accompaniment of partially charred wood, the residuum of the well known blackfellow's fire, (made with two sticks laid crosswise) the custom being to use fire to persuade the oyster to open its shell. These shells which have been fired are easily distinguishable, and are more susceptible of atmospheric influence, becoming brittle. Never in any modern instance can it be seen that stones have been used in opening them.

On the Clarence River one of the most extensive deposits is at the mouth of the South Channel on the Yamba side, where it is several acres in extent, and from three to five feet above high water, being generally level, and may be the result of elevatory movement. At the mouth of the Oyster Channel, or Woolowuya Estuary on the other hand, there are long mounds, on the Yamba or mainland side, and on the Micalo Island side extensive terraces almost entirely of shell, with occasional water-worn boulders and chips of stone, with abundance of estuarine shells other than oysters. These deposits have a remarkably artificial appearance, so much so that no one for a moment seems to doubt their origin as being due to the aborigines, though it seems remarkable that the deposit, especially on the Yamba side, extends deeper than low-water, and that the shells show no trace of damage by fire or otherwise; the delicate edges being intact and the substance of the shell strong and well preserved.

The occurrence of shell strata all along the East and South Coasts of Australia at elevations distinctly above tidal influence, the shells being of recent type and frequently differing from those at present to be found on the contiguous beaches, is well worth careful study. Much of the coast country consists of flat sandy or loamy heath with sand-dunes super-imposed, and forming a narrow fringe along the coast line. I have noticed in many places where the underlying stratum has been exposed along the beach, that these shell-layers are existent, and that they are traceable as extending under the sand-dunes, and are distinctly referable to the flat formation above mentioned on which the sand-dunes are an encroachment. These layers are to be found at levels usually from four to ten feet above high water, and are important as indicating that the East and South Coasts (if not the whole insular mass of Australia) are rising, further support to which conclusion is afforded by the fact of nearly all the streams and estuaries having bar entrances, which in some instances become entirely blocked up until a passage is opened by land-floods. Notable instances may be mentioned as those of Lake Macquarie, the Hastings, Nambucca, Bellinger, Brunswick, and Tweed Rivers; the rivers mentioned, though thus impeded at the mouth, have bold water and long reaches further inland, and have apparently at one time had a much freer discharge. The same phenomenon in a more noticeable degree is to be seen in smaller streams now entirely blocked to ordinary tidal influence, and left, as it were, high and dry. In these latter, oysters and other marine shells no longer exist, though traces of their former abundance are evident.

The elevation of the land has doubtless in no small degree contributed to the filling-up of the larger estuaries. For instance the Clarence, in which it is evident estuarine conditions have extended much further than they do at present, for at Lawrence, twenty-four miles from the sea, I have found shell-beds under alluvial deposit, at or below the level of the present high-water mark, and these beds are frequently come upon in the islands lower down the river, though the present zone of living shell-fish does not extend more than five miles from the sea in consequence of the unfavourable influence of the large volume of fresh-water brought down by the river; the effect of such excess of fresh-water during a prolonged freshet, is to entirely destroy these shell-fish, and in the case of oysters it is said to take from two to three years to re-establish the beds. On the Richmond River, the lower part of which is a delta formation, very similar to that of the Clarence, the existing oyster-beds are confined principally to the estuary of North Creek, and only extend in gradually diminishing quantity for about three miles up that creek, whilst the shell-heaps lately described by Mr. Darley are met with in exactly the reverse order as regards quantity, being more abundant up the creek, and are to be found far above the limit of present favourable conditions.

There are also deposits of shell of considerable extent along Emigrant Creek, in which no living shell is to be found, and these deposits are frequently some considerable distance back from the creek with intervening margins of swamp. The same phenomenon is observable on the Brunswick River, notably on the south branch in which no oysters exist, whilst large banks of shell are to be found. One of these deposits at a spot known as Tyagara-Grass, has been extensively worked for road material, and the shell is apparently of the same age and in the same variety as to be found in the heaps previously mentioned as occurring on the Richmond River. It is however remarkable that this locality is a long way back from the stream, and cut off from it and from the high-land by intervening belts of swamp and brush, yet, along with the shell are numerous blocks and boulders of basalt as well as stone chips and water-worn pebbles.

The antiquity of this deposit is unquestionable, and it affords evidence that estuarine conditions similar to those observable at the North Creek of the Richmond River at one time existed. That the deposits are more ancient than those at North Creek does not necessarily follow, as I shall show that causes of change have been in operation which have brought about a more rapid alteration in this instance. The range of tide is considerably greater in the Brunswick than it is either in the Tweed to the North, or the Richmond to the South, due, I conceive, to the obstruction of the tidal current by the projection of Cape Byron, consequently the silting up of the Brunswick River with sand brought in by the flood tide, has been more rapid and thorough; this section moreover being aided by the insignificance of any flushing action due to land-floods, the watershed of the Brunswick being very limited. The South Arm has almost entirely silted up, and loses itself in a succession of flats and swamps.

On the larger rivers, particularly the Clarence and Richmond, the silting up by the in-draft of sea-sand has taken place to a very great extent, as evinced by the shoaling of the Woolowaya Estuary and the Broadwater on the Clarence, and the Richmond River Broadwater, which apparently are each filled in the same way by tidal action rather than by flood deposit, or the contribution of sand from tributary streams, none of which carry sand, but are as a rule, muddy. The quantities of sand brought in by the tide must be enormous, the action being in operation twice in the twenty-four hours, and it is evident there is ordinarily a large balance in favour of the flood-tide as compared with the ebb, in its silt-carrying capability. That the great bulk of the tidal water enters by an undercurrent would seem to be indicated by the well known phenomenon of the swelling of the tide before the ebb ceases to run out; even during a freshet this action continues, and in the case of the Clarence, the ebb has been observed to run out for three hours after the tide begins to swell. The scouring effect of the flood-tide would thus be intensified by the weight of the superincumbent outgoing current, the sand brought in being deposited at slack water, and the ebb (being mainly an upper current) not to any extent carrying it back again; consequently, much of the sand brought in by the flood-tide would remain, gradually creeping upwards by repetition of this action until permanent shoals were formed.

Cook's River is an instance near at hand which exemplifies this theory, being a muddy stream, the lower portion of which past Tempe becomes sandy. The flats above the Cook's River dam, which are below the level of spring-tides, show numerous beds of shell, the occurrence of which no doubt suggested the idea of oyster-culture, which the late Mr. Thomas Holt so signally failed in, not realizing that conditions had so essentially altered that any such attempt was utterly hopeless.

On the flats below Tempe, shell-beds have been worked for many years for the production of lime: these beds are in places eighteen inches in depth, resting on clay bottom, and covered by about a foot of sandy silt. These flats are now only covered by spring-tides, the diminished rise of tides being due to the obstruction of the tidal flow by the formation of sand shoals in the lower reaches of the river; this sand it is evident must be brought in by the tide, as the contribution of sand by the river itself is insignificant, the flood deposit being clay mud. These shell-beds afford evidence that in geologically recent times the estuary of Botany Bay has extended up to the high land at the Warren, and in all probability to that of Marrickville and St. Peters. The mere obstruction of tidal flow however is insufficient to account for the height at which the beds are found, for if the tides had unrestricted access at the present time they could not be covered to a greater depth than eighteen inches at spring tides, consequently shell fish of the same description as shown in these beds, could not exist under such circumstances, and they must formerly have been submerged to a greater depth which it may be possible to determine approximately by comparison with banks where the same description of shell-fish is in existence.

At Sandringham on the open shore of Botany Bay, the sand brought in by the tide, has, owing to some favouring conditions as regards shelter, accumulated as a nearly level terrace, which has gradually grown outwards and contains abundance of shells, the varying characteristics of which may throw much light on the changes which have taken place in the molluscan life in the bay, and may possibly afford a time measure of some value.

There are well defined Kitchen-middens at this place which are worth examination though not remarkable for size.

The accumulations of shell at North Creek, Ballina, are the most remarkable and interesting of any I have examined; that at North Creek Ferry, which is illustrated by Plate XIV., was cut through for the purpose of making an approach to the ferry four years since. I had the section taken at the time, and have since obtained a longitudinal and other cross sections (Plate XV.) from which the quantity of shell may be approximately arrived at.

The antiquity of this heap is shown by the growth of trees upon it, some of them from four to six feet in girth and of slow growing varieties, and also by the stratum of decayed vegetation which must have taken a long time to accumulate.

The peculiar stratification of this heap is very remarkable and unusual, the thin layers designated ash are composed to a great extent of comminuted shell, sand and mud, with traces of charcoal, whilst the thicker layers are clean shell not injured by either fire or fracture, though boulders and chips of stone are found along with them, and one block of basalt was found, the position of which is indicated on section, and this was encrusted with shells and barnacles; the heap must have been of still larger dimensions as it had evidently been eroded to a considerable extent on the side next the creek. The stratification shown in this section is unusual, I have never noticed it in any similar heap, but on the opposite side of the creek a little down stream of this one, I observed a well defined instance of false bedding, a layer of sand being interstratified with the shell, and extending from top to bottom of the exposed section. It may therefore, be that these layers are of the same nature, the probability of which I infer from the fact of the heap down stream of this section tapering off as a wedge, whilst it may be seen from the longitudinal section that the upstream end and intermediate gap rise abruptly. The heap is superimposed on the muddy banks of the creek, and has not been piled up on a natural oyster bank as I have noticed in other instances, particularly in the one mentioned as occurring on the opposite side of the creek, which either merges or has been washed down into the bed of the creek which is clean shell. Out of this deposit we took some 3,000 yards of shell for road purposes, and during the progress of the work the remains of an aboriginal were found, with his stone axe and a quantity of paddymelon bones. I do not however attribute a high antiquity to these remains, as among them were the fragments of a clay pipe, indeed no particular importance can be attached to any aboriginal remains found in these heaps, as it is known that well defined mounds, especially such as are easily excavated by means of a yam stick, are favourite burial places with aborigines, and when known to exist for such purpose, they would be avoided as a camping ground.

The measurement of the heap at North Creek Ferry is estimated at 13,400 cubic yards, and the wedge of material removed from the down stream end as 1,500 cubic yards, or a total of 14,900 cubic yards; this heap extends about one-tenth of the length of the existing oyster beds. I find from records of the Fisheries Department, that the yield of the Richmond River oyster beds for an average of six years has been 1,759 bushels, equivalent to about eighty-four cubic yards of shell per annum; allowing that North Creek supplies the whole of this quantity, and that one-tenth of it was regularly devoted to the building up of the heap in question, it would take over seventeen hundred and seventy years to accumulate to its present dimensions; the beds may formerly have been more prolific, but on the other hand modern dredging appliances give a much greater range of gathering ground and much larger catch than under conditions when a black gin had no better equipment than her toes and dilly bag. Regarded in this light I think it must be admitted the high antiquity of this heap is established, the state of preservation of the shell speaks neither for nor against its antiquity, for I found large oyster shells in a perfect state of preservation in the Whaler's Bluff at Portland, Victoria, at a height of sixty feet above tide level, in a stratum of clay overlying the cretaceous beds, and overlaid by a sheet of basalt; also in New Zealand I am informed on reliable authority that sea shells with even the delicate colours perfectly preserved are to be found far inland at elevations of over one thousand feet.

That these shell heaps are no less ancient than those of Scandinavia, which are said to be of Neolithic age, is highly probable; in fact there are strong resemblances, both as regards components and mode of occurrence. Geikie describes the Kitchen-middens of Denmark as from three to ten feet high, and sometimes one thousand feet in length, (that at North Creek Ferry is one thousand six hundred and thirty-six feet in length, and from six to thirteen feet in height), "made up of refuse chiefly shells of mussels, cockles, oysters, and periwinkles," so much of this description tallies exactly with what is found at North Creek. With regard to the components of the heaps, twelve specimens of shells are described by Mr. Etheridge, from a collection made by Mr. Wilkins, particulars of which are published in the Mining Report of 1891, page 267, and I have a list of twenty-seven specimens of characteristic living shell, collected by myself on the North Coast and determined by the same authority, but not one of them in Mr. Wilkins' list is represented in the latter, which however, not being strictly local may be merely accidental, it nevertheless shows that a more careful comparison may throw much light on the subject.

Among the accumulations at Ballina Pilot Station, I noticed considerable quantities of Nodular-Pumice, this is to be found in the shell heaps at Ballina Cemetery, and high up on the hill in shell deposit near Mr. Fenwick's residence; this suggests another possibility with regard to these deposits, namely, that they are contemporaneous with the period of volcanic activity, the traces of which are so abundant in that locality, and if Mr. Wilkins was right in attributing the origin of these accumulations to the aborigines it would assign a high antiquity to the race, or else bring down the volcanic period to very recent times. I wish it however to be distinctly understood that I do not attempt to assign a time either for this or the past duration of the aboriginal race; my observations have no special reference to a determination of this sort and are deficient in that thoroughness which would be necessary in such an investigation; the data moreover for the exact calculation of the quantities in the heap (rough estimate of which is given) are not sufficient for this purpose, but serve to show that valuable results may be looked for if a more detailed and systematic investigation is undertaken. After determining which are natural and which are artificial deposits, the first essential would be to trace the position and extent of the old shell banks from which the heaps are derived and the area of gathering ground they afford at a depth not exceeding four feet. Then the Fisheries Department may be in a position to state or ascertain the maximum and average yields per acre of the beds already worked, so that by this means co-efficients may be arrived at by which the length of time required to provide sufficient material for the building up of the heaps referable to these sources, can within definite limits be more accurately ascertained.

It would be a pity to let these interesting relics be swept away by the advance of this utilitarian age, which treats even the Egyptian Mummy with so little respect as to convert it into superphosphate, and is improving the aborigine off the face of the earth, taking scant record of his language, songs, folk-lore, traditions, and that comprehensive nomenclature which included every natural feature and object with which he was familiar, moreover substituting our Dough-boy Hollows, and Quart-pot Creeks, for the more rythmical names which in too few instances we have taken the trouble to retain.

HAIL STORMS.

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

[With Plate XVI.]

[*Read before the Royal Society of N.S. Wales, November 2, 1892.*]

Some recent thunder and hail storms were so violent that they call for more than a passing notice, not only on account of their severity, but also because they are well marked phenomena in our weather. The district in which they were most severe is that around Narrabri, and the weather map for the day indicated this district as one in which storms would probably manifest great intensity. The places from which the best accounts have reached me are Narrabri, Avondale, thirty miles due north of Narrabri, and Tulcumbah, fifty-seven miles south-east of Narrabri.

The Sydney weather chart at 9 a.m. on October 13, the day of these storms, shows us that there was but little difference in pressure all over Australia. To the west of the overland telegraph line it was slightly higher, over western New South Wales and Queensland lower, and higher again over the East Coast, (see reduced copy of weather chart) in which the isobars clearly outline the area of relatively low pressure, and the kinks in them indicate disturbed conditions, local short lived storms, and before the day was over the inference from the state of pressure was fully justified, for storms of extreme violence occurred over the area ; storms which swept down great forest trees two and three feet in diameter. What this means in wind velocity I am unable to say, the trees are eucalypts, and therefore the wood is hard and very strong, but they were treated as if they were reeds, and their strength was as nothing compared with the force of the wind.

These storms are common enough, but owing to the sparse population they seldom pass over towns or dwellings. In this instance such has been the case, and in the future as population increases similar cases must increase in number, for the storms are abundant, indeed these storms form a well marked feature of our summer weather. As a rule they are disconnected, and the most violent part of the wind covers but two hundred or three hundred yards wide, and travels along with great rapidity, leaving a narrow line of destruction in its wake.

On the day in question heavy storms were reported at Goodooga, Armidale, two hundred and forty miles south-east of Goodooga, and at Grafton one hundred miles north-east of Armidale. Storms which seem to have been quite disconnected, for the earliest time was at Grafton, and as a rule they come from the west; these are spoken of as severe storms, but were evidently not specially remarkable, nothing to compare with those in the Narrabri district to which I wish to direct your attention. Unfortunately, data for determining the rate of progress is not available, although that as to the intensity of the storms is abundant. I may mention that three days before these storms, that is on October 10th, a similar storm passed over from Wilcannia to Sydney, a distance of four hundred and eighty miles, at the rate of fifty-five miles per hour ;

and I have before traced one over the same part of the colony, the rate being fifty-seven miles per hour, but we have not traced a sufficient number to determine an average rate.

As to the velocity of the wind along the line of damage in these storms, we have no actual anemometer results, so far we have not had one which passed over one of the anemometers, but judging from the damage done to large and solid trees, two and even three feet in diameter, it cannot I think be less than one hundred and forty or one hundred and fifty miles per hour.

We may now turn to the storms in the Narrabri district (see Plate XVI.). The storm reached Narrabri at 6·15 p.m., and the postmaster reports that the storm which approached Narrabri from North-west was accompanied by thunder and lightning, but no hail. The wind however seems to have been of hurricane violence, trees two feet in diameter were torn up by the roots, limbs twelve inches through were snapped off short, a brick factory completely ruined, roofs, sign-boards, and everything that the wind could move went flying; in the language of the local newspaper, "substantial brick buildings came tumbling in all directions, the air was full of iron tubs, galvanized iron, and tins of every description."

In the district south of Narrabri the storm was even more severe. At Tulcumbah Station fifty-seven miles south-east from Narrabri, at 8 p.m. on October 13th, a violent thunder and hail storm broke over the homestead. It lasted half an hour, and Mr. A. D. Griffiths, my informant and manager of the station, says, "I measured some of the hail stones, six and a-half inches in circumference, this was fifteen or twenty minutes after the storm, and I think I did not get the largest. Next morning I found that nineteen sheep had been killed by the hail, also birds, kangaroo-rats, and other animals were found lying dead in all directions. All the windows exposed to the storm were broken, and the galvanized iron roofing is dented from end to end and many sheets cut through: in several cases the hail stones went through the iron, in one sheet I found thirty holes and in another more than sixty. The bark of the trees in the storm track was all battered by the hail, and the fences and buildings bore traces of the impact of these great lumps of ice. The stones were generally triangular or conoidal in form, many having an uneven surface, which looked as if it had been formed from frozen drops of water collected into masses ; others had an opaque snowlike centre, perhaps the majority were like this, the remainder being like clear ice. It was only the larger stones that were irregular as described, the smaller ones were generally rounded."

At Avondale, thirty miles north of Narrabri, my informant Mr. S. J. Dickson, says, "From the 9th to the 13th of October, the weather was unusually oppressive with threatening storms, and on the evening of the 13th a heavy storm was seen to be working up from the west accompanied by incessant lightning of every description, and about 8 p.m. it broke over the homestead in all its fury, the wind was from south-west and of terrific force, and the rain and hail were very severe. The hail-stones were as large as hen-eggs, and in some of the paddocks, one particularly, it pounded the herbage completely out, so that not a vestige of it was left, although before the storm came on, it was from six to twelve inches high, and in other places strong variegated thistles three to four feet high were beaten down. Trees some two feet thick, that the wind could not tear up by the roots were snapped off short as if made of match-wood. In the storm the hail killed birds innumerable, and even domestic fowls roosting on the trees were killed by it, and after the storm, a large snake was found cut into two pieces by the hail, so at least it appeared. On the open plain the hail laid four to six inches deep, and the whole country looked as if a heavy snow storm had passed over it. Trees in the track of the hail were completely denuded of leaves and the bark knocked off tree trunks and limbs. The storm wind carried away outstations, unroofed the hayshed, damaged the woolshed, and carried away two sides of the house-verandah, and the sheets of iron from it were found nearly half a mile (30 chains) away to the north-east, round wall plates in the hayshed six to eight inches thick were broken to pieces, and the iron roofing on all the buildings was battered by the hail as if some one had pounded it with a hammer all over. The storm track was only a mile to a mile and a-half wide, at least the hail part. Between 7 and 8 p.m. as the storm came up, there seemed to be a white bow in the sky, like a white rainbow stretching from north to south. I have seen heavy storms before but I never wish to see another like this, the shearers were completely terrified and all say that they have never experienced a storm like it, in fact it beggars description and can hardly be realized. It was an experience that we shall remember as long as we live."

North of Narrabri, and especially between Narrabri and Avondale, the storms were very severe. Midway between these places and at Terry-hi-hi and Berrigal Creek the wind worked great destruction in the forest, how violent it was may be gathered from the fact that great trees twelve feet in circumference at three feet from the ground, were snapped off short ten feet above the ground, or entirely stripped of their limbs.

NOTES ON THE RECENT CHOLERA EPIDEMIC IN GERMANY.

By B. SCHWARZBACH, M.D. *Würzburg*, L.F.P. & S. *Glas.*

[*Read before the Royal Society of N.S. Wales, December 7, 1892.*]

IN speaking of the recent Cholera Epidemic in Germany, the outbreak in the city of Hamburg can only be considered, because the appearance of the disease in other parts of the country was entirely of a sporadic nature, with no sign of being an epidemic. The suddeness and fierceness of the outbreak in Hamburg, came like a terrible surprise, not only to the inhabitants of that unfortunate city, but to the civilised world at large. The consternation, which at first prevailed throughout Germany, however soon subsided, as the local nature of the epidemic manifested itself.

In the beginning of August 1892 no marked sign of the malignant disease was noticable in any of the European countries, except in Russia. True, a few isolated cases had appeared in Paris, Havre, and Antwerp, but it was at that time asserted that these cases were not of the Asiatic type, but *Cholera nostras*. Suddenly, August 20th, the telegraph flashed the notice into the world, that a serious outbreak of genuine cholera had taken place at Hamburg, and that some dozen of patients had died. It seems to have taken the city authorities some days to ascertain the true nature of the symptoms. On the 22nd of August eighty-nine fresh cases were recorded, and on the 27th already eight hundred and seven cases had occurred. During the seven weeks the epidemic raged at Hamburg, there were—to give round numbers—eighteen thousand patients, of whom seven thousand six hundred died. Hamburg is, next to Berlin, the largest city in Germany, with about half a million inhabitants. If cholera had appeared in the same proportion in London, about one hundred and seventy thousand cases with eighty thousand deaths would have been recorded in that city. No wonder, therefore, that for a few days consternation reigned supreme and that in the beginning the weapons to battle against the enemy were inadequate. However, after the second week most vigorous measures were adopted, the effectiveness of which was proved by the rigid decrease of the number of fresh cases, so that nearly as suddenly as it had appeared the cholera vanished again.

It probably will never be known, in what manner the malignant germ had been introduced into the town; whether by the wooden freight boats, which have travelled during many weeks from the Russian frontier by the river Weichsel; if emigrants from Russia, passing through Hamburg, have been the cause; or if some steamers with an Indian crew, hailing from Calcutta (where cases of Asiatic cholera appear the whole year round) have been the offenders. It may have been that Antwerp or Havre, with which ports a brisk trade is carried on with Hamburg, were the doors through which the *Comma bacillus* was introduced to a soil most congenial to its further development.

What must have struck the intelligent observer of the nature of the epidemic most keenly, was the fact, that in our time of advanced science, in which we take every opportunity of boasting about the supreme hygienic means at our command aided by microscopical discoveries, the spread of a disease, the nature of which is well understood, could have been so terribly quick and extensive. If we hear that in one Persian town sixty thousand people have died of cholera during the month of September, we are perhaps not over astonished because we consider the primitive state of medical advancement amongst the Mahomedans, the religious fatalism of the race, and the dirt of their abodes. But when we hear that in a highly civilised country, like Germany, eight thousand persons have died within seven weeks in a city, which had, or ought to have had all the modern appliances of science at its disposal, we then come to the conclusion that the so-much-praised advance of prophylactic science is not so efficient, as it is said to be. The only advance which has manifested itself during the last epidemic (and I admit it is a great advance) is the diminishing of the percentage of mortality. During the rage of cholera in 1866 from 50 to 65% of the patients died, whereas in the year 1892 only—only!—42%.

But after all, it may not have been the ineffectiveness of hygienic measures, but the absence of the same, which created such havoc at Hamburg. Let us consider, how it happened, that the cholera, as an epidemic, kept hovering over Hamburg alone, without spreading to any extent sideways. It was well known to the inhabitants of that town, that the drinking water with which they were supplied, is at times not in such a pure state as it should be. Occasionally, especially after much rain,—water from the river Elbe finds its way, by some means or other, into the cisterns which supply the daily wants of the people. The danger of this has often engrossed the attention of the city fathers, and efforts have been made to remedy the fault. In the year 1890 the construction of very extensive waterworks was commenced, the great technical difficulties of which were to terminate—just in time to be too late—in the year 1893. From the beginning the work was considered to require three years for its completion. It is a drastic irony of fate that the cholera itself interrupted these works, which were erected principally to guard against this very enemy. At present about one thousand workmen are daily (even on Sundays) engaged to hasten the completion of the great undertaking before the commencement of the next hot season.

Now, allowing that the Elbe water was undoubtedly the distributor of the cholera germs, the—I may say—nursing of the same took place in those many small unwholesome back dwellings, in which Hamburg abounds. In the quarters of the dock- and wharf-labourers, the peculiar quaint style of the buildings has created many corners, back-terraces, small dark yards and flats devoid of pure air and good light. The poverty of the occupants did not permit the necessary adoption of that special hygiene which the richer people consider all-important for their daily necessities. Of course, to day, after a leg, or many legs have been broken over the stone on the bridge, the stone will be removed—however too late for those who have come to grief by falling over it. But as no wind is said to be so bad that it may not carry some good, so will the late calamity at Hamburg change for the better the life-condition of the poor in that city. The whole country will watch with a critical eye the fufilment of these conditions.

Another advantage in the abstract, caused by the epidemic, must be considered in the thoroughness with which every part of the German Empire has been cleansed and disinfected. In large and small towns, in country places, at railway stations—every backyard, every corner has been "treated" according to law and private inclinations. The smell of carbolic acid, tar, and sulphur was noticeable everywhere, when travelling from Hamburg to Königsberg or from the Baltic to the Bodensee. It may be that this wholesale sweeping and cleansing has helped much to prevent the cholera from taking a hold in other parts of the Empire, though this was more probably caused by the absence of those conditions which existed at Hamburg. All the isolated cases which appeared outside of that city, were traced to infection from the water of the river Elbe, and it was most fortunate that this source of danger was recognised at an early date. Not by the swift communication of railway travelling, but by the slow one of the wooden freight-boats plying on rivers, the cholera germ found its way from Hamburg to other parts of the country, and I have already mentioned that in this manner it might also have been introduced into the town. A special watch was organized in this respect. At fourteen different stations on the river Oder alone, somewhat over 22,000 boats with 75,000 persons on board were inspected, from September 1st to October 15th. Of these boats about 9,000 were carefully disinfected and twelve persons were observed to be suffering from symptoms of Asiatic cholera. This number of patients is certainly not large in comparison to the tremendous boat-traffic, but were of enough consequence to endanger those parts of the country through which they passed. In several of the boats, coming from the mouth of the Elbe, the *Cholera bacillus* was discovered in large quantities to be in the bilgewater, and as the bilgewater is often emptied in different rivers, the possibilities occasioned through this practice may easily be imagined.

One fact may strike perhaps Australians as particularly noticeable. It is this: During the whole of the cholera months, there was not for a single day a stoppage of trade and passenger traffic as far as Germany was concerned. The trade naturally diminished to a great extent, for a time at least, because many people were afraid lest they should import the deadly germ with the goods, but those who were not afraid to keep up a commercial intercourse with the Hansa city, had no reason to regret it. In not a single instance was a case of cholera known to have been originated by the letter- or parcel-post. Also the passenger-trains from Hamburg ran as usual, four to six times a day in all directions, carrying thousands of persons away from the infected port. The passengers were—in Berlin at least, where the authorities had most reason to be guarded, as the stream of fugitives (we may call them so partly) poured principally into its environs—subjected to no inconvenience whatever. The only precaution taken, was the enquiry of some medical men at the station about the health of the people, coming by the train. In two or three instances, persons with suspicious symptoms were conveyed to a proper hospital for observation and their private belongings were disinfected, but the other passengers were allowed to go where they liked with the exception of those who were in the same compartment with the affected. Of cases appearing in Berlin itself, only one was known to have come by a Hamburg train on the day previous. But no harm was done whatsoever by permitting the passenger traffic to go on as usual. Also the luggage was allowed to pass without interference, the impracticability and uselessness of luggage-disinfection being proved by many experiments. The *Cholera bacillus* unlike the *Tubercle bacillus*—is a very sensitive organism and dies off quickly if the moisture necessary for its existence is wanting. The knowledge of this induced the Sanitary Commissions of large cities to avoid molestation without most urgent cause. As may be imagined, in small towns, especially in very small towns, many absurd and even amusing incidents occurred in the endeavour to guard against infection. It was often sufficient that the name of a man was Hamburger, though he may have hailed from Vienna, to be looked at with mistrust and to induce hotel-keepers to boycott him.

A still more unconscious humour was embodied in the action of the Brazilian Government, in prohibiting during the summer the import of natural mineral waters and aerated waters from Germany. Considering that it would be rather a difficult task for the *Comma-bacilli* to find their way to the underground source of natural springs, besides which, if they should find their way to those secluded spots, they would be quickly killed by the mineral substances of the water and still quicker if the water should be aerated, considering this fact well-known to scientists, the action of the Brazilian Government deserves to be chronicled.

In this short paper, which is read to a partly non-medical assembly, I cannot go into details about the disease as such, I mean about its symptomology, anatomical pathology and therapy. In regard to the last named let me mention, that no specific against cholera has as yet been discovered. In most cases the treatment is a symptomatical treatment. The only advance in therapeutics which the last epidemic has developed is the hyperdermic transfusion of a $\frac{2}{3}\%$ solution of salt in warm water. The manipulation of this method is much easier and quite as effective as the transfusion into the blood-vessels direct. This was practiced in a few instances by Dr. Catain in conjunction with the tannin-injections already introduced at the cholera epidemic of Naples. I have seen patients in a perfectly comatose state magically benefited by the subcutaneous or hyperdermic injection of large quantities of the physiological salt water solution. The syrup-like condition of the blood becomes diluted and circulates again; the previous lifeless pulse is again detectable, and after a time—involving perhaps the transfusion of several quarts of fluid—the kidneys are once more active and with the re-appearance of urinary functions the danger, in most cases, is averted.

Of the many would-be specifics against cholera, the plan of inoculating the cholera virus and trying to make the human system immune to infection, as is the case in vaccination to guard against smallpox, has claimed some attention, but nothing whatever has been proved by it. An American reporter, Mr. Stanhope who after being vaccinated in Paris visited Hamburg and mixed freely with cholera patients, can certainly not be looked on in a serious scientific light. A cablegram told us a week or two ago that two German Professors at Munich intentionally swallowed *Cholera bacilli*, without any bad effect to themselves. Indeed, many people seemed to be *eo ipso* immune against infection without any precaution whatever, while with proper precautions there is certainly much less danger from dying of cholera during a cholera epidemic in town, than of dying from the effects of influenza during an influenza epidemic. Of the one hundred and odd medical men, who during the height of this Hamburg calamity attended to patients day and night, wading as it were, in the very essence of the infectious poison, only one took ill with the characteristic symptoms.

The terror, with which whole communities are often stricken, if a case of cholera appears in their midst, is not justified to a great extent. Should the disease ever make its appearance in Australia, which I trust it will not, there is no need for panic and flight. If we say with Cromwell: "Trust in Providence and keep your powder dry," in other words, if we do not lose our heads we will not lose our lives; if we rationally guard against an infection, the infection will not come to us individually. It must always be borne in mind that the cholera can only be eaten or drank. The infection can be acquired by way of the mouth only; but even if this should happen, there is no need for despair. It has been proved beyond doubt, that the *Comma bacillus* will die a natural death in any stomach with a healthy digestion. Only if it should pass the stomach in an undigested state, it will multiply and make itself unpleasant in the intestines. We learn therefore that diet and cleanliness are the two principal and simple weapons with which this enemy can be kept effectively at a distance. But this point has probably been well discussed privately and publicly. To one circumstance, which may not be generally known, I wish to draw attention, that is the danger which flies may inflict by carrying the cholera virus about. This may give us a clue to the cause of the sudden appearance of the disease in divers parts of a town. Dr. Simmonds, Prosector of the "Old General Hospital" at Hamburg, in one of his experiments, put nine flies on the freshly dissected intestines of a late cholera patient, and then isolated each fly, first into empty tubes, and after thirty minutes into tubes half filled with a soft gelatine mass. After the lapse of forty-eight hours it was proved that in six out of the nine gelatine preparations countless numbers of colonies of the *Cholera bacilli* had been bred; in the seventh tube one thousand colonies; in the eighth tube thirty-two colonies; and in the ninth again numbers too numerous to be counted.

It is in this manner shown that after the lapse of more than half an hour, the cholera germs may still adhere to living insects. And if we bear in mind what long distances flies may accomplish in such a time, the possibilities of having eatables infected, such as soup, pudding, milk, etc., must not be undervalued.

In conclusion I wish to remind you of a somewhat heroic deed which an Australian community performed a few years ago. The steamer "Dorunda" had arrived with cholera patients on board at Townsville and was ordered to proceed south. But the Townsville people, most anxious to give help and to separate the healthy from the affected, petitioned the Queensland Government to allow the passengers to land at their Quarantine Station, inviting as it were, the disease into their midst, well knowing what dangerous possibilities to their own welfare this action might involve. I have always considered this spirit of the Townsville people as a true spirit of courage and philanthropy. What a contrast is not this to the action of an American crowd on a similar occasion, who prevented forcibly the landing of females and children—in a healthy state, but exhausted through exposure—at the Quarantine Station near New York in September last.

On NATIVE COPPER IODIDE (MARSHITE) and OTHER MINERALS from BROKEN HILL, N. S. WALES.

By C. W. Marsh, Communicated by Prof. Liversidge, M.A., F.R.S.

[*Read before the Royal Society of N.S. Wales, December 7, 1892.*]

This mineral occurs as implanted crystals, not larger than $\frac{1}{24}''$ through, on siliceous gossany cerusite, coated with ferro-manganese; crystallization, tetragonal-hemihedral. Colour, reddish oil brown, lustre resinous, translucent. Streak, orange-yellow. Brittle, fracture subconchoidal.

Heated in closed tube; partly fuses, spreads up tube, dark brown when hot, reddish-brown when cold; partly volatilized as beautiful violet fumes, condensing on cold part of tube as steel-grey acicular crystals, which are volatilized in violet fumes on heating, leaving a whitish skeleton residue.

Heated in open tube partly fuses with dense violet fumes, condensing on cool part of tube, having acid reaction, fused mass greenish-yellow, by further heating violet-black.

Heated on charcoal in O.F.; effervesces with dense green flame, (similar to tellurium) coating charcoal near assay dirty red, surrounded by yellowish-green, passing over in outer part to bluish-white, with white border. This is consumed by continued blowing in O.F. or R.F. with dirty green flame in outer parts, changing to bluish-green nearer the assay piece, after which iridescent stains are left on the charcoal.

On charcoal in R.F. alone, much the same as above. With soda, dense bluish fumes, with heavy white incrustation, leaving eventually a globule of copper* and magnetic speculæ. (The latter probably due to mechanical impurities). With borax or phosphor salt on platinum wire, gives copper reaction with green flame.

Powder treated with cold HNO_3, slightly soluble, solution brownish-oil green. Hot, gives deep red solution, from which violet fumes escape, condensing on cool part of tube, as translucent steel-grey acicular crystals, (which removed and dissolved in water gives blue solution with starch) similar crystals form in solution while cooling. These may again be dissipated by boiling, after which the clear solution gives with ammonia the reaction for copper, and a yellowish-white precipitate with silver nitrate. No precipitate with barium nitrate, slight colouration with ammonium molybdenum. This precipitate after washing, treated in bead of phosphor salt gives pure green flame colouration; after removal of precipitate the solution gives a blue colour with starch water.

* The globule of metal dissolved in HNO_3 gives copper reaction with ammonia, no precipitate with H_2SO_4 or HCl.

Powder treated with cold HCl; only slightly attacked, solution dark in colour. With hot HCl, partly decomposed, leaving grey residue; the cooling solution deposits white flocculent precipitate which is increased by the addition of water.

Powder treated with H_2SO_4 is partly soluble with violet fumes similar to the nitric acid reaction, only much denser.

Powder treated with acid potassium sulphate in closed tube, fuses to a green mass with dense violet fumes, which turn starch paper blue.

[Mr. Marsh forwarded to me a small specimen of the copper iodide, and I have verified the principal characteristics as given in his description; as the mineral appears to be a new one, I suggest that it be named Marshite, in recognition of Mr. Marsh's discovery and the zeal and diligence which he has shown in collecting and describing the minerals of the Broken Hill district.—A Liversidge.]

Additional notes on the mode of occurrence of Copper Iodide.

The crystals of copper iodide from which the above examinations have been made, are in most cases implanted on what appears to have been similar crystals belonging to an earlier period of formation, but which had already suffered partial decomposition. Their outer surfaces being changed to impure black oxide of copper—in some instances thickly coated with oxide of manganese—with a yellow resinous-like substance in the centre. These partly decomposed crystals on account of the difficulty in getting a pure sample, have as yet only been tested for copper and iodine, for which they give reactions similar to the later formed unaltered ones.

A third, and earlier date still, is traceable in the deposition of well formed crystals of anglesite, against the sides of which crystals of copper iodide, belonging to both the earlier and later formations are imposed.

We have thus indirect evidence of three well marked stages of deposition, which appear to warrant the following conclusions:—

1. A cavity in gossany carbonate of lead ore has been coated with iron and manganese oxides, on which has been implanted at irregular intervals, well formed crystals of anglesite, one of the largest measuring fully 5 mm. along the edge.
2. After the complete development of the anglesite, a crystalline deposit of copper iodide took place, covering the greater part of the floor space between the anglesite crystals. After the completion of the copper iodide deposit, a change of conditions appears to have occurred, resulting in their partial decomposition. This change being accompanied by a deposit of manganic oxide which has in many instances covered the partly altered crystals.
3. These conditions appear to have been again reversed and a second deposit of copper iodide to have been formed upon the partly altered and incrusted surfaces of the older crystals.

These later formed crystals show no signs of decomposition or incrustation by other substances, and appear to favour the assumption that conditions suitable to their development prevailed up to the time of their discovery.

Other Minerals.

(No. 2) A peculiar mineral not yet satisfactorily classified. At first appearance resembles a tangled bunch of cord that had been dipped partly in white and partly black paint. Now if you will imagine the cord to be changed to impure chalcedony, the white paint changed to a fine pearly foliated kaolin-like mineral, the black parts being due to penetrating oxide of manganese, you will have a very fair idea of the appearance of the specimen and a rough outline of its composition.

Result of preliminary trials—*White variety.*—B.B. infusible; in borax and phosphor salt gives reaction for silica only; fused with cobalt nitrate yields blue mass. Heated in glass tube (closed) gives water, also white fumes condensing as faint sky blue sublimate (not tested). Powder boiled in H_2SO_4 becomes highly explosive; partly decomposed in nitro-hydrochloric acid, more completely so if first fused with potassium bi-sulphate. After the removal of silica in the usual manner, alumina is thrown down by ammonia, from the filtrate lime is precipitated by ammonium oxalate, and a little magnesia, by sodium phosphate. *Black variety* gives manganese reaction with borax lead, otherwise essentially similar to above.

[The very small specimen of the white coralloid mineral forwarded to me consists of chalcedony coated with what appears to be Gibbsite or aluminium hydrate; the coating has a greasy feel, and under the microscope is seen to have a fibrous structure, and on scraping it off a white fibrous matted powder is obtained; this gives the reactions described by Mr. Marsh, except that I did not obtain any sublimate, and I am inclined to think that the silica left in the microcosmic salt bead is not combined with the alumina but intermingled mechanically. The black coralloid portions consist mainly of black oxide of manganese, and when treated with HCl give off chlorine copiously and leave a siliceous skeleton or core in much the same way as the stalactitic hæmatite from the Mount Morgan Gold Mine.—(Journ. Royal Soc. N.S. Wales, 1891, p. 236)—A. Liversidge.]

(No. 3) Is a mineral of which we have numerous specimens. It usually occurs as implanted connected crystals on limonite. It consists principally of lead, with varying proportions of phosphorus arsenic and chlorine; some with, others without lime, on some specimens the crystals are coated with a bright gold-yellow to copper-red film, which I have not yet been able to satisfactorily determine. From some of these films I have got the reaction for molybdic acid, whilst from others, apparently similar, no such reactions could be obtained.

These minerals appear to form various links between mimetite and pyromorphite, or more properly speaking a combination in various proportions of the two minerals. But as they cannot be classed directly as either, and as they sometimes contain lime, I have classed them irrespective of their slight changes in composition as hedyphane. Moreover there are many points of essential difference in crystalline structure, and mineral associations between the three minerals; for instance the so-called hedyphane is (1st) usually in short hexagonal prisms. (2nd) The crystals are often coated by films of what appears to be different material, in which case they are usually accompanied by iodide of silver, being in all cases the latest deposit. On the other hand mimetite or pyromorphite when occurring as hexagonal prisms, have a widely different appearance, the latter being usually flat topped or but slightly bevelled, while the former is generally truncated, much bent or bulged out as it were at the top; while the incrusting film and accompanying iodide of silver characteristic of hedyphane (?) have not yet been noticed.

(No. 4) Another peculiarity in composition is found in a mineral that I have classed as aurichalcite. It consists essentially of zinc-copper carbonate; some samples containing water others not. The latter can scarcely be classed as smithsonite since it contains from traces to 3% of copper. This mineral occurs usually as implanted semi-transparent crystals, from a sky-blue to dark bluish-green colour. It is the opinion of many that the copper present is only a mechanical impurity. I look upon it however, as being in chemical combination. Amongst the numerous specimens of this mineral in the collection, it would be almost impossible to get two of similar appearance and composition. This is not only true of the zinc minerals, it applies also to the various lead, copper, and silver ores belonging to this collection, I recognized this fact early in the progress of my work here, and discovered that in order to render the classification of this (*i.e.* the Aldridge) collection useful and instructive, it would be necessary to base it on the more essential constituents of the minerals, neglecting in many cases their minor differences, otherwise the classification would have been encumbered by unimportant information, and the list of varieties carried to an extreme limit.

[This mineral is zinc carbonate containing small quantities of copper, the amount of copper is not sufficient to regard the mineral as aurichalcite.

Later on I wish to submit the specimens of the above four minerals forwarded to me by Mr. Marsh to a fuller examination. —A. Liversidge.]

On the COMET in the CONSTELLATION ANDROMEDA.

