Report of the South African Association for the Advancement of Science.

Lourenço Marques 1913

REPORT

OF THE

ELEVENTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

LOURENCO MARQUES,

1913.

JULY 7—12.

CAPE TOWN:
PUBLISHED BY THE ASSOCIATION.

1914.

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LIST OF PLATES.

OFFICERS AND COUNCIL, 1912-1913.

HONORARY PRESIDENT.

HIS MAJESTY THE KING.

PRESIDENT.

A. W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E.

EX-PRESIDENT.

ARNOLD THEILER, C.M.G., D.Sc.

VICE-PRESIDENTS.

L. Crawford, M.A., D.Sc., F.R.S.E., Professor of Pure Mathematics, South African College, Cape Town.
R. T. A. Innes, F.R.A.S., Union Observatory, Johannesburg.
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J. H. von Hafe, Director of Railways, Lourenço Marques.

HON. GENERAL SECRETARIES.

C. F. Juritz, M.A., D.Sc., F.I.C. Government Analytical Laboratory Cape Town.
H. E. Wood, M.Sc., F.R.Met.Soc., Union Observatory, Johannesburg.

HON. GENERAL TREASURER.

A. Walsh, P.O. Box 39, Cape Town.

ASSISTANT GENERAL SECRETARY.

H. Tucker, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town. P.O. Box 1497. (Telegraphic Address: "Scientific.")

ORDINARY MEMBERS OF COUNCIL.

I. CAPE PROVINCE.

Cape Peninsula.

A. J. Anderson, M.A., M.B., D.P M.R.C.S.
Prof. J. C. Beattie, D.Sc., F.R.S.E.
Rev. W. Flint, D.D.
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Grahamstown.

J. Hewitt, B.A.

Kingwilliamstown.

Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.

Kimberley.

A. H. Watkins, M.D., M.R.C.S., M.L.A.

Port Elizabeth.

W. A. Way, M.A.

Queenstown.

Rev. C. Pettman.

Stellenbosch.

Prof. B. de St. J. van der Riet, M.A., Ph.D.

II. TRANSVAAL.

Johannesburg.

P. Cazalet.
E. A. E. Collins.
W. Cullen, M.I.M.M.
S. Evans.
J. A. Foote, F.G.S., F.E.I.S.
Prof. R. A. Lehfeldt, B.A., D.Sc.
J. Moir, M.A., D.Sc., F.C.S.
Prof. J. Orr, B.Sc., M.I.C.E.
Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.

Pretoria.

J. Burtt-Davy, F.L.S., F.R.G.S.
W. E. C. Clarke, M.A.
F. A. Kanthack, A.M.I.C.E.

Potchefstroom.

A. Holm.

III. ORANGE FREE STATE.

Bloemfontein.

Dr. W. Johnson, L.R.C.S., L.R.C.P.
G. Macdonald.
Prof. G. Potts, M.Sc., Ph.D.

IV. NATAL.

Durban.

A. McKenzie, M.D., C.M., M.R.C.S.

Pietermaritzburg.

Prof. E. Warren, D.Sc.

V. RHODESIA.

Bulawayo.

Rev. S. S. Dornan, M.A., F.G.S.

Salisbury.

G. N. Blackshaw, B.Sc., F.C.S.

VI. BASUTOLAND

Rev. E. Jacottet.

VII. MOZAMBIQUE.

S. Seruya.
F. Flowers, F.R.A.S., F.R.G.S.
J. McCrae, Ph.D., F.I.C.

TRUSTEES.

H. M. Arderne.
Prof. J. C. Beattie, D.Sc., F.R.S.E.
A. D. R. Tugwell.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. CAPE TOWN, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart, M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. JOHANNESBURG, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. JOHANNESBURG, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. KIMBERLEY, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. DURBAN, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.

H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. GRAHAMSTOWN, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. BLOEMFONTEIN, September 27, 1909	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D. F.R.S., F.R.S.E. CAPE TOWN, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. BULAWAYO, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.
ARNOLD THEILER, C.M.G., D.Sc. PORT ELIZABETH, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S. F.R.S.E. LOURENCO MARQUES, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ..	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town ‡	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ..	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques	J. H. von Hafe.	Prof. J. Orr, J. Vaz Gomes.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ..	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ..	Thos. Quentrall, M.I.Mech.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.
CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.		
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.
CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.		
1910. Cape Town ..	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911. Bulawayo ..	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912. Port Elizabeth	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913. Lourenço Marques	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Capt. A. Graça.
SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.		
1903. Cape Town ..	Sir Chas. Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904. Johannesburg *	Lieut.-Colonel Sir Percy Gironard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ..	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbatch, W. Newdigate.
BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.		
1907. Natal	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910. Cape Town †	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911. Bulawayo ..	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912. Port Elizabeth	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, I. L. Drège.
1913. Lourenço Marques	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B. Botelho.
SECTION D.—ARCHAEOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.		
1903. Cape Town ..	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ..	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY, ARCHAEOLOGY: ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.		
1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY AND ARCHAEOLOGY.		
1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.

* Forestry added in 1904.
† Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.

ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.

1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1909. Bloemfontein	Hugh Gunn, M.A.	G. C. Grant, Rev. W. A. Norton.
1910. Cape Town ..	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo ..	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques	J. A. Foote, F.G.S.	H. Pim, J. Elvas.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion — Present and Future.
1906. Kimberley ..	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ..	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy.
Durban	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1910. Cape Town ..	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ..	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform — Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.
1912. Port Elizabeth	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques	S. Seruya.	The history of Portuguese conquest and discovery.

GENERAL MEETING AT LOURENCO MARQUES.

On *Monday*, July 7, at 2.30 p.m., the Association was officially received and welcomed to Lourenço Marques at the Town Hall by His Excellency the Acting Governor-General of Mozambique and His Worship the Mayor. After making acknowledgment, on behalf of the Association, Dr. A. W. Roberts, F.R.A.S., F.R.S.E., took the chair as President, and delivered an address, for which see page 1.

The Acting Governor-General, at the request of the President, then handed the South Africa medal and grant to the Rev. Dr. Flint for conveyance to Dr. A. W. Rogers, M.A., F.G.S., who was unavoidably absent. For the proceedings see page xxi.

At 4 p.m., members of the Association proceeded by special train to the Polana Beach; and at 8 p.m. to the opening of a local Fair and Exhibition of the products of the Province of Mozambique.

On *Tuesday, July* 8, at 2.30 p.m., members proceeded by special train to make a circuit of the town; thereafter alighting at the railway station and being conveyed by train to the harbour works, which were inspected under the guidance of Mr. J. H. von Hafe, Director of Railways and Harbours.

At 8.30 p.m., members attended a musical evening given in their honour at Villa Joia, the residence of Mr. A. Bonn.

On *Wednesday, July* 9, at 2.30 p.m., members visited and were entertained at the Campos Rodriguez Observatory, by invitation of the Director, Lieutenant Teixeira; afterwards proceeding to the Hospital and the Municipal Gardens.

At 9 p.m. they attended a ball given by the military authorities at their headquarters (Gremio Militaire).

On *Thursday, July* 10, at 7.30 a.m., members proceeded on a whole day excursion by launch up the Bay and the Umbeluzi River to the waterworks, and to the Experimental Farm.

On *Friday, July* 11, at 3.30 p.m., members attended a reception by H.E. the Acting Governor-General at the Residency.

At 8 p.m., in the Colonial Hall, Mr. S. Seruya delivered a discourse on "The History of Portuguese Discovery and Settlement in Africa," the Rev. Dr. W. Flint presiding.

On *Saturday, July* 12, at 11 a.m., the Eleventh Annual General Meeting was held in the Government Council Chamber, for the minutes of which see page x.

At 2.30 p.m., members were taken out into the Bay to the Steamship *Chinde*, specially chartered for the occasion, from which they viewed a regatta.

At 8 p.m., the harbour and shipping were illuminated, and a special steamer conveyed members for a short cruise for the purpose of viewing these.

At 9.30 p.m., members were taken by special trams to the Gremio Militaire, the grounds of which were illuminated after the fashion of Northern Portugal; while within, the prizes won at the regatta were distributed by the President.

On *Sunday, July* 13, at 8 p.m., members left Lourenço Marques by special train. H.E. the Governor and other notable residents honoured the departure of the visitors with their presence on the railway platform, and hearty expressions of goodwill were exchanged. The military band played the British and Portuguese National Anthems.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, LOURENCO MARQUES, 1913.

LOCAL COMMITTEE.

Chairman, R. T. A. Innes, F.R.A.S.; *Local Secretary,* H. E. Wood, M.Sc., F.R.Met.S.; P. Cazalet, E. A. E. Collins, W. Cullen, M.I.M.M., S. Evans, J. A. Foote, F.G.S., F.E.I.S., Prof. R. A. Lehfeldt, B.A., D.Sc., J. Moir, M.A., D.Sc., F.C.S., Prof. J. Orr, B.Sc., M.I.C.E., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., S. Seruya, F. Flowers, F.R.A.S., F.R.G.S., J. McCrae, Ph.D., F.I.C.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor of Lourenço Marques; *Hon. Secretary,* J. F. Ferreira; Major A. A. de Sa, J. H. Von Hafe, Lieutenant Arthur de Salles Henriques, Colonel A. C. de Sousa Araujo, Augusto Vidal, A. de Bulhoa Pato, Captain Reis, the Right Rev. the Bishop of Lebombo, A. W. Bayly, G. R. Kennedy, Martin Budd, F. C. Vines, A. C. Saunders, Fritz Wirth, Adalbert Bonn; Presidents of the following Clubs and Societies: English, British, German, Military, Landowners, Commercial Employés, First of January, Portuguese Benevolent, Port and Railway Employés, Maritime, Workmen's Goanese, Shopkeepers, Swiss, Centro Couceiro da Costa, Centro Colonial Democratio, Centro Socialista, Coeite Radical and Portuguese Clubs (Gremio de Lourenço Marques).

SECTIONAL COMMITTEES.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President, J. H. Von Hafe: *Vice-Presidents,* Colonel Bellegarde da Silva and Captain Augusto Teixeira; R. T. A. Innes, F.R.A.S., G. W. Herdman, M.A., M.I.C.E., Prof. J. C. Beattie, D.Sc., F.R.S.E., A. H. Reid, F.R.I.B.A., F.R.San,I., Rev. E. Jacottet, J. F. Ferreira, A. Bonn; *Hon, Secretaries,* Prof. J. Orr, B.Sc., M.I.C.E. (*Recorder*); and J. Vaz Gomes.

SECTION B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President, Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.; *Vice-Presidents,* Dr. J. Moir, M.A., D.Sc., and Prof. B. de St. J. van der Riet, M.A., Ph.D.; Prof. R. Marloth, M.A., Ph.D., P. Cazalet, C. F. Juritz, M.A., D.Sc., F.I.C., Prof. G. Potts, M.Sc., Ph.D., Rev. S. S. Dornan, M.A., F.G.S., G. N. Blackshaw, B.Sc., F.C.S., A. W. Rogers, M.A., ScD., F.G.S., H. Kynaston, M.A., F.G.S.; *Hon. Secretaries*, Prof. G. H. Stanley, A.R.S.M., F.I.C., (*Recorder*), and Staff-Captain Alberto Graça.

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President, A. L. M. Bonn, C.E.; *Vice-Presidents*, Dr. Amaral Leal and F. E. Kanthack, A.M.I.C.E.; Dr. A. H. Watkins, M.D., M.R.C.S., M.L.A., J. Burtt-Davy, F.L.S., F.R.G.S., Dr. A. J. Anderson, M.A., M.B., D.P.H., Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., Dr. W. Johnson, Dr. A. H. McKenzie, C.M., M.R.C.S., Dr. Rolla Pereira, J. E. O. Ferraz; *Hon. Secretaries*, Frank Flowers, F.R.A.S., F.R.G.S. (*Recorder*); and Lieutenant J. B. Botelho.

SECTION D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

President, J. A. Foote, F.G.S., F.E.I.S.; *Vice-Presidents*, J. T. de Souza Barbosa and Dr. D. Pepulim; Rev. Dr. Flint, J. Hewitt, B.A., W. A. Way, M.A., W. E. C. Clarke, M.A., Sam Evans, A. W. Bayly, Dr. Blanco; *Hon. Secretaries*, Howard Pim, C.A. (*Recorder*), and Juvenal Elvas.

PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING OF MEMBERS.

(Held in the Government Council Chamber, Lourenço Marques, on Saturday, July 12, 1913.)

PRESENT: Dr. A. W. Roberts, F.R.A.S., F.R.S.E. (President), in the chair; Mr. J. Daniel, Mr. M. W. Duirs, Mr. H. Feldmann, Rev. J. FitzHenry, Rev. Dr. W. Flint, Mr. F. Flowers, Mr. J. A. Foote, Mr. J. V. M. Gomez, Captain A. C. de F. Graca, Mr. R. T. A. Innes, Mr. A. E. Jensen, Miss S. B. Leiter, Prof. W. A. Macfadyen, Mr. P. v. d. M. Martins, Mr. J. Munro, Miss E. B. Noble, Prof. J. Orr, Dr. D. Pepulim, Mrs. A. W. Roberts, Miss C. Roberts, Prof. W. N. Roseveare, Prof. G. H. Stanley, Miss S. Stafford, Mr. A. Stephen, Mr. J. D. Stevens, Miss E. L. Teasdale, Lieut. A. d'A. Teixeria, Mr. F. G. Tyers, Prof. H. A. Wager, Miss G. Watkinson, Mr. M. White, Mr. H. E. Wood (Hon. General Secretary), and Mr. H. Tucker (Assistant General Secretary).