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

[*Read before the Royal Society of N.S. Wales, December 7, 1892.*]

On November 12th the following cable message from London, dated November 10th, appeared in the *Herald*:—" A comet has been discovered in the constellation Andromeda : it is increasing in brightness." Clouds prevented a search for the comet on the evening of the 12th, but on the following evening the sky was beautifully clear, and I accordingly swept the constellation referred to with an ordinary opera-glass and soon detected a small nebulous object close to the Great Nebula. It could be seen in the same field of view with the Great Nebula, and was just visible to the naked eye. I succeeded in obtaining three differential measures of its position, but they did not afford any indication of proper motion. The object could not, however, be found in a Catalogue of Nebulæ visible in a telescope of four inches aperture. There was therefore *prima facie* evidence of its being the comet telegraphed from London. The next evening the sky was densely clouded, but on the 15th I again succeeded in observing the object and found that it had changed its position sensibly in the forty-eight hours. Its cometary character was therefore established beyond doubt. Had it not been for a sensational London cable message appearing in the daily press on November 16th to the effect that the new comet just discovered in Andromeda would be only a million of miles from the earth on the 27th, I should have left the observation of this object to northern observers, because it is much better situated for them. On November 22nd I pointed out in the daily papers the suspicious circumstance under which the new comet appeared, for the earth was about to enter that region in space where its orbit is intersected by the path of the historical comet of Biela, and our visitor kept an almost invariable apparent position in Andromeda, which is the very part of the sky from which Biela's Comet would come to us if it approached the earth in the way stated in the London cable message. Under the impression that the comet might turn out to be a fragment of the Comet Biela, which it was well known had become widely scattered since the return of 1852, I continued my observations until the increasing moonlight rendered it almost invisible. At no time was it a good object for observation, for it was a large diffused patch of light with no sensible condensation towards its centre. The observations were made in a dark field with a square bar-micrometer adapted to the four and a half inch equatorial, and it was with the utmost difficulty that I could estimate the times when the centre of the comet was on the edges of the bars. The individual measures are therefore more inconsistent *inter se* than is usually the case: indeed this comet is about the most unsatisfactory one I have observed in an experience of upwards of thirty years. At the close of this paper I have given the results of the observations, and they will afford data for an approximate determination of the orbit, a work which I cannot myself undertake at present in connection with the routine of my observatory. The data may, however, be useful to any local mathematician who may have both the desire and the leisure to satisfy public curiosity. Until the orbit is computed it is of course impossible to say definitively whether our visitor is moving in the orbit of Biela's celebrated comet or not. A lookout has been kept at my observatory for meteoric or auroral displays, but nothing of any great importance has been seen. Two or three meteors were seen close to the comet on the evening of November 20th, and while observing with the micrometer on the

24th, a small telescopic meteor flitted across the field of view, the momentary trail left by it being as fine as the threads of the micrometer.

I will conclude this brief notice by stating that an attempt will be made to continue observations after the withdrawal of the moon from the evening sky.

RESULTS OF THE OBSERVATIONS OF THE COMET IN ANDROMEDA.

Date.	Windsor Mean Time.	Comet—Star.		Comparisons	Comet's Apparent.		Reductions of Star Places.		Comp. Star.
		△ R.A.	△ N.P.D.		R.A.	N.P.D.	R.A.	N.P.D.	
1892.	h. m. s.	m. s.	′ ″		h. m. s.	° ′ ″	s.	″	
Nov. 13	10 10 36	−2 46·25	+ 0 31·1	3	0 44 13·19	52 2 17·4	+2·98	−26·3	1
,, 13	10 10 36	−6 35·02	− 2 22·5	3	0 44 13·48	52 2 22·6	+3·02	−26·2	2
,, 15	9 43 53	−3 28·64	+12 43·6	10	0 43 30·79	52 14 29·7	+2·97	−26·5	1
,, 15	9 43 53	−7 17·44	+ 9 48·2	10	0 43 31·04	52 14 33·0	+3·00	−26·5	2
,, 18	10 5 39	−2 37·61	+ 1 26·8	3	0 42 41·72	52 33 28·1	+2·93	−26·9	3
,, 19	9 7 52	−2 49·17	+ 7 55·8	10	0 42 30·15	52 39 57·0	+2·92	−27·0	3
,, 20	8 45 43	−3 0·86	+13 59·8	6	0 42 18·45	52 46 0·9	+2·91	−27·1	3
,, 22	9 38 42	+2 46·46	−12 54·8	3	0 42 7·04	52 59 3·2	+2·84	−27·3	4
,, 22	9 38 42	−5 29·55	−10 30·7	3	0 42 5·49	52 58 59·1	+2·91	−27·2	5
,, 23	9 34 14	−5 33·10	− 4 16·6	10	0 42 1·93	53 5 13·1	+2·90	−27·3	5
,, 24	9 49 1	+2 43·11	− 0 42·3	5	0 42 3·67	53 11 15·5	+2·82	−27·5	4
,, 24	9 49 1	−5 32·81	+ 1 48·3	5	0 42 2·21	53 11 17·9	+2·89	−27·4	5

MEAN PLACES OF THE COMPARISON STARS FOR 1892·0.

Comp Star	R.A.	N.P.D.	Authorities.
	h. m. s.	° ′ ″	
1	0 46 56·46	52 2 12·6	Lalande, 1443; $Yarnall_3$ 450.
2	0 50 45·48	52 5 11·3	American Ephemeris, 1892.
3	0 45 16·40	52 32 28·2	Lalande, 1384.
4	0 39 17·74	53 12 25·3	Lalande, 1180.
5	0 47 32·13	53 9 57·0	Lalande, 1464; $Yarnall_3$ 456.

RESULTS OF OBSERVATIONS OF WOLF'S COMET (II.) 1891, SWIFT'S COMET (I.) 1892, AND WINNECKE'S PERIODICAL COMET, 1892, AT WINDSOR, NEW SOUTH WALES.

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

[*Read before the Royal Society of N.S. Wales, December 7, 1892.*]

Wolf's Comet (II.) 1891.

THIS comet was first detected by Herr Max Wolf at Heidelberg, Germany, on September 17, 1884, and it was soon found that no parabola would satisfy its movements. Elliptic elements were accordingly calculated by several astronomers which gave a period of rather more than six and a half years. It passed its perihelion on November 18, 1884. The *Astronomische Nachrichten*, Vol. CXVII., Nos. 2789 and 2790, contains a definitive investigation of the elements by Pfarrar A. Thraen from a fine series of observations extending from September 20, 1884, to April 6 1885. The resulting period is 2474·5 days, and the return to perihelion was fixed for August 28, 1891. Approximate ephemerides were published for this return, which enabled Spitaler of Vienna and Barnard of Mount Hamilton to detect the comet on May 1 and 2, 1892 respectively. It was subsequently followed at several northern observatories. With the help of Thraen's ephemeris in *Astronomische Nachrichten*, No. 3054, I found the comet on October 9 with the four and a half inch equatorial. From that date to December 26 it was well observed at Windsor with a square bar-micrometer on the eight inch equatorial and in a dark field. The accompanying table gives the deduced apparent positions and the necessary reductions to the earth's centre, these reductions being based on an equatorial horizontal parallax of the sun = 8·85″ and Thraen's values of log. Δ in his ephemerides in Nos. 3054, 3064 of the *Astronomische Nachrichten.*

Swift's Comet (I.) 1892.

This comet was discovered as a bright object on March 7, 1892 by L. Swift at the Warner Observatory, Rochester, New York, and the news of its discovery was cabled from Kiel to the Australian Colonies, the notification reaching me on the evening of the 9th. The sky was cloudy on the following morning, and it was not till the morning of the 11th that I succeeded in finding the stranger. From that date to April 23 inclusive, an excellent series of filar micrometer measures in a bright field were obtained with the eight inch equatorial. All the subsequent observations were made with a square bar-micrometer in a dark field on the four and a half inch instrument. After May 2 the comet was too far north, but its observation was continued by northern observatories. The differential co-ordinates resting on the single comparisons of March 10 and April 9 were obtained by observing the instant when the comet and comparison star were together bisected by the transit or one of the declination threads of the micrometer. As a sufficiently exact ephemeris is not available for the calculation of the reductions to the earth's centre the usual parallax factors log. $\frac{p}{P}$ log. $\frac{q}{P}$ are furnished instead. p and q denote the reductions to the earth's centre in time and arc respectively, and P the comet's equatorial horizontal parallax. There are as yet no very decisive signs of elliptic motion in this comet. Herr Berberich of Berlin finds that observations extending over a period of four months can be satisfied by an ellipse with a period of 20000 years. The comet was visible to the naked eye from the time of its discovery till it ceased to be observed at Windsor. It passed its perihelion on April 7, 1892.

Winnecke's Periodical Comet, 1892.

It will perhaps be within the recollection of the members of the Royal Society that this comet was observed at its last return which took place in 1886. A paper containing the Windsor observations of that year was read before the Society in September 1887 and published in their Journal, Vol. xxi., p. 159. It will be unnecessary to repeat the history of this interesting comet previously to

1886, and the members are therefore merely referred to the paper just cited. I may add that the published positions for 1886 rest mainly on the observations at the Cape of Good Hope and Windsor. Dr. von Haerdtl of the University of Innsbruck, investigated the elements of the comet's motion for its various apparitions since its original discovery, and it will be interesting to the members to know that the observations at the Royal Observatory, Cape of Good Hope, and those made at Windsor, and published in the Society's Journal are characterized by him as "two magnificent and beautiful series." One of the useful results from Dr. von Haerdtl's investigation is a new value of the mass of the giant planet Jupiter. At the return during the current year, the comet was first found by Spitaler of Vienna on March 18, with the help of Dr. von Haerdtl's ephemeris. It was then in 30° N. declination and favourably situated for observation in the northern hemisphere. With the help of the same ephemeris I succeeded in picking up the comet on June 12, but as it was still well situated for northern observatories, local observations were not then made. The comet passed conjunction with the sun on July 7 at a distance of eleven millions of miles from our planet, and on July 18 was picked up as a morning object and observed on all possible occasions from that date to September 27. All my measures were made with a square bar-micrometer in a dark field, those for July 17 with the four and a half inch equatorial and all the others with the eight inch instrument. As Dr. von Haerdtl's ephemeris is pretty exact, I have given the reductions of the comet's apparent places to the earth's centre instead of the usual parallax factors for the reduction. I trust that the observations now submitted will prove as useful as those made at the previous return in 1886. I will conclude my notice of this comet by drawing attention to an interesting observation which I made on September 27, as it throws some light on the extreme tenuity of cometary matter. On looking for the comet on the night of September 27—28 in the position assigned to it in the ephemeris, I could not find it as a separate object, but a star of the 10th magnitude presented itself fringed with a faint nebulous haze. As this was doubtless the comet centrally superposed on the star, I made four comparisons of this star with my comparison star of the preceding evening. The resulting position agrees to a minute of arc with that given in the ephemeris. Clouds prevented further comparisons so that I was unable to witness the subsequent separation of the comet from the star. No micrometric measures could be made of the diameter of the comet, but it could not certainly be less than 15″. Now as the distance of the comet from the earth at the time of observation was fifty-seven millions of miles, fifteen seconds of arc would give a globular volume of cometary matter with a diameter of about four thousand miles, and yet the star was well seen centrally through this mass. I may add that there is at least one instance on record in which the lustre of a fixed star has been increased by being viewed through the head of a comet, and there is yet another in which a star has been almost wholly obscured.

COMET II. (WOLF) 1891.

Date.	Windsor Mean Time.	Comet—Star.		Comparisons	Comet's Apparent.		Parallax Corrections in		Reductions of Star Places.		Comp. Star.
		Δ α	Δ δ		α	δ	α	δ	α	δ	
1891.	h. m. s.	m. s.	′ ″		h. m. s.	° ′ ″	s.	″	s.	″	
Octr. 9	13 44 48	+5 1·50	− 2 46·6	10	4 34 43·69	+ 9 53 38·3	−0·25	−7·2	+2·34	+13·8	1
,, 11	15 56 46	−4 32·25	− 2 11·6	5	4 36 18·02	+ 8 47 13·3	+0·11	−7·2	+2·34	+13·7	2
,, 11	15 56 46	−8 24·17	+ 4 13·3	5	4 36 15·36	+ 8 47 11·3	+0·11	−7·2	+2·32	+13·6	3
,, 30	11 31 39	+7 5·64	− 6 59·0	10	4 41 23·16	− 1 22 44·3	−0·39	−5·9	+2·71	+15·4	4
,, 31	11 2 20	−7 30·78	+ 0 55·9	7	4 41 13·65	− 1 53 2·4	−0·44	−5·9	+2·69	+14·9	5
,, 31	11 2 20	−7 54·50	+ 5 1·8	7	4 41 13·31	− 1 53 2 7	−0·44	−5·9	+2·69	+14·9	6
Nov. 2	11 29 0	+8 29·78	− 3 2·9	7	4 40 46·72	− 2 54 42·8	−0·36	−5·7	+2·77	+15·4	7
,, 2	11 29 0	+0 52·52	− 2 28·7	7	... ...	... ...	−0·36	−5·7	+2·75	+15·2	8
,, 3	10 42 38	+1 49·09	− 1 27·5	10	4 40 30·91	− 3 23 25 7	−0·45	−5·7	+2·77	+15·2	9
,, 3	10 42 38	+0 25·37	+ 3 36·6	10	4 40 31·22	− 3 23 25·7	−0·45	−5·7	+2·76	+15·2	10
,, 4	10 24 0	−0 38·96	+ 0 56·8	8	... ...	... ...	−0·47	−5·6	+2·78	+15·1	11
,, 4	10 24 0	−5 54·65	− 2 21·5	8	4 40 13·04	− 3 52 47·8	−0·47	−5·6	+2·76	+14·9	12
,, 7	11 38 6	−4 48·87	− 9 29·2	10	... ...	... ...	−0·29	−5·2	+2·82	+14·8	13
Dec. 17	9 14 50	+3 12·43	+ 3 57·0	5	4 16 29·39	−14 50 12·2	−0·16	−2·8	+3·22	+ 9·1	14
,, 17	9 14 50	+1 33·52	+ 0 51·4	5	4 16 29·32	−14 50 15·7	−0·16	−2·8	+3·22	+ 9·1	15
,, 20	9 20 53	+2 18·45	+ 3 19·2	6	4 15 35·41	−14 50 50·5	−0·12	−2·7	+3·22	+ 8·6	14
,, 21	8 58 11	+2 4·07	+ 4 6·9	4	4 15 21·03	−14 50 3·0	−0·16	−2·7	+3·22	+ 8·4	14
,, 25	9 22 20	−0 18·75	+ 8 45·4	10	4 14 37·05	−14 42 23·1	−0·07	−2·5	+3·22	+ 7·7	15
,, 26	9 10 42	−0 24·57	+11 40·5	10	4 14 31·23	−14 39 28·2	−0·09	−2·5	+3·22	+ 7·5	15

COMET I. (SWIFT) 1892.

Date.	Windsor Mean Time.	Comet—Star.		Comparisons.	Comet's Apparent.		Parallax. Factors.		Reductions of Star Places.		Comp. Star.
		Δ α	Δ δ		α	δ	Log. $\frac{p}{P}$	Log. $\frac{q}{P}$	α	δ	
1892.	h. m. s.	m. s.	′ ″		h. m. s.	° ′ ″	—	—	s.	″	
Mar. 10	16 19 45	—0 3·31	... ...	13	19 14 13·13	... ...	8·7139	...	—0 83	...	16
,, 10	16 19 45	—0 16·13	— 1 17·4	13	19 14 13·22	—28 43 4·5	8·7139	9·4007	—0·83	— 5·6	17
,, 10	16 35 53	+0 0 01	... ...	1	19 14 16·45	... ...	8·6907	...	—0·83	...	16
,, 10	16 42 33	... ...	0 0·0	1	... ...	—28 42 14·9	...	9·3434	...	— 5·6	16
,, 10	16 56 31	... ...	0 0·0	1	... ...	—28 41 47·1	...	9·3066	...	— 5·6	17
,, 21	16 18 31	—1 34·12	+ 3 45·8	17	20 4 27·89	—18 24 11·6	8·6901	9·5776	—0·70	— 8·5	18
,, 21	16 18 31	—3 47·30	+ 1 7·1	17	20 4 27·62	—18 24 17·0	8·6901	9·5776	—0·71	— 8·5	19
,, 22	16 44 40	—0 12·58	—11 16 3	1	20 8 50·97	—17 22 5·3	8·6514	9·5640	—0·69	— 8·8	20
,, 26	16 24 47	+1 22·24	+ 9 40·4	13	20 25 38·03	—13 13 44·4	8·6729	9·6314	—0 65	— 9·7	21
,, 26	16 24 47	—3 52·79	+ 6 17·1	13	20 25 38·07	—13 13 38·6	8·6729	9·6314	—0·67	— 9·7	22
April 9	16 40 51	+0 29·31	... ...	15	21 19 50·46	... ...	8·6373	...	—0·58	...	23
,, 9	16 40 51	—0 10·49	— 7 33·8	15	21 19 50·60	+ 1 26 56·4	8·6373	9·7509	—0·59	—12·2	24
,, 9	17 25 6	... ...	+ 0 0·2	1	... ...	+ 1 28 49·2	...	9·7533	...	—12·2	23
,, 9	17 27 1	+0 36·27	+ 0 3·4	13	21 19 57·42	+ 1 28 52·4	8·5507	9·7534	—0·58	—12·2	23
,, 9	17 27 1	—0 3·56	... ...	13	21 19 57·53	... ...	8·5507	...	—0·59	...	24
,, 9	17 49 54	+0 0·06	... ...	1	21 20 1·15	... ...	8·4928	...	—0·59	...	24
,, 10	17 7 33	+6 23·89	+ 1 12·8	10	21 23 31·46	+ 2 28 31·8	8·5912	9·7601	—0·55	—12·5	25
,, 10	17 7 33	+5 36·23	... ...	10	21 23 31·46	... ...	8·5912	...	—0·56	...	26
,, 11	17 2 21	+1 14·44	+ 7 46·4	20	21 27 5·18	+ 3 28 20·9	8·6007	9·7669	—0·57	—12·4	27
,, 11	17 2 21	+0 24·46	... ...	20	21 27 5·66	... ...	8·6007	...	—0·58	...	28
,, 12	17 23 34	+3 35·53	+ 4 42·8	11	21 30 41·99	+ 4 28 22·1	8·5573	9·7769	—0·56	—12·6	29
,, 12	17 23 34	+2 4·04	+ 1 41·6	11	... ...	... ...	8·5573	9·7769	—0·57	—12·6	30
,, 13	16 41 57	+1 0·93	+ 8 24·1	8	21 34 7·57	+ 5 25 15·6	8·6351	9·7766	—0·57	—12·6	31
,, 13	17 28 30	+1 7·82	+10 14·8	8	21 34 14·46	+ 5 27 6·3	8 5457	9·7850	—0·57	—12·6	31
,, 13	17 28 30	—2 36·15	... ...	8	21 34 14·52	... ...	8·5457	...	—0·59	...	32
,, 14	17 10 8	+3 31·66	... ...	13	... ...	... ...	8·5853	...	—0·56	...	33
,, 14	17 10 8	+3 15·81	+ 4 34·6	13	21 37 41·92	+ 6 24 12·2	8·5853	9·7885	—0·56	—12·8	34
,, 14	17 22 13	+5 23·30	... ...	10	21 37 43·39	... ...	8·5599	...	—0·55	...	35
,, 15	17 4 59	+0 44·31	— 7 55·5	27	21 41 9·94	+ 7 21 17·8	8·5953	9·7936	—0·57	—12·9	36
,, 16	17 8 15	—3 59·50	+ 5 59·7	6	21 44 36·24	+ 8 17 54·3	8·5890	9·8005	—0·59	—12·7	37
,, 16	17 8 15	—4 38·18	... ...	6	... ...	... ...	8·5890	...	—0·60	...	38
,, 16	17 43 42	—3 54·46	... ...	2	21 44 41·28	... ...	8·5065	...	—0·59	...	37
,, 16	17 43 42	—4 33·27	+ 2 34·8	2	... ...	... ...	8·5065	9·8087	—0·60	—12·7	38
,, 22	17 45 8	+0 11·15	— 4 30·0	11	... ...	... ...	8·5001	9·8445	—0·56	—13·2	39
,, 23	17 40 55	+0 27·55	... ...	5	... ...	... ...	8·5120	...	—0·56	...	40
,, 23	17 40 55	—4 0·96	+ 1 49·1	5	... ...	... ...	8·5120	9·8483	—0·58	—13·1	41
,, 30	17 18 55	+0 3·88	— 4 48·6	10	... ...	... ...	8·5670	9·8695	—0·54	—13·3	42
May 1	16 55 27	—0 17·63	+ 6 49·9	10	22 32 58·86	+20 46 34.1	8·6176	9·8613	—0·54	—13·2	43
,, 2	17 21 11	—0 47·87	— 1 30·0	18	22 36 2·31	+21 30 38·4	8·5612	9·8777	—0·54	—13·2	44

COMET (WINNECKE) 1892.

Date.	Windsor Mean Time.	Comet—Star. Δα	Comet—Star. Δδ	Comparisons.	Comet's Apparent. α	Comet's Apparent. δ	Parallax Corrections in α	Parallax Corrections in δ	Reductions of Star Places. α	Reductions of Star Places. δ	Comp. Star.
1892.	h. m. s.	m. s.	′ ″		h. m. s.	° ′ ″	s.	″	s.	″	
July 17	17 48 57	+0 55·54	+ 2 32·3	10	5 15 18 04	— 4 56 36·9	—2·83	—31·2	—0·11	+12·1	45
,, 19	17 19 27	+1 58·15	— 1 55·0	10	... ...	... ...	—2·72	—27·6	—0·02	+13·6	46
,, 20	17 41 36	—0 37·89	— 2 23·5	10	... ...	... ...	—2·36	—24·9	+0·01	+14·3	47
,, 20	17 48 33	+2 42·36	— 0 46·7	8	... ...	... ...	—2·30	—24·7	+0·02	+14·4	48
,, 21	17 30 57	—3 17·05	— 5 7·8	14	... ...	... ...	—2·29	—23·2	+0·04	+14·9	49
,, 22	17 15 33	+2 53·70	+ 0 36·2	12	4 39 34·06	—12 40 11·1	—2·27	—21·9	+0·12	+15·9	50
,, 23	17 48 41	+7 11·65	— 1 51·9	5	4 33 38·50	—13 54 5·5	—1·82	—19·1	+0·19	+16·7	51
,, 24	17 26 26	—3 38·77	+ 8 53·0	8	4 28 18·80	—14 59 35·5	—1·89	—18·1	+0·17	+17·0	52
,, 27	17 35 16	+0 6·79	+ 7 31·2	11	4 14 2·36	—17 50 23·0	—1·43	—13·8	+0·34	+18·9	53
,, 28	16 31 47	—1 2·85	— 0 44·9	10	... ...	... ...	—1·86	—14·7	+0·38	+19·3	54
,, 28	16 31 47	—4 55·63	+ 9 28·5	10	... ...	... ...	—1·86	—14·7	+0·35	+19 3	55
,, 29	16 15 24	+2 1·60	+ 2 38·6	10	4 6 10·03	—19 22 4·6	—1·87	—14·2	+0·44	+19·9	56
,, 29	16 15 24	+0 58·57	— 5 17·9	10	4 6 10·19	—19 22 6·5	—1·87	—14·2	+0·44	+19·9	57
,, 29	16 57 17	+0 57·45	+10 31·4	7	4 6 3·38	—19 23 21·3	—1·55	—12·7	+0·44	+20·0	58
Aug. 2	16 9 18	+1 43·33	— 2 35·1	9	3 52 22·87	—21 55 32·6	—1·54	—10·6	+0·64	+21·7	59
,, 2	16 9 18	+1 26·47	— 1 7·6	9	3 52 23·05	—21 55 31·1	—1·54	—10·6	+0·64	+21·7	60
,, 3	15 54 24	+1 12·59	+ 7 49·1	10	3 49 21·73	—22 27 48·8	—1·56	—10·4	+0·68	+22·1	61
,, 15	13 50 8	—2 27·04	+ 8 24·0	12	3 19 31·69	—27 12 59·9	—1·47	— 7·9	+1·24	+25·5	62
,, 23	13 57 48	+7 9·54	— 0 13·6	8	3 1 41·85	—29 19 57·8	—1·06	— 4·4	+1·72	+26·7	63
,, 23	13 57 48	—5 48·80	+ 4 18·9	8	3 1 41·78	—29 20 2·4	—1·06	— 4 4	+1·61	+26·8	64
,, 25	13 34 22	—2 1·44	— 6 23·0	10	2 57 12·09	—29 45 42·3	—1·08	— 4·5	+1·74	+26·9	65
,, 26	13 44 17	—1 18·35	+ 9 51·3	10	2 54 53·74	—29 57 52·2	—0·99	— 3·9	+1·80	+27·0	66
,, 27	13 56 2	+3 54·57	+ 6 30·5	10	2 52 35·15	—30 9 32·7	—0·89	— 3·3	+1·89	+27·0	67
,, 27	13 56 2	+2 31·18	+ 6 54·1	10	2 52 35·26	—30 9 32·5	—0·89	— 3·3	+1·88	+27·0	68
Sep. 16	10 0 45	+0 43·27	— 9 52·2	10	... ...	... ...	—1·00	— 4·7	+2·76	+25·4	69
,, 16	10 0 45	—2 19·91	— 0 59·7	10	... ...	... ...	—1·00	— 4·7	+2·74	+25·5	70
,, 17	10 36 5	—1 45·31	— 8 43·6	10	... ...	... ...	—0·88	— 3·5	+2·78	+25·3	69
,, 17	10 36 5	—4 48·47	+ 0 8·3	10	... ...	... ...	—0·88	— 3·5	+2·76	+25·4	70
,, 18	11 10 3	+2 7·38	+ 1 44·2	5	... ...	... ...	—0·75	— 2·5	+2·84	+24·9	71
,, 18	11 10 3	—4 13·13	— 6 54·6	5	... ...	... ...	—0·75	— 2·5	+2·80	+25·2	69
,, 18	11 10 3	—7 16·36	+ 1 58·7	5	... ...	... ...	—0·75	— 2·5	+2·78	+25·3	70
,, 20	11 49 45	+2 34·29	—10 12·9	10	1 54 55·45	—31 46 26·2	—0·54	— 1·5	+2·91	+24·5	72
,, 22	10 33 58	—1 58·05	— 2 28·5	15	1 50 23·15	—31 38 42·1	—0·74	— 2·6	+2·95	+24·2	72
,, 26	11 3 48	+2 15·77	+ 0 0·2	10	1 41 20·79	—31 15 46·1	—0·52	— 1·6	+3·07	+23·0	73
,, 27	11 34 5	+0 2·09	+ 7 31·4	4	1 39 7·13	—31 8 15·0	—0·38	— 1·1	+3·09	+22·9	73

MEAN PLACES OF THE COMPARISON STARS FOR THE BEGINNING OF THE YEAR OF OBSERVATION.

Star.	α	δ	Authorities.
	h. m. s.	° ′ ″	
1	4 29 39·85	+ 9 56 11·1	Greenw. 7 Yr. Cat. 1864, 574; Brussels Cat.. 1865, 1763.
2	4 40 47·93	+ 8 49 11·2	Lalande, 8972 ; Glasgow Cat. 1870, 1158.
3	4 44 40·21	+ 8 42 44·4	Brussels Cat. 1865, 1861 ; Glasgow, Cat. 1870, 1176 ; Greenw. 10 Yr. Cat. 1880, 783.
4	4 34 14·81	— 1 16 0·7	Lalande, 8801 ; Brussels Cat. 1865, 1796 ; Glasgow Cat. 1870, 1126.
5	4 48 41·74	— 1 54 13·2	Lalande, 9224.
6	4 49 5·12	— 1 58 19·4	Lalande, 9232.
7	4 32 14·17	— 2 51 55·3	Lalande, 8741 ; Glasgow Cat. 1870, 1118.
8	4 39 51·4	— 2 52 29	Star 10 mag. Equatorial.
9	4 38 39·05	— 3 22 13·4	Lalande, 8923 ; Brussels Cat. 1865, 1825.
10	4 40 3·09	— 3 27 17·5	Nautical Almanac, 1891.
11	4 40 49·4	— 3 54 0	Star 9½ mag. Equatorial.
12	4 46 4·93	— 3 50 41·2	Lalande, 9142.
13	4 43 53	— 5 10 12	Star 8½ mag. Equatorial.
14	4 13 13·74	—14 54 18·3	Lalaude, 8102 ; Arg-Oeltzen, 2963.

Mean places of the Comparison Stars for the beginning of the Year of Observation—*continued.*

Star.	α	δ	Authorities.
	h. m. s.	° ′ ″	
15	4 14 52·58	—14 51 16·2	Lalande, 8151; Arg-Oeltzen, 2984.
16	19 14 17·27	—28 42 9·3	Wash. Mural Cir. Zone, 182, 57.
17	19 14 30·18	—28 41 41·5	Wash. Mural Cir. Zone, 182, 58; Arg-Oeltzen, 19405.
18	20 6 2·71	—18 27 48·9	Arg-Oeltzen, 20305; Wash. Merid. Tr. Zone 185, 77.
19	20 8 15·63	—18 25 15·6	Arg-Oeltzen, 20333; Wash. Mural Cir. Zone 204, 28.
20	20 9 4·24	—17 10 40·2	Arg-Oeltzen, 20343-4; Yarnall$_3$ 8971.
21	20 24 16·44	—13 23 15·1	Lalande, 39420; Yarnall$_3$ 9119.
22	20 29 31·53	—13 19 46·0	Lalande, 39646; Schjellerup 8141.
23	21 19 21·73	+ 1 29 1·2	Lamont$_1$ 8282; Brussels Cat. 1865, 9450.
24	21 20 1·68	+ 1 34 42·4	Lamont$_1$ 8293; Schjellerup 8670; Brussels Cat. 1865, 9458.
25	21 17 8·12	+ 2 27 31·5	Lamont$_1$ 8253; Brussels Cat. 1865, 9416; Glasgow Cat. 1870, 5442.
26	21 17 55·79	+ 2 18 18·0	Lamont$_1$ 8264; Glasgow Cat. 1870, 5446.
27	21 25 51·31	+ 3 20 46·9	Lalande, 41859.
28	21 26 41·78	+ 3 14 31·4	Lalande, 41891; Schjellerup 8718-9; Glasgow Cat. 1870, 5495.
29	21 27 7·02	+ 4 23 51·9	Lalande, 41907.
30	21 28 38·5	+ 4 26 53	Star 8¼ mag. Equatorial.
31	21 33 7·21	+ 5 17 4·1	Yarnall$_3$ 9712; Brussels Cat. 1865, 9599; Glasgow Cat. 1870, 5533; Armagh.$_2$ 2873; Stone, 11437; Greenwich 10 Yr. Cat. 1880, 3611.
32	21 36 51·26	+ 5 11 18·0	Greenw. 7 Yr. Cat. 1864, 2467; Brussels Cat. 1865, 9640; Glasgow Cat. 1870, 5557.
33	21 34 10·8	+ 6 21 0	Star 8¾ mag. Equatorial.
34	21 34 26·67	+ 6 19 50·4	Lalande, 42207.
35	21 32 20·64	+ 6 8 0·0	Greenw. 7 Yr. Cat. 1864, 2453; Brussels Cat. 1865, 9588; Glasgow Cat. 1870, 5527.
36	21 40 26·20	+ 7 29 26·2	Schjellerup 8836; Glasgow Cat. 1870, 5569. R.As. discordant.
37	21 48 36·33	+ 8 12 7·3	Glasgow Cat. 1870, 5619.
38	21 49 15·1	+ 8 17 37	Star 9 mag. Equatorial.
39	22 4 29·6	+13 45 36	Star 8½ mag. Equatorial.
40	22 7 37·2	+14 28 18	Star 8 mag. Equatorial.
41	22 12 5·7	+14 30 48	Star 7½ mag. Equatorial.
42	22 29 54·3	+20 7 54	Star 9 mag. Equatorial.
43	22 33 17·03	+20 39 57·4	Lalande, 44275.
44	22 36 50·72	+21 32 21·6	Lalande, 44415.
45	5 14 22·61	— 4 59 21·3	Lalande, 9981-2.
46	4 57 34·0	— 8 22 18	Star 8 mag. Equatorial.
47	4 52 59·0	— 9 55 0	Star 9 mag. Equatorial.
48	4 49 36·8	— 9 57 0	Star 9 mag. Equatorial.
49	4 49 0·4	—11 17 54	Star 9 mag. Equatorial.
50	4 36 40·24	—12 41 3·2	Lalande, 8880; Schjellerup 1508-9; Armagh$_2$ 580.
51	4 26 26·66	—13 52 30·3	Lalande, 8575; Schjellerup 1449.
52	4 31 57·40	—15 8 45·5	Lalande, 8745-6; Arg-Oeltzen 3220-1.
53	4 13 55·23	—17 58 13·1	Lalande, 8119.
54	4 11 8·1	—18 36 0	Star 9½ mag. Equatorial.
55	4 15 1·0	—18 47 0	Star 8½ mag. Equatorial.
56	4 4 7·99	—19 25 3·1	Arg-Oeltzen 2842; Cincinnati Zones, 579.
57	4 5 11·18	—19 17 8·5	Lalande, 7815; Armagh$_2$ 516; Cincinnati Zones, 584.
58	4 5 5·49	—19 34 12·7	Arg-Oeltzen 2861; Cincinnati Zones, 583.
59	3 50 38·90	—21 53 19·2	Lalande, 7298; Cincinnati Zones, 542.
60	3 50 55·94	—21 54 45·2	Lalande, 7311; Cincinnati Zones, 543.
61	3 48 8·46	—22 36 0·0	Lalande, 7217; Arg-Oeltzen 2613.
62	2 21 57·49	—27 21 49·4	Arg-Oeltzen 2279; Cordoba Zone 46, 103.
63	2 54 30·59	—29 20 10·9	Arg-Oeltzen 1951; Brussels Cat. 1865, 1165; Cordoba Zone 73, 116; Stone 1233.
64	2 7 28·97	—29 24 48·1	Yarnall$_3$ 1395; Brussels Cat. 1865, 1228; Cordoba Zone 73, 136; Greenw. Cat. 1880, 484; Stone 1317.
65	2 59 11·79	—29 39 46·2	Arg-Oeltzen 2006; Cordoba Zone 73, 123.
66	2 56 10·29	—30 8 10·5	Arg-Oeltzen 1970; Cordoba Zone 73, 120.
67	2 48 38·69	—30 16 30·2	Arg-Oeltzen 1881; Cordoba Zone 73, 109.
68	2 50 2·20	—30 16 53·6	Arg-Oeltzen 1899-1900; Cordoba Zone 73, 110.
69	2 4 0·0	—31 45 0	Star 9 mag. Equatorial.
70	2 7 4·0	—31 54 0	Star 8½ mag. Equatorial.
71	1 57 40·0	—31 55 0	Star 9 mag. Equatorial.
72	1 52 18·25	—31 36 37·8	Cordoba Zone 107, 43; Stone, 770.
73	1 39 1·95	—31 16 9·3	Cordoba Zone 107, 20.

ON THE LANGUAGES OF OCEANIA.

(1.) *The Malayo-Polynesian Theory.*

By JOHN FRASER, B.A., LL.D.

[*Read before the Royal Society, N.S. Wales, December 7, 1892.*]

THE employment of labour brought from the islands of the South Seas is now a political question in these colonies, and especially in Queensland, but to an ethnologist a more important question is the origin of the races to which these labouring 'kanakas' belong, for as yet their origin is undetermined. We have been accustomed to apply the name 'kanaka' to all those black labourers in the Queensland sugar plantations who have been brought from the New Hebrides and other adjacent islands of Melanesia, but the name properly belongs only to the brown inhabitants of Eastern Polynesia—all to the east and north-east of Fiji; for in their dialects everywhere *kanaka* means 'men' or 'a man.' The *k* of that word is for an original *t*, as is often the case in these dialects, and so the Samoan form, *tangata*, is nearer the root, which is *ta*, meaning 'a man.' From this original root derived words are found in all the islands, east and west, with the meaning of 'male,' 'man,' 'father,' 'son,' and the like.

If a traveller leaves Singapore and journeys on towards the east, right across the wide Pacific, always keeping near the Equator, he passes in succession many groups of islands. Those of the East Indian Archipelago, as far as New Guinea, are occupied mostly by Malays; New Guinea and the islands east of it, including Fiji, the New Hebrides, and New Caledonia, have a *blackish* negroid population, and thus the whole are called Melánesia; beyond them are the Tongan and other groups, including Hawaii in the far north-east and the Maories in New Zealand; the people in all of these are commonly called the brown Polynesians or the

Malay-Polynesians. Now, as some competent ethnologists maintain that these last are in no sense Malays, and that to call them Malay-Polynesians is a mistake, it will be convenient to call them Polynesians only, and to restrict the name accordingly to the brown race inhabiting Tonga, Samoa, and those other groups. To me, therefore, there are just three distinct races in the Oceanic islands; these I shall call the Malays, the Melanesians, and the Polynesians. Lying to the north of the Melanesians are many small islands; a suitable geographical name for them is Micronesia; the people there are allied to the brown Polynesians. Then again, to the south of Malaysia and New Guinea, is our own island-continent Australia, the black natives of which deserve a separate place in my list, although their only kindred in Oceania are the blacks of Melanesia.

Now, the question which I wish to touch upon here is this—What is the origin of the Polynesian race? are they Malay-Polynesians? Nearly all those who have considered this question agree in saying that the Polynesians, that is, the brown natives of the islands of Eastern Polynesia, must have come from Asia, although a few writers of less note have advanced the theory that they came from the west coast of America. The traditions of the Polynesians themselves all point to some region to the west and north-west of them as their ultimate home of *origin;* and some legends even call this Atia, which may possibly mean Asia, while the tradition of the Marquesans is that their original ancestor came from a far off Take-he'e-he'e, which may mean merely the 'starting point.' Nevertheless, all Polynesians are agreed that their first land of *settlement*, and consequently the land from which they have all radiated—in short, the cradle of their race—was an island called Havaiki. Here again, there is no certainty as to the location of Havaiki, although Savai'i and Manu'a, islands of the Samoan group, seem to have the best claim to that honour. At all events, the bards of Manu'a strenuously assert that their islands take precedence of all others, and are the favourite resting place of Tangaloa, the great god of the Polynesians.

It is thus evident that the origin of the race cannot be determined from the evidence of Polynesian traditions. Hence the inquirer must fall back on the language of the people, their physical features, and their religion, for evidence in this quest; and their language is mainly our concern at present; for, just as sometimes we know a man by the company he keeps, so the language of a race may, at least, tell us either what was the speech of their ancestors, or with whom the people have since associated. In 1836-40, K. Wilhelm von Humboldt, in his book on the 'Kawi'—the ancient language of Java—showed the relationship of the dialects of Eastern Polynesia with the Malay of the Indian Archipelago and the Malagasy of Madagascar. Hence the name Malayo-Polynesian has been applied to these languages. But this is an unfortunately chosen name and should not be used; for it assumes that the Malays and the Polynesians are the same race, although it is evident that the Malay and the brown Polynesian are, in physique, temperament, and customs, very different styles of men; and it is known that the Malay is only a recent invader of that Archipelago, and is largely Mongoloid, while the Polynesian is not. In 1841, Professor Franz Bopp of Berlin, published his views as to the relationship of the Malay language to the Polynesian. He held that they are both allied to the Aryan family, and, recognizing Sanskrit root-words in both, he said that the Malays brought these words from India, and that the Polynesians had got these and other words from the same source, but through the Malays. Again, the distinguished philologist, Hans Ch. von der Gabelentz, in his two volumes on "Die Melanesischen Sprachen" (1860-73), declared that he found traces of a common origin in the Melanesian and Polynesian languages; but Dr. A. B. Meyer (Leipsic, 1882) thinks differently, and still another opinion is advanced by Dr. A. Lesson in his "Les Polynesiens" (Paris, 1880-82).

In our own language, the most important book on the "Polynesian Race" is one in three volumes by the late Judge Abraham Fornander of Maui, Sandwich Islands (London, 1878-85). He stoutly maintains that the Polynesian dialects come from a pre-Vedic form of the original Aryan speech, and that the Malay words in it are a recent and adventitious element. He devotes the whole of his third volume to a philological examination of the root-words in Polynesian, with the view of showing that they have near kindred among both the eastern and the western members of the Aryan family.

Although that is the most recent of English books on the subject, yet the same problem has occupied the attention of English minds for over a hundred years. From the time that Captain Cook returned from his discoveries in the South Seas, and roused curiosity by bringing with him to England the islander Omai, "that gentle savage," a strong desire existed there to know more of the Islands and their history, past and present; but the war of American Independence and the wars of Revolutionary France prevented. During that period of unrest, Johann Reinhold Forster had published in French his "Observations Made in a Voyage Round the World" (London, 1778). Forster was a German who had settled in England and visited the South Seas as naturalist to Cook's Second Expedition. In his "Observations" he speaks of the Polynesian languages, and says that the existence in them of words the same as those in the Malay region does not imply that the Eastern Polynesians have come from the Malays, but that the two tongues and peoples proceed from some more ancient race, which held possession of the East Indian Islands. It was this theory which K. W. von Humboldt reproduced in an altered form, and which, under the sanction of his name, has gained currency as the Malayo-Polynesian.

The next English authority on this subject is John Crawfurd, the writer of the "History of the Indian Archipelago." In early life, he had been British resident at the Court of Java, and had made himself well acquainted with the language and character of the Malays. In a dissertation attached to his "Grammar and Dictionary of the Malay Language" (London, 1852), he entirely rejects the Malayo-Polynesian descent from a common mother tongue and race, and holds that Oceania has many distinct and independent languages, their connection with the Malay being superficial and recent.

Then come the views of Wallace (H. R.) and Keane (A. H.). Wallace, in his "Malay Archipelago" (London, 1877, 6th edition), takes up a new and very different position. His words are worth quoting :—"The Malayan race, as a whole, undoubtedly very closely resembles the East Asian population from Siam to Mandchouria. . . . The descriptions of the brown Polynesian race beyond the Fijis often agree exactly with the characters of the brown indigenes of Gilolo and Ceram. It is to be especially remarked that the brown and the black Polynesian races closely resemble each other. Their features are almost identical, so that portraits of a New Zealander or Tahitian will often serve accurately to represent a Papuan or Timorese, the darker colour and more frizzly hair of the latter being the only differences. They are both tall races; they agree in their love of art and the style of their decorations; they are energetic, demonstrative, joyous, laughter-loving; and in all these particulars, they differ widely from the Malay. I believe, therefore, that the brown and the black, the Papuan and the Fijian, the inhabitants of the Sandwich Islands and those of New Zealand, are all varying forms of one great Oceanic or Polynesian race."