MINUTES.—The Minutes of the Tenth Annual Meeting, held at Port Elizabeth on 3rd July, 1912, and printed on pp. xviii to xxi of the Report of the Port Elizabeth Session, were confirmed.

ANNUAL REPORT OF COUNCIL.—The Annual Report of the Council for 1912-13, having been suspended in the Council Chamber since Wednesday, 9th July, was taken as read and adopted, on the motion of Mr. J. A. Foote.

REPORT OF GENERAL TREASURER AND STATEMENTS OF ACCOUNTS FOR 1912-13.—The General Treasurer's Report and Financial Statements for 1912-13 having been suspended in the Council Chamber since Wednesday, 9th July, were taken as read and adopted, on the motion of Mr. F. Flowers.

ELECTION OF OFFICERS AND COUNCIL FOR 1913-14.—The following officers were elected for 1913-14:—

PRESIDENT, Prof. R. Marloth, M.A., Ph.D.; VICE-PRESIDENTS, Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Mr. S. Evans, Dr. W. Johnson, L.R.C.P., L.R.C.S., and Mr. A. F. Williams, B.S.; GENERAL SECRETARIES, Dr. C. F. Juritz, M.A., F.I.C., and Mr. H. E. Wood, M.Sc., F.R.Met.S.; GENERAL TREASURER, Mr. A. Walsh.

The following were elected as Members of Council for 1913-14:—

I. TRANSVAAL.—*Witwatersrand*: Mr. P. Cazalet, Mr. W. Cullen, Mr. F. Flowers, F.R.G.S., F.R.A.S., Mr. J. A. Foote, F.G.S., F.E.I.S., Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., Dr. J. Moir, M.A., Prof. J. Orr, B.Sc., M.I.C.E., and Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C. *Pretoria*: Mr. J. Burtt-Davy, F.L.S., F.R.G.S., Mr. F. E. Kanthack, A.M.I.C.E., and Prof. H. A. Wager, A.R.C.S. *Potchefstroom*: Mr. F. G. Tyers, B.A.

II. CAPE PROVINCE.—*Cape Peninsula*: Dr. A. J. Anderson, M.A., M.B., D.P.H., M.R.C.S., Prof. J. C. Beattie, D.Sc., F.R.S.E., Rev. W. Flint, D.D., Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., and Mr. A. H. Reid, F.R.I.B.A., F.R.San.I. *Grahamstown*: Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. *King William's Town*: Mr. F. A. O. Pym. *Port Elizabeth*: Mr. W. A. Way, M.A. *Queenstown*: Mr. E. E. Galpin, F.L.S. *Stellenbosch*: Prof. B. de St. J. van der Riet, M.A., Ph.D.

III. ORANGE FREE STATE.—*Bloemfontein*: Dr. G. Potts, M.Sc., and Mr. A. Stead, B.Sc., F.C.S.

IV. NATAL.—*Pietermaritzburg*: Prof. W. N. Roseveare, M.A.

V. RHODESIA.—*Bulawayo*: Rev. S. S. Dornan, M.A., F.G.S. *Salisbury*: Mr. F. Eyles, F.L.S., M.L.C.

VI. MOZAMBIQUE.—*Lourenço Marques*: Mr. S. Seruya.

The election of Members of Council to represent Kimberley and Durban was referred to the incoming Council.

ANNUAL SESSION, 1913.—The President announced that an invitation, from the Mayor and Council of Kimberley to the Association, to hold the next Annual Session at that place, had been received, and was recommended by the late Council for acceptance; but that since the commencement of the Session, a further similar invitation had been received from the Mayor and Council of Pretoria. It was resolved, on the motion of Professor Orr, to refer the invitation to the incoming Council, for final decision.

APPROPRIATION OF METEORITES BY GOVERNMENT.—The following Resolutions were adopted, on the motion of Prof. Wager:—

> 1. "That the Government of the Union be asked to pass legislation declaring that Meteorites are Government property, and when found should be delivered to the nearest Magistrate, for transmission to the nearest Museum under Government control."
>
> 2. "That the Hon. Secretary convey this resolution to the Prime Minister."

MEETING OF ANNUAL CONGRESSES.—The following Resolution was adopted, on the motion of Mr. R. T. A. Innes:—

> "That the Association endeavour to get Annual Congresses to meet at the same time and place as our Association may each year—so that mutual intercourse of professional and scientific societies may be facilitated."

VOTES OF THANKS.—Mr. Innes moved, and it was carried by acclamation, that the thanks of the Association be accorded to the following:—

· To His Excellency the Acting Governor-General, for his cordial welcome and hospitality to the Association: for his courtesy in placing the Council Chamber at the disposal of Members for the Session, and for honouring some of the functions with his presence; to His Worship the Mayor, the Council, and the Members of the General Committee, for their great kindness and hospitality, the excellent arrangements made for the comfort of the Members, and the facilities afforded for viewing the Fair and Exhibition; to Mr. J. H. von Hafe, Director of Railways and Harbours, for a most interesting Presidential Address, for railway and other facilities, and for the opportunity given to Members to view the Harbour and Railway Works; to Lieut. Teixeira, Directory of the local Observatory, for receiving and entertaining the Members thereat, and explaining the valuable work being carried on under his control; to Captain da Silva and his officers, for the most enjoyable Ball given by them in honour of the visitors; to Mr. J. E. d'O. Ferraz, Director of Agriculture, for his hospitality on the occasion of the visit of Members to the Experimental Farm; to the Medical Officer of Health, for his kindness in receiving and showing Members over the Hospital; to Dr. Pepulim and his Secretaries on the Committees, Messrs. Ferreira and Rodrigues, for the exceedingly kind and efficient manner in which everything was arranged for the comfort and convenience of the visitors; to Mr. Adalbert Bonn, for tramway facilities granted and his kindness in providing for Members an opportunity of visiting the Waterworks; to the Chief of the Maritime Services and the Port Captain, for the preparations made for aquatic festivities to be held on Saturday afternoon and evening; to the British and English Clubs, respectively, for extending their privileges to the visitors; to the local Press, for their most kindly references, and for giving publicity to the Association's proceedings.

Mr. Vaz Gomez, on behalf of the authorities and residents at Lourenço Marques, thanked the President and Members for the kind and flattering remarks which had been made. He stated that the visit of the Association would be long remembered, and had resulted in twenty local members being added. He hoped that a local centre would be developed. The Association's visit constituted a new page in the history of the Province, and they all hoped that another visit would, in due course, be paid to their town.

On the motion of the Rev. Dr. Flint, a hearty vote of thanks was accorded to the President, for the efficient and happy manner in which he had discharged his functions; and also to the Secretaries and the Treasurer. The President and Mr. H. E. Wood responded.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1913.

1. Constitution.—The Annual Meeting of the Association, which was held at Port Elizabeth on the 3rd July, 1912, adopted a series of resolutions amending the Constitution in certain respects. These resolutions remained to be confirmed by this year's meeting. The view was generally held that it was desirable to begin acting on them at the earliest possible date, and a further resolution was therefore adopted, empowering the Council to take the responsibility of so acting, if, after having conveyed the resolutions arrived at to all members by circular, no objection were made within one month. The instructions of the General Meeting were duly carried out, and, no objection having been taken, last year's resolutions were considered fully operative as from the 1st of October.

2. Financial Year.—Amongst the amendments to the Constitution thus affected was one terminating the financial year on the 31st of May instead of on the 30th of June. The result has been the disappearance of the difficulty mentioned in the opening paragraphs of the last two annual reports—the difficulty of submitting a financial statement within a week after the close of the year covered thereby.

3. Abolition of Entrance Fees.—Another amendment removed what seems to have been somewhat of a barrier to intending members—the entrance fee. The result of this was that several associates decided to alter their status to that of full membership, and, in addition to these, several other members have also thus been gained for the Association.

4. Membership.—Notwithstanding these additions, there has been a considerable decrease in the membership roll during the year under report, owing to a determined and continuous effort made throughout the year to collect annual subscriptions, and to purge the Roll of the names of those who for various reasons could no longer be regarded as being of good standing in the Association. As a probable result of the Council's action, there has been a considerable number of resignations of the class of members referred to.

The nett effect on the distribution of members will be seen from the following comparative table:—

	1912.	1913.
Transvaal	263	242
Cape Province	230	219
Orange Free State	43	24
Natal	31	29
Rhodesia	38	31
Basutoland	11	7
Mozambique	8	20
Swaziland	1	1
German South-West Africa	1	1
Resident Abroad	24	19
Residence Unknown	23	1
Total	673	594

There is consequently a numerical difference of 79 between the membership now and a year ago. Since 1st July, 1912, 96 new members have joined the Association, 4 have died, and 171 have resigned or were struck off owing to non-payment of subscriptions. The number of life members is now 33.

5. Report of Bulawayo Meeting, 1911.—The Association's proceedings at Bulawayo, contained in the eighth annual volume, were completed and bound during the year. The book comprises 462 pages, and is therefore a trifle smaller than its immediate predecessor. It contains 38 papers printed in full.

6. Report of Port Elizabeth Meeting, 1912.—It is proposed to complete this in thirteen monthly parts; the final issue will be published during August. The volume will consist of somewhat over 400 pages, and will contain 44 papers printed *in extenso*. The cost of printing the proceedings has been very considerably below the £360 estimated when the monthly publication was first considered in 1909.

7. South Africa Medal and Grant.—On the recommendation of the South Africa Medal Committee, consisting of Prof. J. C. Beattie, D.Sc. (Chairman), Dr. A. W. Roberts, F.R.A.S., F.R.S.E., Dr. A. Theiler, C.M.G., Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Prof. E. Warren, D.Sc., Prof. G. H. Stanley, A.R.S.M., F.I.C., Dr. C. F. Juritz, M.A., F.I.C., Prof. G. Potts, M.Sc., Ph.D., Dr. T. Muir, C.M.G., M.A., F.R.S., Dr. L. Peringuey, F.E.S., F.Z.S., Prof. S. Schönland, M.A., Ph.D., F.L.S., and Mr. H. B. Maufe, B.A., F.G.S., the sixth award of the South Africa Medal, together with a grant of £50 has been made to Dr. Arthur William Rogers, M.A., F.G.S., Assistant Director of the Geological Survey of the Union, in recognition of his geological work in the Cape Province.

8. Grants for Research.—The Association continues to be represented on the General Research Committee organised during the previous year in connection with the Royal Society of South Africa, whose Council administers the funds in conformity with the advice of the General Committee. The present representatives of the Association on this Committee are Rev. Dr. Flint, Prof. Hahn, Prof. Pearson, and Mr. Reid. In connection with the grant of £100 made to Dr. A. W. Roberts by the Association in 1905 for the reduction of his variable star observations, Dr. Roberts reported that he had had the observations, some 60,000 in number, reduced, copied in duplicate, and indexed. The question of printing had, however, been a difficulty.

9. Award for Anthropological Research.—At the Council Meeting in June, 1913, the award to Miss Tucker of the sum of £20, previously specially allocated in the Assocation funds for anthropological research, was resolved upon.

10. Goold-Adams Medals.—The third series of annual awards has been made in connection with the Senior Certificate and Matriculation examinations of the University of the Cape of Good Hope, held during the closing months of 1913. The following are the names of the recipients on this occasion:—

Mathematics: Leo Weinberg, Christian Brothers' College, Kimberley.

Physics: Ronald Percy Freemantle, St. Aidan's College, Grahamstown.

Chemistry: Morris Cohen, Christian Brothers' College, Kimberley.

Elementary Physical Science: John Daniel Newberry, St. Andrew's College, Grahamstown.

Botany: Enid Frances Jennings, Wesleyan High School, Grahamstown.

11. Bloemfontein Philosophical Society.—In accordance with the resolution adopted at the last Annual General Meeting, referring the proposed affiliation of the Bloemfontein Philosophical Society to the incoming Council for further action in connection with the insertion of the new Clause IX (*f*) in the Constitution, negotiations have been continued during the year, but no definite result has been reached.

12. Establishment of Botanical Garden in Cape Peninsula.—In connection with proposals to the above effect in Parliament and the Press, the Council resolved, at its May meeting, on the motion of Professor Pearson, "That this Council re-affirms the resolution passed at the Annual Meeting at Cape Town in 1910, and advocates the establishment of a Botanical Garden in the Cape Peninsula, and is of opinion that such an

institution would greatly advance the scientific and economic study of the vegetation of South Africa." A copy of this resolution was forwarded to the Prime Minister, and the Council is glad to record the fact that Parliament has sanctioned the initiation of the scheme, and voted a substantial sum of money for the purpose.

13. The New Council.—On the basis of membership provided in the Constitution of the Association, Section VI (*d*), the Council for the ensuing year should be distributed as follows:—

Transvaal:

Witwatersrand	8
Pretoria	3
Potchefstroom	1

Cape Province:

Cape Peninsula	5
Port Elizabeth	1
Stellenbosch	1
King William's Town	1
Kimberley	1
Grahamstown	1
Queenstown	1

Rhodesia:

Bulawayo	1
Salisbury	1

Orange Free State:

Bloemfontein	1

Natal:

Maritzburg	1
Durban	1

Mozambique:

Lourenço Marques	1

REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDED MAY 31ST, 1913.

In presenting the Financial Statement of the Accounts of the Society for the eleven months ending May 31st, I am pleased to record an improved position as compared with previous years.

The amount received for current subscriptions shows a slight improvement, 444 members having paid their current subscriptions as against 432 in 1911/12 and 394 in 1910/11 for a similar period. Arrear subscriptions have yielded £120 as against £150 in 1911/12 and £170 in 1910/11. Interest from Endowment Fund has produced £44 1s. 3d.