In Stanford's "Compendium of Geography and Travel," the volume on Australasia (London, 1879) is edited by Mr. Keane in conjunction with Mr. Wallace. Keane is inclined to agree with Forster's opinion, but thinks that a Caucasian element had a large share in forming both the Malayan and the Polynesian races. In Malaysia, the mixture is Mongolian and Caucasian, the latter being the substratum; but the Polynesians are mainly Caucasian.

The present state of the question, then, is this :—There are four main theories as to the origin of the Polynesian race: (1.) The Malays and the Polynesians are two fragments of a disrupted race that once held the Indonesian area; (2.) the Malay and the Polynesian races both come from a similar but independent mixture of Caucasian and Mongolian blood; (3.) the brown Polynesians are Aryan, that is, Caucasian, in their origin and language, and, passing through India from the Aryan home in Central Asia, they occupied Indonesia long before the Mongoloid Malays came there; (4.) the black men of Melanesia and the brown men of Polynesia are only variant forms and aspects of the same Oceanic race. All these solutions agree in believing that the first ancestors of the Polynesians came from Asia. In addition to these, there are a few other theories, but they have no ethnological weight, either in themselves or from those who hold them; for instance, it is said (1.) that the Polynesians came from America; (2.) that the Polynesian area is one of many centres of the creation of races, and that thus these people have an independent origin; (3.) to account for the presence of a Polynesian language in Madagascar, it is said that there was once a land connection between that island and Indonesia through the Seychelles and other groups of islands in the Indian Ocean; just as some naturalists say that Western Australia and the Cape of Good Hope must have been once connected in a similar way, because the heaths of their indigenous flora are so much alike.

This, then, being the state of the question, I proceed now to examine the Malayo-Polynesian theory. And at the outset, I would have you observe that this theory is founded entirely on an observed similarity of words in the two languages. The physical features of the races and their religion—both of which are known to be valuable tests of ethnic relationship—are not taken into account at all; and in these two respects the races are quite unlike. The discussion of the question, therefore, is one for the linguist rather than the ethnologist. And as the Samoan is the only Polynesian dialect that I know sufficiently, I will compare chiefly the Samoan with the Malay.

In Mr. Pratt's Samoan Dictionary (3rd edition) there are between seven and eight thousand words; probably about a thousand of them may be regarded as primary and uncompounded, and of these again about one hundred simple words are identical with corresponding Malay words or closely resemble them. I give a few examples of this similarity :—

Samoan.	*Malay.*	*Samoan.*	*Malay.*
ala, 'path, road'	dara	fua, 'fruit'	buah
asu, 'smoke'	asap	fulu, 'hair'	bulu
ate, 'liver'	ati	malu, 'soft'	maru
ulu, 'head'	ulu	mata, 'eye, face'	mata
utu, 'louse'	kutu	mua, 'first'	mula
fanua, 'land'	benūa	palu, 'to mix'	palu
fatu, 'hard; stone'	batu	tau, 'year'	taun
fili, 'to choose'	pilih	vai, 'water'	wai

The simple forms also of the personal pronouns are similar, and the numerals beyond 'three.'

On such resemblances as these the theory of the identity of the two languages rests; and, for the most part, the rest of the hundred Malayan words, which are quoted in support of the theory, are certainly cognate to their Samoan equivalents. But the argument is weakened by the fact that several of these words are not Polynesian merely but Oceanic, that is, they belong to all the Melanesian dialects as well. Thus, *fatu*, *mata*, *vai*, are common words everywhere among the blacks of the New Hebrides; *kutu* is found as *kutta* in South Australia; *malu* is *mul-mul* in the New Hebrides, and it comes evidently from the same root as the Greek *malakos*, 'soft' and the Latin *mollis; mua*, 'first,' is more nearly allied to the Albannic* word *muka*, 'first' than to the Malay *mula*. Therefore, if similarity of words is to be our only guide, I could say that the Samoans are near of kin to the Ebudan* blacks, and even to our natives in South Australia.

Whatever theory may be used to account for the fact, it is certain that, so far as these hundred words are concerned, the similarity between Malayan and Samoan is remarkable; but, instead of the Polynesians having got them from the Malays, it is

* I use this word, Albannic, to designate the islands immediately to the east and south-east of New Guinea, and Ebudan for the New Hebrides.

quite possible that the Malays, who are recent settlers in Indonesia, found the ancestors of the Polynesian race in possession of that Archipelago, and adopted these words from them. This would explain how it happens that, while they have these few words in common, the two races are in other respects so very unlike. My examination of the Samoan dialect has led me to be strongly of opinion that the basis of it is Indian, and, as to many of its simple root words, Aryan; and so I do not see how a Mongoloid people and speech—the Malay—can have produced the Polynesians who are essentially Caucasian. But, if a Mongol race long ago came down upon the lands of the Eastern Peninsula and ultimately got hold of the adjacent islands, driving from them an earlier Caucasian race, I then understand how the Caucasians were compelled to flee eastwards into Polynesian, and how a small portion of their speech has remained among the people that supplanted them. In support of this view of the question, I purpose to show here that many of these so-called loan-words are not Mongolian but Aryan in their origin, and that therefore they probably belonged to the Polynesian speech before they became Malayan.

This view has, in a general way, been long floating in my mind, but it has been strengthened recently by contact with a Dictionary of the Pâli language. The Pâli is the sacred language of the Buddhists; for it is the language of their sacred writings. The Pâli is one of the Prâkrit or common Aryan vernacular tongues of India, and is, of course, a sister tongue to the polished Sanskrit of the Vedas. It was a language spoken, in the sixth century B.C., and in the very region of India where the prophet Çakya Mouni himself taught his disciples the new faith. It has now been a dead language for over two thousand years, and this is an advantage to us in our present inquiry; for, like Hebrew, these Pâli words have been stereotyped in their original form by the sacred writings, and can be referred to as unadulterated evidence.

And, first, I take up some of the pronouns; for the pronouns and the numerals are considered sure tests of kinship. And for convenience I will use (1) to mean Samoan, (2) Malay, and (3)

Pâli. And so, taking the Pâli as our Aryan touchstone, let us examine the similarity between the vocables of the Malay and the Samoan languages. Let us also bear in mind that the Pâli and the other Prâkrits of India are much older than the Malayan and Samoan—old enough to be the parents of both languages.

1st Pronoun.—(1) *sing.*—a'u, ta, 'ita; *dual* and *plu.*—tā-, mā-. (2) *sing.*—aku, ku; *plu.*, kita, kami; (3) *sing.*—aham, me; *acc.*, mam; *instr.*, maya.

In these Samoan forms the break, ', represents the elision of a *k*, and this brings the Samoan so close to the Malay words that there naturally arises a suspicion of borrowing; but that is weakened by the fact that *k* (for *ku*, *gu*)* is a common suffix form for 'I' among the negroid tribes of the New Hebrides, where Malays have never been. In the same region, singular and plural forms of this first pronoun (detached) are *n-agku*, and *hida*, *kito*, and these also cannot be Malayan, although they seem like it.

But when we look at the Pâli pronoun, the similarity between the Samoan and the Malay can be accounted for. The Pâli and Sanskrit *aham*, 'I' is for *akam;* the classical *ego* and the German *ich* prove this; and, as in many other words, the termination *-am* in *akam* becomes *u* in Malay and Polynesian; thus, *akam* gives *aku.* The oblique cases of the Pâli *aham* show where the *ma*, *mi* of the other languages have come from. The *ta* of the Samoan and the Malay belongs also to the Papuan peoples of Fiji, New Guinea, and the New Hebrides, who certainly did not borrow it from the Malays. It also appears in the old Persian *ad-am*, 'I,' where the *ad-* I take to be for *ak*, and by transposition *ta.*

2nd Pronoun.—(1) *sing.*—'oe, 'thou'; *dual* and *plu.*—'ou-; (2) *sing.*—ang-kau, kau, di-kau, ka-mu, mu; (3) tvam, tuvam; *acc.*, tam, *instr.*, taya, *gen.* and *dat.*, tava. Here again the '*oe* and '*ou* of the Samoan resemble the *kau* of the Malay, but their common

* The Aneityumese suffix pronominal forms are *k*, *m*, *n*, for the first, second, and third persons; the Malay uses the same, for it has diri-ku, 'I myself,' diri-mu, 'thyself,' diri-nia, 'himself.'

source is the Pâli *tam*, *tav-*, that is, *tau*. The *mu* of the Malay is Papuan as well; for the Aneityumese (New Hebrides) say *etma-m*, 'thy father,' using *-m* (for *mu*) as a suffix.

3rd Pronoun (demonstrative)—(1) na, nei, ia, le-nei; *Maori*, te, 'the,' *Samoan*, le, 'the'; (2) diya, iya, inya, itu, iang; *plu.*—ini; (3) ena, na, idam, etam, ete; *oblique cases*, tam, tena.

Of these Pâli forms, *tena* is used both in Maori and Albannic as a demonstrative, and *na*, *ni* are quite common in all the Melanesian region. The Maori also has *ena*, *ana*, *tenei*, Samoan, *lenei*, *lena*. In fact the Polynesian and Melanesian forms are in this instance much nearer to the Pâli* than to the Malay. Again, the *ena*, and *na* of the Pâli are for *etad*, *tad* of the Sanskrit (*n* for *t* or *d*), and the Dravidians of the Dekkan have *idi*, 'this,' *adi*, 'that.'

The Numerals.—These I will dismiss with a few words, as a special paper on them is to follow this. The Samoan for 'one,' 'two,' 'three' is *tasi*, *lua*, *tolu*. The Maori has *tengi* and *ma-tengi* for 'three.' The Malay numerals are *suatu*, *satu*, *sa* for 'one,' *dūa*, 'two,' *tiga*, 'three.' The Pâli are *ekacco*, *eko*, 'one,' 'alone,' *sakim*, 'once'; *duve*, 'two'; in compounds, *dvi*, *di*, *du*, *ba;* 'three' is *ti*, *tayo;* in compounds, *te*. The Polynesian *tasi* is for *eka-si* and is thus nearer to the Pâli than to the Malay; the Indonesian 'one' is *sa* or some form of it. The Polynesian *lua*, 'two,' is, of course, *dua*, the Aryan *duo*. The Malay *tiga*, 'three,' is the Pâli *ti*, and the Polynesian *to-lu* is the Pâli *ta-yo* with a different suffix. The Maori *tengi* seems to be the Pâli *ti*, *te;* but how has that root got to New Zealand? But this question of the primary numerals and of the whole system of Polynesian numeration requires separate discussion.

Of the common words, which I have already given as samples of the correspondence between the Samoan and the Malay tongues,

---

* The demonstratives in Pâli are:—âyam, 'this,' *acc.* imam; *instr.*, anena; *gen.* and *dat.*, assa, imassa, *neut.*, idam; *plu.*, ime, *gen.* and *dat.*, esam, imesam. Eso, esa, so, sa, 'this,' 'that,' 'he,' *acc.*, etam, tam, *instr.*, tena, *plu.*, ete, *plu. fem.*, ta. Idha, iha, 'here,' iti, ti, evam, 'thus,' idāni, 'now.'

one of the most striking is the Samoan *fulu*, 'hair,' which in Malay is *bulu*. The Malay word means the 'hair' of the human body or of beasts; the Samoan means a 'hair,' a 'feather'; and, as *fulu* is a later form than *bulu*, we might say that the Samoan word comes from the Malay; but that would be a hasty conclusion, for the Pâli word is *vālo*, the 'hair' of the head or of animals, and that again is the Sanskrit *bāla*, 'hair,' which in Latin is *pilus* and *capillus*. The last of these words, so far as the etymology is concerned, should therefore be written *cap-pilus*. It is now clear that both *bulu* and *fulu* have an antecedent and common source, and that source is Aryan.

This word *fulu*, 'a hair,' is sometimes quoted as the root of the Samoan numeral for 'ten,' on the plea that a hair may have been used as a tally! The Samoan 'ten' is *se-fulu*, in composition *aga-fulu;* almost everywhere in Oceania, from Java to Easter Island, it is either *pulu* or *fulu* in varying states; as *sanga-fulu*, *anga-fulu*, *nga-fulu*, *sa-pulu*, *se-fulu*, *pulu*, *fulu*. From all this an argument is usually drawn that the Polynesians got their higher numeration from the Malays, who are a commercial people. But is it not possible that, if the Eastern Polynesians did occupy Indonesia long ago, the Malays, when they came in, adopted the system of numerals they found there in preference to their own Mongolian numerals. Here again I am of opinion that both the Malays and the Polynesians got the numeral 'ten' from a common source. For, what is the earliest mode of numbering? By the fingers. Hence 'five' is expressed by 'hand' and 'ten' by 'two hands,' or 'all,' *sc.*, the fingers. Thus the Aryan words *de-cem*, *de-ka*, *da-çam*, *da-sa*, *das* are to me equivalent to 'two-hands,' while our Oceanic word *pulu* I take to mean 'all.' Certainly the Hawaiian *umi*, 'ten,' is the Samoan word *uma*, 'all.' The Malay for 'whole, entire' is *bulah*, and that is sufficiently like *bulu*, 'ten'; Efate and Nguna in the New Hebrides—a Melanesian region—say *bura* for 'full, entire,' and Duke of York Island—a Melanesian region—says *bure*, 'plentiful,' New Britain—a Melanesian region—says *para*, 'all.' Therefore this root word is Oceanic, not exclusively Malayan. Again, the Pâli for 'full' is *puro, punno,* while the Malay for 'full' is *punnuh.* Are not all these words the same? Then as to the Pâli *puro,* 'full,' Curtius says that the Vedic *palus* is for *purus* from the root *pûl,* 'to collect,' and that the Sanskrit pi-*par*-mi, 'I fill,' the Zend *par,* 'fill up,' *perena,* 'full,' the Latin *plenus,* 'full,' *Eng.* 'full,' come all from the same original root.* It now seems to me more likely that the Pâli word *puro* is the source of both *bulu* and *fulu* than that the Polynesians took their word *se-fulu* from 'hair.' And in this view I am confirmed by the prefixes *sanga* and *nga* in the words for 'ten'; for *nga* is the plural article 'the,' in Maori; so *nga-fulu* will mean 'the whole,' *sc.,* fingers. Here it is curious to observe that the Samoans do not use *nga* as a prefix to 'two' but only to 'three' and higher numbers, as if from a consciousness that *nga* must go only with plurals. They say *e lua fua,* 'two bread-fruits,' but *e tolu ga-fua,* 'three bread-fruits'; *e lua lau,* 'two fishes,' *e tolu ga-lau,* 'three fishes.' Then, *sanga-fulu* is to my eye made up of *sa* ('one'), *nga,* and *fulu,* and means 'once-the-whole,' just as the Samoan for 20 is *e lua fulu,* 'twice-the-whole,' but for 30 *e tolu ga-fulu,* where the peculiarity in the use of the prefix *nga* comes in again. The Malay for 10 is *sa-puluh,* and for 20 *dua-puluh;* for 50, *lima puluh.* There the article has no place, and yet it has a distinct place in the 'tens' of Eastern Polynesia. Have the Polynesians, then, borrowed from the Malays? Is it not better to say that these languages have come from the same source, but under different circumstances?

Another simple and yet prominent word in Samoan is *ao;* it means (1) a cloud; (2) daylight; (3) a chief's head; (4) supreme *(ao-ao);* (5) a title of dignity; (6) to collect. A longer form of it in the sense of 'day' is *aso,* and a still longer form is *a'asa,*

* A little incident known to me shows that the native mind considers *ten* as a 'complete' number. Many years ago in Samoa, a midwife rushed out of a house where she had been ministering, and exclaimed to a missionary who was passing, "Now the family is complete (*'atoa*)." There were now *ten* children.

'hot,' for which Aneityum (Melanesian New Hebrides) has *akas*, 'hot,' 'to burn.' The Malay for 'hot,' 'to glow,' is *ängat*, but for 'day' is *āri*. Neither of these words can be the parent of the Samoan *aso*, *ao*, 'day,' but the Pâli *akāso*, 'the sky' is near both to *a'asa* and *āso*, and we know from the derivation of the Latin *dies* and *sub dio* that names for 'sky,' 'day,' are cognate to words for 'bright,' 'shine,' 'glow.'

In the sense of 'cloud,' the Samoan *ao* is near the Malay *awan*, 'a cloud,' but still nearer to the Pâli *abbho*, 'a cloud.' In the sense of 'a chief's head,' 'supreme,' I take *ao* from the Pâli *kam* 'head,' 'top,' which may become *kau*, *kao*, just as *ao*, 'to collect,' is from the Sanskrit root *gam*, 'to gather together,' which gives the Latin *cum*, and many other Aryan words. The Malay for 'collect' is *kum-pul* in which the same root appears.

Ao, 'head' is a word used only to chiefs; the common word for head in Samoan is *'ulu*, where the "break" represents an initial *k*. This word seems to me to be a corruption for *kapala*, which is both Malay and Sanskrit for 'head'; for *kapala*, that is *kamala* may become *kawala*, whence *kulu*, *'ulu*. In two dialects in New South Wales our natives say *kabara* and *ka* for 'head.'

It would occupy too much of your time, if I were to examine all the instances in which I have found Pâli words to be closely parallel to those in Samoan. But I wish to show you that many Malay words may be Indian in their origin, and thus may have come from the same original speech as the Polynesian. I therefore give a list of some correspondences between the (1) Malay and the (2) Pâli; and let it be observed that most of the words in this list represent ideas which are essential to the existence of any language; therefore the Malay forms indicate something more than mere 'borrowing' from the Pâli.

Above—1. atas; 2. adhi.
Act—1. karja; 2. karoti.
Again—1. ka-mbali, pula; 2. puna.
Base—1. hina; 2. hino, 'poor, wretched'; ni-hino, 'base.'

Be—1. ada, jadi ; 2. atthi.

Be, begin—1. asal, 'origin'; 2. atthi ; *cf.* (Samoan) isi, 'be, exist.'

Beat—1. pukul, palu ; 2. potheti, taleti ; *cf.* (Samoan) ta, 'strike'; patutu, palutu, 'beat,' pati, 'clap the hands.'

Being—1. zat ; 2. satto.

Between—1. antara ; 2. antara.

Blue—1. nila ; 2. nilo, kālo ; *cf.* Samoan, 'uli.

Birth—1. ka-jadi-an ; 2. jati.

Broad—1. bukok ; 2. puthu.

Burn—1. ābū (ashes); 2. tapati ; *cf.* (New Britain) kāpa, 'to give light, to shine'; (Duke of York Island) kabu, 'ashes'; (Samoan) afi, 'fire'; (Aneityum) in-cap, 'fire.'

Chief (principal)—1. agūng ; 2. agganno.

Cloud—1. mega ; 2. megho.

Club—1. gādā ; 2. gadā ; *cf.* (Samoan) laau, a 'stick.'

Conceal—1. sembuni ; 2. samvunāti.

Crooked—1. bungkok, bantok ; 2 vanko.

Death—1. se-mati; 2. maccu, maro; *cf.* (Sanskrit) mri, mar, 'to die'; (Polynesian) mate, 'dead.'

Desire—1. ingin; 2. piha ; *cf.* (Samoan) fia.

Die—1. māti ; 2. marati.

Diminutive—1. kētē ; 2. khiyah, 'to decrease'; khuddo, 'small'; *cf.* (Samoan) 'iti, 'little'; (Polynesian) 'utu, 'a louse.'

Drink—1. minum ; 2. panam, 'drink'; pibati, 'to drink,' piti, 'drinking'; *cf.* (Samoan) inu, 'to drink'; ipu, 'drinking cup'; (Sanskrit) pa, 'to drink'; (Australian) bitta, 'drink,' bado, 'water'; (Samoan) tau-fa, 'water.'

Eat—1. makan; 2. bhakketi ; *cf.* (Samoan) tau-mafa.

Fish—1. ika ; 2. maccko ; *cf.* (Samoan) i'a, 'fish'; (Australian) makoro, 'fish.'

Fire—1. api ; 2. aggi, 'firebrand'; *cf.* (New Britain) ugan, 'fire'; (Samoan) afi, 'fire.'

Good—1. bāik ; 2. bhaddo ; *cf.* (New Britain) bo-ina, boābo; (Australian) bu-jari.

Grief—1. sughul; 2. soko.
House—1. gadong; 2. kuti.
Man—1. jantan; 2. tanayo, 'a son'; *cf.* (Samoan) tane, 'a man, a male'; tama, 'a boy, a child'; tamā, 'a father.'
Mankind—1. manush; 2. manavo.
Month—1. bulan; 2. maso, masam; *cf.* (Samoan) masina.
Moon—1. bulan; 2. ma; *cf.* (Samoan) masina, 'moon,' ma, 'pure, clean'; (Sanskrit) mâsa, 'moon'; bhâsm, 'shining'; bhâ, 'to shine.'
Origin—1. pangkal; 2. pakati.
Pure—1. sūchi; 2. sujjhati.
Salt—1. garam; 2. kharo, 'salt'; *cf.* (Duke of York Island) karagap, 'acrid.'
Sand—1. pasir; 2. vannu; *cf.* (Samoan) one (*for* vone?).
Sharp (acid)—1. asam; 2. kasavo, 'sharp,' kasati, 'to shine.'
Shine—1. kilu; 2. viro; *cf.* (Samoan) 'ila'ila.
Speak—1. kata; 2. katheti.
Speech—1. bhasa; 2. bhasa, katha; *cf.* (Ebudan) bisa, fasao.
Stand—1. tegga; 2. thanam, tthati; *cf.* (Samoan) tu.
Take (away)—1. ambel; 2. abbhati.
Voice—1. bhana; 2. vāni, 'voice,' vadati, 'speak.'
Willing—1. sudi; 2. sadiyati.
With—1. sama; 2. amā; *cf.* (Samoan) ma.

Besides the Samoan parallels which are noted in this list, there are numerous simple words in Samoan which are evidently of Aryan descent. In many cases their lineage is disguised by the euphonic peculiarities of the Samoan language, and so it would be a long labour to examine them fully; a few, however, may be noticed. In Samoan, *folau* means 'a voyage,' and 'to sail' (to a distance). This is obviously the Malay 'boat,' *prau;* therefore, it is said, the Polynesians have borrowed *folau* from the Malays. But behind *prau* are the Sanskrit root-words, *plu*, *plavê*, 'float,' 'sail,' *plavas*, 'a boat,' the Greek *pleō*, *ploos*, and many Aryan cognates.

The Samoan *su* means 'wet,' 'waxy' (said of 'taro'), *sua* is 'juice,' 'liquid,' *suāsusu* is 'milk,' *susu*, as a verb, means 'to suck the breast.' The Malay equivalent is *susu*, 'milk.' Therefore, it is said, the Polynesians must be Malays. But there is the Sanskrit root *sû*, whence *sûmas*, *sûmam*, 'milk,' 'water.'

There is the Polynesian word *la*, 'the sun,' 'a sail,' the idea common to both being that of 'whiteness,' 'brightness'; for 'a sail,' the Malays say *lā-yer*. But, here again, we have behind these the Sanskrit *dâha*, 'burning,' and the Greek *daiō*, *dalos*.

Less obvious instances of an Indian connection can be given. For example, the Samoan *'ai* means 'to eat.' The "break" here represents an initial *k*, and the word is *kai*. Now this word in varying forms is used everywhere in Polynesia and in New Guinea, New Britain, Fiji, New Hebrides—Melanesian regions—but the Malay verb 'to eat' is *ma*-kan, as we have seen. The *ka* of *kai* is for *ta*, in my opinion, and that again is a transposition of the Sanskrit root *ad*, 'to eat,' Lat. *edo*.

The Samoan *aga*, *alu*, 'to go,' I trace to the Pâli root *āyā*, Sanskrit *aga*, *ga*, 'to go.'

The Samoan verb *'ave* (for *kave*), 'to take,' seems to me to be the Aryan root *gab*, *gav*, 'to take.'

The Samoan *'avau*, 'to speak loudly,' is the Aryan root-word, *gab*, *gav*, 'to speak.'

And so on.

Now, before I close this discussion you are entitled to ask me how I account for the presence in Oceania of so many words of Aryan origin as I allege to be there. This is a fair question, and I will answer it. My opinion is that the whole of Oceania from the Sunda Straits right across to Easter Island was at first possessed by a negroid race, showing the broad nose, flat lips, and dark skin of the negro. This race came there by way of India from the shores of the Persian gulf—the original seat of the blacks. Their kindred are some of the wild black tribes now in the Dekkan of India, and the dwarfish Samangs of Malacca. To them also belong a *portion* of our native population in Australia, and also a *portion* of the Melanesians.

Next came into Oceania a Negroid-Caucasian race—mixed in India—with a fairer skin and narrow nose, and less negroid features. These men I assume to have occupied chiefly the coasts of the larger islands in Indonesia and eastwards, and many of their tribes seem to have come into Australia, mingling with the earlier indigenes. Thus I account for the varying physique and the varying social institutions of our Australian natives. How far eastwards into Oceania this Negroid-Caucasian flood extended I do not know, but to them, working in union with the original blacks, I ascribe the Cyclopean stone works on Ponape Island and Easter Island, and similar, though less noticeable, erections in many other islands; for these structures remind one of kindred works of stupendous magnitude reared by the black race in India, in Babylonia, and in Egypt.

I think it possible that this mixed race may have been driven onwards from India some time later than the Aryan invasion of that land.

Let me add here that in assuming that even the remotest islands of the South Seas had black races as their earliest inhabitants, I have the support of known facts. The traditions of the Maories say that their ancestors, on their arrival in New Zealand, found black men in that country; the people of some of the smaller groups in Eastern Polynesia are known to be much darker in skin and coarser in their nature than the Samoans and Tongans; they have also some differences of religious cult and of social customs; in the island of Savai'i itself (Samoa), a village bears the name of 'Fiji-inland,' and a dreaded local god is called Fiji; these and other facts like them seem to me to indicate the presence of a dark race at first in all Polynesia. And when, in course of time, the forefathers of the present brown natives arrived—a much fairer race—the earlier and darker occupants were either extirpated or suppressed and amalgamated, and from their union came the fair brown colour which most of the Polynesians now have. But in some of the groups where the dark race was strong and the immigrants few in number, the union produced a grosser type of man than elsewhere. It is true that in some of the Polynesian groups a scarcity of food and sometimes starvation are not uncommon, and that tends to darken the skin by bringing a black pigment to the surface; but the grossness of type to which I refer cannot arise from that cause.

Then you have asked me how so many root-words of Aryan derivation have come to exist in the Polynesian languages. My opinion is that the Polynesian forefathers were an Aryan and Indo-Germanic race who came from India, perhaps some centuries before the Christian era, and took possession of the islands of Indonesia nearest to the mainland, driving the previous negroid inhabitants into the interior of their islands, (for many blacks are still there) and further east and south into Melanesia and Australia.

If these things are so, then these fair Caucasians—fairer than the present Bengalies, whose location on the flats of the Ganges area has doubtless deepened their colour in the course of ages—we may readily suppose that these fair Caucasians brought with them the language and religion of the Vedas—or, at least, one of the Aryan Prâkrits of India such as the Pâli, which we have found to have, in some directions, so close a relation to the present Polynesian tongue. This would also account for the fact that, in the early centuries, Brahmanism is found established in the Sunda Islands and those adjacent, and that to this hour that cult remains there, though in a corrupted form. Here also, as I imagine, arose that reverential respect for chiefs as representatives of deity, and that use of peculiar words of respect in their presence and to them, which at this hour make the Eastern Polynesian manners so different from those of Melanesia. Up to the present day, the common people in the Sunda Islands must address their superiors in a special language of courtesy which is mostly Aryan—a survival from earlier times—and many amusing blunders are made by a subject when he appears at Court and has to use a language which is not his vernacular. This, certainly, must also have been the experience of the subject black races in these islands when in the presence of their Caucasian conquerors. To what extent these fair men may have incorporated themselves with the blacks, it is impossible to say, but their union would always tend towards the production of a brown type, an approach to the colour of the present Polynesians.

If these ancestors of the Polynesians were there, as I imagine, in the early centuries of our era, I do not think it likely that they were so tall and robust a race as their descendants in Samoa and the other groups; for an easy life and abundance of food have surely added much to the bodily dimensions of the eastern islanders in the course of ages, just as any of our native Australian tribes that have in their territory abundance of game, or a lagoon well stored with fish, are found to have a better physique than their neighbours.

But, be it remembered here that all I have now said about the location of these original Polynesians in the Sunda and Timor Islands and the Archipelago generally is mere speculation founded on linguistic evidence, for as yet I have no other evidence in support of this theory except such facts and inferences as I have stated above. The physical and social aspects of the black and the brown races led Wallace, as we have seen, to form a similar opinion.

But it is certain that the most recent arrival in the Archipelago has been the Malays. And now I am on the firm ground of history; for the Malays themselves acknowledge that they have been in possession there not more than five or six centuries. But very long before that Malay period, the waves of race movement, which Hindustan and Farther India and the adjoining regions have so often experienced, could not fail to affect the Archipelago; and so its fair-skinned population from necessity or choice began to move towards the east long before. It may be impossible now to determine the route by which the first of these moving parties reached the more eastern isles; but I think that few of them went through by Torres Straits; for that route was blocked by the savage and inhospitable Papuans of New Guinea and farther

Melanesia, whose way of receiving strangers does not encourage settlement; for it is destructive. In this sense, one of the best known of our missionaries, who has laboured long in that region, said to a friend who urged, "Don't you think that many canoe loads of men, drifting from other islands, have settled among these Papuans"; "Oh! no"; was the reply, "the strangers, as soon as they came ashore, were only clubbed and eaten." And that is quite true; although, from the well-known caprice of savages, influenced as they often are by any passing emotion, many fairer-skinned immigrants may have been allowed to land and live among the coast tribes of New Guinea and other islands near by. Instances of that kind are well-known in several of the Ebudan islands.

I think, therefore, that the first ancestors of the Eastern Polynesians, when they began to move, passed northwards in the Archipelago, and, keeping black New Guinea on the right and Fiji, at last reached Manu'a in Samoa, which, according to concurrent tradition, was their first resting place. I wish we could tell the date at which this took place, but it was probably not much more than a thousand years ago; for the settlement of some of the eastern groups is known to be comparatively recent, and the royal genealogies which we have from Samoa, Hawaii, and elsewhere, do not cover more than thirty or forty generations, and the earlier portions of some of these are evidently fabulous. At all events, whenever the stream of emigration from Indonesia set in, it continued to flow, and probably always by the same route, to avoid the dangers of the fierce Melanesian region lying between. The arrival of the Malays in force in the Archipelago quickened this current to the east, and did much for the full peopling of the Eastern Isles. The Malays themselves may have been so long resident in Farther India as to lose much of their monosyllabic Mongolian speech; but certain it is that, once settled in the Archipelago, they adopted much of the forms of speech which they found already there; for, although the Malay grammar is non-Aryan and very simple, yet their system of word-construction is not Mongolian, and many of the names for simple ideas, essential to a language, are purely Indian.

On the evidence of language, therefore, I have come to be of opinion that, before the Malays, there was in the whole Archipelago a then dominant race of fair-skinned, narrow-nosed Caucasians, whom the Malays found there, and whose language, to some extent, they adopted.

(2.) *The Asiatic origin of the Oceanic Numerals.*

By the Rev. D. Macdonald, M.A., Havannah Harbour, New Hebrides.

It is now sufficiently well-known what is meant when we speak of Oceanic numerals, but samples of them are here given from four widely separated parts of the Island world, viz., the New Hebrides, Samoa, Java, and Madagascar :—

English.	Mallicolo.	Santo.	Samoa.	Java.	Madagascar.
One	te	tewa, tea	tasi	sa	isa
Two	rua	rua	lua	loro, roro	rua
Three	til	tulu	tolu	tâlu	telu
Four	fat	vate	fa	papat	efatra
Five	limi	lima	lima	lima	dimy
Six	kōn	ono	ono	nânâm	enina
Seven	uontit	pitu	fitu	pitu	fitu
Eight	koāl	olu	valu	wolu	valu
Nine	khhhepi	tsiwo	iva	sanga	sivy
Ten	hhangatil	sunuvulu	sefulu	puluh	fulu
Thousand		ruwun	afe	ewu	arivu

To those familiar with the general aspect of the Oceanic numerals in many dialects, it will not be necessary to adduce instances to show that it is impossible to tell from these languages themselves whether *t*, *d*, or *s* was the original consonant of the numeral 'one' in the mother tongue, as we have such forms as *do*, *dua*, *aisa*, *eida*, *aida*, *ite*, *isa*, *sa*, *te*, in different dialects, Malay *asa*, *sa*. We may gather that in the original word there was something before that consonant, not a mere prefix, but a radical part of the word.

Java *siji*, for *sa-wiji*, and Malay *satu*, for *sa-watu*, warn us as to the non-radicalness of a syllable coming after it, *e.g.*, the *wa* in Santo *tewa*, and the *k* (or *kai*) in Efati *sik* or *tik*, Malagasy *saka*. The Samoan *tasi* is more difficult, but, however it is to be explained, there can be no doubt that it includes the original Oceanic word for 'one,' 't,' or 's.'

The Javanese *loro* or *roro* for 'two,' is a reduplication; apparently so also are *papat* and *nanam* (Malay *anam*).

In the Mallicolo *kōn* and *koal*, the *k* is not radical, being the well-known Oceanic prefix; *tit* in *uontit* corresponds to the numeral *pitu*, *fitu*, and the change of *f* to *t*, as *til* in *hhangatil*, 10, corresponds to *vulu*, *fulu* by the same change. The *hh* is for *s*, *hhanga* for *sanga*, the well-known prefix to the word for 'ten' in Oceanic, as is the *hh* in *khhhepi* (for *khsepi*, *k'sepi*, *k* as in *kōn*, *koal*); *hhepi* thus corresponds to Samoan *iva*, Malagasy *sivy*, Tagala *siyam*, or *siam*.

The above noted interchange between *t* and *f* (or *v*) is only the modern apparition of a similar interchange of consonants known to the original mother tongue: for we find the correspondent of *tit* in Malay *tuju*, Malagasy (as given by Sir Joseph Banks) *titou* (titu); and the correspondent of the above *til*, 10, in the Malagasy (Banks) *tourou* (*turu*) (?), Mangaree (Gabelentz) *turu* (?). We cannot tell with certainty from the Oceanic dialects alone whether in the words for 7, and 10, the initial *t* or the *f* (or *v*) is the original consonant.

The Samoan *sefulu*, like Malay *sapuluh* is literally, 'one-ten,' 'a ten,' and *sunu*vulu, *hhanga*til are the same, with the syllable *nu*, *nga* suffixed to the numeral 'one'; or perhaps rather I should say it is the same *su* or *sa* 'one,' 'a,' prefixed to *nu* or *nga vulu*, the *nu* (or *nga*) in that case being an article or demonstrative particle.

Turning now to the Continent of Asia, we find that the Mahri numerals (now used in South Arabia by the descendants of the ancient Himyarites or Sabaeans, whose language was the principal dialect of Arabic before the triumph of Islamism carried the dialect of the Koran into the ruling place) are only variant forms of the well known Semitic numerals. They are as follows:

English.	Mahri. (Dr. Carter.)	Sokotra. (Willsted.)	Arabic. Modern. (Percival.)	Syriac. Modern. (Stoddart.)	Ethiopic. Ancient.	Arabic. Ancient.
One	taad	kat	ahhad	hha, hhda	ahadu	ahad' wahid'
Two	tharo	tarawah	etnein t'nein	t'rai	k'letu	ithnan'
Three	shāthet	tataah	t'laté	t'laa	salastu	thalathat'
Four	robot	arba'ah	arbaà	arbaa	arbaatu	arbaat'
Five	khomo	khemah heimish	khamsé	hhamsha	hamastu	khamsat'
Six	iteet	yitah	sitte	ishta	sedestu	sittat'
Seven	ibet	yibi'ah	seb-à	shoā	sab'atu	sab'at'
Eight	thimaneet	tamani	t'manie t'mani	t'mania	samantu	thamaniat'
Nine	isét	sa'ah	tis-à	itsha	tsa'tu	tis'at'
Ten	ashareet	'ashri	àchra	ŭsrā	'asartu	'asharat'

English.	Hebrew.	Syriac. Ancient.	Assyrian.	Amharic.	Sabæan	Himyaritic.
One	ehad	had	isten edu(*Akh.*)	and adě(*Tigre*	ahhda	ahhdam
Two	shĕnaïm	treyn	sina	hulat	tani	tani
Three	shĕloshah	tolto	salaltu	sost	&c.	taltam
Four	arbaah	arbō	erbitti	arut	arbaat	arbaam
Five	hamishah	hamsho	hamilti	amst	&c.	amsam
Six	shishah	shto	sudu	sedest		sadtam
Seven	shib'ah	shab'o	sibit	sabāt	sabāt	sabam
Eight	shĕmonah	tmonio	sumanu	sment	&c.	tamnam
Nine	tish'ah	tesho	tisit	zatang		tsa'am
Ten	ăsrah	esro	esrit	esr		asram

The grammars of Sayce and Delitzsch give these Assyrian words; for the Sabaean see Halevy's "Etudes Sabéennes," and a paper by Prideaux in the Journal of the Society of Biblical Archæology. For the Mahri see the Journal of the Bombay Branch of the Royal Asiatic Society, July 1847, Vol. II., "Notes on the Mahra Tribe of South Arabia," by Dr. H. J. Carter; and especially H. F. von Maltzan's papers on the Mahri dialect. In the Himyaritic numerals found in the inscriptions the final *m*, sometimes attached and sometimes not, is the Semitic 'mimation,' which, according to Halevy, is an indefinite article, and analogous to the Arabic 'nunation,' or final *n*. This it is necessary to mention here, because the same finals, in the writer's opinion, occur in the Malay and Malagasy *anam*, *enina*, 6, and in the Tagala *siam*, 9, Mallicolo *heppi* (*m* to *p*), Malagasy *sivy*, Samoan *iva* (*m* to *v*), Java *sanga* (*m* to *ng*).

A peculiarity of the Semitic languages is that the feminine or abstract form of the numerals from 'three' to 'ten' was used with masculine nouns, and therefore became the common and prevailing form. We should expect accordingly that the Oceanic numerals, if they are from Arabia, will exhibit traces of this peculiarity. The feminine form was distinguished by a suffixed *t*, which, however (as may be seen by comparing the Semitic numerals, ancient and modern, as given above, which from three to ten are all in the feminine form), often degenerated into *h*, or a mere breathing, or disappears altogether as a consonant. Now, the Oceanic numerals, this *t* of the ancient feminine form is distinctly preserved in all the dialects in the word for 7 (*bitu*, *pitu*); and in all, except the Samoan, in the word for 4, *efatra*, *fat*, *vati*, *papat*, Malay *ampat*.

In the Mahri and Sokotran words for 6, 7, and 9, the original initial consonants (*s* and *t*) are elided, as they are also in the same words in all the Oceanic dialects given above, unless the Santo *tsiwo* be held to preserve the original *t* before the *s* in the word for 9. In the Oceanic also the initial *t* is elided in the word for 2, as may be seen by comparing Mahri *tharo*, Sokotran *tarawah*, Syrian *t'rai*, with Java *ro*, (common) *rua*: in Efate, however, *rua* is often pronounced *trua* in which the *t* may represent the original initial *t*.

The Ethiopic and Amharic word for 2 is not the same as the word for 2 in all the other given Semitic dialects with which the Oceanic is identical, but compares most closely with its Syriac and South Arabian form, in which the original *n* is changed to *r*. So the Assyrian *isten* = 1. (in which the *n* is non-radical) is not the same as the word for 1. in all the other dialects, and which is used in Assyrian also.

The Oceanic word for 8, *valu* (*oal*, *olu*, *wolu*), occurs in Savu in the form of *panu*, in Malay as *lapan*; from the Oceanic alone we could not tell whether the *l* or *n* was the original consonant, though we should be justified in regarding *lapan* as more original than *panu* or *valu*. *Lapan* is held to be identical with the common Semitic word for 8, *tamani*, and others as above, the *m* having become *p* (a change already noted under the word for 9) and the initial *t* has become *l*: in *panu*, *valu*, the initial consonant is elided as in the words for 2, 6, 7, and 9, already remarked on.

In the Oceanic word for 5 the final original *s* is elided as in Mahri and Sokotra, and *dimy* is for *khemah*, *khomo*, &c., by the very common change of *k* to *t*; *dimy* readily passed into *limi* (*t* to *l*). In Aneityum (New Hebrides) this word actually accurs as both *kma* (*kĭma*), and *jma* (*jĭma*). See the late Rev. Dr. John Inglis' "Aneityumese Dictionary," (Williams and Norgate).

The Oceanic word for 'one,' *te*, &c., compares with the common Semitic word given above. The Sumatran *do*, Fijian *dua*, and *aida* in the Oceanic list is manifestly identical with the word occurring in Amharic as *and* (*ande*), Tigre *ade*, Assyrian *edu* (*kh* or *hh* in the other Semitic dialects is generally *e* in Assyrian, or mere *spiritus lenis*); and the *s* of Malay *asa*, *aisa* is to be regarded as standing for the original *d*, as, of course, does *t* in *te*, &c., Efate dialect *ite*. In very many dialects the word for 1. occurs in both forms, in the one having *t*, in the other *s*; in Efate, for instance, this is the case.

The Oceanic word for 10 has hitherto been an unsolved puzzle: but it is only reasonable to think that if the Oceanic numerals from 1 to 9 are, as is shown above, the common Semitic words used from the earliest time and still used, in Arabia and the neighbouring parts of the Asiatic Continent, to denote these numbers, then the Oceanic *fulu*, *turu* is probably also the common Semitic word for 10, that is, if *turu* be really a variant for *fulu*.

As to the word for 1,000, Tagala and Bisaya *libu*, *livu*, Malay *ribu*, Java *ewa*, Samoan *afe*, Malagasy *arivu*, Santo *ruwun* (Himyaritic *alifan*) need only to be placed alongside the common Semitic word, as in *alapu*, *alef*, *alfu*, *olof* (*l* elided as in Samoan), without remark.

In fine, this summary of the Oceanic and the Asiatic numerals will show how they correspond.

	Oceanic	Asiatic.
1	te, do, aida	ade, ahad, hhda
2	ro (-ro), rua, trua	tharo, tarawah, trai
3	telu	t'loa
4	ampat, efatra	arbaat
5	kma (jma), lima	khemah, khomo
6	eni(na), ono (*n* for *t*)	yitah
7	pitu	ibet
8	lapan, panu, valu	tamani, t'mani
9	tsiwo, siam, sivy	sa'ah, tsa'am
10	turu (?), fulu, &c.	'asharat', 'asartu, &c. (Syriac '*shar*, masculine)
1000	libu, &c.	alapu, &c.