On the expenditure side almost every item shows a reduction, and the figures appearing in the Accounts may be taken as the lowest amount necessary to enable the Society to exist efficiently. There are no outstanding Accounts; everything has been paid up-to-date, and there is a balance at the Standard Bank on Revenue Account of £196 18s. 5d., as against £18 2s. 3d. last year. It is sincerely to be hoped that this improved position may continue for many years.

There is still a large amount of subscriptions outstanding; this should not be the case, but I am afraid all similar Societies have a like complaint.

With the exception of an item of Interest which has come in, there has been no alteration in the Medal Fund Account, the grant for this year not having been drawn. The capital of this Fund is invested as follows:—

Cape of Good Hope 4 % Stock	£1,376	0	0
Post Office Savings Bank	95	6	8
In hands of Chairman of Trustees . .	0	0	7
	£1,471	7	3

The Endowment Fund stands at £1,198 0s. 0d., as last year; and under the new rule *re* entrance fees there will not be any increase on this amount from year to year, from that source, although it may still be increased by life subscriptions. The Interest from this amount forms a welcome addition to the ordinary funds of the Society. The amount is invested as follows:—

Standard Bank Deposit	£1,152	15	0
Post Office Savings Bank	45	5	0
	£1,198	0	0

The Journal Account shows the cost for a full twelve months, as the cost for the June, 1911, number was not included in the Accounts last year, so that the amount £226 13s. 3d., or, say, £230 0s. 0d., may be considered as the annual cost of this volume, and it compares very favourably with the cost when the volume was an annual one as distinguished from the present monthly issue.

A. WALSH,

General Treasurer.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT, JULY 1ST, 1912, TO MAY 31ST, 1913.

Expenditure.	£ s. d.	Income.	£ s. d.
To Journal, Expenses of	£226 13 3	By Interest on Endowments	£44 1 3
,, Rent	27 10 0	,, Subscriptions 1912-13	444 0 0
,, Secretary	105 0 0	,, Subscriptions Arrear	120 0 0
,, Printing and Stationery	21 3 1		
,, Stamps and Telegrams	16 17 5		
,, Sundry Charges	29 0 8		
,, Depreciation of Furniture	3 10 8		
	429 15 1		
Balance to Balance Sheet	196 18 5	Balance from Last Year	18 12 3
	£626 13 6		£626 13 6

BALANCE SHEET.

Liabilities.	£ s. d.	Assets.	£ s. d.	£ s. d.
Subscriptions paid in advance	£35 0 0	Medal Fund Trustees		£1471 7 3
Medal Fund	1471 7 3	Endowment Fund		1198 0 0
Endowment Fund	1198 0 0	Furniture Last Year	£29 6 10	
Anthropological Committee	20 0 0	Furniture since added	6 0 0	
Revenue Account, Balance to Credit	196 18 5		35 6 10	
		Less Depreciation 10%	3 10 8	
				31 16 2
		Cash at Standard Bank, Balance as per Pass Book	262 18 11	
		Less Cheques not yet presented	42 16 8	
				220 2 3
	£2921 5 8			£2921 5 8

I hereby certify that I have examined the above Balance Sheet and Revenue Account with the books, vouchers and Bankers' Pass Book relating thereto, and that in my opinion they correctly set forth a true and correct statement of the affairs of the Association as shown by the books thereof.

Hy. Gibson,
Incorporated Accountant,
Certified Accountant (Cape).

Cape Town, 17th June, 1913.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICA MEDAL FUND.

	£	s.	d.		£	s.	d.
To Balance 31st May, 1913	£1,471	7	3	Balance 30th June, 1912	£1,416	6	5
				Interest	55	0	10
	£1,471	7	3		£1,471	7	3

ENDOWMENT FUND.

	£	s.	d.		£	s.	d.
To Revenue Account	£44	1	3	Balance, 30th June, 1912	£1,198	0	0
„ Balance, 31st May, 1913	1,198	0	0	Interest	44	1	3
	£1,242	1	3		£1,242	1	3

I hereby certify that I have examined the above Balance Sheet and Revenue Account with the books, vouchers and Bankers' Pass Book relating thereto, and that in my opinion they correctly set forth a true and correct statement of the affairs of the Association as shown by the books thereof.

Hy. Gibson,
Incorporated Accountant,
Certified Accountant (Cape).

Cape Town, 17th June, 1913.

The South Africa Medal.

SIXTH AWARD OF THE SOUTH AFRICA MEDAL AND GRANT.

(Fund raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

In the unavoidable absence of Dr. A. W. Rogers, to whom the medal had been awarded, the President of the Association, after the conclusion of his address in the Municipal Council Chamber, Lourenço Marques, on Monday, 7th July, 1913, handed the medal to the Rev. Dr. W. Flint for conveyance to Dr. Rogers. In doing so Dr. Roberts said:

" Dr. Arthur William Rogers, M.A., ScD., F.G.S., has been engaged on geological work in South Africa since 1896, at first as Assistant Geologist, and, since 1904, as Director of the Cape Geological Survey. Upon the union of the Cape and Transvaal surveys he assumed the rank of Assistant Director. A very considerable portion of the Cape Province was geologically mapped under his direction, and his writings upon these areas are contained in the sixteen annual reports of the Geological Commission of the Cape of Good Hope. In addition to his departmental writings, Dr. Rogers has contributed a number of papers to the Transactions of the South African Philosophical Society (now the Royal Society of South Africa), and to the Geological Society of South Africa, as well as other publications in South Africa and abroad. In 1910, as President of Section B of this Association, he delivered an important address upon the origin of certain very old rocks, the history of vulcanism, and past climates, with the object of discussing whether they necessitate any serious modifications of the uniformitarian theory. In 1905, Dr. Rogers published a volume on the Geology of the Cape Province, of which a second edition, revised and very largely re-written in the light of new information elicited by the operations of the survey under his direction, appeared in 1909. In these works the physiographical and geological problems of the parts of South Africa dealt with are ably and judiciously set forth. In recognition of his geological work the University of Cambridge some years ago conferred upon him the degree of Doctor of Science, and in 1907 the Geological Society of London awarded him the Bigsby Medal. Dr. Rogers's work has ever been distinguished for its thoroughness, and, in dealing with a science in which speculation and hypothesis are apt to become predominant he has always exercised restraint and caution in dealing with the many difficulties presented to him when endeavouring to unfold the country's almost unique geological problems. Dr. Rogers was a member of the Committee appointed by the British Association in 1905 to investigate and report on the correlation and age of South African strata, and on the question of a uniform stratigraphical nomenclature, and also of the Committee appointed by the same Association to determine the precise significance of topographical and geological terms used locally in South Africa."

The following is a list of Dr. Rogers's principal writings:—

1. "Summary of work done in the South-Western Districts": *Cape Geol. Commission Reports*, 1896.
1a. "Report of a preliminary geological survey of the Oudtshoorn and Prince Albert Districts" (with G. S. Corstorphine): *Cape Geol. Commission Reports*, 1896.
2. "Survey of the Stellenbosch District": *Cape Geol. Commission Reports*, 1897.
3. "Survey of the country between the Karroo and the Langebergen" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1897.
4. "Notes on the recent limestones on parts of the south and west coasts of Cape Colony" (with E. H. L. Schwarz): *Trans. S.A. Phil. Soc.*, 1898.
5 "Report on Caledon, Bredasdorp, Swellendam, and southern parts of Worcester" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1898.
6. "Report on the southern districts between Breede River and George" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1898.
7. "Report on Oudtshoorn" (With E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1898.
8 "Notes on the geology around Worcester" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1898.
9. "Geology of the Orange River Valley in the Hopetown and Prieska Districts" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1899.
10. "The Orange River ground moraine" (with E. H. L. Schwarz): *Trans. S.A, Phil. Soc.*, 1900.
11. "The survey of parts of the Uitenhage and Port Elizabeth Divisions" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1900.
12. "The survey of parts of Clanwilliam, Vanrhynsdorp, and Calvinia Divisions" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1900.
13. "Report on a geological route survey from Beaufort West to Calvinia" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1900.
14. "Report on the Cedarbergen and adjoining country" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1900.
15. "On a glacial conglomerate in the Table Mountain sandstone": *Trans. S.A. Phil. Soc.*, 1901.
16. "The Transkei gap" (with E. H. L. Schwarz): *Trans. S.A. Phil. Soc.*, 1901.
17. "Report on a journey from Swellendam to Mount Bay" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1901.
18. "General survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the cretaceous rocks of Eastern Pondoland" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1901.
19. "The geological survey of the Division of Kentani" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1901.
20. "A survey of parts of the Beaufort West, Prince Albert, and Sutherland Divisions" (with E. H. L. Schwarz): *Cape Geol. Commission Reports*, 1902.
21. "The geological history of the Gouritz River System": *Trans. S.A. Phil. Soc.*, 1903.

22. "Geological survey of parts of Ceres, Sutherland, and Calvinia" (with A. L. du Toit): *Cape Geol. Commission Reports*, 1903.
23. "Geological survey of parts of Piquetberg, Clanwilliam and Vanrhynsdorp": *Cape Geol. Commission Reports*, 1903.
24. "The Sutherland volcanic pipes, and their relationship to other vents in South Africa" (with A. L. du Toit): *Trans. S.A. Phil. Soc.*, 1904.
25. "The glacial conglomerate in the Table Mountain Series near Clanwilliam": *Trans. S.A. Phil. Soc.*, 1904.
26. "Geological survey of the north-western part of Vanrhynsdorp": *Cape Geol. Commission Reports*, 1904.
27. "Geology of the Cape Colony": *Science in South Africa*, 1905.
28. "The volcanic fissure under Zuurberg": *Trans. S.A. Phil. Soc.*, 1905.
29. "An introduction to the Geology of Cape Colony," 1905.
30. "Geological survey of parts of the Divisions of Uitenhage and Alexandria": *Cape Geol. Commission Reports*, 1905.
31. "Geological survey of parts of Hay and Prieska, with some notes on Herbert and Barkly West": *Cape Geol. Commission Reports*, 1905.
32. "A raised beach deposit near Klein Brak River": *Cape Geol. Comsion Reports*, 1905.
33. "The glacial beds in the Griquatown Series": *Report S.A. Assn. for Adv. of Science*, 1906.
34. "The Campbell Rand and Griquatown Series in Hay": *Trans. Geol. Soc. of S. Africa*, 1906.
34a. "Geological Survey of parts of Bechuanaland and Griqualand West": *Cape Geol. Commission Reports*, 1906.
35. "Geological survey of parts of Vryburg, Kuruman, Hay, and Gordonia": *Cape Geol. Commission Reports*, 1907.
36. "The geology of parts of Prieska, Hay Britstown, Carnarvon, and Victoria West" (with A. L. du Toit): *Cape Geol. Commission Reports*, 1908.
37. "Notes on a journey to Knysna": *Cape Geol. Commission Reports*, 1908.
38. "The Tygerberg anticline in Prince Albert": *Cape Geol. Commission Reports*, 1908.
39. "An introduction to the geology of Cape Colony" (2nd ed.) (with A. L. du Toit), 1909.
40. "De jongste geologische onderzoekingen in het noorden van de Kaap Kolonie" *Koninkl. Ned. Aardrykskundig Genootschap*, 1909.
41. "The geology of parts of Kenhardt, Prieska, and Carnarvon" (with A. L. du Toit): *Cape Geol. Commission Reports*, 1909.
42. "The Zwartkops borehole": *Cape Geol. Commission Reports*, 1909.
43. "Verneuk pan": *Trans. Royal Soc. S. Africa*, 1910.
44. Presidential address to Section B. *Report S.A. Assn. for Adv. of Science*, 1910.
45. "Past climates of Cape Colony": *Trans. International Geol. Congress, Stockholm*, 1910.
46. "The iron ores of Cape Colony": *Trans International Geol. Congress, Stockholm*, 1910.
47. "The Kheis Series": *Trans. Geol. Soc. of S. Africa*, 1910.
49. "The geological survey of parts of the Divisions of Vanrhynsdorp and Namaqualand": *Cape Geol. Commission Reports*, 1911.
48. "The geological survey of parts of the Divisions of Beaufort West, Fraserburg, Victoria West, Sutherland, and Laingsburg": *Cape Geol. Commission Reports*, 1910.
50. "The Nama System in the Cape Province": *Trans. Geol. Soc. of S. Africa*, 1912.

The President then handed the medal and cheque for £50 to Dr. Flint, who, on behalf of Dr. Rogers, thanked the President for presenting, and the Council of the Association for bestowing the award, and briefly referred to the self-denying labours of the medallist.

PREVIOUS RECIPIENTS.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.

1910. *Cape Town.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Cape Town.

1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Cape Town.

1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, C.P.

ASSOCIATION LIBRARY.

The following publications are regularly filed at the office of the Association, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town, and are available for perusal by members daily.

General Science.

Proceedings of the Royal Society of Edinburgh.
Transactions of the Royal Society of South Africa.
Memoirs of the Royal Society of South Australia.
Transactions of the Royal Society of South Australia.
Proceedings of the Royal Society of Victoria.
Proceedings of the Royal Institution of Great Britain.
Proceedings of the Royal Philosophical Society of Glasgow.
Journal of the Royal Society of Arts.
Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften.
Servian Royal Academy of Sciences:
 Comptes rendus.
 Year Book.
Michigan Academy of Sciences: Reports.
Bulletins of the Chicago Academy of Sciences.
Atti della Reale Accademia dei Lincei, Rome.
Kungl. Svenska Vetenskapsakademien:
 Handlingar.
 Årsbok.
Koninklijke Akademie van Wetenschappen, Amsterdam:
 Proceedings of the Section of Sciences.
 Verhandelingen.
Revista de la Real Academia de Ciencias de Madrid.
Report of the British Association for the Advancement of Science.
Report of the Australasian Association for the Advancement of Science.
Proceedings of the American Association for the Advancement of Science.
Atti della Società Italiàna per il progresso delle Scienze.
Cambridge Philosophical Society:
 Transactions.
 Proceedings.
Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
Proceedings of the American Philosophical Society.
University of Virginia: Philosophical Society Bulletins.
Science Reports of the Tohoku Imperial University.
Annals of the New York Academy of Sciences.
Proceedings of the American Academy of Arts and Sciences.
Proceedings of the California Academy of Sciences.

Transactions of the Academy of Science of St. Louis.
Proceedings of the Academy of Natural Sciences of Philadelphia.
Archives Néerlandaises des sciences exactes et naturelles.
Annaes scientificos da Academia polytechnica do Porto.
Proceedings of the Rhodesia Scientific Association.
Memoires de la Société de physique et d'histoire naturelle de Genève.
Det Kongelige Norske Videnskapers Selskaps Skrifter.
Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger.
Comptes rendus des séances de la Société de physique et d' histoire naturelle de Genève.
Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Bulletin of the Imperial Institute.
Transactions and Proceedings of the New Zealand Institute.
Annual Report of the Smithsonian Institution.
Annual Report of the Smithsonian Institution (United States National Museum).
Annals of the Transvaal Museum.
Annals of the Natal Museum.
Memoirs of the Queensland Museum.
Field Museum of Natural History Publications.
University of Pennsylvania Museum Journal.
Bulletin of the Public Museum of Milwaukee.
Records of the Albany Museum.
Knowledge.
Science.

Chemistry, Metallurgy, and Geology.

Journal of the Chemical, Metallurgical, and Mining Society of South Africa.
Kungl. Svenska Vetenskapsakademien: Arkiv för Kemi, Mineralogi, och Geologi.
Transactions of the Geological Society of South Africa.
Journal of the Geological Society of Tokyo.
Geological Survey of New South Wales:
- Records.
- Memoirs.
- Mineral Resources.

Bulletins of the Geological Institution of Upsala.
Abstracts of Proceedings of the Geological Society, London.
Bulletins of the Wyoming State Geologist.
United States Geological Survey:
- Bulletins.
- Professional Papers.
- Mineral Resources.
- Annual Reports.

Journal of Industrial and Engineering Chemistry.

The Chemical News.
The Mineralogical Magazine.

Meteorology.

Quarterly Journal of the Royal Meteorological Society.
Bulletins of the Mount Weather Observatory.
United States Department of Agriculture: Monthly Weather Review.

Agriculture.

Annali della Regia Scuola superiore agricoltura di Portici.
International Institute of Agriculture, Rome:
- Bulletin of Agricultural Statistics
- Bulletin of the Bureau of Agricultural Intelligence and of Plant Diseases.

Massachusetts Agricultural Experiment Station:
- Annual Reports.
- Bulletins.

Cedara Memoirs.
Agricultural Journal of the Union of South Africa.
United States Department of Agriculture Experiment Station Record.
Rhodesia Agricultural Journal.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou.
Kungl. Svenska Vetenskapsakademien:
- Arkiv för Botanik.
- Arkiv för Zoologi.

Journal of the Linnean Society, Botany.
Bulletin of the Wisconsin Natural History Society.
Transvaal Medical Journal.
University of California: Publications in Botany.
Missouri Botanical Garden Annual Reports.
Smithsonian Institution (United States National Museum):
- Contributions from the United States National Herbarium.

Entomology.

Report of the South African Central Locust Bureau.
Zeitschrift für wissenschaftliche Insektenbiologie.

Astronomy, Mathematics and Physics.

Royal Astronomical Society:
- Memoirs.
- Monthly Notices.

Union Observatory Circulars.
Observatoire Royal de Belgique: annuaire astronomique.

British Astronomical Association:
Journal.
Memoirs.
Lick Observatory Bulletins.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
Proceedings of the London Mathematical Society.
Die Tätigkeit der physikalisch-technischen Reichsanstalt, Charlottenburg.
National Physical Laboratory, Middlesex:
Collected Researches.
Reports.
Proceedings of the Physical Society of London.

Political Economy and Social Science.

United Empire.
International Institute of Agriculture, Rome: Bulletin of the Bureau of Economic and Social Intelligence.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Bollettino del Comitato talassografico.
Comitato talassografico Italiano: Memorias.

The Geographical Journal.
Bulletin of the American Geographical Society.
United States Geological Survey: Water Supply Papers.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institute of Engineers.
Transactions of the South African Institute of Electrical Engineers
Proceedings of the South African Society of Civil Engineers.

Technology.

Patents for Inventions: Abridgments of Specifications.
The Illustrated Official Patents Journal.

PRESIDENT'S ADDRESS.

ADDRESS

BY

ALEXANDER WILLIAM ROBERTS, D.Sc., F.R.A.S., F.R.S.E.,

PRESIDENT.

I am deeply conscious of the grave and singular honour that has been conferred upon me, in taking me out of the circumstances and thoughts of ordinary school life and work, though occupation most profoundly interesting and absorbing, and placing me for a brief space in the notable position of president of this Association, an Association of Scientific workers and thinkers drawn from all parts of South Africa.

And I am the more conscious of the honour that has fallen to me when I give proper place to the knowledge that this is the first occasion when our Association has met outside the boundaries of the British Dominion.

For ten successive years we have met annually in one or other of the leading towns of British South Africa. This year we have ventured afield into the beautiful colonial capital of our friendly neighbour. Our friendly neighbour! For it is to be had in remembrance—indeed, the truth is a common-place, and requires no setting of mine to ensure its acceptance, that the people in whose territory and under whose flag we are met, whose hospitality we enjoy, are among the oldest and most loyal friends of our own land and race.

Yet more! We are met among a people who owe their unique national history, a history of whch they may well be proud, not to the waging of great wars, not to political intrigue and dexterity, but to a long succession of brilliant discoveries, to the epoch-making achievements of a galaxy of heroes of gallant adventure.

The future we know not! The past alone is certain, and so long as time runs, the pioneer work accomplished by many sons of Lusitania, in Maritime Discovery, in Travel, in Science, will be an ornament in their own history and an inspiration to all who set forth new worlds to discover.

We can never forget that it was Portugal that first lifted the curtain from off this fair southern land, that set great highways across the seas, that gave to the round earth of ours its true proportions.

As an Association we are glad to be allowed to have our first meeting outside British territory in a land so neighbourly, among a people so friendly, and amidst traditions so worthy and inspiring.

Ten years ago Sir David Gill concluded his presidential address with these words:—

> "Science knows no nationality. It forms a meeting ground on which men of every race are brethren working together for a common end—and that end is truth."

It is in this spirit that I welcome all to these meetings of our Association, not as units divided by language, or race, or tradition, or history, or even conditions, but as workers bound together by common aims and ideals, and inspired by a common faith and purpose. Truth, it is well said, is a diamond of many facets. And when one remembers its many manifestations, and how peculiar is the light and setting required to reveal its beauty, one is timorous lest his exhibition of it may conceal and obscure that which he wishes to declare and intensify.

My purpose to-night is to have you as comrades with me in the belief that a splendid work is being done in South Africa in scientific research and enquiry, to make it clear that achievements great and worthy are being won along every road and path of scientific investigation in this land; to make it clear to you that we have witnessed, and have been vicariously partakers in triumphs as great as any country can show.

The history of our own Association, a view of the names on our register, and the labour and achievement that these names suggest, is my most efficacious argument in this claim I make on your behalf.

We may range indifferently in any of the sciences that our Association undertakes to advance, and the same evidence will be manifest. In Astronomy—we have had as our first president a man of world-wide reputation, one whose name and fame will last with the stars he knew so intimately and loved so sincerely: in Mathematics—again looking back a few years, we can remember this chair filled by one who takes high rank amid his fellows of any age: in Chemistry—and here also we have had as our president a worker who has summed up in his own career a wealth of achievement and endeavour: in the domain of Biology—and it is but yesterday that one of the most eminent of living Bacteriologists occupied the place where I now stand: in Engineering—it is to this department of science, to its commanding position in this land, to the distinction of many of its members that our Association owes much of its force and prestige: in Geology—one has only to think of the honoured place held by our medallist this year to be assured of the progress made in South African Geology: in Botany, in Anthropology, in Meteorology and in its sister science Seismology, we have a record of things accomplished of which any Association may be proud.

Now all this breadth and scope of outlook, this intensity of endeavour, this harvest of achievement makes it necessary for one addressing himself to the scientific progress of his day to confine himself to an area of inquiry in the which he shall wander less as a stranger than he would in other fields.

This is my reason for taking as a type of what is being done in other regions of scientific research (such fields as I have already indicated) the progress made in Astronomy by South African workers during the past century.

Even thus limiting the scope of this address to one special science, it will be necessary to leave out much that not a few may think worthy of report. For such omissions those whose knowledge of the history of Astronomy in this land is both immediate and intimate will pardon me.

Astronomical science, especially of late years, circles round three great problems: The distance of the stars, the movements of the stars, the structure and evolution of the stars. These three lines of advance all converge in one great question.

The constitution, history and cosmography of the Universe as a whole. Perhaps it lies in the Ithurial touch of this haunting land of far distances, but somehow, on these southern shores, astronomers have never lost sight of the final goal of all their endeavour. Indeed, again and again, and yet again, they can claim priority in each epoch-making departure in astronomical progress. These leaders in scientific thought have seldom lost sight of the wood because of the trees.

While busy, necessarily busy, for days and weeks and months measuring errors in the runs of screws, or recording star discs by machine with the monotony of a knife grinder, they have seen the far-off end, the imperial issues to which all their labour tended. End and issues which would never be reached unless the divisions on a scale were accurately gauged, or the dots on a photograph surely indexed.

These things have to be done. They are part of the price we have to pay for our results. And let us be thankful that results, like gold and diamond, have to be mined for by the toil of our fingers and the sweat of our souls.

The other day I was again reading through the classical volumes on the solar parallax, by Gill. They form Vols. VI and VII of the Cape Annals, two bulky tomes running to over a thousand pages, mostly packed with figures. These volumes represent the labour of ten years: they are the condensed summary of computations that, if stacked in a pile, would reach the height of thirty feet. And all to settle the second decimal place in an astronomical constant? Nay! but to supply with all available accuracy a base line with which to measure the universe!

In the correspondence between Sir David Gill and Dr. Kapteyn, concerning the proposal of the latter to measure all the photographs taken at the Cape, and so form a photographic Durchmusterung of southern stars, the following pregnant remark occurs. Kapteyn is writing to Gill.

> "I have talked the matter of the Photographic Durchmusterung over with Dr. Bakhuyzen and his brother. I am bound to say that they were not very enthusiastic about the matter; of course, they thought the results once reached of immense value, but the drudgery to be gone through before these results are once got into the form of a catalogue almost unbearable. However, I think my enthusiasm for the matter will be equal to six or seven years of work."

This was in December, 1885.

In 1899, Kapteyn wrote:

> "The Cape Photographic Durchmusterung may at last be considered complete. The work has cost nearly double the time, the six or seven years' which I originally estimated would be required."

Of this magnificent sidereal survey more anon; it is of the present, to point out that its completion meant fourteen years of unremitting labour, and the examination, again and again, for position and brightness, of nearly half a million stars.

I mention these two supreme labours here (labour characteristic of all scientific research) lest by passing on simply, as I shall, to the results achieved, it be forgotten by what strenuous service, by what arduous toiling these results have been attained.

It is the mind to work, and the capacity to toil, that makes the difference between the true scientist and the one who is simply interested in science—and no more.

A chronicle of pioneer work in Astronomy makes good reading for those who delight in South African achievement. It is to our signal honour that we can claim priority in many a forward movement in this science.

It was at the Cape that a sounding line was first thrown across the stellar spaces. It was at the Cape that the idea of stellar photography was born, grew up, and reached maturity. It was at the Cape, or perhaps by the results obtained at the Cape, that the first vision was got of those wonderful streams of stars that sweep majestically through our universe.

It was at the Cape that the classical distance of the sun was reached. It was at the Cape that the first accurate parallax of the moon, and, later on, its weight, was determined. It was at the Cape that the most refined measures of stellar distance have been secured.

And to-day, South Africa practically carries the whole of Southern astronomy on its shoulders. There is more being done in southern double-star work by one man, than by all the other observers in this field put together.

The long lists of discoveries made by our distinguished Vice-President, his patient toil in accumulating valuable observations of the position and movements of binary systems merit our warmest appreciation. It is now thirteen years ago since his well-known catalogue saw the light, and since then he has enriched astronomy by his work on variable stars, on the Jovian system, on sidereal cartography. The Union Observatory has, indeed, a fine future before it, a future full of promise and of possibilities, and that mainly because it is presided over by one who is wholly and truly an ideal astronomer.

When the genius of Kapteyn made manifest the certainty of star streaming, the attention of astronomers was forthwith directed to the then unaccountable phenomenon. Kapteyn's researches date from 1904; but prior to this —years prior—Gill had set his face against the conception of the uniform distribution of the stars through space. I remember, as if it were yesterday, how, in his old roomy study at the Royal Observatory, he foreshadowed in prophetic spirit the very direction that investigation and discovery is now taking. I had then in purpose—I speak of a day twenty years ago—determining the position of the Solar apex from the proper motions in Stone's catalogue. I went over my "postulates" with Gill, and was vehemently assured I was basing my equations on wrong premises. "How do you know that the stars move hap-hazard?" he demanded. I did not know! "They may be moving in streams: the whole universe may be a big whirlpool."

And for a space, not to be measured by time-beats, this prince among astronomers allowed his imagination, his inspired imagination, to wander hither and thither among the great questions that thronged in on his soul. But Gill was only one of many to whom the idea of stellar streaming occurred as an explanation of outstanding anomalies in proper motion.