NOTES ON THE OCCURRENCE OF PLATINUM, GOLD AND TIN IN THE BEACH SANDS IN THE RICHMOND RIVER DISTRICT, N.S. WALES.

By JOHN C. H. MINGAYE, F.C.S., M.A.I.M.E., Analyst to the Department of Mines.

[*Read before the Chemical and Geological Section of the Royal Society of N.S. Wales, July 5, 1892.*]

THE ocean beaches and river sands in various parts of the world have been extensively worked for gold and platinum. *In America much attention is given to the occurrence of gold in these ocean placers, or beach diggings, and they are being worked in the State of Oregon, where it is reported that two of the claims have yielded as much as £160 for two weeks' work. *In Japan, at Hakodaki, small quantities of gold are found along the beach, which is covered for miles with thick layers of auriferous black sand. In New Zealand, the sea beaches are extensively worked for the gold and platinum present. At North Beach, five miles from the Maori River, the wash yielded as much as one ounce a day per man. So valuable are these claims considered, that they are commonly sold for as much as £200 to £300 each, independently of water race and appliances.

The presence of gold and platinum in the beach sands of the Richmond River was pointed out by †Mr. W. A. Dixon, F.I.C. &c. in 1878, the sample examined containing gold 1 dwt. 5 grains per ton; platinum a trace, being less than 5 grains per ton. These sands have been extensively worked for years, with the result that some hundreds of ounces of gold have been obtained, also a small quantity of platinum, iridosmine, etc.

The sand may be described as follows:—Consists largely of white sand and magnetite, with lesser quantities of ilmenite,

* "Gold, its Occurrence and Extraction."—Alfred G. Lock.
† Annual Report, Department of Mines, 1878.

zircons, quartz, and a small amount of cassiterite, platinum, iridosmine and gold. A large number of samples of the crude sand and concentrates, have been examined in the Laboratory connected with the Department of Mines, the following being a few of the results obtained :—

1. Gold a trace (under 2 dwts. per ton), platinum a trace (a few grains per ton).
2. Gold a trace (under 2 dwts. per ton), platinum a trace (a few grains per ton).
3. Gold 1 oz. 12 dwts. 16 grs. per ton, platinum a trace (a few grains per ton).
4. Gold 1 oz. 12 dwts. 16 grs. per ton, platinum a trace (a few grains per ton).
5. Gold 6 dwts. 12 grs. per ton ; silver 1 oz. 12 dwts. 16 grs. per ton ; tin a trace ; platinum a trace (a few grains per ton).
6. Gold 5 dwts. 10 grs. ; silver 10½ dwts. per ton ; tin a trace ; platinum a trace (a few grains per ton).
7. Gold 15 grs. ; silver 4 dwts. per ton ; platinum a trace (a few grains per ton).
8. Gold and silver, traces ; platinum a trace (a few grains per ton).
9. Gold and silver, traces ; tin 2·5% ; platinum a trace (a few grains per ton).
10. Gold 15½ dwts., silver 5½ dwts. per ton ; tin, 7·20% ; platinum (under 1 dwt. per ton).

Concentrates—

1. Platinum 501 oz. 2 dwts. per ton ; tin, 51·03 per cent.
2. Platinum 19 oz. 18 dwts. 12 grains per ton.
3. Platinum 1160 oz. 10 dwts. 20 grains per ton.
4. Platinum 4·3 per cent., metallic tin 13·58 per cent.
5. Platinum 395 oz. 11 dwts. 20 grains per ton.

Note.—Tin was present in all these samples, but the percentage was not determined in every case. The gold had been separated by amalgamation.

Mr. E. Jones, J.P., Warden for the Richmond River district, in his Annual Report to the Under Secretary for Mines and

Agriculture, states—"That during the year the amount of gold won in his district was about 400 oz., also that he was informed that a considerable amount of platinum is in the hands of some miners at Evan's Head, there being no purchasers in the locality. A sample of the concentrates forwarded to Messrs. Johnston, Matthey & Co., London, was valued at about £1000 per ton."

The late Government Geologist, Mr. C. S. Wilkinson, F.G.S., who with Mr. Slee, F.G.S., in 1889 thoroughly examined this district, stated:—"that there is no doubt, that the gold and platinum in the sand and gravel on the beach, which have for years past been worked to the north and south of Black Rock, have been derived from the denudation of the basalt—the rippling action of the ocean surf tending to throw back the gold with the black sand and shingle drift above high-water level."

As found in other countries where these ocean placers are carried on, the sand is very patchy, the richness of the deposits depending in the Richmond River district on the heavy southerly and westerly gales, which by their action on the waves, wash up the gold, platinum, and cassiterite on to the beach. It is stated that one exceptionally rich patch about twenty-five yards square, worked by Messrs. Rowan and party, yielded for about six inches in depth of wash, seventy-five ounces of gold.

A bulk sample of the stone from the Black Rock at Ballina, sent to the Royal Mint Sydney for treatment, yielded:—Fine gold 1 oz. 7 dwts. per ton. A mining lease of twenty-five acres has been taken up with a view of thoroughly working the stone.

The sand and magnetite on microscopic examination, is almost round in shape, the platinum, gold and iridosmine being in the form of very small thin scales, hence it will be a very difficult matter to save the gold and platinum, excepting silvered copper plates and blankets are used in the concentrating appliances. At present the sand is worked in a very crude manner, it being passed through an ordinary hand cradle, containing two silvered copper plates to save the gold, the heavy sand which collects in the cradle is again passed through false bottomed boxes, and the concentrates are saved.

PLATINUM AND ITS ASSOCIATED METALS IN LODE MATERIAL AT BROKEN HILL, N.S. WALES.

By JOHN C. H. MINGAYE, F.C.S., M.A.I.M.E., Analyst to the Department of Mines.

[*Read before the Chemical and Geological Section of the Royal Society of N.S. Wales, July 5, 1892.*]

THE presence of platinum and its associated metals in lode material at Broken Hill has been previously pointed out by me in a paper read before this Society entitled:—" Notes on some Minerals, &c."* A large number of samples from the same district have since been examined for the presence of platinum, and in nearly every case was that metal detected, yielding from traces up to 1 oz. 9 dwts. per ton.

Experiments were conducted at the Clyde Works, Granville, with a view of ascertaining if the platinum could be saved by concentration over the Frue Vanner. The results obtained however, were not very satisfactory, as in the first place the platinum present was found to be very small. It was thought that enough metal probably would be obtained so as to determine in what state the platinum exists in the mineral.

An average sample of dry crushed ore weighing 17 cwts. 2 qrs. when passed over the Frue Vanners yielded 66 ℔s. of concentrates. The concentrates yielded, platinum 16 dwts. 17 grs. per ton. A second sample weighing 1 ton 1 cwt. yielded 26 ℔s. of concentrates, which contained platinum 9 dwts 18 grs. per ton.

The concentrates weighed very heavy, and a qualitative analysis was made with a view of ascertaining their composition. The following metals were detected—lead, zinc, antimony, arsenic, bismuth a trace, lime, magnesia etc., combined with sulphur and carbonic acid.

* Journ. Roy. Soc. N.S. Wales, Vol. XXIII., 1889, p. 326.

No platinum or its associated metals were detected by a careful examination of the residue, after some of the concentrates had been treated with acids and further concentrated. It is impossible at present to state for certain in what form the platinum exists in the lode material, as the amount hitherto found has been very small, and the metals associated with it are so complicated, but from the presence of iridium and traces of rhodium detected, it is probable that the platinum exists in the metallic state, in very fine division, combined with iridium.

Messrs Johnston, Matthey & Co., of London, to whom samples of these minerals were submitted by Dr. Belgrave of Broken Hill, for assay and report, I am informed, found platinum present in every case, varying from a few dwts. to two and a half ounces per ton, and state that its metallic associations appear to be such, and the form in which it is found so unprecedented, that the cost of its isolation and treatment would apparently be at present too great to yield a profit.

On referring to the qualitative analyses made of the concentrates it will be seen that their composition is complicated, therefore it will be a very difficult matter to extract the platinum from these minerals, and certainly will not pay unless the ore before concentration contains a much larger quantity of metal than either of the bulk samples concentrated at the Clyde Works at Granville.

Assays of Broken Hill Platinum Minerals.

Description of Mineral.	Platinum. ozs.	dwts.	grs.	per ton.
1. Clear blebs of quartz in felspathic base with garnets	0	1	15	,,
2. Ferruginous felspathic material, containing carbonates of copper	0	1	0	,,
3. Ditto, ditto, ditto	a few grs.			,,
4. Ditto, ditto, ditto	0	4	6	,,
5. Ditto, ditto, ditto	0	5	6	,,
6. Hematite ore with a small quantity of copper carbonates and a trace of nickel	1	2	18	,,

Description of Mineral.	Platinum. ozs.	dwts.	grs.	per ton.
7. Felsite and granite rock	0	4	0	,,
8. Ochreous felspathic rock	1	9	9	,,
9. Compact ferruginous clay stone	0	6	12	,,
10. Ferruginous felspathic rock with green carbonate of copper	0	5	0	,,

Small quantities of gold and silver are present in these minerals.

Exhibits.

Specimens of the Richmond River beach sand.

Ditto, highly concentrated.

Six specimens of the Broken Hill minerals containing platinum.

Specimen of sand containing platinum from the Western District.

PROCEEDINGS

OF THE

THE ROYAL SOCIETY OF NEW SOUTH WALES,

WEDNESDAY, MAY 4, 1892.

Annual General Meeting.

H. C. Russell, B.A., C.M.G., F.R.S., President, in the Chair.

Fifty-three members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st March, 1892, was presented by the Hon. Treasurer and adopted:—

GENERAL ACCOUNT.

Receipts.		£ s. d.	£ s. d.
Subscriptions	One Guinea	212 2 0	
	Two Guineas	443 2 0	709 16 0
	Arrears	51 9 0	
	Advances	3 3 0	
Entrance Fees			126 0 0
Parliamentary Grant on Subscriptions received during 1891			500 0 0
Rent of Hall			61 12 10
Sundries			8 5 0
Total Receipts			1405 13 10
Balance on 1st April, 1891			41 12 0
			£1447 5 10

Payments.	£ s. d.	£ s. d.
Advertisements	31 17 0	
Assistant Secretary	250 0 0	
Books and Periodicals	170 14 0	
Bookbinding	55 1 5	
Freight, Charges, Packing, &c....	15 3 4	
Furniture and Effects	39 2 1	
Gas	29 11 2	
Carried forward	£591 9 0	

Payments—*continued.*	£	s.	d.	£	s.	d.
Brought forward	591	9	0			
Housekeeper	10	0	0			
Insurance	9	10	0			
Office Boy	26	0	0			
Petty Cash Expenses	19	6	3			
Postage and Duty Stamps	37	12	6			
Printing	32	17	0			
Printing and Publishing Journal	278	11	6			
Prize Essay Award	25	0	0			
Rates	39	18	9			
Refreshments and attendance at Meetings ...	17	19	6			
Repairs	137	14	9			
Stationery	7	11	9			
Sundries	10	3	3			
Total Payments				1243	14	3
Transfer to Building and Investment Fund...				165	0	0
Balance on 31st March, 1892				38	11	7
				£1447	5	10

BUILDING AND INVESTMENT FUND.

Receipts.	£	s.	d.
Transfer from General Account	165	0	0
Interest on Fixed Deposit	37	13	0
Amount of Fund on 1st April, 1891	566	17	1
	£769	10	1

	£	s.	d.
Fixed Deposit in Union Bank	769	10	1
	£769	10	1

CLARKE MEMORIAL FUND.

Receipts.	£	s.	d.
Interest on Fixed Deposit	15	0	0
Amount of Fund on 1st April, 1891	300	1	8
	£315	1	8

	£	s.	d.
Fixed Deposit in Union Bank	315	1	8
	£315	1	8

Audited, H. O. WALKER. ROBERT HUNT, *Honorary Treasurer.*
S. MACDONNELL. W. H. WEBB, *Assistant Secretary.*

Sydney, 14th April, 1892.

Messrs. H. A. Lenehan and P. N. Trebeck were duly 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. THE EARL OF JERSEY, G.C.M.G.

President:

PROF. WARREN, M. INST. C.E., WH. SC.

Vice-Presidents:

C. W. DARLEY, M. INST. C.E.
Prof. T. W. E. DAVID, B.A., F.G.S.
PROF. LIVERSIDGE, M.A., F.R.S.
H. C. RUSSELL, B.A., C.M.G., F.R.S.

Hon. Treasurer:

ROBERT HUNT, C.M.G., F.G.S.

Hon. Secretaries:

F. B. KYNGDON.
PROF. ANDERSON STUART, M.D.

Members of Council:

JAMES GRAHAM, M.A., M.D. *Edin.*
W. M. HAMLET, F.C.S., F.I.C.
A. LEIBIUS, PH. D., M.A., F.C.S.
J. A. McDONALD, M. INST. C.E.
H. G. McKINNEY, M.E., M. INST. C.E.
J. H. MAIDEN, F.L.S., F.C.S.
CHARLES MOORE, F.L.S., F.Z.S.
J. ASHBURTON THOMPSON, M.D.
PROF. THRELFALL, M.A.
H. G. A. WRIGHT, M.R.C.S.E., &c.

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

Sturt, Clifton, L.R.C.S., L.R.C.P. *Edin.*, L.F.P.S. *Glas.;* Bulli.

The certificates of five new candidates were read for the second time, and of eleven for the first time.

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

Section B. and C.—Chemistry and Mineralogy, Geology and Palæontology.

Chairman—Prof. T. W. Edgeworth David, B.A., F.G.S.
Secretary for Chemistry—W. M. Hamlet, F.C.S., F.I.C.
Secretary for Geology—Rev. J. Milne Curran, F.G.S.
Committee—Mr. F. Guthrie, F.C.S., Prof. Liversidge, M.A., F.R.S., F.C.S., Messrs. J. H. Maiden, F.C.S., J. C. H. Mingaye, F.C.S.

Meetings held on the First Tuesday in the month at 8 p.m.

Section E.—Microscopical Science.

Chairman—Mr. H. O. Walker.
Secretary—Mr. S. MacDonnell.

Committee—Messrs. T. M. Brindley, G. D. Hirst, P. R. Pedley, T. F. Wiesener. Dr. H. G. A. Wright.

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

Section H.—Medical.

Chairman—Dr. Fiaschi.

Secretaries—Dr. Hull and Dr. Huxtable.

Committee—Dr. W. Chisholm, Dr. James Graham, Dr. W. H. Goode, Prof. Anderson-Stuart, M.D., Dr. Rennie, Dr. MacCormick.

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

Section K.—Civil and Mechanical Engineering.

Chairman—Cecil Darley, M. Inst. C.E.

Secretary—J. A. McDonald, M. Inst. C.E.

Committee—H. Deane, M. Inst. C.E., J. M. Smail, M. Inst. C.E., H. G. McKinney, M. Inst. C.E., D. M. Maitland, L.S.

Meetings held on the Third Wednesday in each month, at 8 p.m.

One hundred and sixteen volumes, six hundred and twenty-one parts, one hundred and forty-one pamphlets, two atlases and fifteen loose Meteorological charts received as donations since the last meeting were laid upon the table and acknowledged.

The following letter was read from Prof. W. T. Thiselton Dyer, C.M.G., M.A., B.Sc., F.R.S., Director of the Royal Gardens, Kew:—

Royal Gardens, Kew.
8th February, 1892.

Dear Sir,—It was with mingled suprise and pleasure that I received your very kind letter of 23rd December, informing me that the Council of the Royal Society of New South Wales had done me the very signal honour of conferring upon me the Clarke Memorial Medal (which came safely into my hands at the same time).

I cannot but feel, however, that this distinction is one which has been earned rather by the Institution over which I have the honour to preside than by any merit of my own. That, however, rather enhances than diminishes the satisfaction which I derive from it.

The connection between Kew and the Australian Colonies has always been peculiarly close; and I observe that this is no less than the third occasion upon which it has been recognised by your Society. That connection began in the last century with Sir Joseph Banks, who, though not actually connected in any official way with Kew, was virtually its scientific director; it was resumed by the splendid work on the elucidation of the Australian flora of my immediate predecessor in office, Sir Joseph Hooker; and it culminated in the preparation at Kew, by Mr. Bentham of his classical description of the whole Australian flora. It is, I feel, no small distinction to be associated in the eye of Australian scientific men with these two eminent recipients of the Clarke Medal. My own work has, I feel, been the much humbler one of continuing a tradition, which by the wisdom of the Government has made Kew as much an Imperial as a local institution.

The services to which you allude have become so much a matter of routine that they scarcely seem to possess any exceptional merit. Their reward, if they deserve any, continually manifests itself in the kindness and sympathy which Kew never fails to receive at the hands of its Colonial correspondents. If anything is needed to lighten the continuous and perhaps sometimes onerous labours of the Kew staff, it is the feeling that they are working not merely for a limited section of the home community, but for the pleasure and gratification of intelligent persons in every part of the Empire.

Kew has undoubtedly in the last half-century been successful in effecting much for the advancement of many material interests. Its highest work has, however, perhaps been accomplished in the encouragement and help which it has been able to afford to the cultivation of science in England beyond the seas. In Australia, with its splendid Universities, energetic scientific societies, and fine botanic gardens, it sees an offshoot of the best home intellectual life, which must always command its warmest sympathy.

I am, dear Sir, yours truly,
W. T. THISELTON DYER,
Director.

W. H. WARREN, Esq., Hon. Secretary,
Royal Society of New South Wales.

Mr. H. C. RUSSELL, B.A., C.M.G., F.R.S., then read his address.

A vote of thanks was passed to the retiring President, and Prof. WARREN, Wh. Sc., M. Inst. C.E., was installed as President for the ensuing year.

WEDNESDAY, JUNE 1, 1892.

Prof. WARREN, M. Inst. C.E., President, in the Chair.

Twenty members and two 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 eleven for the second time, and of two for the first time.

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

Alexander, Stanley, M. Inst. C.E.; Sydney.
Dymond, Edmund, Assoc. M. Inst. C.E., &c.; Sydney.
Seager, S. Hurst, A.R.I.B.A.; Sydney.
Stuart, Charles M'Donnell ; Sydney.
Wells, William Seymour, Assoc. M. Inst. C.E.; Newcastle.

Twenty-one volumes, eighty-four parts, twenty pamphlets and thirteen meteorological charts, received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "Oceanic Philology," by SIDNEY H. RAY.
2. "A determination of the Magnetic Elements at the Physical Laboratory, University of Sydney," by C. COLERIDGE FARR, B.Sc.

   Remarks were made by Messrs. H. C. Russell, A. J. Pollock, H. F. Madsen, and Prof. David.
3. "On certain Geometrical Operations," by G. FLEURI.

   Remarks were made by Messrs. C. C. Farr and A. J. Pollock.
4. "Analyses of some of the Well, Spring, Mineral and Artesian Waters of New South Wales and their probable value for Irrigation and other purposes," by JOHN C. H. MINGAYE, F.C.S., &c.

   Remarks were made by Prof. David and Mr. W. M. Hamlet.

Mr. H. C. RUSSELL made some remarks on the large Sun-spots, visible at the present time.

WEDNESDAY, JULY 6, 1892.

Prof. WARREN, M. Inst. C.E., President,, in the Chair.

Forty-one members and seven visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eleven new candidates were read for the third time, of two for the second time and of six for the first time.

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

Cowdery, G. R.; Sydney.

Gundlach, Louis Richard; Manly.

Kesteven, Leighton, M.R.C.S. *Eng.*, &c.; North Sydney.

MacCarthy, Charles W., M.D., F.R.C.S. *Irel.*, &c.; Sydney.

McDonagh, John M., B.A., M.D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*; Sydney.

Power, John J., M.B., M. Ch. *Univ. Dub.*; Sydney.

Rossbach, William, Assoc. M. Inst. C.E.; Sydney.

Scarr, Percy; Sydney.

Schofield, James Alexander; Sydney.

Webster, James Phillip, Assoc. M. Inst. C.E.; Marrickville.

Woodward, G. P. M., M.D. *Brux.*, M.R.C.P. *Irel.*, F.R.C.S. *Irel.*; Sydney.

Thirty-four volumes, ninety-five parts, nine pamphlets and one hydrographic chart received as donations since the last meeting were laid upon the table and acknowledged.

A letter from Mr. James Nisbet of Narrawin Station to Mr. H. C. Russell was read, in which reference was made to the unaccountable death of large numbers of fish in the station lagoon, in a single night.

Mr. J. M. SMAIL, M. Inst .C.E., read a paper "On the Ventilation of Sewers and Drains."

The discussion upon this paper was postponed to the next meeting of the Civil and Mechanical Engineering Section.

A model of the Cowra Bridge was exhibited by Mr. ROBERT HICKSON, M. Inst. C.E., and a Weather Forecasting Diagram was exhibited and explained by Mr. H. C. RUSSELL, B.A., C.M.G., F.R.S.

WEDNESDAY, AUGUST 3, 1892.

Prof. WARREN, M. Inst. C.E., 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 two candidates were read for the third time, of six for the second time, and of three for the first time.

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

Halloran, Henry Ferdinand ; Sydney.
White, Harold Pogson ; Kogarah.

Twenty-one volumes, one hundred and twenty-two parts, and five pamphlets received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read:—

1. "Flying Machine Work and the $\frac{1}{6}$ I H.P. Steam Motor, weighing $3\frac{1}{4}$ lbs.," by LAWRENCE HARGRAVE.

   Remarks were made by Prof. Threlfall and the Chairman.

2. On the venom of the Australian Black snake (*Pseudechis porphyriacus*), by C. J. MARTIN M.B., B Sc., Demonstrator of Physiology in the University of Sydney, and J. MCGARVIE SMITH.

   Remarks were made by Mr. W. M. Hamlet, Prof. Anderson Stuart, and Prof. Liversidge.

Mr. W. M. HAMLET exhibited and described a new form of Blowpipe apparatus.

Mr. H. C. RUSSELL exhibited a photograph of Winnecke's Comet, obtained the day previously after three hours exposure.

WEDNESDAY, SEPTEMBER 7, 1892.

Prof. WARREN, M. Inst. C.E., President, in the Chair.

Twenty-six members and four visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of six 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:—

Bell, Walter Farmer, M. Inst. C.E.I.; Sydney.

Davis, Joseph, M. Inst. C.E.; Sydney.
Everett, William Frank; Sydney.
Kiddle, Hugh Charles; Burrumbuttock East, viâ Albury.
Statham, Edwyn Joseph, Assoc. Inst. C.E.; Newtown.
Vickery, George B.; Sydney.

Twenty-eight volumes, one hundred and eighty-five parts, fifteen reports, twenty-one pamphlets and fifteen meteorological diagrams received as donations since the last meeting, were laid upon the table and acknowledged.

The following paper was read:—"The effect which settlement in Australia has produced upon Indigenous Vegetation," Part I., by Alex. G. Hamilton.

Remarks were made by Prof. Anderson Stuart, Messrs. C. Hedley, H. G. McKinney, W. D. Campbell, and H. C. Russell.

Mr. Hedley exhibited several coloured drawings prepared from original sketches on the spot by Mr. Harry Stockdale, illustrating the various modes of burial practised by natives of the Alligator River, Northern Territory. They showed the corpses wrapped in Melaleuca bark, and placed on niches of rocks, among the branches of trees or on scaffolds erected on the plains.

Prof. Anderson Stuart, M.D., exhibited an improved form of the apparatus for demonstrating the nature of a sound-wave, and made from the original model constructed at the Sydney University by the Cambridge Scientific Instrument Company. The beauty of workmanship, and unique way in which wave motion was made apparent to the eye elicited much admiration.

WEDNESDAY, OCTOBER 5, 1892.

Prof. Warren, M. Inst. C.E., President, in the Chair.

Twenty members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The Chairman announced with deep regret the death of Mr. Robert Hunt, C.M.G., F.G.S., Deputy Master of the Royal Mint, Sydney, who had been a member of the Council since 1880, and Hon. Treasurer from 1885.

The Rev. Dr. W. WYATT GILL called attention to the reprint by the Government Printer of Mr. L. E. Threkeld's "An Australian Language, as spoken by the Awabakal, the people of Awaba, or Lake Macquarie, being an account of their language, traditions, and customs," and gave an account of the steps which led up to the Government undertaking the work. He eulogised the work of Dr. Fraser, who had edited the book as a labour of love.

The certificates of three candidates were read for the third time, of three for the second time, and of two for the first time.

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

Flint, Charles Alfred, M.A.; Stanmore.
Hodgson, Charles George; Sydney.
Mollison, James Smith, Assoc. M. Inst. C.E.; Sydney.

Twenty-five volumes, seventy-four parts, fourteen reports, seven pamphlets, and one meteorological chart received as donations since the last meeting were laid upon the table and acknowledged.

The Society's bronze medal and cheque for £25 were presented to Mr. Alexander G. Hamilton, Master of the Public School at Mount Kembla, for his essay "On the effect which settlement in Australia has produced upon indigenous vegetation." The President congratulated Mr. Hamilton on his contribution, who proceeded to read the second division of his essay, the first portion having been read at a previous meeting. In summing up the paper, Mr. Hamilton said that he was of opinion that the causes of the destruction of native flora were—(1) the destruction of various timbers, and in cultivating the soil or improving the pastures; (2) by the alteration of surface drainage, by the surface being broken either designedly or by cattle; (3) by the overstocking of the natural pastures without any means being resorted to for renovating them, and by the destruction and modification of the flora caused by the checking or modification of the native fauna, and the introduction of new flora.

Prof. ANDERSON STUART said the subject had been handled in a very interesting way, and there were a great many points that awakened interest. One of these was the prediction that the rabbit plague would bring its own cure. It happened that the other evening he (Prof. Stuart) was reading some ancient history, and he saw it stated that a rabbit plague was the means of practically depopulating the whole of the south of France and of Spain 100 B.C., and yet in the succeeding century no mention was made of any such plague, and there was no such plague there to-day; and it was pointed out that what happened there might happen here in Australia. Various means of getting rid of the rabbits had been proposed, but still there was no doubt whatever in his mind that the only way of getting rid of the plague was by the introduction of a suitable infectious rabbit-disease. "Fowl cholera" had not succeeded, still that by no means was to say that other microbe diseases would not succeed. He believed that a microbe would be found which would cope with the evil. The way to get that microbe was not by offering a prize. It would only be got by having competent men in sufficient numbers with ample opportunity and means to study the whole subject. To merely offer a prize, and to expect men to do work for a prize, was, he was certain, entirely futile. Both Pasteur and Koch, when in conversation with him during the past two winters, had spontaneously expressed themselves in exactly the same terms with regard to this question of a prize.

Mr. KYNGDON gave expression to his appreciation of the paper.

Mr. BENBOW referred to an aspect of the rabbit question which he thought had not been touched. In Europe rabbits bred only during the spring and the summer. In these colonies on account of the favourable climate the rodents bred all the year round. This constant breeding must, he thought, have a weakening effect upon their constitutions, and their vitality must be greatly lowered allowing diseases, which they could resist now, in time to come to decimate them. It was quite possible that in the course of a few years the rabbits would become so vitiated as to be extremely susceptible to natural poison.

The following were exhibited :—

1. A steam engine for a Flying-machine, by Mr. L. HARGRAVE.
2. Drawings of the planet Mars from observations taken with an eight and a half inch reflecting equatorial telescope by Mr. WALTER GALE.

WEDNESDAY, NOVEMBER 2, 1892.

Prof. WARREN, M. Inst. C.E., President, in the Chair.

Twenty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three candidates were read for the third time, of two for the second time, and of seven for the first time.

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

Kirkaldie, David : Sydney.
McNeill, John Patrick, M.D. *Dub. Univ.*, L.R.C.S.I.; Burwood.
Speak, Savannah J.; Sydney.

Nineteen volumes, eighty-three parts, nine pamphlets, four reports, one hydrographic chart, one photograph, and one engraving received as donations since the last meeting, were laid upon the table and acknowledged.

The CHAIRMAN announced that the Council recommended the election of the following gentleman as an Honorary Member of the Society, viz., WILLIAM HUGGINS, D.C.L., LL.D., Ph. D., F.R.S., &c., 90 Upper Tulse Hill, London.

The election was carried unanimously.

The following papers were read :—

1. "Preliminary note on Limestone occurring near Sydney," by HENRY G. SMITH, (Communicated by J. H. Maiden, F.L.S., F.C.S.)

2. "On Hail Storms," by H. C. RUSSELL, B.A., C.M.G., F.R.S.

3. "Some Folk-songs and Myths from Samoa," translated by the Rev. G. PRATT, with Introduction and Notes by JOHN FRASER, LL.D.

Prof. WARREN, M. Inst. C.E., exhibited two extensometers to measure $\frac{1}{10000}$ part of an inch, in connection with the testing of the elastic limit and modulus of elasticity of materials, and the Rev. J. MILNE CURRAN, F.G.S., exhibited a series of photographs and micro-photographs, illustrating the geology of New South Wales.

WEDNESDAY, DECEMBER 7, 1892.

Prof. WARREN, M. Inst. C.E., President, in the Chair.

Thirty-five members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two new candidates were read for the third time, of seven for the second time, and of two for the first time.

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

Statham, Hugh Worthington; North Sydney.
Thow, William ; Ashfield.

The CHAIRMAN announced that the Clarke Medal for 1893 had been awarded by the Council to Professor Ralph Tate, F.L.S., F.G.S., University of Adelaide.

It was resolved that Messrs. S. MacDonnell and P. N. Trebeck be appointed Auditors for the current year.

Twenty-three volumes, ninety-six parts, twenty-five reports, six pamphlets, two hydrographic charts and two meteorological charts received as donations since the last meeting, were laid upon the table and acknowledged.

The following letter was read :—

Sydney, December 5, 1892.

The Hon. Secretary, Royal Society of N.S.W.

Dear Sir,—I enclose herewith a cheque for one hundred pounds, which sum I desire to be placed in the hands of the Council of the Royal Society of New South Wales, with the object of bringing about an exhaustive study of certain features of Australian weather.

I will in a short time, and in another letter, indicate more fully the particular weather features, the study of which I desire to promote.

Believe me,

Yours very truly,

RALPH ABERCROMBY,

by H. C. RUSSELL.

Mr. Russell, in a letter to the Society on the subject, said that the points for consideration which the Hon. Mr. Abercromby had mentioned to him were—the effect of the north-west monsoon and our southerly busters. Mr. Abercromby, however, had not quite made up his mind, and was not sure whether the appointment of a committee or the offering of prizes would the better fulfil the purpose he had in view. It was unanimously resolved that a letter be sent to Mr. Abercromby thanking him for his gift and also for the confidence which he had placed in the Council.

The following papers were read :—

1. "Observations on Shell Heaps and Shell Beds: the significance and importance of the record they afford," by E. J. Statham, Assoc. Inst. C.E.

   Remarks were made by Messrs. C. W. Darley, C. Hedley, L. Hargrave, and W. M. Hamlet.

2. "A New Mineral from Broken Hill," by C. W. Marsh, (communicated by Prof. Liversidge).

3. "Notes on some Australian Stone Weapons," by Professor Liversidge, M.A., F.R.S.

4. "Notes on the recent Cholera Epidemic in Germany," by Dr. Schwarzbach.

Remarks were made by Mr. Hamlet, and Prof. Anderson Stuart, M.D

5. "Results of Observations of Wolf's Comet II., 1891, Swift's Comet I., 1892, and Winnecke's Periodical Comet, 1892, at Windsor, N.S. Wales," by JOHN TEBBUTT, F.R.A.S.

6. "On the Comet in the Constellation Andromeda," by JOHN TEBBUTT, F.R.A.S.

7. "Languages of Oceania," by JOHN FRASER, B.A., LL.D.

8. "Is Mars inhabited"? by H. C. RUSSELL, B.A., C.M.G., F.R.S.

Some implements and other articles from the South Sea Islands were exhibited by Mr. C. A. BENBOW.

PROCEEDINGS OF THE SECTIONS

(IN ABSTRACT.)

CHEMICAL AND GEOLOGICAL SECTION.

A requisition dated 5th August, 1891 was presented to the Hon. Secretaries signed by various members of the Royal Society asking for the re-establishment of the Geological Section. Subsequently, at a meeting held in the Library on April 4th, 1892, it was arranged that Sections B—Chemistry and Mineralogy, and C—Geology and Palæontology should be combined with the hope of securing a better attendance, and a larger and wider interest than could otherwise have been obtained. Meetings were therefore held in the Library of the Royal Society on the third Tuesday in each month, when the following exhibits were placed before the members and papers were read :—

"An account of a visit to New Guinea together with some notes on the community of life between Australia and New Zealand," by Mr. Charles Hedley.

"On the occurrence of Platinum and associated minerals in the sands of the Richmond River ; also in the lode-material of Broken Hill illustrated by specimens," by Mr. J. C. H. Mingaye.

"On a remarkable specimen of auriferous quartz containing fossil encrinites," by the Rev. J. Milne Curran.

"On some Chinese lozenges containing quinine and morphia, said to be used to make drunken men sober," by Mr. W. M. Hamlet.

"An account of some intrusive rocks in the neighbourhood of Sydney, illustrated by microscopic sections and photographs," by the Rev. J. Milne Curran.

"On a new mineral containing Iodide of Copper found at Broken Hill," by Mr. W. M. Hamlet.

Exhibits.

Photographs of spheroidal weathering of rocks, and of limestone and basalt near Orange, by the Rev. J. Milne Curran.

Some interesting minerals from Fiji, by Mr. J. C. H. Mingaye.

Some of the silver-bearing kaolins from Broken Hill, by Mr. W. M. Hamlet.

Dicks' Petrological Microscope, new and larger model, by the Rev. J. Milne Curran.

Geological photographs, by Mr. B. Dunstan.

Some New South Wales Minerals, by Mr. J. H. Campbell.

CIVIL AND MECHANICAL ENGINEERING SECTION.

At the preliminary meeting held on April 6th, the following officers were elected for the 1892 Session:—Chairman: Mr. Cecil Darley, M. Inst. C.E. Hon. Secretary: Mr. J. A. McDonald, M. Inst. C.E. Committee: Mr. H. Deane, M. Inst. C.E., Mr. J. M. Smail, M. Inst. C.E., Mr. H. G. McKinney, M. Inst. C.E., Mr. D. M. Maitland, L.S.

Monthly meeting held May 18, 1892.

Mr. C. Darley in the Chair.

It was resolved that the members be asked to subscribe 10s. per annum towards the cost of printing the papers read before the Section and that the Committee be empowered to send a circular to that effect to all members.

The evening was devoted to a discussion on Dr. Ashburton Thompson's paper on "The Sewerage of Country Towns," and was opened by the reading of a short contribution from Mr. A. F. Osborne. Messrs. J. T. Jones, Henson, Campbell, Grimshaw, Pollitzer, Seaver and the Chairman took part in the discussion, and Dr. Thompson replied.

A letter was received from Mr. Hickson, Commissioner for Roads, inviting the members to visit the outfall works of the Western Suburbs Sewerage Scheme, and an invitation was given by the Chairman for the members to visit the Pumping Works at Ryde.

Monthly meeting held June 15, 1892.

Mr. C. Darley in the Chair.

The Chairman read a description of the engines &c. recently erected at Ryde Pumping Station, giving the results of the tests applied, and illustrating his remarks by diagrams.

A discussion then ensued in which Messrs. Haycroft, Grimshaw, Houghton, Dare, King, Pridham, and Boys took part.

Monthly meeting held July, 20th, 1892.

Mr. C. Darley in the Chair.

The evening was devoted to a discussion on a paper by Mr. J. M. Smail, M. Inst. C.E., on the "Ventilation of Sewers and Drains," which had been read before the Royal Society on July 6th, 1892. The following gentlemen spoke—Mr. Darley, Col. Wells, Messrs. Maitland, Henson, Knibbs, Prof. Selman, and Mr. Haycroft. Mr. Smail then replied.

Monthly meeting held August, 16th, 1892.

Mr. C. Darley in the Chair.

A paper by Mr. W. F. How, A. M. Inst. C.E., on "Various Systems of Tramway Traction," was read and the discussion was adjourned to a future meeting.

Monthly meeting held September 21st, 1892.

Mr. C. Darley in the Chair.

The discussion on Mr. How's paper was opened by the Secretary reading a communication from Mr. Norman Selfe, and was continued by Messrs. Grimshaw, Thow, and Price. The further discussion was then adjourned to the next meeting.

Monthly meeting held October 19th, 1892.

Mr. C. DARLEY in the Chair.

The further discussion of Mr. How's paper was opened by Mr. R. E. Jones, and carried on by Messrs. Cowdery, Elwell, Haycroft, and Prof. Selman. Mr. How replied.

Monthly meeting held November 16th, 1892.

Mr. C. DARLEY in the Chair.

Mr. NARDIN read a paper on "Recent Bridge Building in New Zealand," by Mr. A. H. ALABASTER, with an introduction by himself. The discussion was adjourned to the next meeting.

Mr. HOUGHTON then read a paper on "Notes on the Economical use of Steam," the discussion on which was also adjourned.

Monthly meeting held December 21st. 1892.

Mr. H. DEANE in the Chair.

The discussion on Mr. Alabaster's paper was opened by Mr. Grimshaw, and continued by Mr. Parkinson, Profs. Selman and Warren, and Mr. Bell.

The discussion on Mr. Houghton's paper was further adjourned till next Session.

A paper was read by Mr. C. O. BURGE on "Light Railways for New South Wales," the discussion being adjourned till next Session.

The average attendance of members at the meetings during this Session has been twenty-six, and the number of members subscribing to the printing fund is fifty-six.

MEDICAL SECTION.

At the preliminary meeting held in April, the following officers were elected:—Chairman: Dr. THOS. FIASCHI. Committee: Prof. T. P. ANDERSON STUART, Drs. JAMES GRAHAM, WM. CHISHOLM,

W. H. GOODE, E. H. RENNIE, and A. McCORMICK. Secretaries: Drs. L. R. HUXTABLE and Walter HULL.

During the session two general meetings were held. At the first, Dr. RENNIE contributed a paper upon the subject: "Recent work on the pathology of Cancer. There was a large attendance of members, and at the conclusion of the meeting Dr. Rennie was thanked for his valuable contribution.

At the second meeting Dr. CHISHOLM read notes of a case of hydatid of the brain, and Dr. FIASCHI read those of a case of sarcoma of the testis in a cryptorchid removal. There was a fair attendance.

MICROSCOPICAL SECTION.

A preliminary meeting of this Section was held on 6th April, 1892. Dr. H. G. A. WRIGHT being in the Chair. The following officers were elected for the year:—Chairman: Mr. H. O. WALKER. Secretary: Mr. S. MACDONNELL. Committee: Dr. H. G. A. WRIGHT, Messrs. T. M. BRINDLEY, G. D. HIRST, P. R. PEDLEY, and T. F. WIESENER.

Monthly meeting 9th May, 1892.

Mr. P. R. PEDLEY in the Chair.

Dr. WRIGHT called attention to the omission in the new edition of "Carpenter on the Microscope" of the details of structure observed in mounted preparations of the foot of the blowfly, prepared by Mr. H. Sharp, of Adelong, and brought specially before the notice of the editor, the Rev. Dr. Dallinger.

Mr. KYNGDON exhibited a pattern of microscope, now out of date, but in its day considered to be one of the best of the cheap instruments of thirty years ago. The stand was known as Smith and Beck's "Universal."

Dr. WRIGHT exhibited photographs of the blowfly's tongue, showing the structure alluded to above.

Monthly meeting 13th June 1892.

Mr. P. R. Pedley in the Chair.

Dr. W. Morris exhibited Powell & Lealand's $\frac{1}{10}$th inch apochromatic objective of 1·5 numerical aperture, showing anthrax and cholera bacilli and the podura scale.

Mr. P. N. Trebeck exhibited a dipping from Port Jackson in the neighbourhood of Milson's Point, the water at the time of taking having been highly phosphorescent.

Dr. H. G. A. Wright exhibited a series of photographs showing the arrangement of suckers on the pseudo-tracheæ of the tongue of the blowfly.

Mr. S. MacDonnell exhibited a current-slide for observing growth of minute aquatic life.

Monthly meeting 11th July, 1892.

Mr. P. R. Pedley in the Chair.

Mr. G. D. Hirst exhibited a couple of positive eye-pieces mounted on handles.

Dr. H. G. A. Wright exhibited photographs of *Isthmia nervosa* and *I. enervis.*

Monthly meeting 8th August, 1892.

Dr. H. G. A. Wright in the Chair.

Dr. Wright exhibited a series of photographs illustrating the transverse markings on the difficult test diatom "amphipleura pellucida" taken with Powell & Lealand's new $\frac{1}{12}$ inch apochromatic objective after an hour's exposure. This duration gave a good result, which might have been improved had the exposure been still longer. The unaided eye is unable to see these faint striæ with the magnification of the $\frac{1}{12}$ inch—600 diameters—but photography has succeeded in fixing them on the sensitive plate.

On behalf of Dr. Morris, Mr. S. MacDonnell exhibited a somewhat rare fungus *(Æcidium bellidis)*, found on the green leaves of the common daisy. Also leaves of the marguerite and of the summer chrysanthemum infested with the various stages of development of a fly, which punctures the leaf and lays its eggs within the tissues. This insect is supposed to be the "black-horned leaf-miner," *Phytomyza nigricornis.* The name "miner" is given to the grub because it clears away the substance of the leaves in galleries.

Mr. WIESENER showed some photographic prints taken by Zeiss, the well-known optician of Jena, with an anastigmatic photographic lens that has been constructed on a new optical formula with the Schott glass. The clearness and beauty of these photographs elicited high praise.

Monthly meeting 12th September, 1892.

Mr. G. D. HIRST in the Chair.

Mr. F. B. KYNGDON exhibited Reichert's Petrological Microscope.

Rev. J. M. CURRAN exhibited a series of foreign rock sections.

Monthly meeting 10th October, 1892.

Dr. H. G. A. WRIGHT in the Chair.

Mr. WIESENER exhibited Zeiss's microscopes and high power objectives sent to the recent Medical Congress, also Abbe's aptometer and Reichert's student's microscope.

Mr. T. BRINDLEY exhibited rock sections by polarised light.

Monthly meeting 14th November, 1892.

Dr. H. G. A. WRIGHT in the Chair.

A microscopical preparation of the skin of a negro who had died in the West Indies from leprosy, showing the bacilli in great abundance, was exhibited. The slide was stained and mounted by Mr. J. McGARVIE SMITH.