It was left, however, to Kapteyn, and to Kapteyn first and foremost, to place beyond the region of doubt the hitherto vague and uncertified judgments regarding star drifting.

Those who were privileged to be present at the meeting in Cape Town, in 1905, when Kapteyn dealt with his remarkable discovery of two symmetrical star streams sweeping through the spaces will remember the sensations akin to awe with which they heard of rivers of stars flowing on and on and on, silent, majestic, irresistible.

What the nature of this vast movement is, whether in a straight line, or along the arc of some majestic circle, how controlled and how conditioned, no vision can determine accurately, no analysis reveal fully. Kapteyn's pioneer work has been splendidly supplemented by the labours of Dyson, Eddington, Boss, Schwarzschild, and Campbell. In the Southern Hemisphere, Hough and Halm have attacked the problem from another direction, that of spectroscopic proper motions. A word of explanation may be pardoned me as to the content of this problem of star gauging, for upon its solution depends our assured conception of the structure and configuration of the stellar universe as a whole. All round us is the firmament of stars. Any movement of our Sun through space will reveal itself in two ways. We shall have a telescopic proper motion of every star near enough to indicate a parallactic displacement, and, second, we shall have a spectroscopic proper motion of every star in the sky, far or near, which the sun in its journey through space is either approaching or receding from. To these relative movements, due to the sun's motion, we must add the real stellar movements due to each star's own absolute motion.

Now, if the stars are uniformly distributed in space, and if the sum total of their real proper motions amounts to zero, then a simple application of the laws of probability will yield the direction and the amount of the Sun's motion in space, and, consequently, the real proper motion of every star near enough to show secular change of position in the telescope, or bright enough to reveal line of sight motion in the spectroscope.

But recent investigation has clearly proved that the stars are not uniformly distributed in space. Indeed, one needs the aid of no refined analysis to come to this conclusion.

A clear night and a pair of seeing eyes are all we need.

But what neither a clear night nor seeing eyes will reveal, is whether the hazy stretches of misty light seen in the midnight sky are faint stars, because they are far away, or are dimly luminous because they are small suns crowded together. Without doubt, the instruments Halm and Hough have chosen for their attack on the problem of stellar movements and groupings are those that in days to come will yield the best results.

Already Halm has been enabled, from the spectroscopic data at his disposal, to come to two very far-reaching conclusions. First, the two streams discovered by Kapteyn are not symmetrical with regard to the sun, that is, they are not equally distributed in space.

They have, instead, their own definite locus, their own celestial basin. Second, there are more than two streams of stars. One is tempted to speculate on the future of this region of research. Shall we some day be able to distinguish, not three streams of stars, but three thousand? Shall we so enlarge our boundaries that at no very remote day astronomers will be taken up mainly with realms and kingdoms of stars, defining their boundaries, determining their size, deducing their age, foretelling their destination in time and space. Already something has been done in this direction. The stars have been grouped according to their spectroscopic characteristics, that is, according to their composition: and it is found that their proper motions are most intimately connected with their size and structure. Stars of a certain type, heavy, massive stars, move slowly through space; stars of another definite type move more rapidly. Once more, it is a Cape Astronomer who is bent on running this relation to its cause.

Halm has on hand an investigation in which proper motion is held to be a function of the state of evolution of each star.

The investigation is purely a dynamical one, based on the Maxwellian law of the distribution of velocities.

When in this connection we consider that, a hundred years ago, men despaired of ever fathoming the abyss that lies between us and the outposts of the stars: that spectroscopy is only fifty years old; that stellar photography has not been in use for more than a quarter of a century, it is impossible to say what even a decade may bring to us of advance and discernment.

The matter of photographing the stars has naturally been referred to again and again. We have said that in South Africa it was born, born the hour Gill looked upon the photograph of the 1882 comet, taken with an ordinary portrait camera, and saw as in a vision, the power of the new arm.

The first comprehensive photographic survey of the heavens was taken at the Cape.

The present great international photographic star map, a labour that will take three decades to complete, that will cost over three quarters of a million adequately to finish, but which will put on permanent record at least 15,000,000 stars, had its inception and its stimulus at the Cape.

In exact astronomy, or fundamental astronomy, as it is often called, there has been a brilliant succession of men in South

Africa—Henderson, Maclear, Gill, Hough, each man a leader in his own particular branch of enquiry.

Henderson was not long at the Cape when the desire to obtain a more accurate parallax of the moon, and, if possible, the parallax of some of the stars, held him.

His determination of the distance of *Alpha Centauri* is an epoch in the history of astronomy. True, his results were published after those of Bessel on 61 · *Cygni*, but the priority of observations belongs certainly to Henderson. The delay of almost seven years between observation and publication was due to official neglect and indifference, neglect and indifference which drove a man of Henderson's refinement and timidity into reticence. But the work he did remains until this day. His determination of the moon's distance, of the longitude and latitude of the Cape, of the position of the principal southern stars, can scarcely be bettered even with the most refined instruments of to-day. He gave to South African astronomy a certain distinction and culture; he breathed into it his own refinement and scrupulous honesty. And yet his residence at the Cape is measured by months, not years. What an elusive intangible thing personality is.

Henderson's work on stellar parallax was taken up by Maclear, and carried to its furthest issues by Gill. The heliometer work of the latter, on certain well-known stars, will remain the high-water mark in this direction until a new method of determining stellar distances is discovered.

But the name of Gill will be indissolubly associated with the determination of the Sun's distance. I remember how, in moments of confidence, seated by his study fire, he told how he was attracted early to this problem, the problem of a generation ago, just as stellar cosmography is the problem of to-day. When Gill took up the problem, it was practically in chaos as a definite singular deduction.

Leverrier, even as late as 1872, despairing of ever determining the Solar parallax by any direct process, attempted to derive it from some of its related functions, such as aberration and nutation.

The transit of Venus results of 1874 gave values that differed from one another by at least 3,000,000 miles, one-thirtieth of the total amount to be determined. It is difficult to realise that this uncertainty belongs to a period of time only forty years remote from our own. But lest the scientific worker in other fields may judge ungenerously this amplitude of error, we may remind ourselves that the total angle on which the determination of the sun's distance depends is less than that subtended by a shilling at a distance of one-fifth of a mile. Yet, to-day, we know the sun's distance to one-thousandth part of its true value, to such a high level of refinement has modern observations been brought. Gill's first essay at the problem was made at Mauritius in 1874. The method he adopted was that of finding the parallax of Juno, and, consequently, of the sun, by taking diurnal observations of the planet. The experience gained in this expedition led him to a second determination. The series of observations of Mars, which was the planet used as "intermediary" between the earth and the sun, resulted in a value of the sun's parallax equal to 93,080,000 miles.

Unsatified even with this result—what true scientist is ever satisfied with his results?—Gill, in 1888, organized a combined attack on the problem. Five Northern observatories and one Southern entered upon a heliometric campaign against the minor planets Iris, Victoria and Sappho. The observations secured were reduced at the Cape, which throughout formed the headquarters of the investigation. The work done, its magnitude, its importance, its finality, have been already referred to. It was not till 1897, ten years after embarking on the campaign, that Gill was able to announce a distance of 92,875,000 miles as the result of his labours.

In more recent years two other notable determinations of this fundamental constant of astronomy have been secured, both by novel methods.

Last year, Hinks, of Oxford, from photographic measures of Eros, taken also at a number of observatories, found a distance of 92,826,000 miles, and four years ago, Halm, at the Cape, by spectroscopic measures of stars in the line of sight, arrived at a value of the solar parallax equal to 92,896,000 miles. Combining these three determinations, obtained by radically diverse methods, we obtain a value of the solar parallax equal to 92,866,000 miles.

In any determination of the sun's distance three other constants come within the radius of the investigation: the moon's distance and mass, for it is the distance of the centre of gravity of the earth-moon system that has to be finally determined; the constant of aberration, that is, the relation subsisting between the solar parallax and the velocity of light; and the oblateness of the earth's form.

Lacaille, one hundred and seventy years ago, determined, from his meagre home in Strand Street, the moon's distance, the aberration constant, and also set out on this southern land the first geodetic base line. The present Astronomer Royal at the Cape, faithful to these old traditions, is covering unexplored Northern Rhodesia with a network of triangulations, in hope, one day, of carrying the line that Lacaille began to the confining northern sea, and thus linking it on to the great web of European stations. It seems strange to connect the measuring of an insignificant base line out on the Cape Flats with spacious sidereal soundings, but there is an unbroken sequence in endeavour and in conception between estimating the length of a standard rod and spanning a universe. The humble student toiling at some laboratory analysis is an arm in the same service that seeks to explore the remotest distances, lay bare the most hidden secrets, declare the foundational laws that govern this manifold, many-mirrored universe. There is no isolated labour under the sun. The long series of observations of the moon, discussed and worked into theory by Neison of Natal, though long unused, has now found its fitting place in a new theory of the moon's motion. This new theory brings into pre-eminence a consideration of tidal retardation, and the consequent slowing down of the earth on its axis. And at this point we reach another aspect of astronomical research, that which deals with the life history of our own good green earth. It would seem a very far cry to relate all this lunar work to the winking changes seen in a variable star. One man works at the moon's position, and evolves a theory of its movements; another finds that this theory means a slowing down of the earth on its axis and an outward spiral movement—slow with the terrible patience of Nature—of the moon's path; and yet another, examining some far-off binary star, finds its period of revolution increasing in the process of the years. Then comes the unifying touch, and all this is seen to be part of one great whole, to which each worker has added his part.

The study of variation in the brightness of stars, due either to eclipse, or to some condition of orbital motion, or to intrinsic light changes in the star itself, has been especially studied in South Africa. We have already referred to Innes's work, as embodied in the Annals of the Cape Observatory, Vol II, and in many of the Circulars of the Union Observatory.

At Lovedale, the work undertaken during the past twenty years has been the systematic recording of the changes in brightness of over a hundred well-known stars. I do not mean here to do aught but refer to the bigger issues which this long series of observations has revealed, and I do so because of my desire to give weight to the thought of the unity of all scientific effort.

A study of the light variation of certain eclipsing stars yields not only the form and nature of the orbit in which they move but also the shape, density, and relative size of the component stars. It will readily be seen that such deductions, if reasonably substantiated, have an important bearing on the question of stellar evolution.

That eclipsing stars are very probably in the early stages of their life history, seems a reasonable conclusion; thus any facts that emerge regarding their form, or structure, or density are of no ordinary interest. It is of importance to note that every close binary star is of a density many times less than that of the sun; that few of them reveal an outer atmosphere; that the oblateness yielded by an examination of their light curve is in close agreement with that which the theory of rotating bodies would lead us to expect.

Allied to the study of stellar variation is the still more important branch of stellar photometry.

The profound problem of the structure of the universe is at present based mostly on catalogues of position and spectra. Except for the brighter stars we have no authoritative southern catalogue of stellar magnitudes.

True the Cape Photometric Durchmusterung supplies us with all we at present need.

But the day is not very remote when momentous cosmic problems will rely for their solution on the most refined estimates of stellar brightness, just as at present we are depending on certain fundamental catalogues of position for delineation of star streams.

The extent of our Universe, the constitution of the milky way, the extinction of light in its passage through space, are questions that must depend, to some extent at least, on photometric surveys for an answer.

For some years past work in this direction has been done at the Union Observatory, at Bulawayo, at Lovedale, but the time is near for a more serious consideration of the matter. Astronomy is enlarging its bounds in every direction: no longer is it the detailed study of single stars that concern us most; rather it is the weighing, charting, photometrically evaluating battalions of stars, that we may thereby place the end of our measuring rod against the outer rim of the Universe, cast all its stars into scales, and focus into one huge glow its multitudinous lights.

My self-elected task of relating what has been done in Southern Astronomy is nigh ended. I know I have left much unsaid.

I have also left many activities untouched or considered but poorly. I would fain hope I have not left aught out regarding those who have added a kindly humanity to their exalted talents, men whose friendship I have been honoured with for the better part of a lifetime, and to whom I owe a debt of gratitude that no words can sufficiently acknowledge, far less discharge.

There is a great future before astronomy in this land, and just as in past days men have been found who have responded to the clear call and the certain claim, and have kept their science high and honourable, never lowering their ideals, or narrowing their outlook, so in the days to come men will arise who will fill adequately the room, the yet larger room, waiting for them, because of the inspiration and distinction of a worthy past.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President of the Section.—J. H. von Hafe.

TUESDAY, JULY 8.

The President delivered the following address:—

THE HARBOUR AND RAILWAYS OF LOURENCO MARQUES AND THEIR RELATION WITH THE UNION OF SOUTH AFRICA.

I wish I could deliver a contribution according to the high scientific rank of the distinguished Assembly I have the honour to address, but lack of competence on one side, and lack of leisure on the other, preventing my making even a modest attempt in that direction, I shall confine myself to a short review of the harbour of Lourenço Marques.

This harbour, the beauty and magnificence of which you have now the opportunity of admiring, is one of the finest and safest in the world, and is the natural outlet to the sea from a vast country embracing the most valuable and best developed territory of the Union, Swaziland, the Southern part of Rhodesia, and of the Province of Mozambique.

Its entrance is sheltered from rough seas, thus allowing free and permanent access, even under stormy weather. The anchorage extends from Inyack Island to Port Matolla, a stretch of water 25 miles in length, 20 miles along the outer bay and four on the Espirito Santo River, where the commercial harbour is located, a wide waterway of considerable depth which receives the waters from the rivers Tembe, Umbeluzi, and Matolla.

Large vessels have access to the inner harbour through the Polana Channel, three and a half miles long, with an average depth of 22 feet below springtide low water; dredging being, however, carried on, so as to allow the largest steamers free access at any height of tide.

A series of luminous buoys and beacons permit navigation into the harbour at any time, day and night.