A first class microscope by Carl Zeiss, optician of Jena, was shown by Mr. WIESENER, together with a three-millimetre ($\frac{1}{8}$ in.) apochromatic homogenous objective by the same maker, having a numerical aperture of 1·40.

Mr. J. C. Pound showed a slide of *Spirillum undula*, obtained from ponds in the neighbourhood of Sydney, beneath Reichert's eight-millimetre ($\frac{1}{3}$ in.) objective, which bore the extreme magnification of 500 diameters without any indistinctness, so much so that the flagellæ were clearly seen without the aid of any staining fluid.

Monthly meeting 12th December, 1892.

Dr. H. G. A. Wright in the Chair.

Dr. Wright exhibited prints of photo-micrographs of the podura scale, and photographs of the tongue of the blowfly.

ADDITIONS
TO THE
LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1892.

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

TRANSACTIONS, JOURNALS, REPORTS, &c.

Aberdeen—University Calendar for 1892-93. *The University.*

Adelaide—Mining Department. Ten (10) Geological Reports, 1882 - 1891. *The Department.*

Observatory. Meteorological Observations during 1889. *The Observatory.*

Public Library, Museum, and Art Gallery of South Australia. Report of the Board of Governors, 1891-1892. *The Director.*

Royal Society of South Australia. Transactions and Proceedings, Vol. xiv., Part ii., 1891; Vol. xv., Part i., 1892. *The Society.*

Albany—New York State Library. Regents Bulletin, Nos. 1 - 7, 1890-91. State Library Bulletin, Additions No. 1, Legislation No. 2, Library School No. 1. *The Regents.*

University of the State of New York. Annual Report (44th) of the Regents of the New York State Museum for 1890. Bulletin, Vol. i., No. 1, March, 1892. ,, AMSTERDAM—Koninklijke Akademie van Wetenschappen. Verslagen en Mededeelingen, Derde Reeks, Deel. VIII., 1891. Jaarboek voor 1891. *The Academy.*

AUCKLAND—Auckland Institute. Annual Report for 1891-2 *The Institute.*

BALLAARAT—School of Mines. Annual Report, 1891. *The Registrar.*

BALTIMORE—Johns Hopkins University. Annual Reports of the President, 8, 9, 10, 12, 13, 14, 1883-84, 85, 87, 88 and 89. American Chemical Journal, Vol. XIII., Nos. 2 - 8, 1891; Vol. XIV., No. 1, 1892. American Journal of Mathematics, Vol. XIII., Nos. 3, 4; Vol. XIV., No. 1, 1891. American Journal of Philology, Vol. XI., No. 4, 1890; Vol. XII., Nos. 1 - 3, 1891. Studies from the Biological Laboratory, Vol. V., No. 1, 1891. Studies in Historical and Political Science, Vol. IX., Nos. 1 - 12, 1891; Vol. X., Nos. 1 - 3, 1892. Circulars, Vol. XI., Nos. 92 - 100, 1891-92. Register, 1890-91. *The University.*

BATAVIA—Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indië. Natuurkundig Tijdschrift, Deel LI., Serie 8, Deel XII., 1892. Boekwerken, 1891. *The Society.*

BERGEN—Museum. Bergens Museums Aarsberetning, 1890. *The Museum.*

BERLIN—Association Géodésique Internationale. Comptes Rendus des Séances de la Commission Permanente réunie a Florence du 8 au 17 Octobre 1891. *The Association.*

Gesellschaft für Erdkunde. Verhandlungen, Band XVIII., Nos. 7 - 10, 1891; Band XIX., Nos. 1 - 7, 1892. Zeitschrift, Band XXVI., Nos. 4 - 6, 1891; Band XXVII., Nos. 1 - 3, 1892. *The Society.*

Königlich Preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 1 - 53, and Index, 1891; Nos. 1 - 25, 1892. *The Academy.*

Königlich Preussische Geodätisches Institut. Gewichtsbestimmungen für Seitenverhältnisse in schematischen Dreiecksnetzen. [1889.] Polhöhenbestimmungen aus dem Jahre 1886 &c. [1889]. *The Institute.*

Königlich Preussische Meteorologisches Instituts. Abhandlungen, Band I., Nos. 4, 5, 1892. Ergebnisse, Heft II., 1891; Heft 1, 1892. ,,

BERNE—Département Fédéral de l'Intérieur (Section des Travaux Publics). Graphische Darstellung der Lufttemperaturen &c., Bl. 1, 2, 3, Bl. I*a*, I*b*, I*c*, I*d*, II*a*, II*b*, II*c*, III., IV*a*, V*a*, V*b*, VI., 1891. Tableau graphique des observations hydrométriques suisses, Pl. 1, 2, 3, 1890, I*a*, I*b*, I*c*, I*d*, II*a*, II*b*, II*c*, III., IV., V*a*, V*b*, VI., 1891. *The Department.*

BIRMINGHAM—Birmingham and Midland Institute. Programme for Session 1892-93. Report of the Council for the year 1891. *The Institute.*

Birmingham Philosophical Society. Proceedings, Vol. VII., Part ii., Session 1890 - 1891. *The Society.*

BOLOGNA—R. Accademia delle Scienze dell' Istituto di Bologna. Memorie, Serie 4, Tomo X., 1889. Del Meridiano Iniziale e dell'ora Universale. *The Academy.*

BONN—Naturhistorischer Vereines der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück. Verhandlungen, Jahrgang XLVIII., Folge 5, Band viii., Hälfte 2, 1891; Jahrgang XLIX., Folge 5, Band ix., Hälfte 1, 1892. *The Society.*

BOSTON (Mass.)—American Academy of Arts and Sciences. Memorial of Joseph Lovering late President of the Academy [1892]. *The Academy.*

Boston Society of Natural History. By-Laws and List of Officers and Members, 1891. Proceedings, Vol. XXV., Parts i. and ii. *The Society.*

BREMEN—Naturwissenschaftlicher Verein. Abhandlungen, Band XII., Heft 2. „

BRISBANE—Chief Weather Bureau. Standard Weather Chart of Australasia and Surrounding Regions, 9 a.m., March 28, April 29, 1892. Meteorology of Australasia, 9 a.m., Feb. 17, April 1 - 4, 6 – 11, 13, 14. *Government Meteorologist.*

Department of Agriculture. Bulletins No. 14, Dec., 1891; No. 18, May 1892 (Botany, Bulletin No. v.). Lithograms of the Ferns of Queensland, by F. M. Bailey, F.L.S. *The Department.*

Geological Survey Office. (Third Report on the) Mount Morgan Gold Deposits 1892, by R. L. Jack. Alluvial Cinnabar Deposit near Kilkivan 1892, by W. H. Rands. Styx River Coal Field 1892, by W. H. Rands. New Discovery of Coal near the Callide Creek, Port Curtis District 1892, by W. H. Rands. The Physical Geology of Magnetic Island 1892 by A. G. Maitland. Moondilla Gold Field, 1891, by R. L. Jack, F.G.S. *The Survey.*

Natural History Society. Reports of Meetings, May 5, 19, June 3, July 7, Aug. 18, Sept. 1, 15, Oct. 6, 20, Nov., 1892. The Birds of Cardwell with a few Notes on those occurring at Herberton by K. Broadbent. *The Society.*

Queensland Museum. Annals No. 2, 1892. Report of Trustees for the years 1876, 1877-8, 1878-9, 1879-80, 1881-82, 1882, 1883, 1884, 1885, 1886, 1891. *The Trustees.*

Royal Geographical Society of Australasia. Proceedings and Transactions of the Queensland Branch, Vol. VII., Parts i., ii., Session 1891-92. *The Society.*

Royal Society of Queensland. Report of Meeting, 6 May, 1892. „

BRISTOL—Bristol Naturalists' Society. Proceedings, New Series, Vol. VII., Part i., (1891-92). Annual Report for year ending April 30, 1892. „

BRUSSELS—Académie Royale des Sciences, des Lettres et des Beaux Arts. Annuaire, 1890, 1891. Bulletins, 3 Ser., Tome XVII. - XX., 1889-90. *The Academy.*

Société Royale de Malacologique de Belgique. Annales, Tome XXV., 1890. Procès Verbal, Tome XIX., 1890, pp. 89 – 116; Tome XX., 1891, pp. 1 – 54. *The Society.*

BUCHAREST—Institut Meteorologique de Roumănie. Annales, Tome V., 1889. Bulletin, Jan., March - June, 1892. *The Institute.*

BUENOS AIRES—Instituto Geografico Argentino. Boletin, Tomo XII., Cuadernos 1-12, 1891-92. Revista Argentina de Historia Natural, Tomo I., Entrega 5 and 6, 1891. *The Institute.*

BUFFALO, N.Y.—Buffalo Society of Natural Sciences. Bulletin, Vol. V., No. 3, 1891. *The Society.*

CAEN—Académie Nationale des Sciences, Arts et Belles-Lettres. Mémoires, 1890, 1891. *The Academy.*

CALCUTTA—Asiatic Society of Bengal. Journal, Vol. LX., Part i., Nos. 2 and 3, 1891, Part ii., Nos. 2, 3, 4 and Index, 1891; Vol. LXI., Part i., Nos. 1, 2, 1892, Part ii., Nos. 1, 2, 1892. Proceedings, Nos. 7-10, 1891, Nos. 1-7, 1892. *The Society.*

Government of India. Scientific Results of the Second Yarkand Mission—Introductory Note and Map. Aves, by R. Bowdler Sharpe, LL.D., F.L.S. *The Government of India.*

Geological Survey of India. Memoirs, Contents and Index of Vols. I.-XX., 1859-1883, by W. Theobald [1892]; Vol XXIII. Memoirs, Palæontologia Indica, Index to the Genera and Species described in the Palæontologia Indica up to the year 1891, by W. Theobald [1892]; Ser. XIII., Vol. IV., Part ii. Records, Vol. XXIV., Part iv., 1891; Vol. XXV., Parts i.-iii., 1892. *The Director.*

CAMBRIDGE—Philosophical Society. Proceedings, Vol. VII., Parts iv.-vi. and Address by J. Willis Clark, 27 October, 1890. Transactions, Vol. XV., Parts ii. and iii., 1891-92. *The Society.*

Public Free Library. Annual Reports, (35th and 37th) 1889-90, 1891-92. *The Library.*

University Library. Annual Reports of the Library Syndicate for 1890 and 1891. „

Union Society. Annual Report, 1892. *The Society.*

Woodwardian Museum. Catalogue of the Type Fossils in the Woodwardian Museum by Henry Woods, 1891. *The Syndics of the Cambridge University Press.*

CAMBRIDGE (Mass.)—Entomological Club. *Psyche*, Vol. VI., Nos. 187-198, 1891-92. *The Club.*

Museum of Comparative Zoology at Harvard College. Annual Report of the Curator, 1890-91. Bulletin, Vol. XVI. (Geol. Ser. Vol. II.) No. 10; Vol. XX., No. 6, 1890; Vol. XXII., Nos. 1-4, 1891-92; Vol. XXIII., Nos. 1-3, 1892. Memoirs, Vol. XIV., No. 2; Vol. XVII., No. 2, 1892. *The Museum.*

CASSEL—Verein für Naturkunde. Bericht, Vols. XXXVI. and XXXVII., 1889-90. *The Society.*

CHRISTIANIA—Norwegian North-Atlantic Expedition, 1876-1878. Zoology, Vol. XXI., Crinoida, Echinida, by D. C. Danielssen. *The Editorial Committee.*

University. Jahrbuch des Norwegischen Meteorologischen Instituts für 1890. Forhandlinger, 1886. *The University.*

CINCINNATI—Cincinnati Society of Natural History. Journal, Vol. XIV., Nos. 1 - 4; Vol. XV., No. 1, 1891-92. *The Society.*

COLOMBO—Royal Asiatic Society. Journal of the Ceylon Branch, Vol. XI., No. 39, 1892; Vol. XII., No. 42, 1891. "

COPENHAGEN—Société Royale des Antiquaires du Nord. Mémoires, Nouvelle Serie, 1891, Tillæg. 1891. "

CRACOW—Académie des Sciences. Bulletin International, Nos. 4, 6 - 10. 1891; Nos. 5, 6, 1892. *The Academy.*

DENVER—Colorado Scientific Society. Proceedings, Report on the Technical Determination of Zinc (11 June 1892). Transactions, 1 Feb. 1892. On the Ore Deposits of Newman Hill. The Nature of the Chemical Elements. *The Society.*

DIJON—Académie des Sciences, Arts et Belles-Lettres. Mémoires, 4 Série, Tome II., 1890-91. *The Academy.*

DRESDEN—General Direktion der Königlichen Sammlungen für Kunst und Wissenschaft. Mittheilungen aus dem K. Mineral.-geolog. und prähistorischen Museum in Dresden, Heft X. Ueber Gefässe mit Graphit-Malerei aus Sächsischen Urnenfeldern von Dr. J. V. Deichmüller (1890). *The Director.*

K. Mineralogische Museum. Mittheilungen, Heft XI., 1892. "

K. Säch. Statistisches Bureaus. Zeitschrift, Jahrgang XXXVI., Heft 3 and 4, 1890; Jahrgang XXXVII., Heft 1 - 4, 1891. *The Bureau.*

DUBLIN—Royal Irish Academy. "Cunningham Memoirs" No. 7, 1892. Proceedings, Third Series, Vol. II., Nos. 1, 2, 1891-92. Transactions, Vol. XXIX., Part xix., 1892. *The Academy.*

DUDLEY—Dudley and Midland Geological and Scientific Society and Field Club. Proceedings, Vol. IV., No. 2, Nov. 1891. *The Club.*

EDINBURGH—Botanical Society of Edinburgh. Transactions, Vol. XIX, pp. 89 - 232. *The Society.*

Geological Society. Transactions, Vol. VI., Part iii., 1892. "

Highland and Agricultural Society of Scotland. List of Members, 1891. Transactions, 5 Ser., Vol. IV., 1892. "

Royal Physical Society. Proceedings, Vol. XI., Part i., Session 1890-91. "

Royal Scottish Geographical Society. *The Scottish Geographical Magazine*, Vol. VII., Nos. 11 and 12, 1891; Vol. VIII., Nos. 1 - 9, 1892. "

Royal Society of Edinburgh. Proceedings, Vol. XVII., 1889-90. Transactions, Vol XXXIV., Vol. XXXVI., Part i., 1889-90. "

University. Edinburgh University Calendar 1892-93. *The University.*

FLORENCE—Società Africana d' Italia. Bullettino della Sezione Fiorentina, Vol. VII., Fasc. 5, 6, 1891; Vol. VIII., Fasc. 1, 2, 3, 1892. *The Society.*

FLORENCE—*continued.*
Società Entomologica Italiana. Bullettino, Anno xxiii., Trimestre 1 – 4, 1891; Anno xxiv., Trimestre 1, 2, 1892. *The Society.*
Società Italiana di Antropologia e di Etnologia. Archivio, Vol. xxi., Fasc. 3, 1891; Vol. xxii., Fasc. 1, 1892. ,,

FORT MONROE (Va.)—United States Artillery School. Journal of the United States Artillery, Vol. i., No. 3, July 1892. *The Staff of the Artillery School.*

FRANKFURT A/M.—Senckenbergische Naturforschende Gesellschaft. Abhandlungen, Band xvi., Heft 3, 4; Band xvii., Abth 1, 2, 1884 – 1891. Bericht, 1892. Katalog der Batrachier-Sammlung im Museum, 1892. *The Society.*

FREIBURG I.B.—Naturforschende Gesellschaft. Berichte, Band iv., Heft 1 – 5, 1888-89 (complete); Band v., Heft 1, 2, 1890-91. ,,

GENEVA—Institut National Genevois. Bulletin, Tome xxx. 1890; Tome xxxi., 1892. *The Institute.*

GIESSEN—Oberhessische Gesellschaft für Natur-und-Heilkunde. Bericht, Band xxviii., 1892. *The Society.*

GLASGOW—Philosophical Society of Glasgow. Proceedings, Vol. vii., Nos. 1, 2, 3, 1868 – 71; Vol. viii., Nos. 1, 2, 1871 - 73; Vol. ix., Nos. 1, 2, 1873 - 75; Vol. x., Nos. 1, 2, 1875 – 77; Vol. xi., Nos. 1, 2, 1877 – 79; xii., complete, 1879-80; xiii., Nos. 1, 2, 1880 - 82; Vol. xiv., 1882-83; Vol. xv., 1883-84; Vol. xvi., 1884-85; Vol. xvii., 1885-86; Vol. xviii., 1886-87; xxii., 1890-91. ,,
University. Glasgow University Calendar for the year 1892-93. *The University.*

GÖTTINGEN—K. Gesellschaft der Wissenschaften und der Georg-Augusts Universitat. Nachrichten, Nos. 1 – 16, 1890; Nos. 1 – 11, 1891. ,,

GRATZ—Naturwissenschaftlicher Vereines für Steiermark. Mittheilungen, Heft 28, Jahrgang 1891. *The Society.*

HALIFAX—Yorkshire Geological and Polytechnic Society. Proceedings, New Series, Vol. xii., Part i., 1892. ,,

HALIFAX N.S.—Nova Scotian Institute of Science. Proceedings and Transactions, Vol. vii., Part iv., 1889 1890; Second Series, Vol. i., Part i., Session 1890-91. *The Institute.*

HALLE—K. Leopoldina—Carolina Deutsche Akademie der Naturforscher. Katalog der Bibliothek, Lief 3, 1891. Leopoldina, Heft. xxv., xxvi., xxvii., Jahrgang, 1889-91. Nova Acta, Vol. liv., lv., lvi., 1890-91. Geschichte, 1852 - 1887. Das Vorkommen der Naturlichen Kohlenwasserstoffund der anderen Erdgase von C. F. Zincken. *The Academy.*

HAMBURG—Colonial Museum. Beschrijvende Catalogus, Deel i. – v., 1884 – 88; Deel vi., Stuk 1 - 2, 1889-90. Bulletin, Nos. 1 – 3, 1892. Officieele Mededeelingen, Stuk ii., 1892. Overzicht van het Museum, Druk 3 Weekblad, Nos. 14 - 26, 1892. *The Museum.*

HAMBURG—*continued.*

Deutsche Meteorologische Gesellschaft. Meteorologische Zeitschrift, Nov. and Decr., 1891. *The Society.*

Deutsche Seewarte. Aus dem Archiv, Jahrgang XIV., 1891. Deutsche Ueberseeische Meteorologische Beobachtungen, Heft IV. Ergebnisse der Meteorologischen Beobachtungen, Jahrgang XIII., Lustrum 1886 - 1890. Resultate Meteorologischer Beobachtungen von Deutschen und Holländischen Schiffen für Eingradfelder des Nordatlantischen Ozeans. Quadrat 113, No. x., 1891. *The Observatory.*

Geographische Gesellschaft in Hamburg. Mittheilungen, Heft I., 1891-92. *The Society.*

Naturhistorisches Museum. Mitteilungen, Jahrgang VIII., 1890; Jahrgang IX., Hälfte 1, 2, 1891. *The Museum.*

Naturwissenschaftlicher Verein in Hamburg. Abhandlungen, Band XI., Heft 2 and 3, 1891. *The Society.*

HAMILTON (Ont.)—Hamilton Association. Journal and Proceedings, Parts vii., viii., for Sessions 1890-92. *The Association.*

HARLEM—Musée Teyler. Archives, Série 2, Vol. III., Parts v. - vii., 1890 - 92. *The Museum.*

Société Hollandaise des Sciences. Archives Néerlandaises des Sciences Exactes et Naturelles, Tome XXV., Liv. 3, 4, 1891; Tome XXVI., Liv. 1, 2, 1892. *The Society.*

HARRISBURG—Second Geological Survey of Pennsylvania. Report of Progress F^3 1888 - 1889. Atlas Western Middle Anthracite Field, Part iii. AA., 1889. Atlas Northern Anthracite Field, Part vi. AA., 1889. Southern Anthracite Field, Part iv. AA. 1889. *The Survey.*

HAVRE—Société Géologique de Normandie. Bulletin, Tome XIII., Années 1887-88-89. *The Society.*

HEIDELBERG—Naturhistorisch-Medicinischer Verein. Verhandlungen, N.F. Band IV., Heft 5, 1892. ,,

HELSINGFORS—Société des Sciences de Finlande. Bidrag, Heft 49, 50. Ofversigt, Vol. XXXII., 1889-90. Acta, Tomus XVII., 1891. ,,

HOBART—Office of Mines. Systematic Account of the Geology of Tasmania, by R. M. Johnston, F.L.S. [4° 1888]. Reports of the Inspector of Mines for 1883-4. Reports of the Secretary of Mines for 1885 - 1892. Reports on :—The North Western Mineral Deposits. Mineral Resources and Permanency of the Den Gold Field. Back Creek Gold Field. Lefroy Gold Field. Recently discovered Gold Field at Mount Victoria, County of Dorset, Tasmania. Stanniferous Deposits at Ringarooma. Waratah and Penguin Mining Districts. Mount Cleveland and Corinna Gold Fields. Western Mining Districts. Silver Lead Deposits near Mount Zeehan, Montagu County, West Coast of Tasmania. Mount Victoria, Dan Rivulet, Black Boy, and Mangana Gold Fields. Scamander Silver and Gold Deposits. Linda Gold Field: Its Auriferous and other Mineral Deposits.

HOBART—Office of Mines—*continued.*
Heazlewood Silver Lead and other Ore Deposits in the County of Russell, W. Tas. Mount Zeehan Silver and Auriferous Lead Lodes and other Ore Deposits in the County of Montagu, W. Tasmania. New Town Coal Deposits by F. W. Krausè, F.G.S. Blue Tier Tin Fields by A. Montgomery, M.A. *The Secretary for Mines.*

Royal Society of Tasmania. Papers and Proceedings, and Report for 1891. Abstract of Proceedings, April 1892—Inaugural Address to the Australasian Association for the Advancement of Science by Sir Robert G. C. Hamilton, K.C.B., LL.D., 7 Jan. 1891. *The Society.*

JEFFERSON CITY—Geological Survey of Missouri. A Preliminary Report on the Coal Deposits of Missouri, 1891. Bulletin, No. 5. *The Survey.*

IOWA—Iowa Weather and Crop Service. Monthly Review, Vol. II., Nos. 1 - 5, 1891. *The Director.*

JENA—Medicinisch Naturwissenschaftliche Gesellschaft. Jenaische Zeitschrift, N.F. Band XVIII., Heft 3, 4, 1891; Band XIX., Heft 1 - 4, 1892. *The Society.*

KIEFF—Société des Naturalistes. Mémoires, Tome X., Liv. 3 and 4, Tome XI., Liv. 1 and 2. „

KÖNIGSBERG—Physikalisch-ökonomische Gesellschaft. Schriften, Jahrgang XXXII., 1891. „

LA PLATA—Museo de La Plata. Revista, Tomo I., 1890-91; Tomo II., Entrega 2, 1891. *The Museum.*

LAUSANNE.—Société Vaudoise des Sciences Naturelles. Bulletin, 3 Ser. Vol. XXVII., No. 105; Vol. XXVIII., Nos. 106, 107, 1892. *The Society.*

LEEDS—Conchological Society of Great Britain and Ireland. Journal of Conchology, Vol. VI., No. 12, 1891; Vol. VII., Nos. 1 - 3, 1892. „

Philosophical and Literary Society. Annual Report for 1891-2. „

LEIPZIG—K. Sächsische Gesellschaft der Wissenschaften. Berichte, Math.-phys. Classe, Nos. 1 - 5, 1892. „

Vereins für Erdkunde. Mitteilungen, 1891. Beiträge zur Geographie des Festen Wassers, 1891. (Wissens. Veröffentlichungen, Band I.) „

LIEGE—Société Géologique de Belgique. Annales, Tome XVIII., Liv. 2; Tome XIX., Liv. 1 ,2, 1891-92. „

Société Royale des Sciences. Mémoires, Série 2, Tome XVII., 1892. „

LILLE—Société Géologique du Nord. Annales, Tomes XVII., XVIII., XIX., 1889 - 1891. „

LINCOLN (Nebraska)—University of Nebraska. Bulletin of the Agricultural Experiment Station, Vol. IV., No. 17, 1891; Vol. V., No. 21, 1892. Fifth Annual Report, 1891. *The University.*

LONDON—Anthropological Institute. Journal, Vol. XXI., Nos. 2 - 4, 1892. *The Institute.*

LONDON—*continued.*

British Museum. Catalogue of the Fossil Birds in the British Museum, by R. Lydekker, B.A., 1891. Catalogue of the Palæozoic Plants in the Department of Geology and Palæontology, British Museum by R. Kidston, F.G.S., 1886. Systematic List of the Frederick E. Edward's Collection of British Oligocene and Eocene Mollusca in the British Museum, by R. B. Newton, F.G.S., 1891. *The Museum.*

Geological Society. Quarterly Journal, Vol. XLVII., Part iv., No. 188, 1891; Vol. XLVIII., Parts i. - iii., Nos. 189 - 191, 1892. *The Society.*

Institution of Civil Engineers. Minutes of Proceedings, Vols. CVII. - CX., Session 1891-92, Parts i. - iv. Brief Subject—Index, Vols. LIX. - CX., Sessions 1879-80 - 1891-92. *The Institution.*

Institution of Naval Architects. Transactions, Vol. XXXIII., 1892. "

Iron and Steel Institute. Journal, No. 2, 1891, No. 1, 1892. "

Linnean Society. Journal, Botany, Vol. XXVIII., Nos. 195 and 196; Vol. XXIX., Nos. 198 - 201, 1891-92; Zoology, Vol. XXIV., Nos. 149 - 152, 1891-92. List of the Linnean Society, 1891-92. *The Society.*

Meteorological Office. Cyclone Tracts in the South Indian Ocean. Daily Weather Charts to illustrate the tracks of two Cyclones in the Arabian Sea, *Off. No. 80.* Harmonic Analysis of Hourly Observations *Off. No. 93.* Hourly Means, 1887, 1888, *Off. Nos. 94, 97.* Meteorological Charts of the portion of the Indian Ocean adjacent to Cape Guardafui and Ras Hafún. Meteorological Observations at Stations of the Second Order, 1887, *Off. No. 95.* Monthly Weather Report, May - Dec. 1887, *Off. No. 77.* Quarterly Weather Reports, Parts iii., iv., July - Sept. 1880, *Off. No. 50.* Report of the Meteorological Council for year ending 31 March, 1891. Summary of the Observations made at the Stations included in the Daily and Weekly Weather Reports for the Calendar Months Jan. - Dec., 1891. Ten Years Sunshine, 1881 - 90, *Off. No. 98.* Weekly Weather Report, Vol. VIII., Nos. 1 - 52, 1891 and Appendices. *The Meteorological Council.*

Mineralogical Society. Mineralogical Magazine, &c., Vol. IX., No. 44, 1891. *The Society.*

Pharmaceutical Society of Great Britain. Calendar for 1892. Journal and Transactions, Third Series, Vol. XXII., Nos. 1113 - 1148; Vol. XXIII., Nos. 1149 - 1166, 1891-92. "

Physical Society of London. Proceedings, Vol. XI., Parts ii. and iii., 1891-92. "

Quekett Microscopical Club. Journal, Ser. 2, Vol. IV., No. 30; Vol. V., No. 31, 1892. *The Club.*

LONDON—*continued.*

Royal Agricultural Society of England. Journal, Third Series, Vol. II., Part iv., 1891; Vol. III., Parts i., ii., Nos. 9, 10, 1892. *The Society.*

Royal Astronomical Society. Monthly Notices, Vol. LI. No. 9, Supplement Number, 1891; Vol. LII., Nos. 1 - 8, 1891-92. "

Royal College of Physicians. List of the Fellows, Members, Extra-Licentiates, and Licentiates, 1892. *The College.*

Royal College of Surgeons. Calendar, July 14, 1892. "

Royal Colonial Institute. Proceedings, Vol. XXIII., 1891-92. *The Institute.*

Royal Geographical Society. Proceedings, New Monthly Series, Vol. XIII., Nos. 11, 12, 1891; Vol. XIV., Nos. 1 - 9, 1892. *The Society.*

Royal Historical Society. Transactions, New Series, Vols. IV., V., 1889 - 91. "

Royal Institution of Great Britain. Proceedings, Vol. XIII., Part ii., No. 85, 1892. *The Institution.*

Royal Meteorological Society. Quarterly Journal, Vol. XVII., Nos. 78 - 80, 1891; Vol. XVIII., Nos. 81 - 83, 1892. Record, Vol. X., Nos. 39, 40, 1890; Vol. XI., Nos. 41 - 43, 1891. List of Fellows, March 1, 1892. *The Society.*

Royal Microscopical Society. Journal, Parts v., vi., Nos. 84, 85, 1891; Parts i. - iii., Nos. 86 - 88, 1892. Charter and Bye-Laws, List of Fellows, 1892. "

Royal Society. Philosophical Transactions, Vol. CLXXXII., Parts A. and B., 1891. Proceedings, Vol. L., 1891-2. List of Fellows, 30 Nov., 1891. "

Royal United Service Institution. Journal, Vol. XXXV., Nos. 165, 166, 1891; Vol. XXXVI., Nos. 167 - 175, 1892. List of Members to 1 Jan., 1892. *The Institution.*

Secretary of State for India. Tribes and Castes of Bengal, by H. H. Risley, Vols. I., II. Anthropometric Data. *The Secretary.*

Society of Psychical Research. Proceedings, Vol. VII., Part xx., Feb. 1892. *The Society.*

Zoological Society of London. Proceedings, Parts ii. - iv., 1891; Parts i., ii., 1892; Index 1881 - 1890. Transactions, Vol. XIII., Parts iii., iv., 1891-92. "

LUBECK—Naturhistorische Museum. Jahresbericht for 1889 and 1890. Mitteilungen Zweite Reihe, Heft 1, 2, 1890. Geschichte von Dr. Heinr. Lenz. [1889] *The Museum.*

LUXEMBOURG—Institut Royale Grand-Ducal. Publications, Tome XXI. Observations Météorologiques de 1884 - 1888. *The Institute.*

LYME REGIS—Rousdon Observatory. Meteorological Observations, Vols. VII., VIII. for the years 1890-91. *The Observatory.*

MADISON (Wis.)—Wisconsin Academy of Sciences, Arts and Letters. Transactions, Vol. VIII., 1888 - 1891. *The Academy.*

MADRAS—Government Observatory. Meridian Circle Observations 1865, 1866, 1867 and 1871, 1872, 1873. Meteorological Results, 1861 – 1890. Results of Observations of the Fixed Stars made with the Meridian Circle in the years 1874, 1875 and 1876. [4° Madras, 1892.] *The Right Honourable the Governor in Council.*

MANCHESTER—Literary and Philosophical Society. Memoirs and Proceedings, Fourth Series, Vol. v., Nos. 1, 2, 1891-92. *The Society.*

Manchester Geological Society. Transactions, Vol. XXI., Parts xi. – xx., Session 1891-92. „

MARBURG—Gesellschaft zur Beförderung der gesammten Naturwissenschaften. Sitzungsberichte, No. 1, Jan. 1890. „

University. Eighty-three Inaugural Dissertations. *The University.*

MARSEILLES—Faculté des Sciences de Marseille. Annales, Tome I., 1891-92; Tome II., Fasc. 1, 1892. *The Faculty.*

MELBOURNE—Field Naturalists' Club of Victoria. *The Victorian Naturalist,* Vol. VIII., Nos. 8 – 12; Vol. IX., Nos. 1 – 7, 1891-92. *The Club.*

Government Botanist. Iconography of Australian Salsolaceous Plants, by Baron Ferd. von Mueller, K.C. M.G., F.R.S., &c., Decades 8 and 9, 1891. *The Government Botanist.*

Government Statist. Victorian Year-Book for 1890-91, Vols. I. and II. *The Government Statist.*

Mining Department. Annual Report of the Secretary for Mines for 1891. Reports and Statistics, Quarters ending 30 June – 30 Sept. 1891. *The Secretary for Mines.*

Public Library. Catalogue of Newspapers, Magazines, Reviews, Publications of Societies and Government Periodical Publications currently received at the Melbourne Public Library, 1891. Report of the Trustees of the Public Library, Museums and National Gallery of Victoria for 1891. South Sea Languages, Vols. I. and II., by the Rev. D. MacDonald, 1889-91. *The Trustees.*

Royal Geographical Society of Australasia, Victorian Branch. Transactions, Vol. IX., Part ii., May 1892. *The Society.*

Royal Society of Victoria. Proceedings, New Series, Vol. IV., Parts i., ii., 1892. Transactions, Vol. II., Part ii., 1891. „

Victorian Institute of Surveyors. Transactions and Proceeeings, Vol. III., 1885 – 91. *The Institute.*

Working Men's College. Reports for 1889, 1890, 1891. *The College.*

METZ—Vereins für Erdkunde. Jahresbericht XIII. für 1890-91. *The Society.*

MEXICO—Observatorio Astronómico Nacional de Tacubaya. Anuario Año XII., 1892. Boletin, Tome I., Núms 6 – 11, 1891. *The Observatory.*

Observatorio Meteorológico-Magnético Central. Boletin Mensual, Tomo III., Núm 3, 1890. „

Sociedad Cientifica "Antonio Alzate." Memorias y Revista, Tomo IV., Cuadernos Núms 5, 6, 11, 12, 1890-91; Tomo V., Cuadernos Núms 1 – 12, 1891-92; Tomo VI., Cuadernos Núms 1, 2, 1892-93. *The Society.*

MILAN—Reale Istituto Lombardo di Scienze e Lettere. List of Members 1892. Rendiconti, Serie 2, Vol. XXIII., 1890. *The Institute.*

Società Italiana di Scienze Naturali. Atti, Vol. XXXIII., 1890. *The Society.*

MINNEAPOLIS—Minnesota Academy of Natural Sciences. Bulletin, Vol. III., No. 2, 1891. *The Academy.*

MODENA—R. Accademia di Scienze, Lettere ed Arti. Memorie, Serie 2, Vol. VII. [1890] *The Academy.*

MONTPELLIER—Académie des Sciences et Lettres. Mémoires, Section des Sciences, Tome XI., No. 2, 1887. „

MONTREAL—Natural History Society. *The Canadian Record of Scienee,* Vol. IV., Nos. 6 – 8, 1891; Vol. V., Nos. 1 – 3, 1892. *The Society.*

MOSCOW—Société Impériale des Naturalistes. Bulletin, Nos. 2 – 4, 1891; No. 1, 1892. *The Society.*

MULHOUSE—Société Industrielle de Mulhouse. Bulletin, Sept. – Dec. 1891, Jan. – July, 1892. Chemin de Fer de Strasbourg a Bale. Notes et Documents historiques présentés par M. P.-D. Bazaine, 1891. Le Transport de la Force par l'electricité, 1892. Lois Allemandes sur les Brevets d' Invention (7 Avril 1891) et sur les Modèles de Fabrication (1 Juin 1891) mises en vigueur 1 Oct. 1891. Programme des Prix proposés en Assemblée générale le 25 Mai 1892, A Décerner en 1893. Table générale des Matières de Vol. I. – LX., 1826 – 1890. Table des Matières du Programme des Prix proposés pour l'année 1891-92. Table des Matières des sujets traités aux Comités d'utilité publique de commerce, et d' histoire de statistique et de géographie, 1891. „

MUNCHEN—Bayerische Botanische Gesellschaft. Berichte, zur Erforschung der heimischen Flora, 1891. „

NANTES—Société des Sciences Naturelles de l'Ouest de la France. Bulletin, Tome I., 1891; Tome II., Nos. 1 and 2, 1892. „

NAPLES—Società Africana d' Italia. Bollettino, Anno X., Fasc. 5 – 12, 1891; Anno XI., Fasc. 1 – 6, 1892. „

Società Reale di Napoli. Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche, Ser. 2, Vol. IV., Fasc. 1 – 12, 1890; Vol. VI., Fasc. 1 – 6, 1892. „

Stazione Zoologica. Mittheilungen, Band X., Heft 1 – 3, 1891-92. *The Director.*

NEWCASTLE-UPON-TYNE—North of England Institute of Mining and Mechanical Engineers. Annual Report of the Council &c., 1890-91. Transactions, Vol. XXXVIII., Part vi.; Vol. XL., Parts 1 – 4, 1891; Vol. XLI., Parts 1 – 4, 1892. *The Institute.*

Northumberland, Durham and Newcastle-upon-Tyne Natural History Society. Transactions, Vol. XI., Part i., 1892. *The Society.*

NEW YORK—American Chemical Society. Journal, Vol. XIII., Nos. 7 – 10, 1891; Vol. XIV., Nos. 1 – 7, 1892. „

New Yord—*continued.*
American Geographical Society. Bulletin, Vol. xxiii., No. 4, Parts i., ii., 1891; Vol. xxiv., Nos. 1, 2, 1892. *The Society.*
American Museum of Natural History. Annual Report of the President &c. for 1891. Bulletin, Vol. iii., Nos. 1, 2, 1891-92. „
Journal of Comparative Medicine and Verterinary Archives, Vol. xii., Nos. 10 - 12, 1891; Vol. xiii., Nos. 1 - 3, 1892. *The Editor.*
New York Academy of Sciences. Annals, Vol. v., Extra Nos. 1 - 3, 1891. Transactions, Vol. x., Nos. 2 - 6, 1890-91. *The Academy.*
New York Microscopical Society. Journal, Vol. vii., No. 4, 1891; Vol. viii., Nos. 1 - 3, 1892. *The Society.*
School of Mines, Columbia College. *The School of Mines Quarterly,* Vol. xiii., Nos. 1 - 4, 1891-92. *The School of Mines.*

Ottawa—Geological and Natural History Survey of Canada. Annual Report, New Series, Vol. iv., 1888-89, and Parts D. and N. Catalogue of Canadian Plants, Part vi., Musci, by John Macoun, M.A., F.L.S., 1892. Contributions to Canadian Micro-Palæontology, Part iii., by Prof. T. Rupert Jones, F.R.S., 1892; Part iv., by Dr. D. Rüst, 1891. *The Director.*

Oxford—Radcliffe Library. Catalogue of Books added during 1890. *The Trustees.*
Radcliffe Observatory. Results of Astronomical and Meteorological Observations made in the year 1887, Vol. xlv. [1891] „

Palermo—Reale Accademia di Scienze Lettere e Belle Arti. Bullettino, Anno ix., Nos. 1 - 3, 1892. *The Academy.*

Paris—Académie des Sciences de l' Institut de France. Comptes Rendus, Tome cxiii., Nos. 21 - 26, 1891; Tome cxiv., Nos. 1 - 26, Tome cxv., Nos. 1 - 17, 1892. „
Ecole d' Anthropologie de Paris. Revue Mensuelle, Année i., Nos. 11, 12, 1891; Année ii., Nos. 1 - 10, 1892. *The Director.*
Ecole Nationale des Mines des Paris. Statistique de l'Industrie Minérale et des appareils à vapeur en France et en Algérie pour l'année, 1890. *Ministére des Travaux Publics.*
Ecole Polytechnique. Journal, Cahier 60 - 62, 1890-92. *The Director.*
Feuille des Jeunes Naturalistes. Catalogue de la Bibliothèque, Fasc. No. 2, 1888; Nos. 11 - 13, 1891; No. 15, 1892. Revue Mensuelle d' Histoire Naturelle, Anne xxii., Nos. 253 - 265, 1892. *The Editor.*
Institut Pasteur. Annales, Tome v., Nos. 9 - 12, 1891; Tome vi., Nos. 1 - 8, 1892. *The Institute.*
Observatoire de Paris. Rapport Annuel for 1891. *The Observatory.*
Société d' Anthropologie de Paris. Bulletins, 4 Sér. Tome i., Fasc. 2 - 4, 1890; Tome ii., Fasc. 1 - 4, 1891. Mémoires 2 Ser., Tome iv., Fasc. 2, 3, 1890-92. *The Society.*
Société de Biologie. Comptes Rendus, Série 9, Tome iii., Nos. 28 - 38, 1891; Tome iv., Nos. 1 - 31, 1892. „
Société d' Encouragement pour l' Industrie Nationale. Bulletin, 4 Série, Tome vi., 1891. „

PARIS—*continued.*

Société Entomologique de France. Bulletin, 1890, 1891 complete, Nos. 1, 2, 1892. *The Society.*

Société Française de Minéralogie. Bulletin, Tome xiv., Nos. 6 – 8, 1891; Tome xv., Nos. 1 – 6, 1892. „

Société Française de Physique. Bulletin Bimensuel Nos. 1, 3. 4, 6 – 9, 1892. Séances, Mai – Decémbre, 1891, Janvier – Avril, 1892. „

Société de Géographie. Bulletin, 7 Série, Tome xii., Trimestre 3, 4, 1891. Tome xiii., Trimestre 1, 2, 1892. Comptes Rendus, Nos. 2, 16 – 20, 1891; Nos. 1 – 14, 1892. „

Société Géologique de France. Bulletin, 3 Ser., Tome xviii., No. 9, 1890; Tome xix., Nos. 7 – 13, 1891; Tome xx., No. 1, 1892. „

Société Zoologique de France. Bulletin, Tome xvi., Nos. 3, 8 – 10, 1891; Tome xvii., Nos. 1, 2 4 – 6, 1892. Mémoires, Tome iii., Part v., 1890; Tome iv., Parts iii. – v., 1891; Tome v., Parts i. – 4, 1892. „

PERTH—Geological Survey of Western Australia. Annual General Report for 1888-1889, 1890, by Harry Page Woodward, F.G.S., F.R.G.S., Govt. Geologist. Catalogue of Exhibits at the International Exhibition of Mining and Metallurgy, London, 1890 with appendix. Report on the Gold Fields of the Kimberley District, 1891. *The Survey.*

PHILADELPHIA—Academy of Natural Sciences. Proceedings, Parts i. – iii., 1891; Part i., 1892. *The Academy.*

American Entomological Society. Transactions, Vol. xvii., Nos. 2 – 4, 1890; Vol. xviii., Nos. 1 – 3, 1891. *The Society.*

American Philosophical Society. Proceedings. Vol. xxix., Nos. 135, 136, 1891; Vol. xxx., Nos. 137, 138, 1892. List of Surviving Members, Jan. 9, 1892. „

Franklin Institute. Journal, Vol. cxxxii., Nos. 791, 792, 1891; Vol. cxxxiii., Nos. 793 – 798; Vol. cxxxiv., Nos. 799 – 802, 1892. *The Institute.*

Zoological Society. Annual Report (20th) of the Board of Directors, 28 April, 1892. *The Society.*

PISA—Società Toscana di Scienze Naturali. Atti, Memorie, Vol. vi., Fasc. 3, 1892. Processi Verbali, Vol. vii., pp. 81 – 96, 129 – 346; Vol. viii., pp. 1 – 84. „