Loading and unloading operations are usually done alongside the wharf, the extension of which is being continually carried on, in view of the ever increasing traffic of the port. The total wharf length will be, at the end of this year, a little under one mile.

For the handling of goods there is a fine equipment and ample sheds, with spacious room for 90,000 tons, as well as an open area for the storage of over 100,000 tons of goods.

In order to meet the rapidly increasing export of coal, a coaling hoist of the McMyler Patent is now being built, with a handling efficiency of 400 tons per hour.

As most of the goods landed are bound for the Transvaal and other parts of the Union, free of Customs duties, several bonded sheds, warehouses and yards, belonging to forwarding Companies, have been established, where goods await orders for despatch.

These are the most noteworthy characteristics of this Harbour, which, as every other harbour, has its own features due to the influence that its geographical situation, the riches and extent of its hinterland and the wealth of the community has on its traffic, circumstances that, varying from one harbour to another, offer a criterion for grouping them into classes, according to their different functions.

Coastal harbours are, from this point of view, to be distinguished from inland harbours established on large navigable rivers, usually at some distance from the sea. The first are, as a rule, called at by passing steamers, for passenger service, mails and small quantities of cargo, while inland harbours deal mainly with cargo boats and full shipments.

Southampton, Dover, Plymouth, Cherbourg and Vigo are therefore only ports of call and small traffic, while London, Liverpool, Glasgow, Hamburg, Rotterdam, Antwerp, Rouen and other river-served harbours are essentially ports for heavy traffic.

There are, of course, some exceptions where the coastal traffic is rather intense, for instance, Marseilles, Genoa, Barcelona, Havre, and most of the harbours where coal and ore are shipped for export, such as Cardiff, Barry Docks, Bilbao and some others, but the ratio between the gross tonnage and the effective tonnage of goods handled, or, in other terms, the handling co-efficient of shipped and landed goods is, as a rule, lower in coastal as compared with inland ports, keeping, in the first-mentioned class, between 0.10 and 0.20, and reaching, in some few instances, up to 0.60, whilst inland ports show a co-efficient averaging between 0.80 and 1.20.

The character of harbours is also affected by their dominant economical function. Many of them supply the wants of distant countries to which they are connected by waterways or by rail, either through import of goods asked for from oversea markets or through export of produce of those countries served by such ports. In these the bulk of goods handled in transit towards their places of destination hardly stops. Their function is therefore particularly regional. Rotterdam, which is the natural outlet of the Rhine, the most important trade artery of the world, is a typical instance of a port of this class. Others live upon large transactions in oversea goods. At Havre, which is, besides Hamburg, the main *entrepot* of the world for coffee, and of France for cotton and metals, the merchandise is kept in warehouses until it has been the object of sale to other markets. The same happens in Liverpool, with the wool, cotton and timber trade. The prevailing function of these harbours is essentially commercial. In some other harbours the traffic consists especially in the import of rough goods that after chemical or mechanical transformation are exported as industrial products. Chemical manure from superphosphates, soap and other products of oily plants, pottery, metallurgy and many other industries constitute the principal elements of life of certain ports, which become famous because of the industrial purpose they supply.

Sometimes these three fundamental functions are met with in one and the same harbour, especially in large ones, such as London and Hamburg.

These factors have obviously an important influence on the arrangement of every harbour and on the economy of the centre of population to which it is attached.

Coaling ports show huge wagon-dumpers instead of rows of cranes. Sheds are generally dispensed with to give place to, sometimes, an extensive net of sidings, allowing an uninterrupted hauling in of loaded trucks and the release of empties without interfering with each other.

The amount of sheds and warehouses is much larger in commercial harbours where the goods are kept for some time, than in others where they have only a short stay.

Close to harbours with important commercial connections, the centres of population grow more rapidly, and attain larger proportions, than those near others where the goods only pass in transit without sustaining any transformation, or which are the object of commercial transactions on a large scale.

All these peculiarities have a strong influence on the life and character of harbours and their urban surroundings, and are the determinants of their special arrangement to meet the requirements of the trade.

At Lourenço Marques it is to be noted that vessels, colliers excepted, being detained only for shipping or landing partial shipments, the same happening in other South African Ports, the handling co-efficient of the Harbour is nevertheless rather high, owing to its being the natural gateway of a vast hinterland of large consumption and production. The effective tonnage of goods imported or exported during the year 1910 was, independently of the coal traffic, 595,823 tons, which compared with the gross tonnage, 2,207,179, shows a co-efficient of 0.27, whilst the same co-efficient at Cape Town was only 0.13, at Port Elizabeth 0.15, East London 0.14, and Durban 0.20. These figures show that, of all South African Ports, Lourenço Marques is the one that deals with larger shipments of general cargo; that is to say that, considered as an investment of capital, it is, therefore, the one that pays the best returns.

Of the whole tonnage dealt with at Lourenço Marques, that same year, 682,000 tons were in transit, and only 30,000 tons were destined for local trade, which shows the unquestionable regional function of the harbour that, it must be noted, is becoming ever more important on account of the rapidly increasing export of Transvaal coal and the re-exportation of Mozambique products from the more northerly ports of the Province.

Some conclusions may already be arived at as to the specific feature which the economical function of this harbour imprints on this place. Not having its own industries, the reason for Lourenço Marques's commercial existence lies only in its port's traffic; it is therefore quite natural that not only the affairs of the community, but also the physiognomy of the town must be influenced by the circumstances under which that traffic is carried on. As most of the navigation lines that call at this Port are foreign, and the shipments consigned to a foreign country, no wonder that shipping and forwarding agents are also foreigners, as well as the numerous staff employed by them; this is why the principal trade of the town is in the hands of foreigners. Attracted by such an important body of foreigners, people of other nationalities are carrying on retail businesses, small industries and other vocations. This circumstance is the source of the accentuated cosmopolitanism that prevails amongst us, and blots out from the general outlook of the town as well as from the habits of its people, the national *cachet* that is to be met with in other Portuguese Colonies, excepting those few where identical circumstances are in force, as, for instance, the town of Beira. The welfare of the community depends, in fact, upon the foreign *clientele* of the Harbour, which, offering unequalled material advantages, and affording every facility for the quick and easy despatch of goods, might hold its own and help the rapid development of the town, were it not for the competition of rival ports trying to deviate, for own profit, the bulk of the traffic which has naturally gravitated to this harbour.

Competition being a striking feature of modern life, it is no matter for surprise if we see every effort being made to divert and secure the benefits that accrue to a foreign harbour, although this may be the easiest and most accessible maritime gateway to the interior.

It must, however, be said that trade once following its natural course can only be deviated towards a less convenient route by means that, in many cases, are anti-economical.

The rivalry among South African Ports in respect of the competitive area traffic brought about the Mozambique Convention, a treaty that provided for the division of the seaborne trade.

It must, however, be admitted that this agreement has failed in achieving its purpose, and that the true interests of the hinterland commerce have not been well served. Competing routes, because much longer, have at least been responsible for a waste of time, fuel, wages and depreciation of rolling stock, all caused by drawing the traffic from its natural course.

It seems to me that a more rational scheme might be agreed upon. The Portuguese Administration, acknowledging the great benefits resulting from the through international traffic passing through this port, might allow the Union a participation in such benefits whenever they exceeded a stipulated percentage over and above the net revenue of the Harbour and Railways of Lourenço Marques, providing that no preferential rates were to be established in favour of any of the rival ports. Such an agreement might take the form of a bonus granted to the Union, or be secured by means of a pool between all South African ports, after mutual definition of the zones of influence or that radius of trade interests which should naturally fall to every port in this Sub-Continent. If such an arrangement could be reached, I feel sure it would conduce to the abiding prosperity of both coast and hinterland, and raise the importance of the Harbour of Lourenço Marques as a factor of wealth and development in regard to its natural and extensive zone of influence.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President of the Section.—Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.

WEDNESDAY, JULY 9.

The President delivered the following address:—

In glancing over the past presidential addresses to the various Sections of this Association, I have observed that quite a number of them are of a rather general character; doubtless the result of endeavours to avoid inflicting on so mixed an assembly papers that could interest only a very few. With the same merciful intention in mind, I have decided merely to illustrate the improved conditions of geological research in this country by putting before you a contrast between its past and present state, with some random reflections on the latter. I shall endeavour to be brief.

We are at present fast approaching what I might term the humdrum period of geology, when, all the outlines having been sketched, there will remain only the very useful, though less interesting, work of filling in the details. The pioneer, armed with a hammer and Lyell's "Principles of Geology," has retired before the highly trained specialist. Geology, from being a passion, has become a profession, with its ways made comparatively smooth by a friendly and enlightened Government. This change was inevitable, and has made for efficiency, yet sometimes one cannot help regretting it, for, with the close of the heroic period, much of the romance of our science has vanished.

Our South African geologists, of the true pioneer type, like Bain, Stow, and Atherstone, were late in life made geologists by a process having some affinity to what is known in religious life as "conversion." Geology was then a comparatively new science, and the wonderful picture which it drew of the vicissitudes through which the earth has passed, with its procession of old-world life forms, things which to us familiarity from our school-days has rendered almost commonplace, struck the imagination of these men with the force of a vision, took possession of their thoughts, and kindled an unquenchable zeal to wrest for themselves from the rocks some of their secrets. The spirit in which the pioneers entered on their labours, and the excitement and enthusiasm with which they greeted their first successes are fully revealed in their writings, from which I shall quote two passages. The first is from a paper* by Andrew Geddes Bain, the "Father of South African Geology."

* "Reminiscences and Anecdotes connected with the History of Geology in South Africa," reprinted in the *Trans. Geol. Soc., S.A.* Vol. II. pp. 59-75.

"I had the good fortune to meet with Lyell's 'Principles of Geology,' which I took home and read with avidity over and over again. I was smitten. Lyell had made a convert of me. I lamented that I had never read his or any other geological work before. Soon after, being in Grahamstown, I learnt that a merchant had imported a copy of Buckland's 'Bridgewater Treatise,' for which he asked me the moderate price of 36 rix dollars, and if he had asked as many pounds, I should have given it with pleasure to possess that inestimable work. I was now set up. My zeal knew no bounds, and I literally left no stone unturned in search of fossils and minerals. I used to ride about with a large hammer slung in my belt, and a bag on my shoulder, which conduct some charitable friends were kind enough to attribute to lunacy, when in truth it was nothing but a severe attack of lithomania. My mouth was ever full of stones and fossils, and nothing would go down with me but organic remains."

The second passage is a description* by Atherstone of a discovery of fossils made in company with Bain.

"Next morning we were up at break of day, and ere I had finished my coffee, a loud 'hurrah!' from the cliffs above me summoned me with a bound to the spot. My friend Bain had gone off without his coffee and got the start of me. There he stood half-dressed, with a splendid gryphaea incurva in his hand, beckoning us to come. 'The cliffs are Liassic then!' we both exclaimed; and now commenced a most exciting scene. Gryphaeas, trigonias, ammonites, gervillias, exogyras, nautili, whole and in fragments, were thickly strewn over the sides of the cliff, lying uncovered by the rain of years. Each fresh discovery was announced by a louder shout of triumph. The two lads ran up, and their sister was not slow in following with their hammer. The black fellows, too, thinking by the shouts and running that there certainly must be gold now, scrambled up after us. Such a scene of excitement! . . . As for breakfast, who thinks of eating under *such* circumstances?"

It required such fiery enthusiasm as this to overcome the obstacles which the pioneers found blocking their way. The principal of these were lack of knowledge and training, and the absence of sympathy and encouragement on the part of the Government and the general South African public.

"As for myself [says Stow], having nothing in the world trustworthy to refer to—not even a cabinet of rocks and minerals—I feel the greatest possible diffidence in calling a stone a stone. I always do so in fear and trembling; and this notwithstanding the burning earnest desire I have that I may be enabled to do some, if even but a little, good to my generation."†

Of all the pioneers, Stow had the hardest lot, and of his troubles, lack of sympathy, and even active obstruction, on the part of Government officials were not the least. It must be mentioned, however, that men like Sir Henry Barkly, Sir H. Bartle Frere, and President Brand thoroughly appreciated the value of scientific research, but even such men found themselves comparatively powerless amidst the general ignorance and prejudice that surrounded them. The following passages taken from letters written about thirty years ago by a living geologist, who did good work in South Africa, describe this state of affairs:—

* "Geology of Uitenhage." *The Eastern Province Monthly Magazine*, June, 1857.

† R. B. Young. "The Life and Work of George William Stow," p. 25.

"I have accumulated a considerable store of facts bearing on our geology, which I hope to write up as opportunity affords, but the almost total absence of any sympathy with my work here, and the poverty and meanness of the powers that be, are serious difficulties in the way of geological work in South Africa. The work that is published by the Government here is simply disgraceful and one is ashamed to own to it.

"At the Cape I struggled through many years of very uphill work, always hoping for better times and hoping that geology would receive more attention, but my patience quite gave out, and I felt that I was merely wasting my life."

However, against the disadvantages under which these early geologists worked, must be placed the supreme interest which is attached to work in an absolutely new field. As their researches, crude though they were, proceeded, they were privileged to see unfolding, for the first time, in its grand outlines, the wonderful history of this portion of the earth. In the case of Stow, for instance, it was surely some compensation for the hardships which he had undergone, to be able to picture, for the first time, in all its grandeur, the great ice age of South Africa. Unfortunately, owing to lack of support, he was not allowed the satisfaction of communicating his great discovery to the world at large, but only to the favoured few who were privileged to read, in manuscript, the remarkable memoir which he had prepared. No one who has perused the manuscript of this great work of Stow can doubt that, had it been published, the great controversy which lasted for many years after his death, regarding the origin of the Dwyka conglomerate, would never have occurred. As it turned out, Stow's discovery was slowly rediscovered piecemeal, and the conclusions which he had arrived at, as early as 1876, cannot be considered as having been finally established before 1905, the year of the visit of the British Association for the Advancement of Science to this country. By that visit the doubts which still existed in the minds of foreign geologists, regarding the genuineness of the South African ice age, were cleared away.