PRAGUE—Königlich Böhmische Gesellschaft der Wissenschaften. Math. Natur, Classe, Abhandlungen, Folge 7, Band iv., 1890-91; Sitzungsberichte 1891. Philos. Histor. Philolog. Classe, Abhandlungen, Folge 7, Band iv., 1890-91; Sitzungsberichte 1891. Jahresbericht 1891. O Theorii Ploch napsal Eduard Weyr. (Cislo vi., 1891.) „

RIO DE JANEIRO—Observatoire Impérial. Revista do Observatorio, Anno vi., Nos. 9 – 12, 1891. *The Observatory.*

ROCHESTER (N.Y.)—Geological Society of America. Bulletin, Vols. i. and ii., 1890-91. *The Society.*

ROME—Accademia Pontificia dei Nuovi Lincei. Atti, compilati dal segretario, Anno XLIII., Sessione VIIa, 1890; Anno XLIV., Sessione Ia – VIa, 1891. *The Academy.*

Biblioteca e Archivio Tecnico. Giornale del Genio Civile, Anno XXIX., Fasc. 9 – 12, 1891 ; Anno XXX., Fasc. 1 - 7, 1892. *Minister of Public Instruction, Rome.*

Biblioteca Nazionale Centrale Vittorio Emanuele di Roma. Bullettino, Vol. VI., Nos. 10, 11, 1891 and Indice Alfabetico ; Vol. VII., Nos. 13, 14, 1892. *The Library.*

R. Accademia dei Lincei. Atti, Serie quarta, Rendiconti, Vol. VII., Fasc. 7 – 12, Semestre 2, 1891 ; Serie quinta, Rendiconti, Vol. I., Fasc. 1 - 12, Semestre 1, Fasc. 1 – 7, Semestre 2, 1892. Rendiconto dell' adunanza solenne del 5 Giugno 1892. Onorata dalla presenza di S. M. Il Re. *The Academy.*

R. Comitato Geologico d'Italia. Bollettino, Vol. XXII., Nos. 3, 4, 1891 ; Vol. XXIII., No. 1, Vol. XXIV., No. 2, 1892. *The Committee.*

R. Ufficio Centrale di Meteorologia e di Geodinamica. Annali, Serie II., Vols. III. - VII., Parts i. – iii., 1881 - 1885 ; Vol. VIII., Parts i. – iv., 1886 ; Vol. IX., Parts i. - v., 1887 ; Vol. X., Parts i. - iv., 1888 ; Vol. XI., Part iii., 1889. *The Director.*

Società Geografica Italiana. Bollettino, Ser. 3, Vol. IV., Fasc. 10 - 12, 1891 ; Vol. V., Fasc. 1 – 7, 1892. *The Society.*

Società Romana per gli Studi Zoologici. Bollettino, Vol. I., Nos. 1 – 5, 1892. ,,

ST. ETIENNE—Société de l' Industrie Minérale. Bulletin, 3 Ser., Tome IV., Liv. 4, 1890 ; Tome V., Liv. 2, 3, 1891 and Atlas. Comptes Rendus Mensuels, Jan. Oct. – Dec., 1891 ; Jan. - Mar., 1892. ,,

ST. LOUIS—Academy of Science. The Total Eclipse of the Sun, Jan. 1, 1889. A Report of the Observations made by the Washington University Eclipse Party at Norman, California. *The Academy.*

SAINT PETERSBURG—Académie Impériale des Sciences. Bulletin, Tome XXXII., No. 4, Supplement ; Tome XXXIV., N.S. Tome II., Nos. 1 – 4, 1891-92. ,,

Comité Géologique Institut des Mines. Bulletins, Tome IX., Nos. 9, 10, 1890 ; Tome X., Nos. 1 – 9, and Supplement, 1891; Tome XI., Nos. 1 - 4, 1892. Mémoires, Tome XI., No. 2, 1891 ; Tome XIII., No. 1, 1892. *The Committee.*

Russisch-Kaiserl. Mineralogische Gesellschaft. Verhandluugen, Ser. 2, Band XXVIII., 1891. *The Society.*

SALEM (Mass.)—American Association for the Advancement of Science. Proceedings, Vol. XXXIX., 1890, Indianapolis Meeting. *The Association.*

Essex Institute. Bulletin, Vol. XXI., Nos. 7 – 12, 1889. Vol. XXII., Nos. 1 – 12, 1890. Historical Collections, Vols. XXV. and XXVI., 1888 and 1889. Our Trees, by John Robinson. (8° Salem, 1891.) *The Institute.*

SAN FRANCISCO—California Academy of Sciences. Proceedings, Second Series, Vol. III., Part i., 1891. *The Academy.*

SANTIAGO—Deutsche Wissenschaftliche Vereins. Verhandlungen, Band II., Heft 3, 1891. *The Society.*

SCRANTON Pa.—The Colliery Engineer Co. *The Colliery Engineer,* Vol. XII., Nos. 4 - 12, 1891-92; Vol. XIII., Nos. 1 – 3, 1892. *The Proprietors.*

SINGAPORE—Royal Asiatic Society. Journal of the Straits Branch, No. 23, June 1891. *The Society.*

STAVANGER—Museum. Aarsberetning for 1891. *The Museum.*

STAWELL—The Stawell Technical College and School of Mines. Technics, Vol. I., Nos. 1 – 7, 1892. *The Director.*

STUTTGART—K. Statistisches Landesamt. Württembergische Jahrbücher für Statistick und Landeskunde, Band I., Heft 1 - 3, Jahrgang 1890 ond 1891. *The "Landesamt."*

Württembergische Vereins für Handelsgeographie. Jahresbericht IX. u. X., 1890 und 1891. *The Society.*

STRASSBURG I.E.—Centralstelle des Meteorologischen Landesdienstes in Elsass-Lothringen. Ergebnisse der Meteorologischen Beobachtungen im Reichsland Elsass-Lothringen im Jahre 1890. *The Director.*

SYDNEY—Australasian Association for the Advancement of Science. Report of the Third Meeting held at Christchurch, N.Z., Jan. 1891, Vol. III. *The Association.*

Australian Museum. Catalogue of the Marine Shells of Australia and Tasmania, Part i., Cephalopoda, Part ii., Pteropoda, by John Brazier, C.M.Z.S., F.L.S. (*Cat. No. 15).* Records, Vol. I., No. 10 and Contents and Index, 1891; Vol. II., Nos. 1 – 3, 1892. Report of the Trustees for 1891. Report regarding the proposed establishment of a National Aquarium in Sydney. *The Trustees.*

Board of Health. Coast Hospital, Little Bay, Report for 1891. Dairies Supervision Act, Report on administration of, for the year 1891. Epidemic of Influenza during 1891, Report on. Government Laboratory, Report for 1891. Leprosy in New South Wales, Report on, for 1891. Maintenance of Sick Paupers, Report on vote for the year 1891. Typhoid Fever in Sydney and Suburbs from 1876 to 1891. Vaccination, Report for 1891. Vessels arriving at and leaving Ports of N.S. Wales, Returns for 1891. *The Board.*

Colonial Treasurer. An Australian Language as spoken by the Awabakal, the people of Awaba or Lake Macquarie, by L. E. Threlkeld, edited by John Fraser, B.A., LL.D., [1892] *The Colonial Treasurer.*

Department of Agriculture. Handbook of Australian Fungi, by M. C. Cooke, M.A., LL.D., 1892. *The Agricultural Gazette,* Vol. II., Parts X. – xii., 1891; Vol. III., Parts i. – x., 1892. Index to Vol. I., 1890. *The Department.*

Department of Public Instruction. *The New South Wales Educational Gazette,* Vol. I., Nos. 7 – 12, 1891-1892; Vol. II., Nos. 1 – 6, 1892, Technical Education Series. No. 8 Report on a Beetle destroying boots and shoes in Sydney, by Walter W. Froggatt, 1891. No. 9, Illustrations of Types of Wool. No. 10, A Bibliography of Australian Economic Botany, Part i., by J. H. Maiden, F.L.S., F.C.S., 1892. "

SYDNEY—*continued.*

Engineering Association of New South Wales. Minutes of Proceedings, Vol. v., 1889-90. *The Association.*

Free Public Library. Report from Trustees for 1891. *The Trustees.*

Government Printer. The Statutes of N.S. Wales (Public and Private), passed during the Session of 1891-2. *The Government Printer.*

Horticultural Society of N.S. Wales. *The Horticulturist,* Vol. I., Nos. 1, 2, 3, 5, 7, 8, 10, 1892. *The Society.*

Institution of Surveyors, N.S. Wales. *The Surveyor,* Vols. III., IV., 1890-91; Vol. IV., Nos. 1 – 11, 1892. *The Institution.*

Linnean Society of New South Wales. Proceedings, Second Series, Vol. VI., Parts 2 – 4, 1891; Vol. VII., Parts 1, 2, 1892. In Memoriam Sir William Macleay KT., F.L.S., M.L.C. *The Society.*

Mining Department. Annual Report for 1891. Memoirs of the Geological Survey of N.S. Wales, Palæontology, No. 5, Part ii., 1892; No. 8, Part ii., 1891. Records, Vol. II., Part iv., Vol. III., Part i., 1892. Report on Artesian Boring by J. W. Boultbee, 1892. *The Department.*

Observatory. Physical Geography and Climate of New South Wales by H. C. Russell, B.A., C.M.G., F.R.S., (Second edition) 1892. Results of Meteorological Observations made in N.S. Wales during 1880 to 1884 incl., and 1889. Results of Rain, River, and Evaporation Observations made in N.S. Wales during 1890. *The Observatory.*

Sydney Architectural Association. S. A. A. Notes, Vol. I., Nos. 9 – 12; Vol. II., Nos. 1 – 7, 1892. *The Association.*

Technological, Industrial, and Sanitary Museum. Tenth and Final Report of the Committee of Management for 1889. Report of Curator for 1890. *The Museum.*

University. Calendar of the University of Sydney for the year 1892. *The University.*

TAIPING—*The Perak Government Gazette,* Vol. IV., Nos. 35 – 41, 1891 and Index; Vol. V., Nos. 1 – 35, 1892. *Secretary to the Government.*

TOKIO—Asiatic Society of Japan. Transactions, Vol. XIX., Parts ii. and iii., 1891. *The Society.*

Imperial University of Japan. Journal of the College of Science, Vol. IV., Part ii., 1891; Vol. V., Parts i., ii., 1892. The Calendar for the years 1890-91 and 1891-92. *The University.*

Seismological Society of Japan. Transactions, Vol. XVI., 1892. *The Society.*

TORONTO—Canadian Institute. Annual Archæological Report (Session 1891). An Appeal to the Canadian Institute on the Rectification of Parliament, by Sandford Fleming, C.M.G., LL.D., &c. 1892. Fourth Annual Report (Session of 1890-91). The General Adoption of the Twenty-four-o'clock Notation on the Railways of America, 1892. Time-Reckoning for the Twentieth Century by Sandford Fleming, C.M.G., LL.D., C.E. Transactions, Vol. I., Part ii., No. 2, 1891; Vol. II., Parts i., ii., No. 3, 4, 1891-92. *The Institute.*

TOULOUSE—Académie des Sciences, Inscriptions et Belles-Lettres. Mémoires, N.S., Tome III., 1891. *The Academy.*

TRENTON—New Jersey Natural History Society. Journal, Vol. II., No. 2, Jan. 1891. *The Society.*

TRIESTE—Osservatorio Marittimo. Rapporto Annuale, Vol. V., 1888; Vol. VI., 1889. *The Observatory.*

Società Adriatica di Scienze Naturali. Bollettino, Vol. XIII., Parts i. and ii., 1891-92. *The Society.*

TROMSO—Tromso Museum. Aarshefter, Vol, XIV., 1891. *The Museum.*

TURIN—Osservatorio Astronomico della R. Università di Torino. Aschieri (Tomaso)—Effemeridi del Sole e della Luna, per l'orizzonte di Torino e per l'anno, 1892. Rizzo (G. B.)—Osservazioni Meteorologiche fatte nel l'anno 1890; Di un notevole tipo isobarico Subalpino; Variazioni prodotte dal calore in alcuni spettri d' assorbimènto. *The Observatory.*

VENICE—Reale Istituto Veneto di Scienze, Lettere ed Arti. Atti, Tomo XXXVIII., Ser. 7, Tomo II., Disp. 1-10, 1890-91. Memorie, Tomo XXIII., 1890. *The Institute.*

VIENNA—Anthropologische Gesellschaft. Mittheilungen, Band XXI., (N.F. XI.) Heft 4-6, 1891; Band XXII., (N.F. XII.) Heft 1, 2, 1892. *The Society.*

Kaiserliche Akademie der Wissenschaften. Sitzungsberichte, Math. Natur. Classe—

Abtheilung,	I.,	Band XCIX.,	Heft 4-10,	1890
,,	IIa,	,,	,, 4-10,	,,
,,	IIb,	,,	,, 4-10,	,,
,,	III.,	,,	,, 4-10,	,,
Abtheilung,	I.,	Band C.,	Heft 1-7,	1891
,,	IIa,	,,	,, 1-7,	,,
,,	IIb,	,,	,, 1-7,	,,
,,	III.,	,,	,, 1-7,	,,

The Academy.

K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Jahrbücher, [Officielle publication] Jahrgang 1890, N.F. Band XXVII., *The Institute.*

K. K. Geographische Gesellschaft. Mittheilungen, Band XXXIV., (N.F. XXIV.) 1891. *The Society.*

K. K. Geologische Reichsanstalt. Jahrbuch, Band XL., Heft 3, 4, Jahrgang 1890; Band XLI., Heft 1-3, Jahrgang 1891. Verhandlungen, Nos. 8-18, 1891; Nos. 1-10, 1892. *"The Reichsanstalt."*

K. K. Gradmessungs-Bureau. Astronomische Arbeiten, Band III., 1891. Zur Einführung der mitteleuropäischen Zeit in Wien, von Dr. Robert Schram. *The Bureau.*

K. K. Naturhistorische Hofmuseum. Annalen, Band VI., Nos. 1, 2, 1892. *The Museum.*

K. K. Zoologisch-Botanische Gesellschaft. Verhandlungen, Band XLI,, Quartal 1-4, 1891. *The Society.*

WASHINGTON—American Historical Association. Annual Report for the year 1889. *The Association.*

Bureau of Education. Circular of Information, No. 1, 1891, Whole No. 170—[Contributions to American History No. 10]. Circular, Nos. 3, 7, 1891, Whole Nos. 173, 177. Report of the Commissioner of Education, Vols. I. and II., 1888-89. *The Bureau.*

WASHINGTON—*continued.*

Bureau of Ethnology. Bibliography of the Algonquian Languages by J. C. Pilling, 1891. Catalogue of Prehistoric Works East of the Rocky Mountains by Cyrus Thomas, 1891. Contributions to North American Ethnology, Vol. II., Parts i., ii., 1890; Vol. VI., 1890. (U.S. Geog. and Geol. Surv. of the Rocky Mountain Region) Omaha and Ponka Letters by James Owen Dorsey, 1891. *The Bureau.*

Chief of Engineers, (U.S. Army). Annual Reports for 1890, Parts i. – iv.; 1891, Parts i. – 6. *Engineer Department U.S. Army.*

Department of Agriculture. Division of Chemistry, Bulletin, Nos. 13, 32, 34, 1891-92; Entomology, Bulletin, No. 27, 1891; Ornithology and Mammalogy —North American Fauna, No. 5, 1891, Statistics, New Series, Reports No. 90 – 98, Index to Reports, Nos. 81 – 91: Reports on Condition of Crops, July, Aug. Sept., 1892; Vegetable Pathology, Bulletin, No. 1, 1891. Farmers' Bulletin, Nos. 7, 9, 1892. Fibre Investigations, Report No. 4, 1892. Report of the Secretary of Agriculture, 1891. Report on the Uue of Maize (Indian Corn) in Europe and on the possibilities of its extension. *The Department.*

Director of the Mint. Annual Report for the Fiscal year ended June 30, 1891. Report upon the Production of the Precious Metals in the United States during the Calendar Year 1891. *The Director.*

National Academy of Sciences. Constitution and Membership, May 5, 1892. *The Academy.*

Office of Indian Affairs. Report of the Commissioner, Vols. I., and II., 1892. *The Commissioner.*

Secretary of the Treasury. Annual Report for the year 1891. Annual Report on the State of the Finances for the year 1891, pp. 1 – 64. *The Secretary.*

Smithsonian Institution. Annual Reports of (Report of the National Museum) the Board of Regents, years ending June 30, 1889 and July, 1890. Smithsonian Miscellaneous Collections, Nos. 594, 663, 785, Vol. XXXIV. Smithsonian Contributions to Knowledge, No. 801, Vol. XXVII. (Experiments in Aerodynamics by S. P. Langley). *The Institution.*

U.S. Geological Survey, Annual Report (Tenth) 1888-9 Part i., Geology, Part ii., Irrigation. Bulletin, Nos. 62, 65, 67 – 81 incl. 1890-91 *The Survey.*

U. S. Hydrographic Office. Charts—No. 1280, Great Circle Sailing Chart of the North Atlantic Ocean; No. 1281, South Atlantic Ocean; No. 1282, North Pacific Ocean; Nos. 1283, South Pacific Ocean; No. 1284, Indian Ocean; No. 1290, The West Indies with the Gulf of Mexico and Caribbean Sea; No. 1294, North America, West Coast of Lower California Abreojos Anchorage and Vicinity; 1310, Ditto, Cerros Island to Abreojos Point; No. 1335, Ditto, Topolobampo Harbor. Notice to Mariners, Nos. 39 – 52, 1891 and Index; Nos. 1 – 38, 1892. Pilot Chart of the North Atlantic Ocean, Sept. 1892. *The U.S. Hydrographer.*

WASHINGTON—*continued.*
U.S. Patent Office. The Official Gazette of the U.S. Patent Office, Vol. LVII., No. 6, 1891. *The Office.*
War Department. Report of the Secretary of War, Vol. I., Vol. II., Parts 1-4, Vols. III., IV., 1890. *The Department.*

WELLINGTON, N.Z.—Colonial Museum and Geological Survey of N.Z. Annual Report (26th) on the Colonial Museum and Laboratory, 1890-91. Reports of Geological Explorations during 1890-91, No. 21. *The Director.*
Department of Mines. Reports of the Mining Industry, 1879 to 1892 incl. *The Under Secretary for Mines.*
New Zealand Institute. Transactions and Proceedings Vol. XXIV., N.S. Vol. VII., 1891. *The Institute.*
Polynesian Society. Journal, Vol. I., Nos. 1-3, 1892. *The Society.*

WINNIPEG—Historical and Scientific Society of Manitoba. Annual Reports for 1890 and 1891. Transactions, Nos. 40-43, Seasons 1890-92. „

ZAGRAB (Agram)—Société Archéologique Croate. Viestnik, Godina I., II., 1879, 1880; Godina, XII., Br. 1, 1890. Godina XIII., Br. 4, 1891; XIV., Br. 1-3, 1892. „

ZURICH—Naturforschende Gesellschaft. Vierteljahrschrift, Band XXXVI., Heft. 1-4, 1891; Band XXXVII., Heft 1, 2, 1892. Neujahrsblatt, No. XCIV., 1892. „

MISCELLANEOUS.

(Names of Donors are in *Italics.*)

Baltet, M. Carlos—El Corrimiento de las Uvas, 1890. *D. Mariana Vergara.*

Bragg, W. H., M.A.—Address by the President of Section A. Astronomy, Mathematics, Physics, and Mechanics at the Fourth Meeting of the Australasian Association for the Advancement of Science, held at Hobart, Jan. 7, 1892. *The Author.*

Bruck, Ludwig—The Australasian Medical Directory and Handbook, Third Edition, 31 Aug. 1892. „

Buchanan, J. Y., F.R.S.—On the composition of Oceanic and Littoral Manganese Nodules, 1891. On the Occurrence of Sulphur in Marine Muds and Nodules, and its bearing on their Mode of Formation. „

Chandler, C. F., PH.D., LL.D.—Photo-Mechanical Processes. *Prof. Liversidge,* M.A., F.R.S.

Columbia College in the City of New York, Part IV. School of Mines Annual Register 1891-92. „

Cudmore, P.—The Civil Government of the States, and the Constitutional History of the United States, 1875, (Second edition). *The Author.*

Dendy, A., D.Sc., F.L.S., and Lucus, A. H. S., M.A., B.Sc.—An Introduction to the Study of Botany. *The Publishers.*

Dollfus, G., and Ramond, G.—Bibliographie de la Conchyliologie du Terrain Tertiaire Parisien, 1886. *The Authors.*

Gilchrist, Douglas A., B.Sc.—Second Report of Manurial Experiments on Pasture Land during 1890 and 1891. *The Author.*

Graham, James, M.A., M.D.—Hydatid Disease in its Clinical Aspects (1891) 8° Edinburgh and London. *The Author.*

Hart, Ludovico W.—The Mysteries of the Unseen World. „

Hein, Alois Raimund—Mäander Kreuze, Hakenkreuze uud Urmotivische Wirbelornamente in Amerika. „

Hutton, Capt. F. W., F.G.S.—The Moas of New Zealand (*Reprinted from Trans. N.Z. Inst.*, Vol. XXIV.) „

Jack, R. L.—Report on Moondilla Gold Field, Q'land, 1891. „

King, Hon. P. G., M.L.C.—Comments on Cook's Log (H.M.S. Endeavour, 1770) with Extracts, Charts and Sketches, April 1891. „

Loir, Dr. Adrien—La Microbiologie en Australie, 1892. „

Manouvrier, Dr. L.—La Détermination de la Taille d' après les grands os des Membres, 1892. „

Marcou, Jules—Biographical Notice of Ebenezer Emmons, 1891. Geology of the Environs of Quebec, with Map and Sections. „

Moody, T. P., M.E.—How Nature produces Gold, 1892. „

Palmieri, L.—Sul periodo diurno dell' elettricità atmosferica. „

Pfeil, L. Graf von—Kometische Strömungen auf der Erdoberfläche und das Gesetz der Analogie im Weltgebäude

Ramond, G.—Esquisse Géologique de l'Aqueduc de dérivation vers Paris des Sources de la Vallée d'Avre (1) (*Extrait du Bulletin de la Société Géologique de France.* 1891). Asie et Océanie. (*Extrait de l' Annuaire Géologique Universel,* 1890.) „

Ramond, G. and Dollfus, G.—Notice Explicative du Profil Géologique du Chemin de Fer de Mantes a Argenteuil. (*Extrait du Bulletin de la Société Géol. de France* 1891.) „

Rands, William H.—Report on New Discovery of Coal near the Callide Creek, Port Curtis District, Queensland, 1891. *R. L. Jack,* F.G.S.

Ray, Sidney H.—Note on the People and Languages of New Ireland and Admiralty Islands. Note on a Vocabulary of Ulia. Vocabulary of the Tangoa Dialect, Espiritu Santo, New Hebrides. *The Author.*

Report of the Carrington Centennial Hospital for Convalescents, Camden, for the year ending Decr. 31, 1891. *The Secretary.*

Russell, H. C., B.A., C.M.G., F.R.S.—Description of the Star Camera at the Sydney Observatory. President's Address delivered to the Royal Society of New South Wales, 4 May, 1892. *The Author.*

Tate, Prof. Ralph, F.L.S., F.G.S.—Descriptions of New Species of Australian Mollusca, Recent and Fossil. A Second Supplement to a List of the Lamellibranch and Palliobranch Mollusca of South Australia. The Gastropods of the Older Tertiary of Australia, Part iii., and Plates. A Bibliography and Revised List of the Described Echinoids of the Australian Eocene, with Descriptions of some New Species. „

Tebbutt, John, F.R.A.S., &c.—Results of Meteorological Observations at Windsor, N.S. Wales in 1886-7-8-9-90. Results of Double-star Measures with the 8 inch Equatorial at Windsor, N.S. Wales in 1891. Report of Mr. Tebbutt's Observatory, The Peninsula, Windsor, N.S. Wales, for the year 1891. The Conjunction of Venus and Jupiter 1891, April 7, Observed at Windsor, N.S. Wales. The Conjunction of Venus and Jupiter, Feb. 6, 1892. (As a test of the powers of unassisted vision.) *The Author.*

Tommasi, Dott. B.—Thermæ Selinuntinæ (1892 8° Napoli). ,,

Topinard, Paul—L' Anthropologie du Bengale ou Etude des documents anthropométriques, recueillis par M. Risley. (*L' Anthropologie*, 1892.) ,,

Waters, A. W., F.L.S., F.G.S.—North Italian Bryozoa, Part ii., Cyclostomata. Observations on the Gland-like Bodies in the Bryozoa. ,,

Wilde, Henry, F.R.S.—On the Causes of the Phenomena of Terrestrial Magnetism, and on some Electro-Mechanism for exhibiting the Secular Changes in its horizontal and vertical Components. ,,

Zeiss, Carl—Catalogue of Microscopes and Microscopical Accessories, No. 29, 1891. *T. F. Wiesener.*

Astronomy and Astro-Physics, No. 101, Jan. 1892. *The Publisher.*

La Curiosite Universelle, Année vi., No. 260, 11 Jan., 1892. ,,

Medical Press and Circular, Vol. cv., No. 2784, Sept. 14, 1892. ,,

The Cosmopolitan, No. 4, 1 Jan., 1892. ,,

The Australasian Journal of Pharmacy, Vol. vi., No. 72, 1891; Vol. vii., Nos. 73 – 80, 82, 83, 1892.

Wiener Entomologische Zeitung, Jahrgang xi., Heft 1, 1 Jan., 1892.

Periodicals Purchased in 1892.

American Journal of Science and Art, (Silliman).
American Monthly Microscopical Journal.
Analyst.
Annales des Chime at de Physique.
Annales des Mines.
Annals of Natural History.
Astronomische Nachrichten.
Athenæum.
Australian Mining Standard.

British Medical Journal.
Building and Engineering Journal of Australia and New Zealand.

Chemical News.
Curtis's Botanical Magazine.

Dingler's Polytechnisches Journal.

Electrical Review.
Engineer.

Engineering.
Engineering Record.
English Mechanic.

Fresenius Zeitschrift für Analytische Chemie.

Geological Magazine.

Industries.

Journal and Transactions of the Photographic Society.
Journal de Médecine.
Journal of Anatomy and Physiology.
Journal of Botany.
Journal of Morphology.
Journal of the Chemical Society.
Journal of the Institution of Electrical Engineers.
Journal of the Society of Arts.
Journal of the Society of Chemical Industry.

Knowledge.

Lancet.

Medical Record of New York.
Mining Journal.

Nature.
Notes and Queries.

Observatory.

Petermann's Geographischen Mittheilungen.
Philadelphia Medical Times and Register.
Philosophical Magazine.
Proceedings of the Geologists' Association.

Quarterly Journal of Microscopical Science.

Revue de l' Aeronautique.

Sanitary Record.
Science.
Science Gossip.
Scientific American.
Scientific American Supplement.

Zoologist.

BOOKS PURCHASED IN 1892.

Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique Mémoires Couronnés et autres Mémoires, Tomes XLIV. and XLV.
Astronomische Nachrichten, General-Register der Bande 81 bis 120.
Australian Handbook, 1892.

Biedermann's Technisch-Chemisches, Jahrbuch, Vol. XIII., 1890-91.
Braithwaite, J.—Retrospect of Medicine, Vol. CIV., 1891, Vol. CV., 1892.
Braithwaite, R.—British Moss Flora, Part xiv., 1892.
British Association Report, 1891.
Buchanan, John—The Indigenous Grasses of New Zealand. [Fol. Wellington, N.Z., 1880]. *(Col. Mus. N.Z.)*

Carpenter, W. B.—The Microscope and its revelations, Seventh Ed. 1891.
Challenger Report, Deep Sea Deposits.
Chemical Industry Society, Journal, Vol. x., 1891.
Clarke, Rev. W. B.—Researches in the Southern Gold Fields of New South Wales. [1860.]
Clinical Society, Transactions, Vol. xxv., 1892.

Dampier, Capt. William—The Voyages and Adventures of, 2 Vols. [8° London, 1776.]
Dana, James Dwight—The System of Mineralogy of, 1837 - 1868. Descriptive Mineralogy, Sixth Edition by E. S. Dana. [1892]

Ewald, Dr. C. A.—Lectures on Diseases of the Digestive Organs, Vols. I. II. *(New Syd. Soc. Pub.* Vols. CXXXVI., CXXXIX.)

Goeppert, H. R.—Monographie der Fossilen Coniferen mit Beruecksichtigung der Lebenden. [4° Leiden, 1850.] *(Holland Soc. of Sci.)*
Gordon, George—The Pinetum; being a synopsis of all the coniferous plants at present known. [8° London, 1880.]
Gore, G.—The Electrolytic Separation of Metals.

Hochstetter, Dr. Ferdinand von—New Zealand, its Physical Geography, Geology and Natural History. [4° Stuttgart, 1867.]

Hooker, Sir W. J.—Niger Flora; or an enumeration of the Plants of Western Tropical Africa, collected by the late Dr. Theodore Vogel. [8° London, 1849.]

Jahresbericht der Technologie, 1891.

Kirk, T.—The Forest Flora of New Zealand. [Fol. Wellington N.Z. 1889.] *(Govt Printer, N.Z.)*

Lexicon of Medicine and the Allied Sciences, Parts xviii., xix. (Power and Sedgwick). *(New Syd. Soc. Pub.* Vols. CXXXVIII., CXLI.)
Lowne, B. Thompson—Anatomy, Physiology, Morphology and Development of the Blow-Fly *(Calliphora erythrocephala)* 3 Parts, 1890-92.
Lyell, Sir Charles, Bart.—Life, Letters, and Journals of, edited by his Sister-in-Law Mrs. Lyell. 2 Vols. [8° London, 1881.]

Marie, Dr. Pierre and Souza-Leite, Dr.—Essays on Acromegaly. (*New Syd. Soc. Pub.* Vol. CXXXVII.)
Medical Officers' Annual Report (20th) 1890.
Medico-Chirurgical Society, Transactions, Vol. LXXIV., 1891.
Mineralogical Magazine, Nos. 41, 42, 43.
Morphology Journal of, Vol. v., No. 3, 1891; Vol. VI., Nos. 1 and 2, 1892.
Murchison, Sir Roderick J. Bart.—Life of, by Archibald Geikie, LL.D., F.R.S. 2 Vols. [8° London, 1875.]

Nautical Almanac for 1895.
New Sydenham Society's Publications, Vols. CXXXVI. - CXL., 1891; Vol. CXLI., 1892.

Obstetrical Society, Transactions, Vol. XXXIII., 1891.

Palæontographical Society, Publications, Vol. XLV., 1891, Vol. XLVI., 1892.
Pathological Society, Transactions, Vol. XLII., 1891.
Philosophical Institute of Victoria, Transactions, Vol. I., 1855-56.

Pozzi, S.—A Treatise on Gynæcology, Clinical and Operative. (*New Syd. Soc. Pub.*, Vol. CXL.)

Quarterly Journal of the Geological Society, Index 1868 - 1889.

Royal Colonial Institute, Proceedings, Vols. I., II., IV., V.
Royal Society of London—Catalogue of Scientific Papers (1874 - 1883) Vol. IX., ABA - GIS.

Schmidt, Adolf—Atlas der Diatomaceen-Kunde, Heft 31 - 40.
Sowerby, John E. and Johnson, C. Pierpoint—The Useful Plants of Great Britain. [4° London, 1861 ?]

Technologist (The)—A Monthly Record of Science applied to Art and Manufacture. Edited by Peter Lund Simmonds. 7 Vols. [8° London 1861–67.]
Thomson, C. Wyville—The Depths of the Sea. [8° London, 1873.]

Year Book of Australia 1892.
Year Book of Learned Societies, 1892.

INDEX.

T

U

V

F. W. WHITE, TYP.

EXCHANGES AND PRESENTATIONS

MADE BY THE

ROYAL SOCIETY OF NEW SOUTH WALES,

1891-92.

The Journal and Proceedings of the Royal Society of N.S.W. for 1891 and 1892, Vols. XXV.-XXVI., have been transmitted by book post :—

The Smithsonian Institution, Washington, U.S.A., and Messrs. Kegan Paul, Trench, Trübner & Co., Limited, Paternoster House, Charing Cross Road, London, W.C., have kindly undertaken to receive and forward to Sydney all communications and parcels intended for the Royal Society of New South Wales.

Presentations to the Society are acknowledged by letter, and in the Society's Annual Volume.

* Exchanges of Publications have been received from the Societies and Institutions distinguished by an asterisk.

Argentine Republic.

1 CORDOBA ... ...*Academia Nacionale de Ciencias.
2 LA PLATA ... ...*Directeur-Général de Statistique de la Province de Buénos Ayres.
3 „ ... ...*Museo de La Plata. Provincia de Buenos Aires.

Austria—Hungary.

4 AGRAM (Zagrab) ...*Société Archéologique Croate.
5 BISTRITZ (in Siebenbürgen) *Direction der Gewerbeschule.
6 CRACOW ... ...*Académie des Sciences.
7 GRATZ ... ...*Naturwissenschaftlicher Verein für Steiermark in Graz.
8 PRAGUE ... ...*Königlich Böhmische Gesellschaft der Wissenschaften.
9 TRENCSIN ... ...*Naturwissenschaftliche Verein des Trencsiner Komitates.
10 TRIESTE ... ...*Museo Civico di Storia Naturale.
11 „ ... ...*Società Adriatica di Scienze Naturali.
12 VIENNA ... ...*Anthropologische Gesellschaft.
13 „ ... ...*Kaiserliche Akademie der Wissenschaften.
14 „ ... ...*K. K. Central-Anstalt für Meteorologie und Erdmagnetismus.
15 „ ... ...*K. K. Geographische Gesellschaft.
16 „ ... ...*K. K. Geologische Reichsanstalt.
17 „ ... ...*K. K. Gradmessungs Bureau.
18 „ ... ...*K. K. Naturhistorische Hofmuseum.
19 „ ... ...*K. K. Zoologisch-Botanische Gesellschaft.
20 „ ... ...*Section für Naturkunde des Osterreichischen-Touristen Club.

Belgium.

21 BRUSSELS ... ...*Académie Royale des Sciences, des Lettres et des Beaux Arts.

22 Brussels ... ...*Musée Royal d'Histoire Naturelle de Belgique.
23 „ ... ...*Observatoire Royal de Bruxelles.
24 „ ... ...*Société Royale de Malacologique de Belgique.
25 Liege ... ...*Société Géologique de Belgique.
26 „ ... ...*Société Royale des Sciences de Liège.
27 Luxembourg ...*Institut Royale grand-ducal de Luxembourg.
28 Mons ... ...*Société des Sciences, des Arts et des Lettres du Hainaut.

Brazil.

29 Rio de Janeiro ...*Observatoire Impérial de Rio de Janeiro.

Chili.

30 Santiago ... ...*Sociedad Cientifica Alemana.

Denmark.

31 Copenhagen ...*Société Royale des Antiquaires du Nord.

France.

32 Bordeaux ... ...*Académie Nationale des Sciences, Belles-Lettres et Arts.
33 Caen ... ...*Académie Nationale des Sciences, Arts et Belles-Lettres.
34 Dijon ... ...*Académie des Sciences, Arts et Belles-Lettres.
35 Havre ... ...*Société Géologique de Normandie.
36 Lille ... ...*Société Géologique du Nord.
37 Marseilles ...*Faculté des Sciences de Marseille.
38 Montpellier ...*Académie des Sciences et Lettres.
39 Nantes ... ...*Société des Sciences Naturelles de l'Ouest de la France.
40 Paris ... ...*Académie des Sciences de l' Institut de France.
41 „ ... ... Bibliothèque de l'Université à la Sorbonne.
42 „ ... ...*Depôt des Cartes et Plans de la Marine.
43 „ ... ...*Ecole d'Anthropologie.
44 „ ... ...*Ecole Nationale des Mines.
45 „ ... ... Ecole Normale Supérieure.
46 „ ... ...*Ecole Polytechnique.
47 „ ... ... Faculté de Médicine de Paris.
48 „ ... ...**Feuille des Jeunes Naturalistes.*
49 „ ... ...*Institut Pasteur.
50 „ ... ...*Musée d'Histoire Naturelle.
51 „ ... ...*Ministère de l'Instruction Publique, des Beaux Arts, et des Cultes.
52 „ ... ...*Observatoire de Paris.
53 „ ... ... Société Botanique.
54 „ ... ...*Société d'Anatomie.
55 „ ... ...*Société d' Anthropologie de Paris.
56 „ ... ...*Société de Biologie.
57 „ ... ... Société de Chirurgie de Paris.
58 „ ... ...*Société d' Encouragement pour l' Industrie Nationale.
59 „ ... ...*Société Entomologique de France.

60 Paris ... ...*Société Française de Minéralogie.
61 „ ... ...*Société Française de Physique.
62 „ ... ...*Société de Géographie.
63 „ ... ...*Société Géologique de France.
64 „ ... ... Société Météorologique de France.
65 „ ... ... Société Philotechnique.
66 „ ... ...*Société Zoologique de France.
67 St. Etienne ...*Société de l' Industrie Minérale.
68 Toulouse ... ...*Académie des Sciences, Inscriptions et Belles-Lettres.
69 Villefranche-sur-Mer (Alp. Mar.)... ... Laboratoire de Zoologie.

Germany.

70 Bremen ... ...*Naturwissenschaftlicher Verein zu Bremen.
71 Berlin ... ... Deutsche Chemische Gesellschaft.
72 „ ... ...*Gesellschaft für Erdkunde zu Berlin.
73 „ ... ...*Königlich Preussische Akademie der Wissenschaften.
74 „ ... ...*Königlich Preussische Meteorologische Institut.
75 Bonn ... ...*Naturhistorischer Vereines der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück.
76 Braunschweig ...*Verein für Naturwissenschaft zu Braunschweig.
77 Carlsruhe ...*Grossherzoglich-Badische Polytechnische Schule.
78 „ ...*Naturwissenschaftlicher Verein zu Carlsruhe.
79 Cassel ... ...*Verein für Naturkunde.
80 Chemnitz ... ...*Naturwissenschaftliche Gesellschaft zu Chemnitz.
81 Dresden ... ...*Königliches Mineralogisch und Naturhistorisches Museum.
82 „ ... ...*Offentliche Bibliothek.
83 „ ... ...*Statistische Bureau des Ministeriums des Innern zu Dresden.
84 „ ... ...*Verein für Erdkunde zu Dresden.
85 Elberfeld ...*Naturwissenschaftlicher Verein in Elberfeld.
86 Frankfurt a/m. ...*Senckenbergische Naturforschende Gesellschaft.
87 Freiberg (Saxony) Königlich-Sächsische Berg-Akademie.
88 Freiburg (Baden) *Naturforschende Gesellschaft.
89 Giessen ... ...*Oberhessische Gesellschaft für Natur- und Heilkunde.
90 Görlitz ... ...*Naturforschende Gesellschaft in Görlitz.
91 Göttingen... ...*Königliche Gesellschaft der Wissenschaften in Göttingen.
92 Halle, A.S. ...*Kaiserliche Leopoldina—Carolina Akademie der Deutschen Naturforscher.
93 Hamburg ... ...*Deutsche Meteorologische Gesellschaft.
94 „ ... ...*Deutsche Seewarte.
95 „ ... ...*Geographische Gesellschaft in Hamburg.
96 „ ... ...*Naturhistorisches Museum.
97 „ ... ...*Verein für Naturwissenschaftliche Unterhaltung in Hamburg.
98 Heidelberg ...*Naturhistorisch Medicinischer Verein zu Heidelberg.
99 Jena ... ...*Medicinisch Naturwissenschaftliche Gesellschaft.

100 KÖNIGSBERG ...*Königliche Physikalisch-ökonomische Gesellschaft.
101 LEIPZIG (Saxony) *Königliche Sächsische Gesellschaft der Wissenschaften.
102 „ ... ...*Vereins für Erdkunde.
103 LUBECK ... ...*Naturhistorische Museum.
104 MARBURG... ...*Gesellschaft zur Beförderung der gesammten Naturwissenschaften in Marburg.
105 „ ... ...*University.
106 METZ ... ...*Vereins für Erdkunde zu Metz.
107 MULHOUSE ...*Société Industrielle de Mulhouse.
108 MUNCHEN... ...*Königlich Bayerische Akademie der Wissenschaften in München.
109 „ ... ... Société Botanique Bavaroise.
110 STUTTGART ...*Königliches Statistisches Landesamt.
111 „ ... ...*Verein für Vaterländische Naturkunde in Württemberg.
112 „ ... ...*Wurttembergischer Verein für Handelsgeographie.

Great Britain and the Colonies.

113 BIRMINGHAM ...*Birmingham and Midland Institute.
114 „ ...*Birmingham Philosophical Society.
115 BRISTOL ... ...*Bristol Naturalists' Society.
116 CAMBORNE ...*Mining Association and Institute of Cornwall.
117 CAMBRIDGE ...*Philosophical Society.
118 „ ... Public Free Library.
119 „ ... Union Society.
120 „ ... University Library.
121 HALIFAX ... ...*Yorkshire Geological and Polytechnic Society.
122 KEW ... ... Royal Gardens.
123 LEEDS ... ...*Conchological Society.
124 „ ... ...*Leeds Philosophical and Literary Society.
125 „ ... ...*Yorkshire College.
126 LIVERPOOL ...*Literary and Philosophical Society.
127 LONDON ... ...*Aëronautical Society of Great Britain.
128 „ ... ... Agent-General (two copies).
129 „ ... ...*Anthropological Institute of Great Britain and Ireland.
130 „ ... ... British Museum.
131 „ ... ...*British Museum (Natural History).
132 „ ... ... Chemical Society.
133 „ ... ... Colonial Office, Downing Street.
134 „ ... ...*Geological Society.
135 „ ... ... Institute of Chemistry of Great Britain and Ireland.
136 „ ... ...*Institution of Civil Engineers.
137 „ ... ...*Institution of Naval Architects.
138 „ ... ...*Iron and Steel Institute.
139 „ ... ... Library, South Kensington Museum.
140 „ ... ...*Linnean Society.
141 „ ... ... London Institution.
142 „ ... ...*Lords Commissioners of the Admiralty.
143 „ ... ...*Meteorological Office.
144 „ ... ...*Mineralogical Society.
145 „ ... ... Museum of Practical Geology.