So much for the beginnings of geological research in this country. Let us now glance at the conditions under which it is being carried on at present.

The Geological Survey of the Transvaal and the Geological Commission of the Cape have recently been merged in the Geological Survey of the Union, with a staff of six geologists, besides other officials, costing altogether, for maintenance, about £10,000 per annum. Of the field-geologists, three are working in the Transvaal, two in the Cape Province, and one in Natal. While it is satisfactory to think that the increased prosperity of the country and the advance of public opinion have made the establishment of a permanent survey of this character possible, yet, when one considers the great area of the country comprised by the Union, and the extent to which its prosperity depends on the exploitation of its mineral wealth, it becomes evident that the staff of the present Survey is quite inadequate. Large tracts of South Africa have perforce to lie neglected, while in the other parts work has necessarily to proceed at a very slow pace. There would be greater likelihood of having this state of affairs rectified if the special utility to a mining country of geological survey work were more widely realised than it is at present, and I shall take this opportunity of saying a few words on the subject.

By many people, geology is still looked upon as a "nice amusement," an "elegant pursuit," to quote the words of one of our prominent politicians, and to them the connection between the systematic geological survey of a country and the exploitation of its mineral wealth is not at all obvious. We never hear of the discovery by any member of the Survey of new mineral deposits. The gold and diamond mines, which constitute so much of the wealth of the country, have all resulted from the discoveries of plodding prospectors, men generally possessing very little geological knowledge. From time to time, in the early history of Cape Colony, geologists have been temporarily employed by the Government, in the hope of making great discoveries of economic minerals, but always with little or no result, if we except the discovery, by Stow, of the Vereeniging coal-field. There might seem, therefore, some reason for doubting the utility of geological survey work, and it must be allowed that, so far as the *discovery* of mineral deposits is concerned, the geological mapping of the country can contribute only indirectly, by sketching out the lines along which prospecting can most profitably be carried out. The actual discovery still rests with the prospector, but he can be told where his work is most likely to be crowned with success, and where it is absolutely hopeless. Where, for instance, a certain class of deposit is found to be associated with a particular type of igneous rock, or with its contact with metamorphic or sedimentary rocks, it is obvious that the systematic mapping of the distribution of these rocks must be of great assistance to the prospector. The recent very detailed survey of the Witwatersrand district by Dr. Mellor illustrates well the negative value of geological mapping, and anyone familiar with the results of Dr. Mellor's work, and with the history of the Rand, must realise that, while the mapping is of great present value, yet, had it been possible to have had, earlier, the elucidation of the true nature of the Witpoortje "break," or of the stratigraphical position of the Du Preez series, supported by careful and indisputable mapping, a great saving of energy and money would have resulted. For the prevention of wild enterprises, such as boring in granite for coal, which actually happened near Cape Town some ten years ago, no geological mapping is necessary: the presence of someone in the neighbourhood who had mastered an elementary text-book of geology might have been deemed sufficient.

In the great majority of cases, for the economic development of a mining property, a knowledge of the geological structure of the immediate area in which the mineral deposit lies is essential. During a tour round the mining districts of Rhodesia, just before the institution of a Geological Survey in that territory, I found the want of geological information and guidance, such as could be properly given only by a systematic survey, everywhere expressed among mining men, and it was doubtless largely as a result of this widespread feeling, that the present Survey was established. It might be thought that for the solution of all the geological problems, having a direct practical bearing, presented by any ore-deposit, a short visit by a geologist to the property would be sufficient; but this is far from being the case. For the proper understanding of the features in the immediate vicinity of the mine, a knowledge of the structure of wide stretches of the surrounding country is often necessary, and no one is more grateful than the consulting geologist for reliable geological mapping.

A great part of the literature on ore deposits consists of papers by different observers on isolated occurrences. The mere fact that they are the result of the examination of isolated occurrences takes away from their value. I might add that, as far as my observation goes, in no section of geological literature is there so much unreliable matter as in that on ore-deposits. This is due partly to the insufficient data presented by most mines at any particular stage of development, and partly to the fact that it is not generally recognised how much detailed and laborious work is usually necessary to avoid the possibility of a total misconception of the nature of an ore-deposit. It is no uncommon thing to find the results of macroscopic examination largely refuted by a further microscopic study. All of these considerations add to the value of careful and co-ordinated work like that contained in the Transvaal Survey Memoir on the Waterberg Tin-fields. In the first place it is an account, not of an isolated tin-deposit, but of the deposits of a large district, all of them genetically connected, and capable of throwing light one on another. It is written by highly trained and experienced men, conscious from their position of their responsiblities, and with all the resources of an organised survey behind them. Again, the work is subject to revision and enlargement by the same observers from time to time as the data revealed by further development render it necessary.

I need hardly add that there are other ways in which the work of a geological survey amply repays the cost of maintenance, and, besides, putting aside all considerations of cash-value, we must, if we are to maintain our dignity as a civilised and intellectual community, take our place beside the rest of the world in supporting science for its own sake, and for all the indirect or unforeseen benefits which follow surely in the train of increased knowledge.

I remarked earlier that we were approaching the humdrum period of geology, but I did not mean to imply that there was any likelihood of our exhausting the problems presented by the rocks of this country. As research advances, fresh problems appear. Indeed, some of the problems that first attracted the attention of South African geologists still await solution. There is much work to be done before the correlation of the formations in the different regions of South Africa can be completed. This is especially the case with respect to the older rocks of the country. There is still considerable mystery surrounding the origin of the South African diamonds. The origin of the gold in the banket is still an open question, though the investigations of the last few years have confined it to narrower limits.

That the last-mentioned controversy has lingered so long on the stage is worthy of some comment. No other ore-deposit in the world affords such facilities for study as does the banket. It is exposed along its strike for more than forty miles, and on the dip to depths as great as five thousand feet. Why, then, has the history of the rock, including that of its contained gold, not been fully made out by this time? In the first place, notwithstanding the apparently simple character of the banket, on careful investigation it is found to have undergone many remarkable changes, which have obliterated certain features which the rock must have originally possessed. In the second place, it is essential that the manner of distribution of the gold in the banket should be known. Sufficient data for the elucidation of this have been acquired, but they remain locked up in the assay plans of the various mines. An analysis of these would involve great labour, such as would not readily be undertaken by any individual. It is unlikely, too, that the Geological Survey, with its present inadequate staff, would care to embark on a task demanding so large an expenditure of its time and energy. However, failing the Government, perhaps our enlightened Chamber of Mines might consider itself justified in spending money on the investigation of a matter which lies so close to them, and which is of absorbing theoretical interest and, at the same time, of considerable practical importance.

I shall now revert from what must appear to you to be a lengthy digression to my original theme, and mention briefly certain respects, not yet referred to, in which the conditions of geological work in South Africa show great improvement.

Our early geologists found themselves mentally isolated. They were regarded as cranks, and their interest in the geology of the country was looked upon as an idiosyncracy. Besides, they could find no suitable avenue in South Africa for the publication of their work. Even those geologists who were temporarily engaged by Government usually found their employers unwilling to go to the expense of printing their reports in full. Now we have a public, a comparatively small one it is true, interested in geological work. The geological reports yearly issued by the Government are worthy of the country. For the private worker there is a flourishing Geological Society where he may have his papers read, published and discussed to his heart's content.

Again, if the results of scientific research are not made easily accessible they lose much of their value, and an obstacle is raised in the way of further work; and till 1905 what was known about the geology of South Africa was hidden away in numerous scattered papers and reports. In that year, however, appeared the excellent text-books on the geology of Cape Colony and of South Africa as a whole by Dr. Rogers and Drs. Hatch and Corstorphine respectively. We have also the translation by Mr. Ronaldson, of Molengraaff's memoir, on the geology of the Transvaal. There is still room for more work of this kind, and text-books on the economic geology of South Africa and on its mineralogy and petrology would be welcomed.

For the appreciation and utilisation of the results of geological work some previous knowledge of the subject is necessary. In the primary and secondary schools, an elementary course of geology and mineralogy has not yet found a place, and, though it may at first appear somewhat unreasonable to suggest that this subject should be included in what is already an over-crowded curriculum, yet I think that a very good case for this could be stated. In the higher branches of education geology cannot now be said to be neglected. When I first came to South Africa, ten years ago, I found myself occupying temporarily the only chair of geology in the country; that at the South African College. Now there is provision for the teaching of the subject in seven colleges within the Union. The greatest advance has been made at Johannesburg, where the South African School of Mines and Technology, following the lead of many European and American colleges, has recently established a Chair of Economic Geology in addition to the Chair of Geology and Mineralogy.

Section C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President of the Section: A. L. M. Bonn, C.E.

SATURDAY, JULY 12.

The President delivered the following address:—

THE DEVELOPMENT OF DELAGOA BAY.

Lourenço Marques, the capital and chief seaport of the Province of Mozambique, the most important of Portuguese oversea possessions, is now a town containing 5,324 European and 8,029 Native and Asiatic inhabitants. It is situated on the western shore of Delagoa Bay and, combined with its commanding position and magnificent Bay frontage, has by nature a situation unequalled by other towns in the whole of South Africa. Strange to say, Lourenço Marques and its neighbourhood were not colonized until long after the occupation of the more northerly parts of Mozambique and the colonization of Natal, although the Bay was discovered as far back as 1502 by Antonio de Campo, and explored in 1506 by a trader, from whom the town derives its name.

In 1824 a Whaling Station was established, and in 1846 the Bay was surveyed by Captain Owen, of the British Navy, with the intention of annexation. Up to this time the locality appears to have been seldom visited, and one might say, almost unclaimed. There appears to have been little, if anything, in the nature of any development till about 1870, when, owing to the opening up of trade with the Transvaal, and the establishment of regular steamship communication with Europe, the importance of Delagoa Bay became recognized.

It is only from this time forward that its existence as a town can be dated (although its rapid development has been greatly eclipsed by that of other towns in South Africa), and when this is taken into consideration, with the transformation that has taken place during the past forty years, in the filling in of vast swamps, the practical eradication of malaria, the construction of extensive wharf accommodation, and the general laying out of a township, it must be admitted that good work has been accomplished, and this in the face of serious opposition, of which the combating of fever and Natives forms no small portion. In reviewing its growth one cannot say that its development has been aught but spasmodic. Improvements have been effected at long intervals and this, coupled with the sparing increase of population, has undoubtedly handicapped the good work of progress. During the last eight years the European population has been increased by only 633, and that of the Natives by 2,870. In addition, prejudice has contributed in no small measure to retard its progress, and even at this date its previous unhealthy reputation, no doubt at one time justified, is proverbial in the adjacent parts of this continent.

It is markedly to the credit of the responsible authorities that the eradication of malaria, previously so common, was undertaken and practically forms the base of all subsequent improvements. Measures were adopted for clearing the town and surrounding land of bush, grass, and undergrowth, and this is rigorously enforced at the present date. In addition, the various large swamps within the municipal area were filled in, the effective inspection of tanks and surface drains established. All these wise regulations have contributed to the enjoyment of immunity from fever, and the steady decline of the death-rate, and eventually resulted in Delagoa Bay being enabled to be compared most favourably as regards health with any town in South Africa. It is a remarkable fact that other infectious epidemics to which most towns within the Union are subject, have been and are conspicuous by their absence.

The Administration of Lourenço Marques is in the hands of Municipal Government (Camara Municipal), under whose supervision the important duty of sanitary service and cleaning of the town is maintained. In this respect Lourenço Marques has no reason to take second place to any other town or city. This work is performed in an excellent manner. In the general development of the locality it is only fair to bear testimony to the valuable assistance rendered by the Delagoa Bay Development Corporation, Limited, an English Company that has obtained the important concessions of water supply, lighting and tramways, and these undertakings have contributed in no small manner to the progress and development made in the past.

In 1895 a concession was obtained for the establishment of waterworks. Up to this time water for domestic and other purposes was obtained from the numerous springs and swamps located in various parts of the township. With the advent of the Waterworks Company, considerable drainage works were constructed, spring and surface water being collected and distributed by means of an efficient installation. It was found, apart from the fact of such supply being insufficient for future development, that the water thus available was of unsuitable quality. The Company proceeded with the erection of a Pumping Station, situated on the Umbeluzi River, and, by means of a steel conduit conveyed the water thus obtained a distance of eighteen miles to Lourenço Marques. This work was completed in 1906, and has resulted in water of excellent standard of purity and of copious constant supply being available. The approximate daily consumption for domestic purposes averages 8.6 gallons per head of the total population. The installation is complete and adequate in dealing with demands in excess of five times the present total consumption.

In 1898, owing to the instrumentality of a French Company, the whole of the town and Municipal area was illuminated by means of electricity; this replaced the oil lamps previously installed by the Municipality. This undertaking was eventually absorbed by the Delagoa Bay Development Corporation, Limited, in 1910. The public lighting is done in a most efficient manner by means of a matter of 1,000 metallic filament lamps and 12 Arc lamps, distributed over the entire Municipal area, and, in this respect, is one of the best, if not the best illuminated town in South Africa. In connection with both water and lighting supply, public service is rendered by the Corporation to both Government and Municipality at a greatly reduced rate, and by these means such supply is made without entailing any special rate to the inhabitants.