146	London ...	... Patent Office Library.
147	„ ...	...*Pharmaceutical Society of Great Britain.
148	„ ...	...*Physical Society of London.
149	„ ...	...*Quekett Microscopical Club.
150	„ ...	...*Royal Agricultural Society of England.
151	„ ...	...*Royal Astronomical Society.
152	„ ...	...*Royal College of Physicians.
153	„ ...	...*Royal College of Surgeons.
154	„ ...	...*Royal Colonial Institute.
155	„ ...	...*Royal Geographical Society.
156	„ ...	...*Royal Historical Society.
157	„ ...	...*Royal Institution of Great Britain.
158	„ ...	...*Royal Meteorological Society.
159	„ ...	...*Royal Microscopical Society.
160	„ ...	... Royal School of Mines.
161	„ ...	...*Royal Society.
162	„ ...	... Royal Society of Literature.
163	„ ...	...*Royal United Service Institution.
164	„ ...	...*Sanitary Institute.
165	„ ...	... Society of Arts.
166	„ ...	... University of London.
167	„ ...	... War Office—(Intelligence Division).
168	„ ...	...*Zoological Society.
169	Manchester	...*Literary and Philosophical Society.
170	„	...*Manchester Geological Society.
171	„ ...	... Owens College.
172	Newcastle-upon-Tyne... ...	*Natural History Society of Northumberland Durham and Newcastle-upon-Tyne.
173	„	...*North of England Institute of Mining and Mechanical Engineers.
174	„ ...	... Society of Chemical Industry.
175	Oxford ...	...*Ashmolean Library.
176	„ ...	...*Bodleian Library.
177	„ ...	...*Radcliffe Library.
178	„ ...	...*Radcliffe Observatory.
179	Penzance...	...*Royal Geological Society of Cornwall.
180	Plymouth	...*Plymouth Institution and Devon and Cornwall Natural History Society.
181	Windsor ...	... The Queen's Library.

CAPE OF GOOD HOPE.

182	Cape Town	...*South-African Philosophical Society.

CEYLON.

183	Colombo ...	...*Royal Asiatic Society, (Ceylon Branch).

DOMINION OF CANADA.

184	Halifax (Nova Scotia)	*Nova Scotian Institute of Science.
185	Hamilton (Ont.)	*Hamilton Association.
186	Montreal	...*Natural History Society of Montreal.
187	„ ...	...*Royal Society of Canada.
188	Ottawa ...	...*Geological and Natural History Survey of Canada.
189	„ ...	... Ottawa Literary and Scientific Society.
190	Toronto ...	...*Canadian Institute.
191	„ ...	... University.
192	Winnipeg	...*Manitoba Historical and Scientific Society.

INDIA.

193 Calcutta... ...*Asiatic Society of Bengal.
194 ,, ...*Geological Survey of India.

IRELAND.

195 Dublin ... ...*Royal Dublin Society.
196 ,, ...*Royal Geological Society of Ireland.
197 ,, ...*Royal Irish Academy.

MAURITIUS.

198 Port Louis ...*Royal Society of Arts and Sciences.
199 ,, ... Société d'Acclimatation de l' Ile Maurice.

NEW SOUTH WALES.

200 Sydney ... ...*Australian Museum.
201 ,, ...*Department of Agriculture.
202 ,, ...*Engineering Association of New South Wales.
203 ,, ...*Forest Department.
204 ,, ...*Free Public Library.
205 ,, ...*Linnean Society of New South Wales.
206 ,, ...*Mining Department.
207 ,, ...*Observatory.
208 ,, ... New South Wales Government Railways Institute.
209 ,, ... Public Works Department.
210 ,, ...*Royal Geographical Society of Australasia (New South Wales Branch).
211 ,, ... School of Arts.
212 ,, ...*Technological Museum.
213 ,, ...*United Service Institution of New South Wales.
214 ,, ...*University.

NEW ZEALAND.

215 Auckland ...*Auckland Institute.
216 Christchurch ... Philosophical Institute of Canterbury.
217 Dunedin ... ... Otago Institute.
218 Wellington ...*Colonial Museum.
219 ,, ...*New Zealand Institute.

QUEENSLAND.

220 Brisbane... ...*Acclimatization Society of Queensland.
221 ,, ...*Geological Survey of Queensland.
222 ,, ... Parliamentary Library.
223 ,, ...*Queensland Museum.
224 ,, ...*Royal Geographical Society of Australasia (Queensland Branch).
225 ,, ...*Royal Society of Queensland.

SCOTLAND.

226 Aberdeen ...*University.
227 Edinburgh ...*Editor, *Encyclopædia Britannica,* (Messrs. A. and C. Black).
228 ,, ...*Edinburgh Geological Society.
229 ,, ...*Highland and Agricultural Society of Scotland.
230 ,, ...*Royal Botanic Garden.
231 ,, ...*Royal Observatory.
232 ,, ...*Royal Physical Society.
233 ,, ...*Royal Scottish Geographical Society.
234 ,, ...*Royal Society.
235 ,, ...*University.

236 Glasgow ... ...*Geological Society of Glasgow.
237 „ ... ...*Philosophical Society of Glasgow.
238 „ ... .. *University.
239 St. Andrews ... University.

SOUTH AUSTRALIA.

240 Adelaide... ...*Geological Survey of South Australia.
241 „ ... ...*Government Botanist.
242 „ ... ...*Government Printer.
243 „ ... ...*Observatory.
244 „ ... ...*Public Library, Museum, and Art Gallery of South Australia.
245 „ ... ...*Royal Geographical Society of Australasia (South Australian Branch).
246 „ ... ...*Royal Society of South Australia.
247 „ ... ...*University.

STRAITS SETTLEMENTS.

248 Singapore ...*Royal Asiatic Society (Straits Branch).

TASMANIA.

249 Hobart ... ...*Royal Society of Tasmania.
250 Launceston ...*Geological Survey of Tasmania.

VICTORIA.

251 Ballaarat ...*School of Mines and Industries.
252 Maryborough ... District School of Mines, Industries and Science.
253 Melbourne ...*Field Naturalists' Club of Victoria.
254 „ ...*Government Botanist.
255 „ ...*Government Statist.
256 „ ...*Mining Department.
257 „ ...*Observatory.
258 „ ...*Public Library.
259 „ ...*Registrar-General.
260 „ ...*Royal Geographical Society of Australasia (Victorian Branch).
261 „ ...*Royal Society of Victoria.
262 „ ...*University.
263 „ ...*Victorian Institute of Surveyors.
264 „ ...*Working Men's College.
265 Stawell ... ...*School of Mines, Art, Industry, and Science.

WESTERN AUSTRALIA.

266 Perth ... ...*Geological Survey of Western Australia.

Hayti.

267 Port-au-Prince... Société de Sciences et de Géographie.

Italy.

268 Bolonga ... ...*Accademia delle Scienze dell'Istituto di Bologna.
269 „ .. ... Università di Bologna.
270 Florence ...*Società Africana d' Italia (Sezione Fiorentina),
271 „ ... ...*Società Entomologica Italiana.
272 „ ... ...*Società Italiana di Antropologia e di Etnologia.
273 Genoa ... ...*Museo Civico di Storia Naturale.

274 MILAN ... ...*Reale Istituto Lombardo di Scienze Lettere ed Arti.
275 „ ... ...*Società Italiana di Scienze Naturali.
276 MODENA ... ...*R. Accademia di Scienze, Lettere ed Arti.
277 NAPLES ... ...*Società Africana d' Italia.
278 „ ... ...*Società Reale di Napoli (Accademia delle Scienze Fisiche e Matematiche).
279 „ ... ...*Stazione Zoologica (Dr. Dohrn).
280 PALERMO ... ...*Reale Accademia Palermitana di Scienze Lettere ed Arti.
281 „ ... ... Reale Istituto Tecnico.
282 PISA ... ...*Società Toscana di Scienze Naturali.
283 ROME ... ...*Accademia Pontificia dé Nuovi Lincei.
284 „ ... ...*Biblioteca e Archivio Tecnico (Ministero dei Lavori Pubblico).
285 „ ... ...*R. Accademia dei Lincei.
286 „ ... ...*R. Comitato Geologico Italiano.
287 „ ... ...*R. Ufficio Centrale di Meteorologia e di Geodinamica.
288 „ ... ...*Società Geografica Italiana.
289 SIENA ... ...*R. Accademia dei Fisiocritici in Siena.
290 TURIN ... ... Reale Accademia della Scienze.
291 „ ... ...*Regio Osservatorio della Regia Università.
292 VENICE ... ...*Reale Istituto Veneto di Scienze, Lettere ed Arti.

Japan.

293 TOKIO ... ...*Asiatic Society of Japan (formerly in Yokohama).
294 „ ... ...*Imperial University.
295 „ ... ...*Seismological Society of Japan.

Java.

296 BATAVIA ... ...*Kon. Natuurkundige Vereeniging in Nederl Indië.

Mexico.

297 MEXICO ... ...*Sociedad Cientifica "Antonio Alzate."

Netherlands.

298 AMSTERDAM ...*Académie Royale des Sciences.
299 „ ...*Société Royale de Zoologie.
300 HARLEM ... ...*Bibliothèque de Musée Teyler.
301 „ ... ...*Colonial Museum.
302 „ ... ...*Société Hollandaise des Sciences.

Norway.

303 BERGEN ... ...*Museum.
304 CHRISTIANIA ...*Köngelige Norske Fredericks Universitet.
305 „ ...*Videnskabs-Selskabet i Christiania.
306 TROMSO ... ...*Museum.

Roumania.

307 BUCHAREST ...*Institutul Meteorologic al Roumăniei.

Russia.

308 HELSINGFORS ...*Société des Sciences de Finlande.

309 KIEFF ... ...*Société des Naturalistes.
310 MOSCOW ... ...*Société Impériale des Naturalistes.
311 " ... ...*Société Impériale des Amis des Sciences Naturelles d'Anthropologie et d'Enthnographie à Moscow (Section d' Anthropologie).
312 ST. PETERSBURG ...*Académie Impériale des Sciences.
313 " ...*Comité Géologique—Institut des Mines.

Spain.

314 MADRID ... ... Instituto geografico y Estadistico.

Sweden.

315 STOCKHOLM ...*Kongliga Svenska Vetenskaps-Akademien.
316 " ...*Kongliga Universitetet.

Switzerland.

317 BERNE ... ...*Société de Géographie de Berne.
318 GENEVA ... ...*Institut National Genèvois.
319 LAUSANNE ...*Société Vaudoise des Sciences Naturelles.
320 NEUCHATEL ...*Société des Sciences Naturelles de Neuchatel.
321 ZURICH ... ...*Naturforschende Gesellschaft.

United States of America.

322 ALBANY ... ...*New York State Library, Albany.
323 ANNAPOLIS (Md.) *Naval Academy.
324 BALTIMORE ...*Johns Hopkins University.
325 BELOIT (Wis.) ...*Chief Geologist.
326 BOSTON ... ...*American Academy of Arts and Sciences.
327 " ... ...*Boston Society of Natural History.
328 " ... ... State Library of Massachusetts.
329 BROOKVILLE (Ind.)*Brookville Society of Natural History.
330 " ... Indiana Academy of Science.
331 BUFFALO (Ind.) ...*Buffalo Society of Natural Sciences.
332 CAMBRIDGE (Mass.)*Cambridge Entomological Club.
333 " ...*Museum of Comparative Zoology at Harvard College.
334 CHICAGO ... ... Academy of Sciences.
335 CINCINNATI ...*Cincinnati Society of Natural History.
336 COLDWATER ... Michigan Library Association.
337 DAVENPORT (Iowa)*Academy of Natural Sciences.
338 DENVER ... ...*Colorado Scientific Society.
339 FORT MONROE (Va.)*United States Artillery School.
340 HOBOKEN (N.J.) ...*Steven's Institute of Technology.
341 IOWA CITY (Iowa) *Director Iowa Weather Service.
342 JEFFERSON CITY...*Geological Survey of Missouri.
343 MINNEAPOLIS ...*Minnesota Academy of Natural Sciences.
344 NEWHAVEN (Conn) *Connecticut Academy of Arts and Sciences.
345 NEW YORK ...*American Chemical Society.
346 " ...*American Geographical Society.
347 " ...*American Museum of Natural History.
348 " ...*Editor *Journal of Comparative Medicine and Veterinary Archives.*
349 " ... Editor *Science.*
350 " ...*New York Academy of Sciences.
351 " ...*New York Microscopical Society.
352 " ...*School of Mines, Columbia College.
353 PHILADELPHIA ...*Academy of Natural Science.

354	Philadelphia	...*American Entomological Society.
355	,,	...*American Philosophical Society.
356	,,	...*Franklin Institute.
357	,,	...*Geological Survey of Pennsylvania.
358	,,	...*Wagner Free Institute of Science.
359	,,	...*Zoological Society of Philadelphia.
360	Rochester (N.Y.)	*Geological Society of America.
361	Salem (Mass.)	...*American Association for the Advancement of Science.
362	,,	...*Essex Institute.
363	,,	...*Peabody Academy of Sciences.
364	St. Louis ...	...*Academy of Science.
365	San Francisco	...*California Academy of Sciences.
366	,,	...*California State Mining Bureau.
367	Scranton (Pa.)	...*The Colliery Engineer Co.
368	Washington	... American Medical Association.
369	,,	...*Bureau of Education (Department of the Interior).
370	,,	...*Bureau of Ethnology.
371	,,	...*Chief of Engineers (War Department).
372	,,	...*Chief of Ordnance (War Department).
373	,,	...*Department of Agriculture, Library.
374	,,	... Department of Agriculture, Weather Bureau.
375	,,	...*Director of the Mint (Treasury Department).
376	,,	... Library (Navy Department).
377	,,	...*National Academy of Sciences.
378	,,	...*Office of Indian Affairs (Department of the Interior).
379	,,	...*Philosophical Society.
380	,,	...*Secretary (Department of the Interior).
381	,,	...*Secretary (Treasury Department).
382	,,	...*Smithsonian Institution.
383	,,	...*Surgeon General (U.S. Army).
384	,,	...*U. S. Coast and Geodetic Survey (Treasury Department).
385	,,	...*U.S. Geological Survey.
386	,,	...*U. S. National Museum (Department of the Interior).
387	,,	... U.S. Patent Office.
388	,,	...*War Department.

Number of Publications sent to	Great Britain	...	... 85
,, ,,	India and the Colonies		... 68
,, ,,	America	... ...	... 71
,, ,,	Europe	... ...	... 155
,, ,,	Asia, &c.	... ...	... 5
,, ,,	Editors of Periodicals		... 4
	Total	...	... 388

F. B. KYNGDON.............. } Hon. Secretaries.
T. P. ANDERSON STUART }

The Society's House, Sydney, 31st December, 1892.

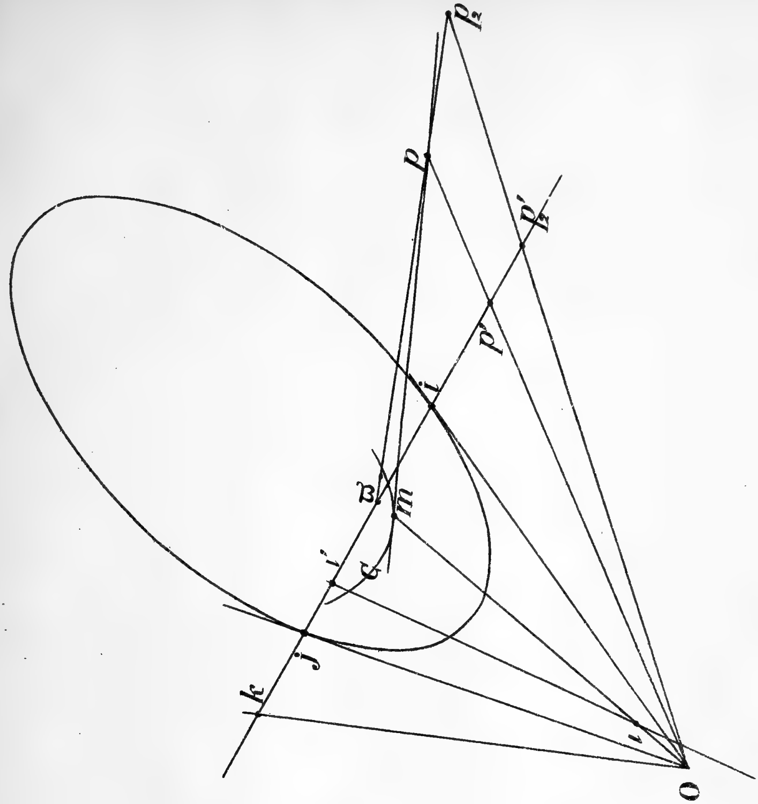


figure II

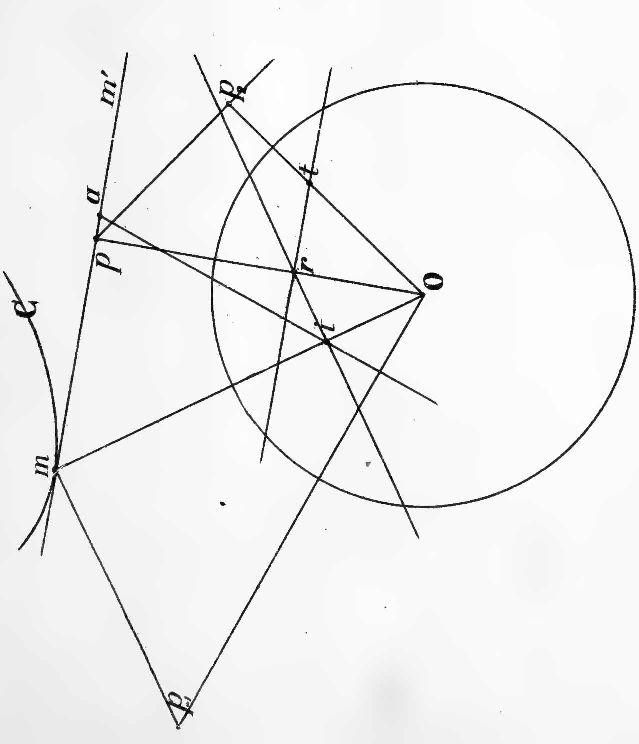
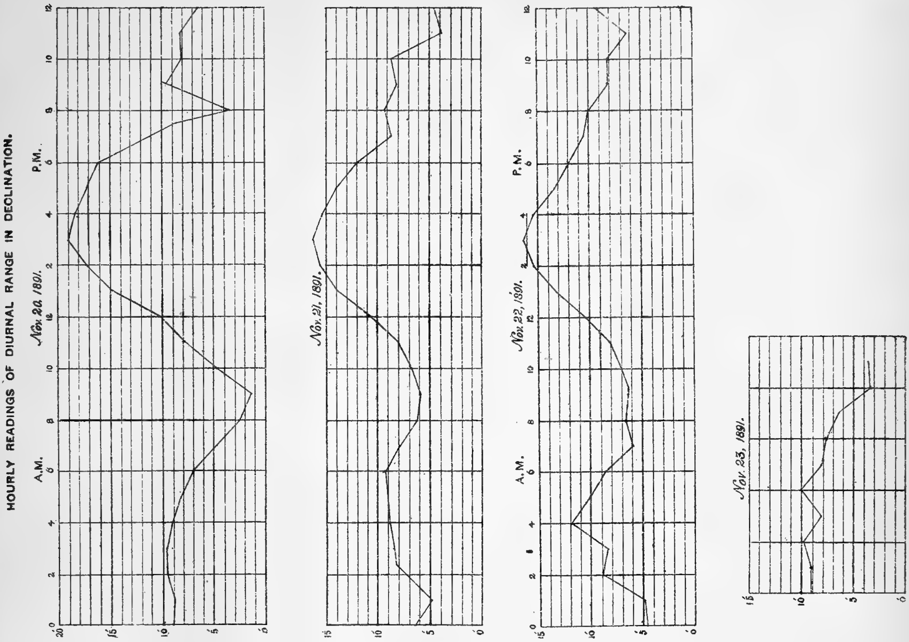
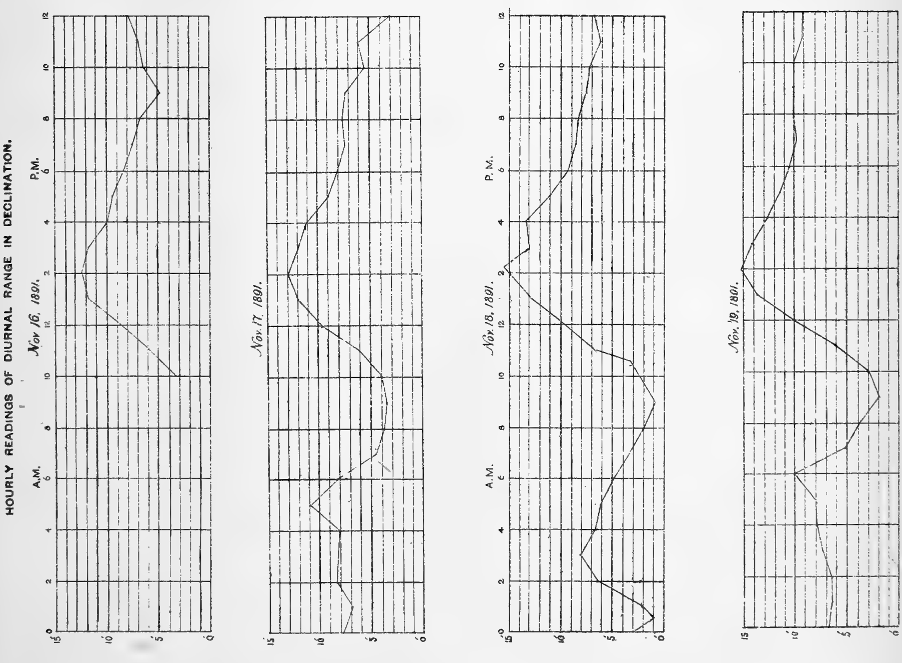
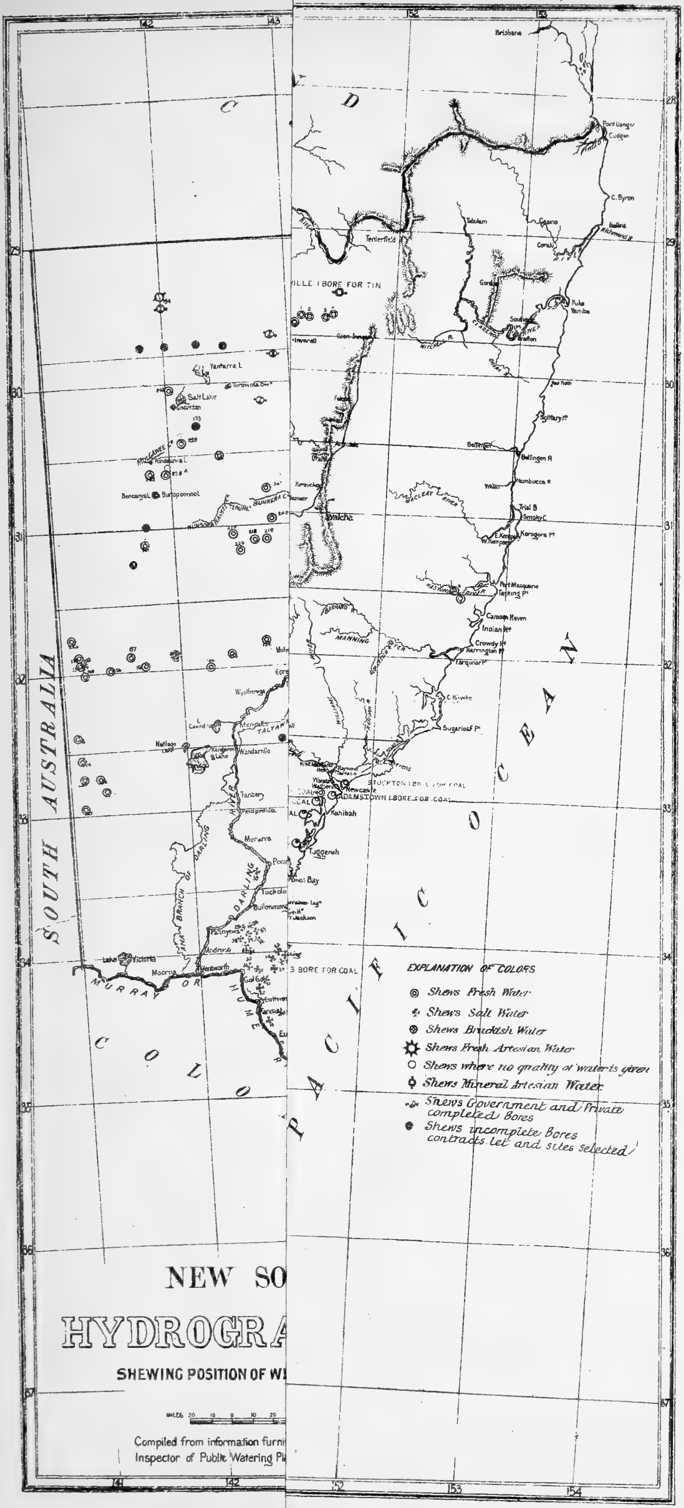
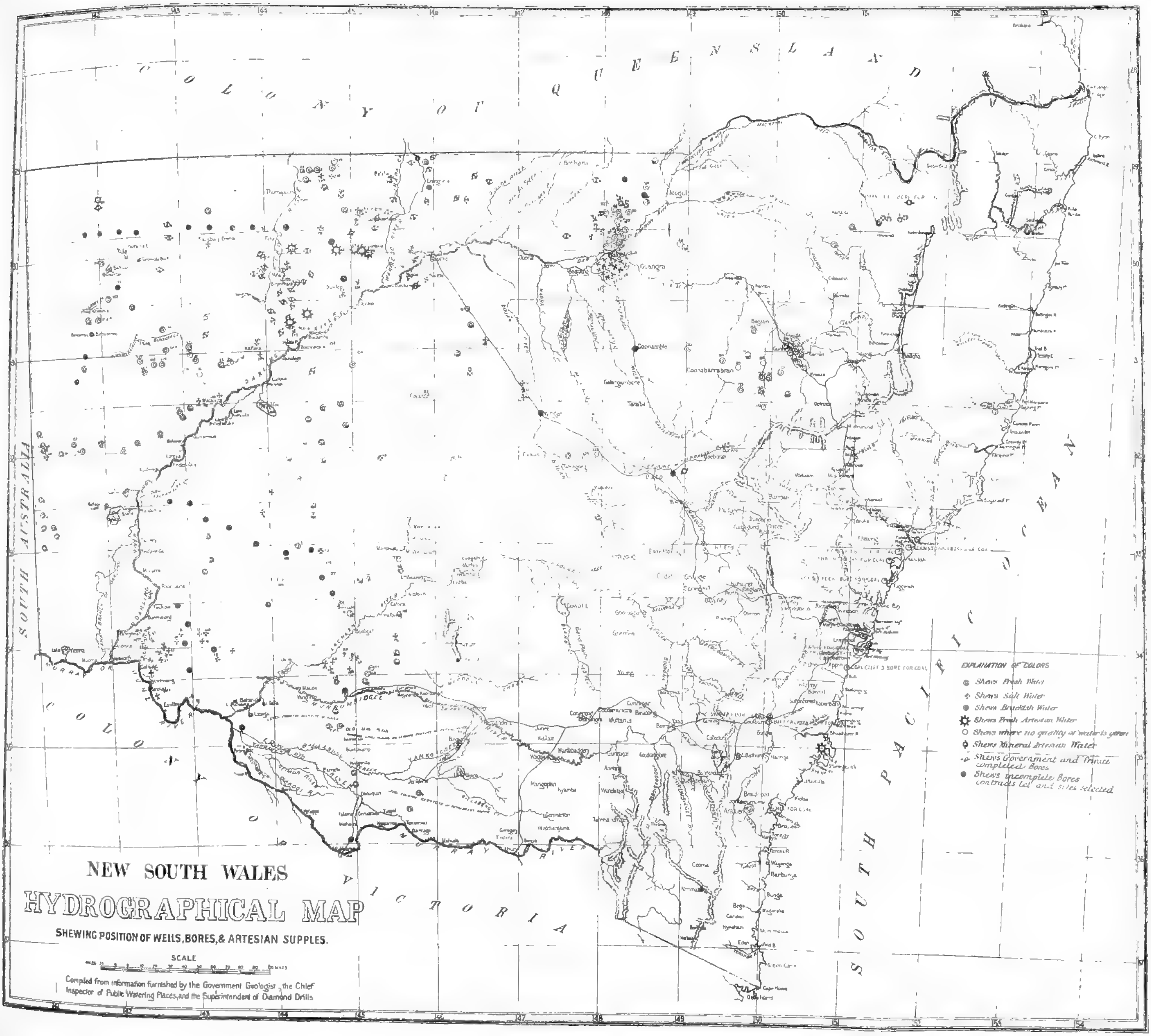


figure I


HOURLY READINGS OF DIURNAL RANGE IN DECLINATION.
A.M.
P.M.
Nov. 20, 1891.
Nov. 21, 1891.
Nov. 22, 1891.
Nov. 23, 1891.

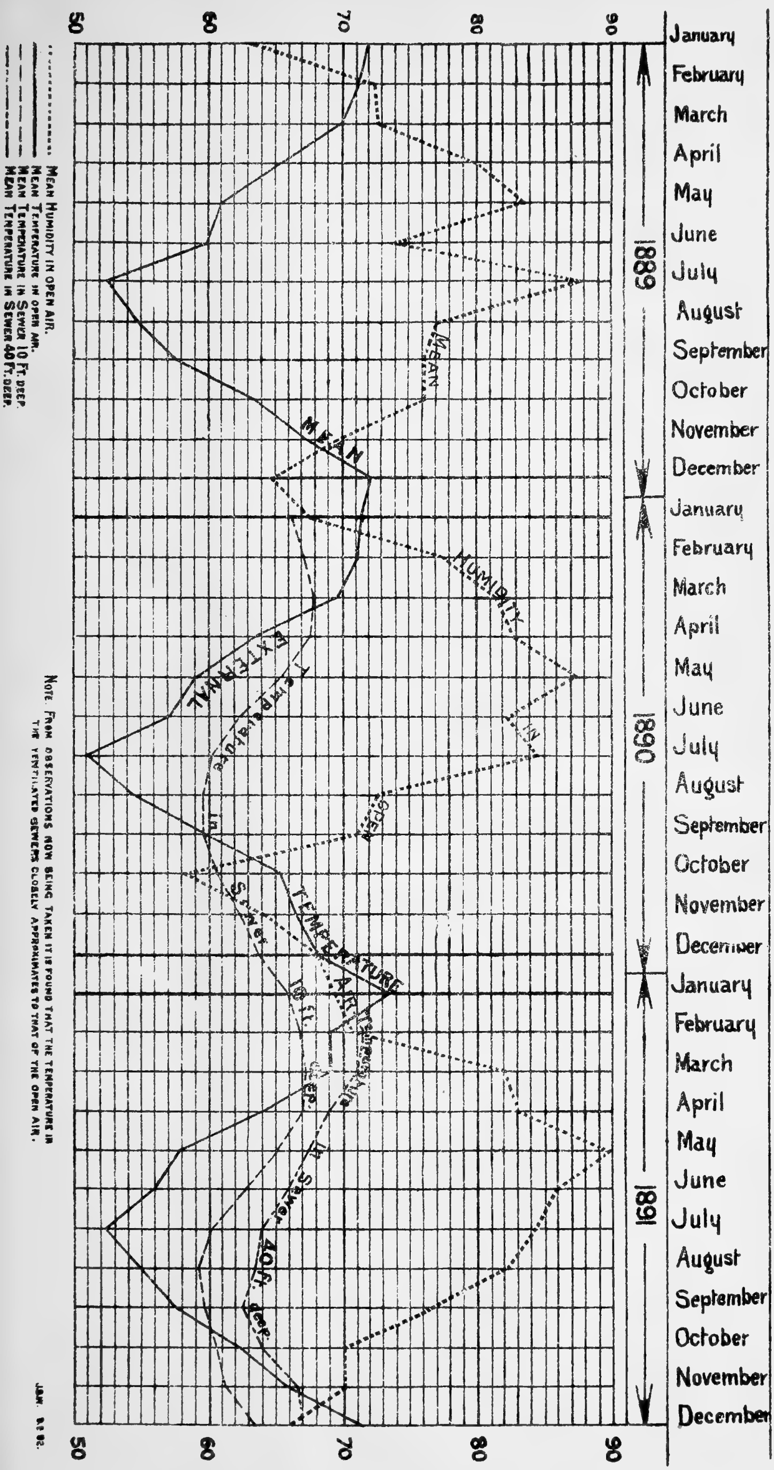

HOURLY READINGS OF DIURNAL RANGE IN DECLINATION.
A.M.
P.M.
Nov. 16, 1891.
Nov. 17, 1891.
Nov. 18, 1891.
Nov. 19, 1891.

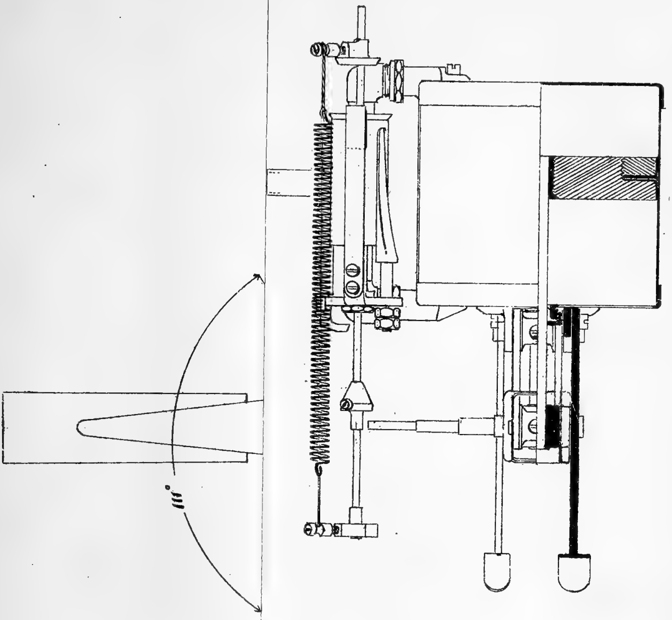

NEW SO
HYDROGRA
SHEWING POSITION OF WE
Compiled from information furni
Inspector of Public Watering Pl
EXPLANATION OF COLORS
Shews Fresh Water
Shews Salt Water
Shews Brackish Water
Shews Fresh Artesian Water
Shews where no quality of water is given
Shews Mineral Artesian Water
Shews Government and Private completed Bores
Shews incomplete Bores contracts let and sites selected
SOUTH AUSTRALIA
PACIFIC OCEAN
MURRAY
DARLING
Brisbane
Tenterfield
Walcha
Newcastle
Port Macquarie
Grafton


COLONY OF QUEENSLAND
SOUTH AUSTRALIA
COLONY OF VICTORIA
SOUTH PACIFIC OCEAN
MURRAY RIVER
MURRUMBIDGEE
NEW SOUTH WALES
HYDROGRAPHICAL MAP
SHEWING POSITION OF WELLS, BORES, & ARTESIAN SUPPLES.
SCALE
Compiled from information furnished by the Government Geologist, the Chief Inspector of Public Watering Places, and the Superintendent of Diamond Drills
EXPLANATION OF COLORS
Shews Fresh Water
Shews Salt Water
Shews Brackish Water
Shews Fresh Artesian Water
Shews where no quality of water is given
Shews Mineral Artesian Water
Shews Government and Private completed Bores
Shews incomplete Bores contracts let and sites selected

DIAGRAM

Showing means of external temperature, temperature in Sewers 10 + 40 ft. deep + humidity for the years 1889, 1890 + 1891.



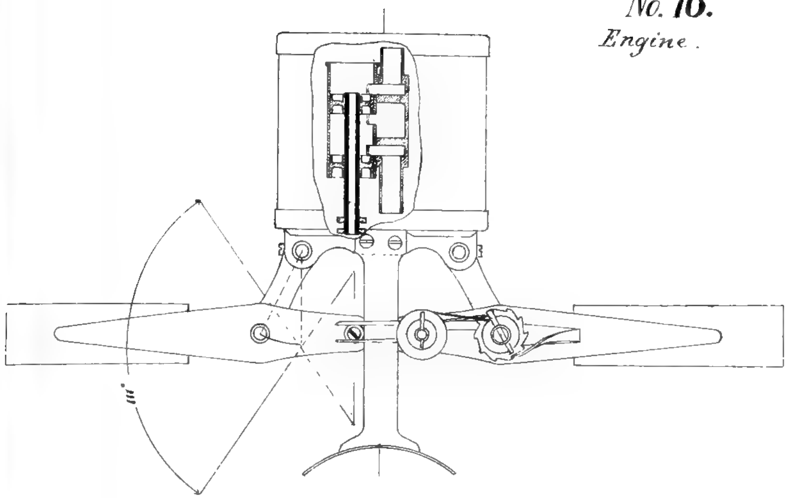


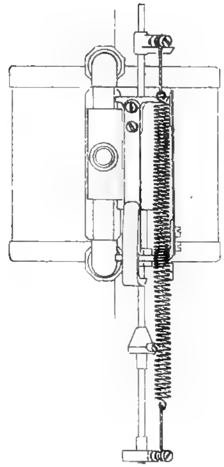
cylinder. 2 inches.
1·5 - - - -
pressure 60 lbs per sq. in. ±
e engine 9 ounces

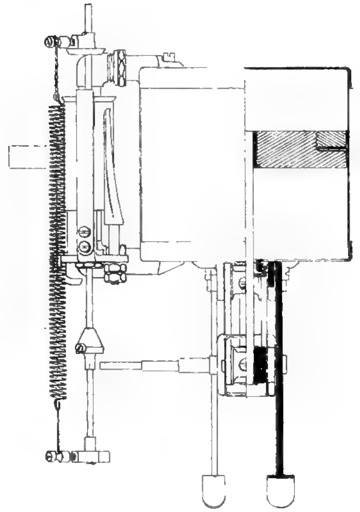
rations of this engine made
, drove the flying-machine

No. 16.

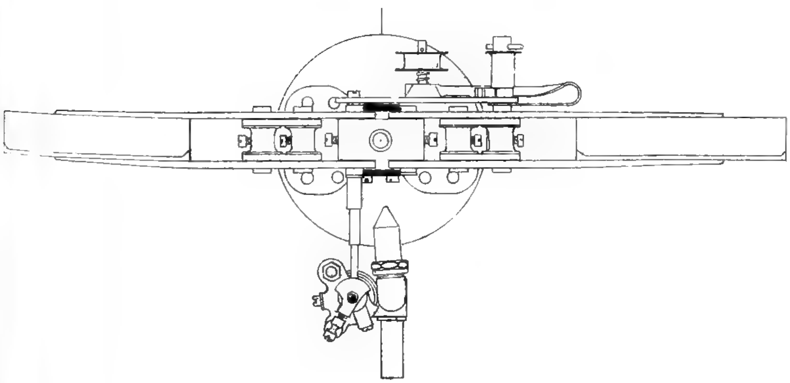
Engine.







Scale



Diameter of cylinder.	2 inches.
Stroke	1·5 - - - -
Reduced air pressure	60 lbs per sq. in. ±
Weight of the engine	9 ounces

54½ double vibrations of this engine made in 23 seconds, drove the flying-machine 343 feet

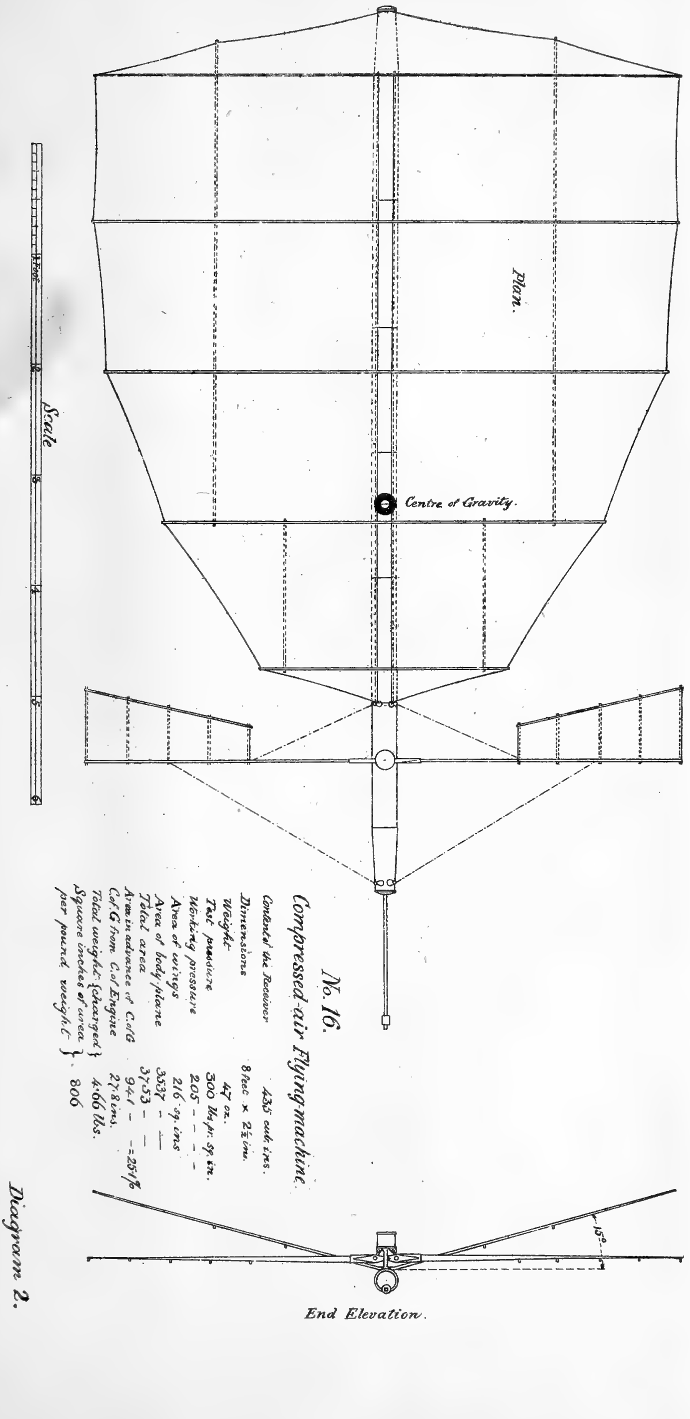
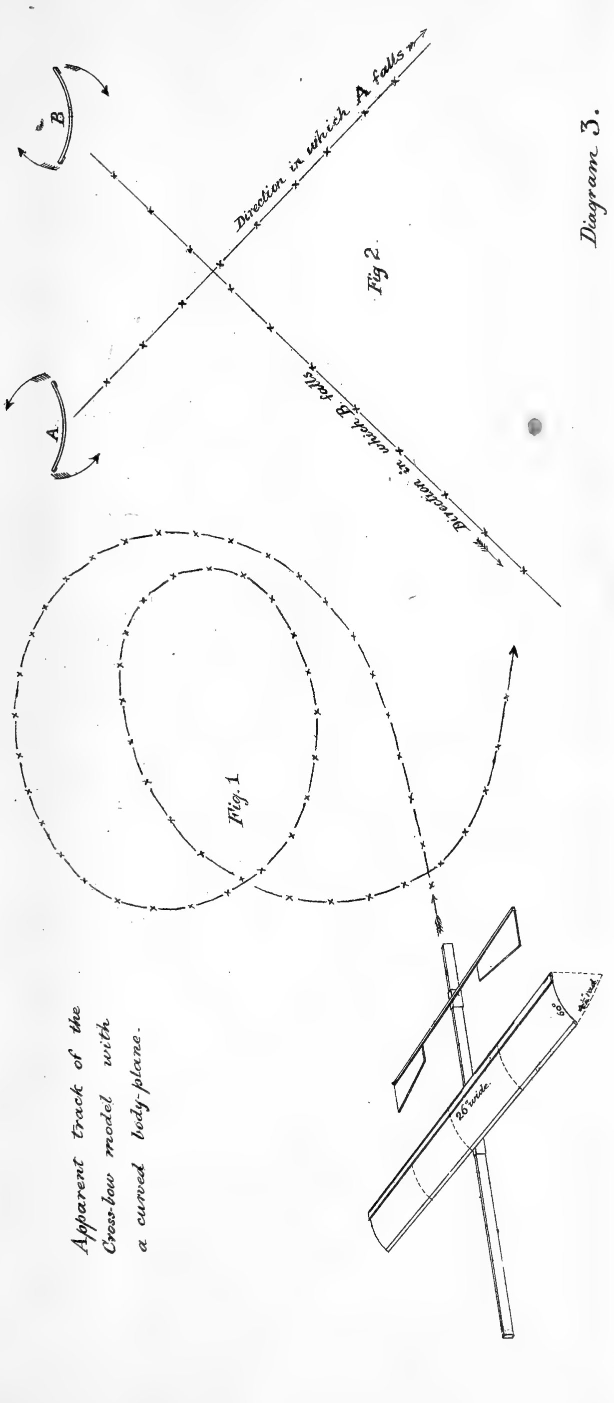

Plan.
Centre of Gravity.
Scale
1 Foot
2
3
4
5
6
No. 16.
Compressed-air Flying-machine.
Content of the Receiver 435 cub. ins.
Dimensions 8 feet × 2¼ ins.
Weight 47 oz.
Test pressure 300 lbs. per sq. in.
Working pressure 205 — — —
Area of wings 216 sq. ins
Area of body plane 3537 — —
Total area 3753 — —
Area in advance of C. of G 941 — — = 25·1%
C. of G from C. of Engine 27·8 ins.
Total weight (charged) 4·66 lbs.
Square inches of area per pound weight 806
15°
End Elevation.

Diagram 2.


B
A
Direction in which A falls
Direction in which B falls
Fig 2
Diagram 3.
Fig. 1
26" wide.
60°
Apparent track of the Cross-bow model with a curved body-plane.

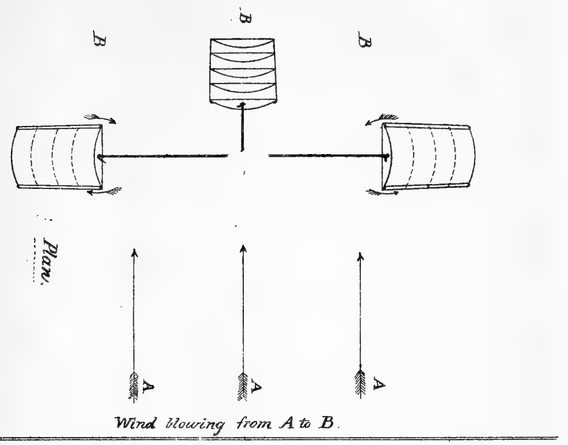


Fig. 1

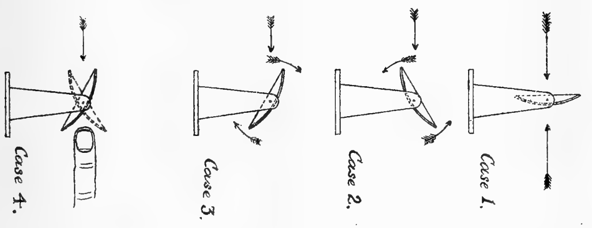


Fig. 2

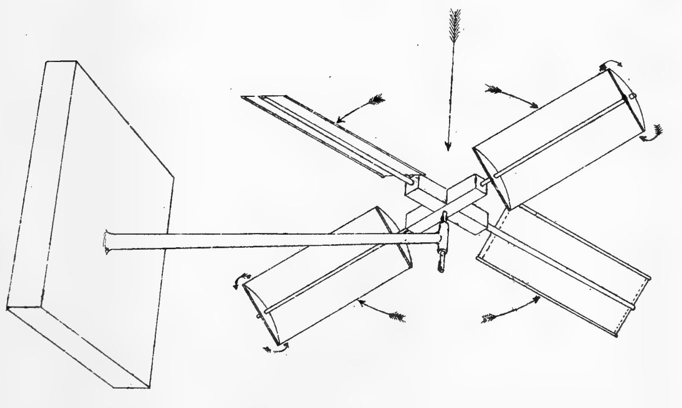
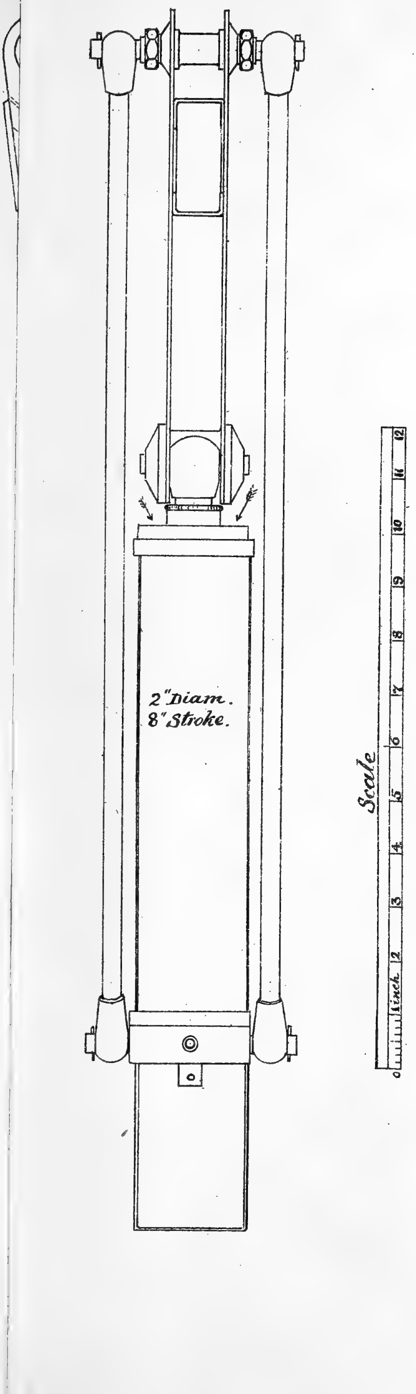
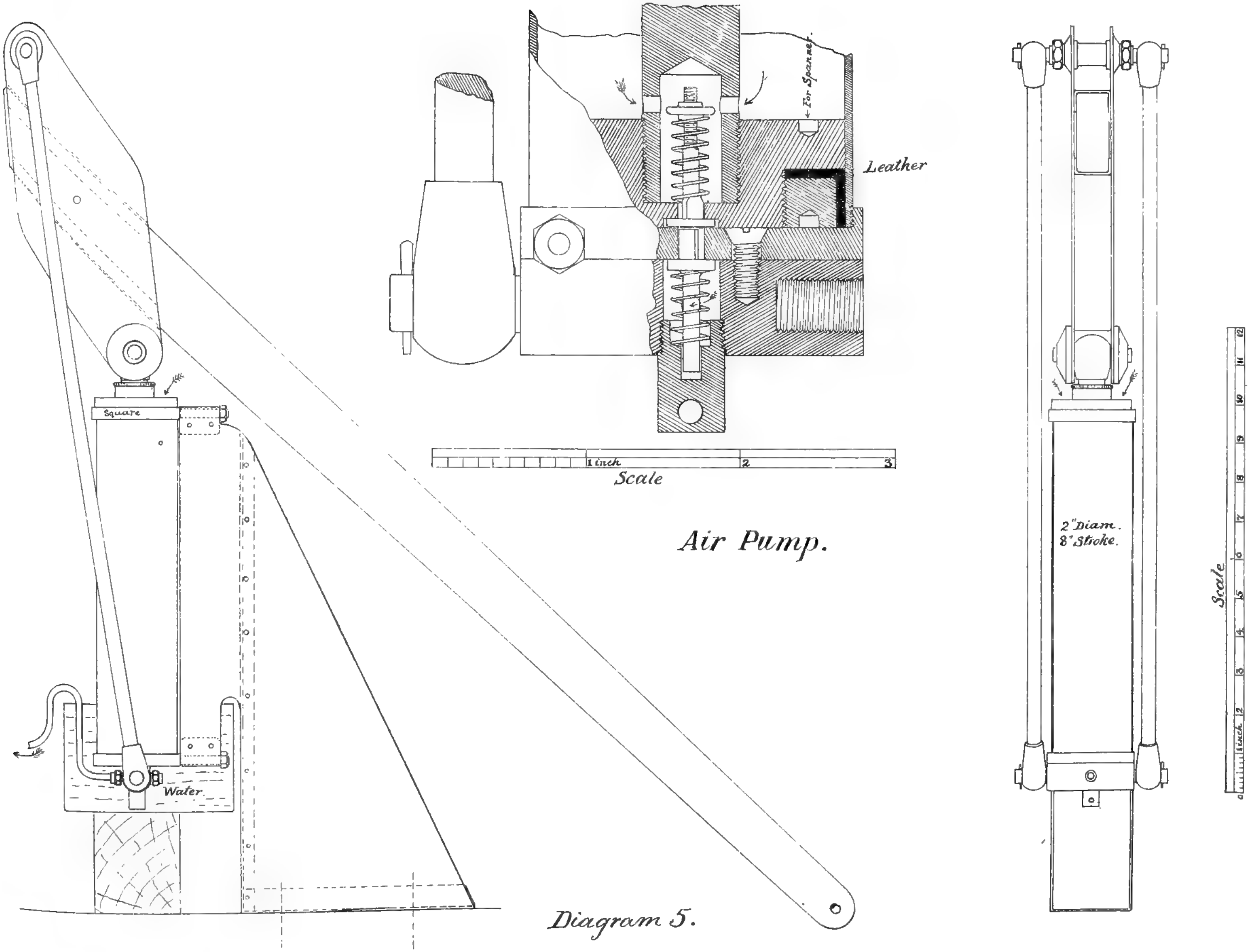


Fig. 3

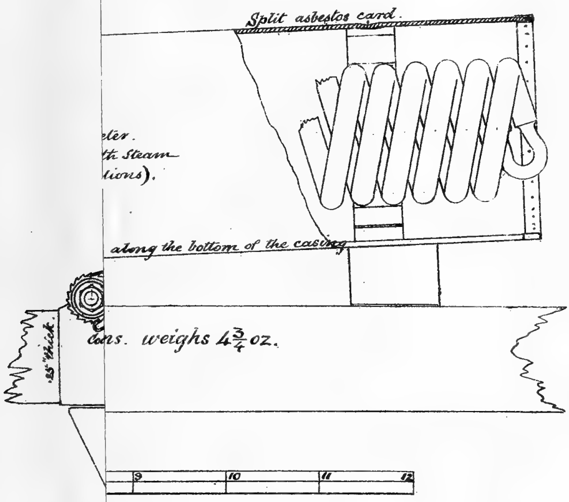
Diagram 4.


2" Diam.
8" Stroke.
Scale
0 1 inch 2 3 4 5 6 7 8 9 10 11 12



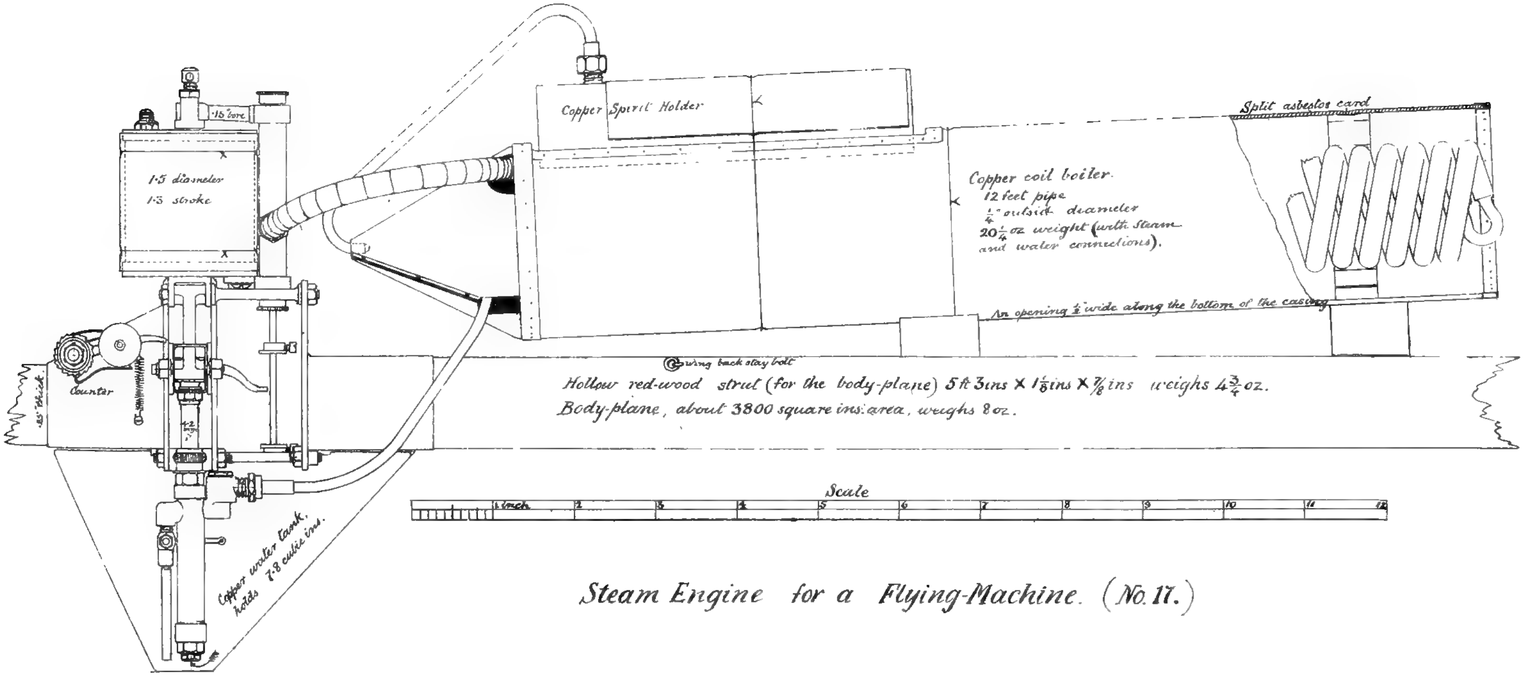
Air Pump.

Diagram 5.



No. 17.)

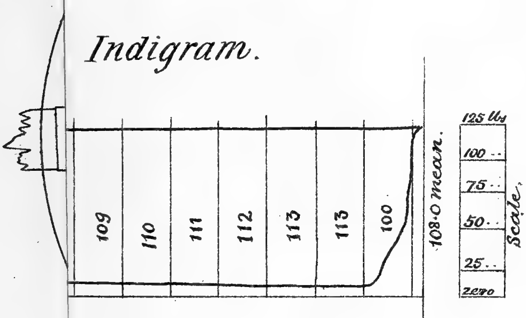
Diagram 6.



Steam Engine for a Flying-Machine. (No. 17.)

Diagram 6.

Indigram.



the top of No. 17 Engine.

ibrations per minute 141

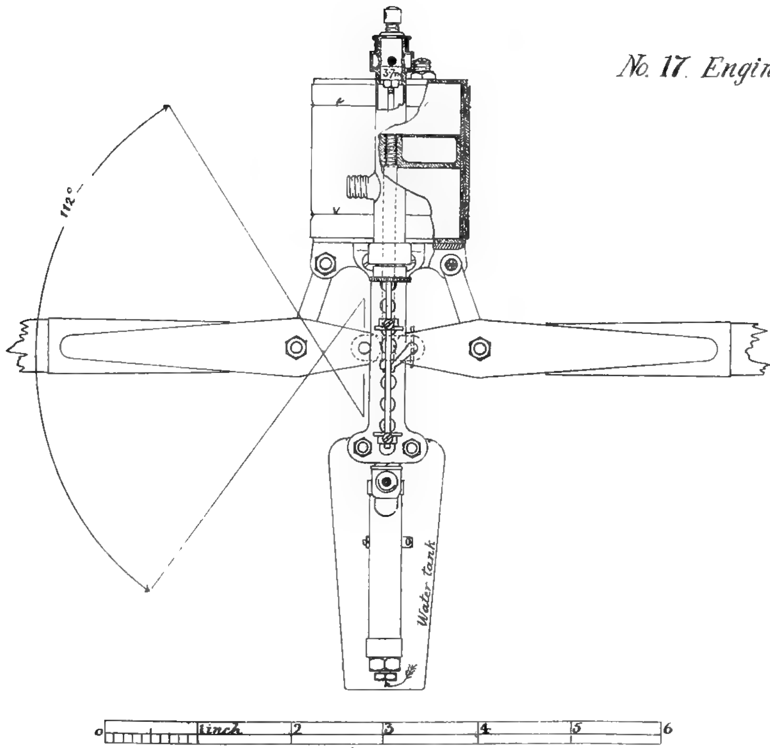
— · — · — · — – 1·27 ins.

ces — — — — — – ·03 ins.

ed Horse Power ·169

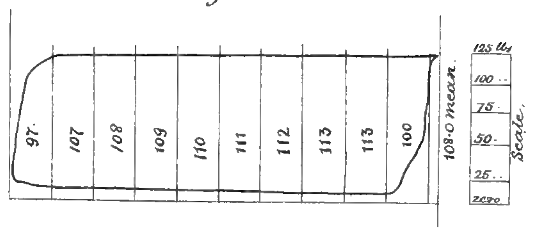
Diagram 7.

No. 17. Engine {Steam}



Scale.

Indigram.



from the top of No. 17 Engine

Double vibrations per minute 141

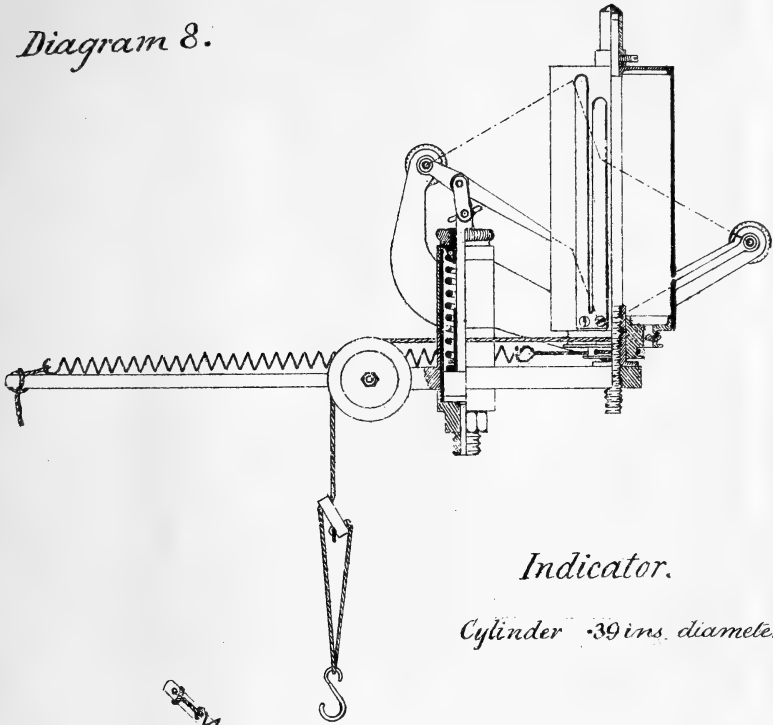
Stroke 1·27 ins.

Clearances ·03 ins.

Indicated Horse Power ·169

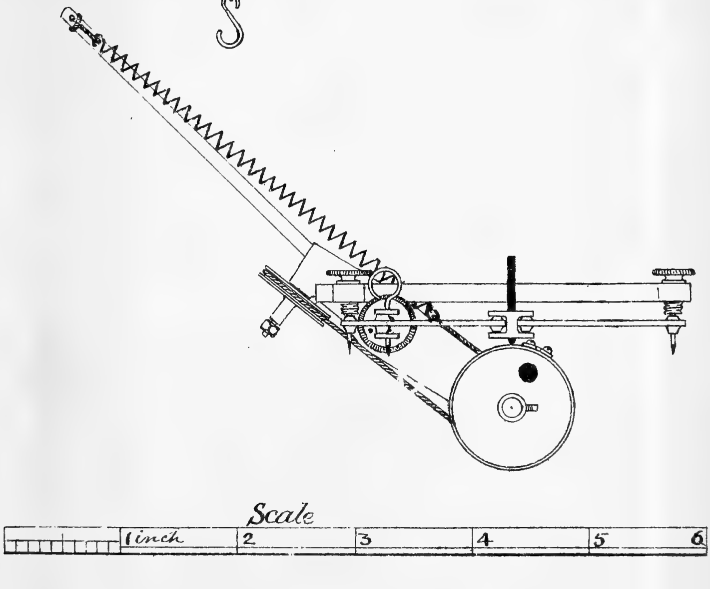
Diagram 7.

Diagram 8.



Indicator.

Cylinder ·39 ins. diameter



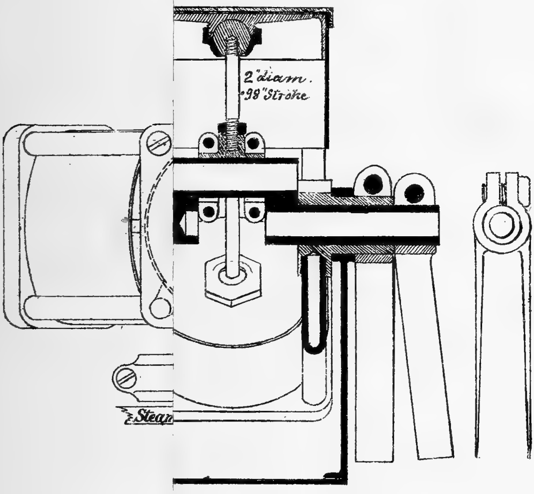


Diagram 9.

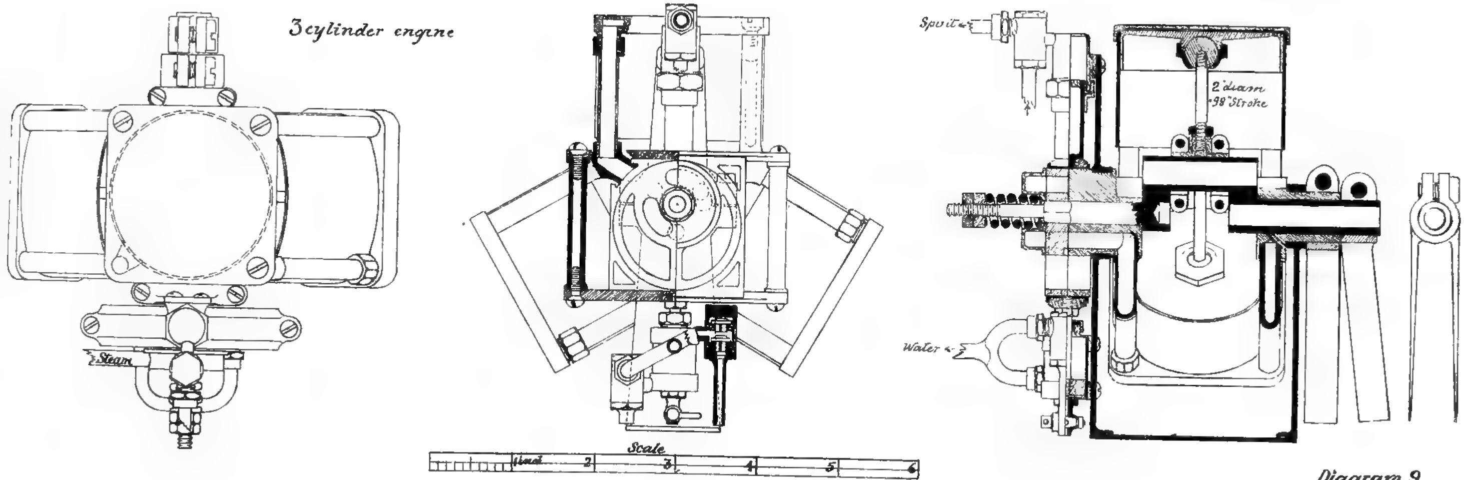
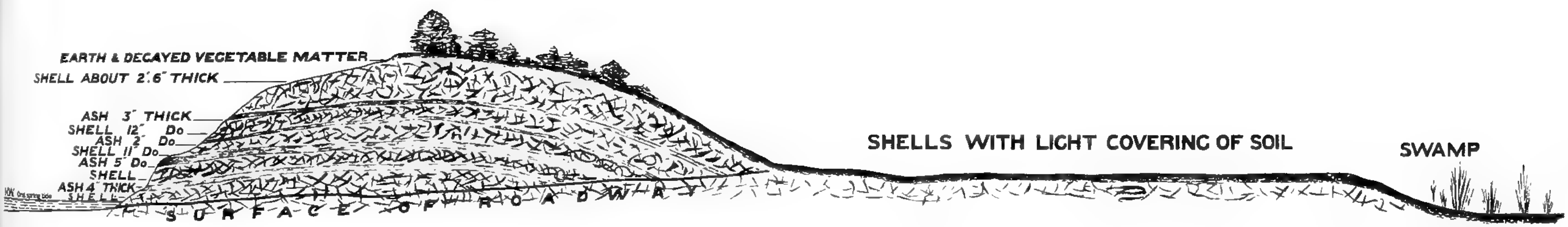

3cylinder engine
Steam
Scale
2
3
4
5
6
Spirit
2" diam
·98" Stroke
Water

Diagram 9.

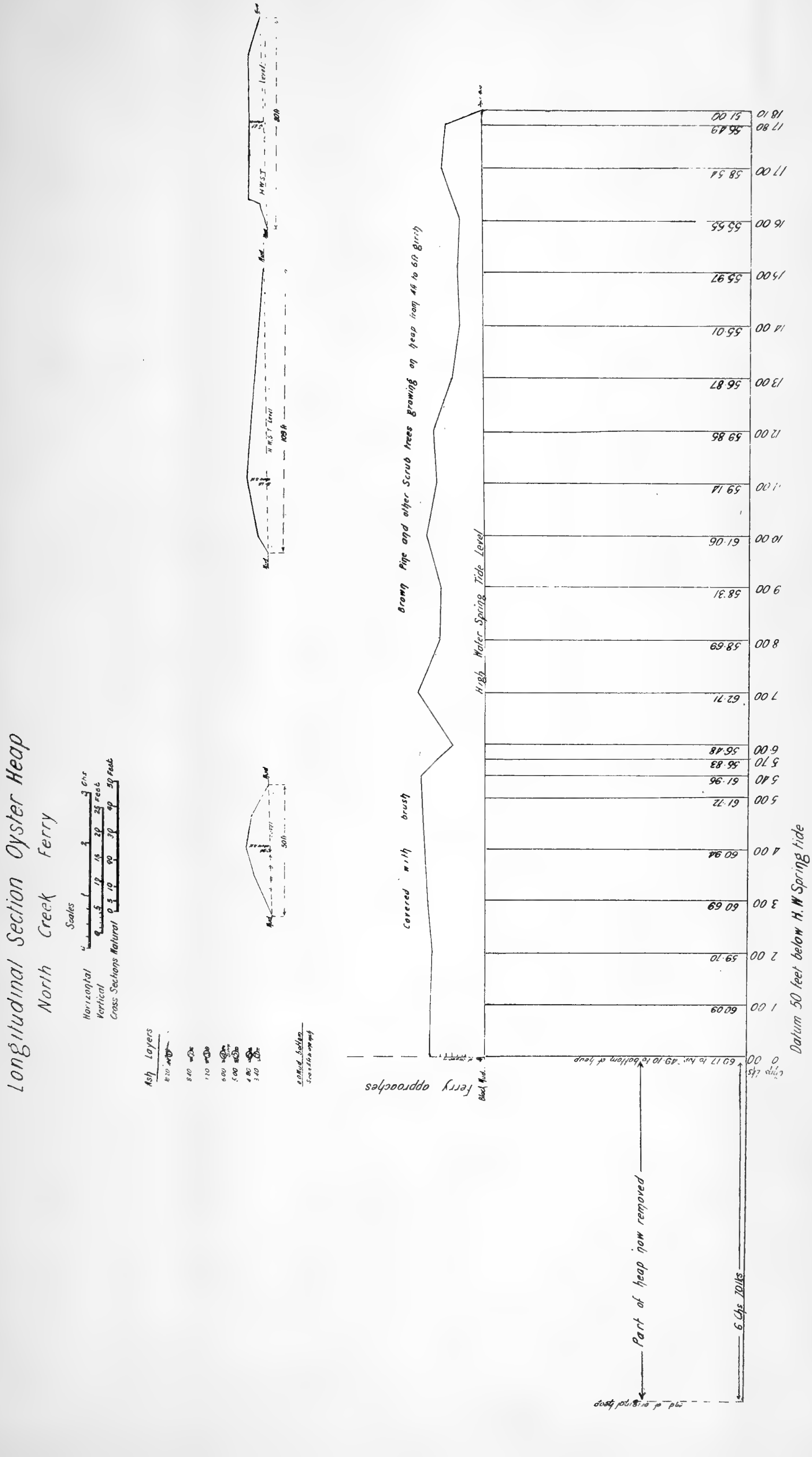
NOTE. LINE OF SECT

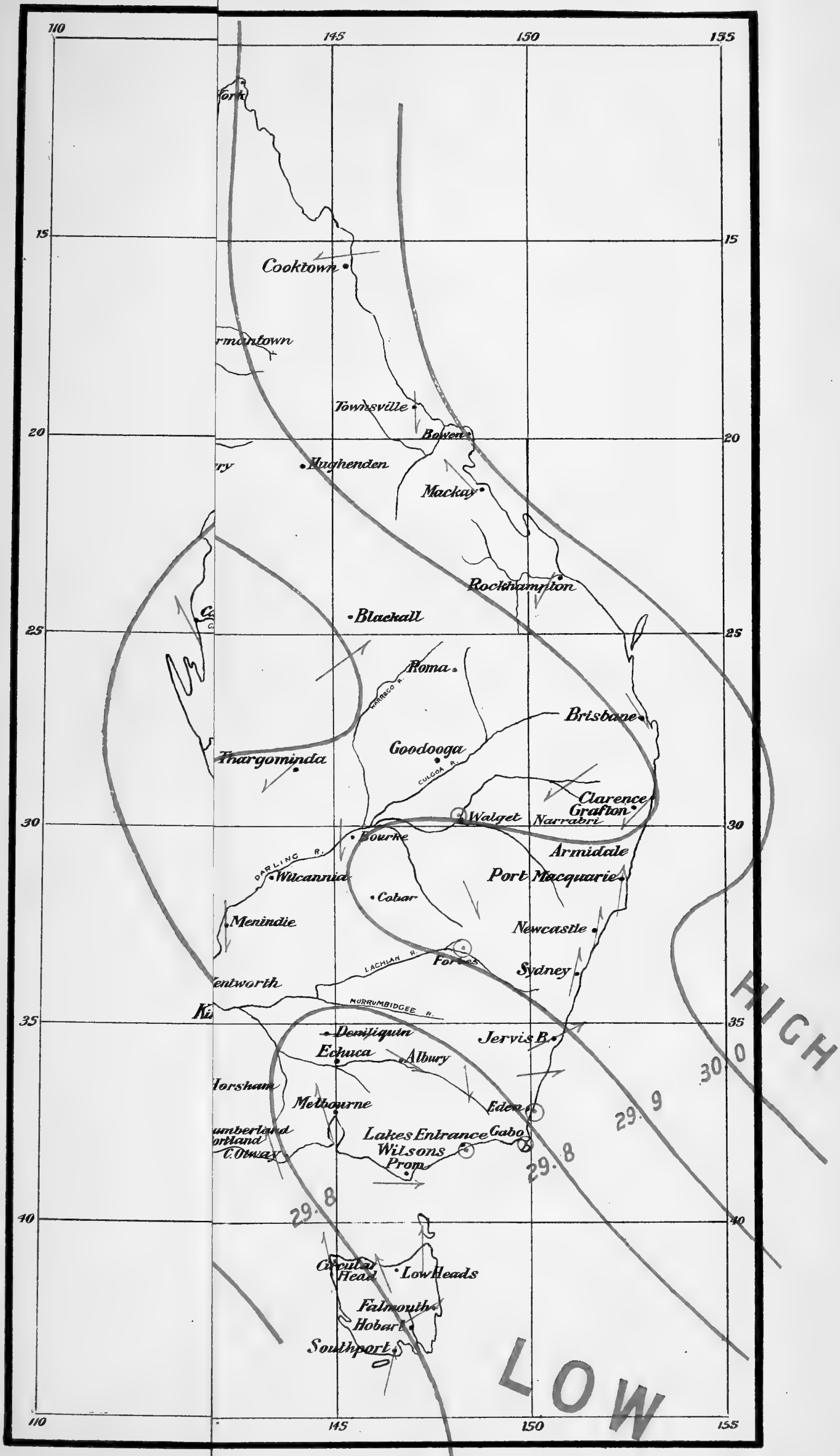
SECTION OF SHELL BANK AT NORTH CREEK, RICHMOND RIVER

Scale 0 1 2 3 4 5 10 FEET



NOTE. LINE OF SECTION BEARS ABOUT EAST FROM NORTH CREEK

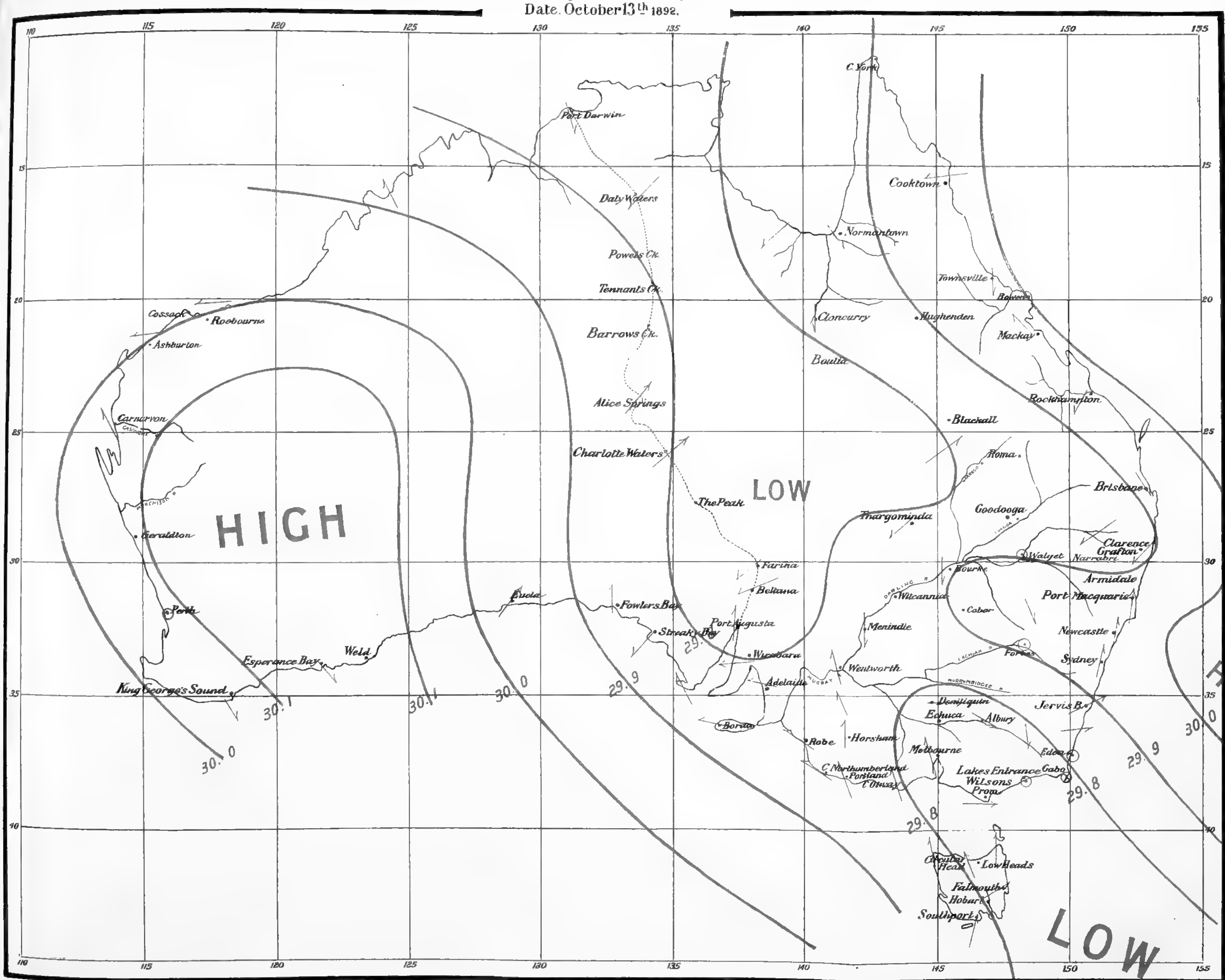

Longitudinal Section Oyster Heap
North Creek Ferry
Scales
Horizontal
Vertical
Cross Sections Natural
Ash Layers
Ferry approaches
Black Mud
Covered with brush
Brown Pine and other Scrub trees growing on heap from 4ft to 6ft girth
High Water Spring Tide Level
Datum 50 feet below H. W Spring tide
Part of heap now removed
6 Chs 70lks


110
145
150
155
15
20
25
30
35
40
Cooktown
Townsville
Bowen
Hughenden
Mackay
Rockhampton
Blackall
Roma
Brisbane
Goodooga
Thargomindah
Clarence
Grafton
Walget
Narrabri
Bourke
Armidale
Port Macquarie
Wilcannia
Cobar
Menindie
Newcastle
Forbes
Sydney
Wentworth
Deniliquin
Jervis B.
Echuca
Albury
Horsham
Melbourne
Eden
Lakes Entrance
Gabo
Wilsons Prom
C. Otway
Low Heads
Falmouth
Hobart
Southport
DARLING R.
LACHLAN R.
MURRUMBIDGEE R.
CULGOA R.
WARREGO R.
29.8
29.8
29.9
30.0
HIGH
LOW

WEATHER CHART

Sydney Observatory

Date. October 13th 1892.



Vol. XXVI. 1892.

JOURNAL & PROCEEDINGS
OF THE
ROYAL SOCIETY
OF
NEW SOUTH WALES,

EDITED BY

THE HONORARY SECRETARIES.

CONTENTS. PAGE

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

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH.
LONDON:
KEGAN PAUL, TRENCH, TRÜBNER & Co., LIMITED.
PATERNOSTER HOUSE, CHARING CROSS ROAD, LONDON, W.C.

F. White, Typ., Sydney.

The Royal Society of New South Wales.

OFFICERS FOR 1892-93.

Honorary President:
HIS EXCELLENCY THE RIGHT HON. THE EARL OF JERSEY, G.C.M.G.

President:
PROF. WARREN, M. INST. C.E., WH. SC.

Vice-Presidents:
C. W. DARLEY, M. INST. C.E.
Prof. T. W. E. DAVID, B.A., F.G.S.
PROF. LIVERSIDGE, M.A., F.R.S.
H. C. RUSSELL, B.A., C.M.G., F.R.S.

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

Hon. Secretaries:
F. B. KYNGDON.
PROF. ANDERSON STUART, M.D.

Members of Council:
JAMES GRAHAM, M.A., M.D. *Edin.*
W. M. HAMLET, F.C.S., F.I.C.
A. LEIBIUS, PH.D., M.A., F.C.S.
J. A. McDONALD, M. INST. C.E.
H. G. McKINNEY, M.E., M. INST. C.E.
J. H. MAIDEN, F.L.S., F.C.S.
CHARLES MOORE, F.L.S., F.Z.S.
J. ASHBURTON THOMPSON, M.D.
PROF. THRELFALL, M.A.
H. G. A. WRIGHT, M.R.C.S.E., &c.

Assistant Secretary:
W. H. WEBB.

SECTIONAL COMMITTEES—SESSION 1892.

Section B. and C.—Chemistry and Mineralogy, Geology and Palæontology.

Chairman—Prof. T. W. Edgeworth David, B.A., F.G.S.
Secretary for Chemistry—W. M. Hamlet, F.C.S., F.I.C.
Secretary for Geology—Rev. J. Milne Curran, F.G.S.
Committee—Mr. F. Guthrie, F.C.S., Prof. Liversidge, M.A., F.R.S., F.C.S., Messrs. J. H. Maiden, F.C.S., J. C. H. Mingaye, F.C.S.

Meetings held on the First Tuesday in the month at 8 p.m.

Section E.—Microscopical Science.

Chairman—Mr. H. O. Walker.
Secretary—Mr. S. MacDonnell.
Committee—Messrs. T. M. Brindley, G. D. Hirst, P. R. Pedley, T. F. Wiesener. Dr. H. G. A. Wright.

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

Section H.—Medical.

Chairman—Dr. Fiaschi.
Secretaries—Dr. Hull and Dr. Huxtable.
Committee—Dr. W. Chisholm, Dr. James Graham, Dr. W. H. Goode, Prof. Anderson-Stuart, M.D., Dr. Rennie, Dr. MacCormick.

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

Section K.—Civil and Mechanical Engineering.

Chairman—Cecil Darley, M. Inst. C.E.
Secretary—J. A. McDonald, M. Inst. C.E.
Committee—H. Deane, M. Inst. C.E., J. M. Smail, M. Inst. C.E., H. G. McKinney, M. Inst. C.E., D. M. Maitland, L.S.

Meetings held on the Third Wednesday in each month, at 8 p.m.