In February, 1904, an excellent service of electric trams was installed, giving complete and rapid means of conveyance to all parts of the town. This service has undoubtedly contributed more than aught else to opening up the more distant confines of the Municipality, making such parts accessible for the purpose of residential districts. It is remarkable that even in this respect Lourenço Marques has led the way to other towns in South Africa by introducing electric means of transit, a twenty minutes' service being available from 5.30 a.m. to 11.30 p.m., and this in a town which at that time scarcely numbered 4,700 European inhabitants. In maintaining the above-mentioned services, the Corporation has undoubtedly met the requirements of the public in an efficient and up-to-date manner, which by other means would have been impossible; it has secured advantages that are denied to towns of even considerably larger population than Lourenço Marques; and it has, at the same time, relieved the Municipal Administration of serious responsibility .

Municipal enterprise has hitherto been much handicapped in inaugurating progress of considerable extent, owing principally to a serious absence of continuity of policy and the lack of necessary funds, the total yearly revenue, principally derived from a Municipal tax on imports, amounting in round figures to £60,000 per annum, and from this sum all Municipal enterprises have had to be made and maintained. On the other hand, it is highly creditable to note that the town is, with the exception of a matter of £70,000, free from debt of any description, comparing more than favourably in this respect with other towns within the Union.

Good and solid work has been done in the establishment of an excellent Public Market, Public Gardens, an excellently equipped Fire Brigade, the hardening and laying out of streets and public places, and, although much remains to be done, there are evident indications of works of important nature being undertaken in the near future, which will place Delagoa Bay in the forefront of towns in South Africa. To the Government also praise is due for the establishment of a large general Hospital, equipped in a highly creditable manner. The rapid development of the maritime possibilities and the natural advantages of Delagoa Bay as a port, is also in active progress, and the construction of wharfs and equipment now under completion will undoubtedly make this the most up-to-date and best-equipped shipping port in Africa.

One cannot but regret that the advantages which nature has so bountifully given in regard to Delagoa Bay have not been more generally utilised to develop and assist in the establishment of a port of pre-eminence and health resort long ere this, but to its future one can look with confidence. Such is bound eventually to be prosperous, and, in spite of numerous obstacles which have retarded the general progress of the locality, much is to be learnt here by the Municipal Government of other towns within the Union, more especially in the judicious investment of Municipal enterprise with limited funds, and in the face of contentious opposition. In turn, Delagoa Bay has benefited by lessons learnt from the various Municipal undertakings in towns throughout South Africa, and one cannot but believe that their lessons will be even more utilised in the immediate future. The work of development will steadily proceed, and amongst that of the first importance an efficient drainage and sewerage system is being seriously considered, the proper and adequate housing and locating of the large Native and Asiatic population, modern and up-to-date equipment of abattoirs, crematoria, refuse destructors, the paving of side-walks, and the development of the marine resort at Polana—these are matters of vital and far-reaching importance, and will, when realised, effectually eliminate the fallacy and prejudice that is still so common to those who have but a vague knowledge of what has been, and is still to be, done to make Delagoa Bay and Lourenço Marques the best equipped port and town in South Africa.

Section D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY.

President of the Section:—J. A. Foote, F.G.S., F.E.I.S.

FRIDAY, JULY 11.

The President delivered the following address:

THE EDUCATION OF TO-MORROW.

The educational subject which has aroused most interest during the last two years in South Africa is the question of the future University; but University Education, important though it undoubtedly is, counts as dust in the balance, when compared with the education of the whole people. The highly educated few at the top will avail South Africa little, if the mass of the people is lacking in character, intelligence, training, and skill.

The social and political importance of the children—all the children—has steadily increased in the eyes of those who give serious thought to social and economic questions. The main centre of interest therefore in the educational field should be the average boy, for national education is not organized for the benefit of the few who climb to the highest rungs of the ladder. "Education cannot save a nation, but no nation can be saved without it," said Roosevelt. The salvation of South Africa is in progress in the schools. But this saving process may be retarded by influences both outside and inside. In England the interests of the children are sometimes sacrificed to religious differences outside the schools. It is to be hoped that in South Africa the schools will be shielded from the blight of outside political animosities.

But the foes of Education are sometimes those of her own household. Educational authorities are hopelessly divided on many questions inside the school. One writer speaks of education as "the sport of prophetic persons pointing in a mist." Another, in a chapter headed "The Chaos of the Hour," gives a list of the eccentricities of opinion among educational lecturers and professors. But amid all this uncertainty of thought, the idea is crystallizing that the object of education should be, more directly than it has hitherto been, a preparation for life, and that curricula should be so formed as to have more direct bearing on the future careers of those taught.

The education of to-morrow will be distinguished by the predominance of the practical. Ruskin was no democrat. He was a believer in divinely appointed inequalities, but he said, "I believe that all youths of whatever rank ought to learn one manual trade thoroughly." One reason why education has failed to produce the results which enthusiasts expected from it when it was made a national concern, is that it has been looked upon as something altogether apart from life. Education should be a preparation for both work and play. Yes, play. Was it not Aristotle who said that the real test of a man's education is the manner in which he spends his leisure time?

The educator of to-morrow will not exclude from the school the higher spiritual life of culture, but he will constantly keep before him the principle of training for practical life, in a practical world of work. One half of the education of to-morrow will consist of *doing*. "How do you do?" will be the appropriate salutation to the young scholar. And if to doing is added thinking, the efficient youth will be the result.

It has long been acknowledged that bodily activity assists brain development rather than hinders it. The dormant mind and the dormant body usually go together. The relation of mind and muscles is a fact of extreme importance in pedagogy. Motor training for the mental development of subnormal children has long been known to be useful; but the education of to-morrow will make more use of the muscles for the mental development of normal and supernormal children. Mosso believes that long-continued motor activity among a people promotes intellectual development. In support of this view he says that—

"during the first epoch of the Renaissance, the greatest artists of Florence were all apprentices in the workshops of the goldsmiths Luca della Robbia, Lorenzo Ghiberti, Filippo Brunelleschi, Francia, Domencio Ghirlandaio, Sandro Botticelli, Andrea del Sarto—to mention a few examples—performed, during their apprenticeship, the simplest labours in the workshop of a goldsmith. But the exercise with which they gained their manual dexterity contributed much to the development of the great masters of genius.

"A fact which cannot be doubted is the many-sidedness of genius which some Italians of the Renaissance possessed, and which has never again appeared with like copiousness. Giotto was painter, sculptor, and architect Leonardo da Vinci was a celebrated musician, a great painter, an engineer, and architect, a man of letters and of science. Andrea del Verrocchio was a goldsmith, sculptor, engraver, architect, painter, and musician. These facts are to be read in many histories of art. An incomparable example, however, is Michelangelo. For twelve years he studied anatomy on the cadaver and afterwards painted the Sistine Chapel and executed the tombs of the Medici and the dome of St. Peter's. . . . . I am convinced that muscular movements have formed the omnipotence of genius, just as, *vice versa*, intellectual exercises affect advantageously the development of the muscles."

The education, then, of to-morrow will be dynamic rather than static. The young learner will not be kept in a seat during his growing years, with folded arms, poring over a book. There will be a clearer recognition of the fact that a child's thought is never dissociated from his muscles, and that an idea is not complete until it is realized in action. More practical Arithmetic, more practical Geometry, more practical Geography, more practice in the laboratory and more manual activity in the workshop—these will be features of the education of to-morrow.

But not only will the education of to-morrow tend to lay more stress on motor activity, but it will tend to become more vocational in character. The pressing subject of vocational education cannot be dismissed by mumbling old formulæ about early specialization. In future there will be more points of contact between the school life of the pupil and his future occupation Modern psychology has all but rejected the old idea of faculty training. "No one," says Bernard Shaw, "learns to do one thing by doing something else." This remark states aptly the new psychological dictum which is to the effect that there is no evidence that the power of reasoning, cultivated through, say, mathematics or classics, "transfers" or "flows over" to the affairs of everyday life. In fact, say the psychologists, there is experimental evidence to the contrary. We are even told nowadays that the cultivation of the memory in one direction does not guarantee that there will be retentiveness in other directions. Dr. Roberts may know the name of every star in the firmament. Professor Wager, like Solomon, may know the names of every tree, from the cedar that is in Lebanon to the hyssop that springeth out of the wall. Others among our members may know, again like Solomon, all beasts, fowl, creeping things and fishes—and yet they may forget to post their wives' letters.

Mr. W. P. Welpton, lecturer on education in the University of Leeds, in a book published last month, says:—

"There are many who are doubtful about including utilitarian work in their conception of education. The very mention of utility gives their educational conscience a painful shock. Education to them is the preparation for a cultural spiritual life in which 'bread and butter' work finds no place. The term 'manhood,' of course, is frequently mentioned in their educational theory, but it is an emasculated manhood, divorced from all concerns of daily toil. What is such manhood worth? What appeal to virile youth can a manhood have that is unsullied by the taint of utility, that is dissociated from those activities that every boy of the middle and working classes is looking forward to during adolescence as the essential and distinctive work of man's estate."

Why do many boys leave school so early? Frequently it is, of course, from economic necessity. More often it is because they see no connection between school and reality, at a time of life when reality is beginning to appeal to them. School is nothing to them but an enforced contact with the unreality of books; and they leave as soon as they persuade their parents to let them. Every boy towards the end of the primary school course experiences what I might call a "vocational itch." He wants to be doing, or, at least, preparing for the real things of real life. This healthy instinct—for it is healthy—persists throughout the secondary school course, but there it is held in check by the knowledge that the objective of the secondary school course—the Matriculation Examination—is really a vocational one. But there is no such check in the case of the senior boy of the primary school, and that, in my opinion, is one of the reasons why the highest class there is usually a mere rump.

In the Transvaal primary course there are seven standards, and before the boy leaves school pass in standard five is compulsory, or the attainment of the age of fifteen. I think that in urban areas the legal standard might well be raised to six, the age of fifteen still being retained, as the normal child should finish standard six at fourteen.

After passing this compulsory standard six, at which stage he should have a fair knowledge of his mother tongue and the other official language of the Union, the pupil would then have the choice of beginning a four years' course of further education at a secondary school, or of remaining in a voluntary standard seven at the primary school. I have come to the opinion that the work of this standard should not be a continuation of the work of the previous six standards, but should be vocational in character. This might be provided for at selected schools in each urban area, the courses being commercial, industrial or general. I believe that in this way, the work of the highest class of the primary school could be given a meaning, and more pleasurable interest, without which learning is impossible, would be awakened. As Profesor Adams said, "The theory of interest does not propose to banish drudgery, but only to make drudgery tolerable by giving it a meaning." Most boys, I am convinced, look on the standard seven work as meaningless drudgery. I believe that the raising of the compulsory standard to six, with voluntary vocational work to follow would be cheaper and more effective than the establishment of compulsory continuation classes. Continuation classes, so called, are almost exclusively vocational. Boys will not go to evening classes to learn English Composition or South African History. An extra year at day school is worth several years of evening work, consisting, as the latter does, of only three or four hours a week. Let there be voluntary continuation classes by all means, with courses as varied and as interesting as possible; another year's day school preparation will tend to increase the demand for them, and will contribute much to their efficiency.

A national system of this kind, beginning with a primary course of six standards, followed either by supplementary vocational courses, or by a four years' secondary course, would have at the apex of the pyramid its University education, regarding which in South Africa a far-reaching constructive policy is soon to be announced.

It cannot be denied that hitherto there has been a want of intelligent direction in the higher education of South Africa. Like Topsy—it growed. I often wonder why the Transvaal University College, at its inception, did not take all the embryo teachers in that colony under its care. The Transvaal University College has never been like the old woman who had so many children she didn't know what to do. Neither, indeed, has any of its sister colleges. If, after the War, there had been started only one Normal College in the Transvaal under the ægis of the Transvaal University College all the non-professional work could have been taken in the ordinary Transvaal University College classes; and only professional subjects, such as singing and drawing, would have been taken in the Normal College Department. The Principal of the Normal College would then have been Professor of Education in the Transvaal University College, and mayhap Principal of that institution, for the majority of the students would have been future teachers. This would not have meant that every student proceeded to his degree, but it would have raised a healthy ambition in many to do so; and it would have prevented that cloistered seclusion of the teacher, which is not the best preparation for a calling, where one's *ipse dixit* is accepted without challenge all day long.

But this refers not to a to-morrow, but to a to-morrow that might have been. A different policy has been made permanent in South Africa, in bricks and mortar and vested interests, to the detriment, I think, of the teaching profession, and the University Colleges themselves.

The Education of a not too distant to-morrow will be recognised as an exact science. It has already begun to present its data and conclusions in quantitative as well as in qualitative terms. "The hope of the evolution of education lies in experiment," said Professor Adams at last year's meeting of the British Association for the Advancement of Science, which body, by the way, is giving an increased attention year by year to educational questions. The experimental psychologists have, during the last few years, been elaborating "intelligence tests," and the researches of investigators like Binet, Pearson, Brown, Spearman, Galton, Burt, Winch, Ebbinghaus and Whipple, may in time lead to the formulation of an entirely new kind of examination for entrance to the Universities and the Government services. Professor Pyle, University of Missouri, has recently concluded a series of tests for mental efficiency involving the use of such mental powers as learning, logical memory, rote memory, attention, association, imagination and invention. A total mental efficiency mark is given to each pupil, according to the average of the results obtained in each of the tests, and this mark is regarded as a reliable index of mental capacity.

The average teacher in this country has neither the time, the mathematical ability nor the training in scientific method; a combination of the three is required to conduct such tests. But at some future date mental tests *will* be applied to South African children, and certain questions fraught with import suggest themselves. Is the quality or character of certain mental processes different in South African children when compared with those of

European children of the same age? Is the South African child's capacity for mental work quantitatively more or less than that of the European stock from which it sprang? Anthropometric measurements might prove that there was no physical depreciation—probably it would be found that there was physical appreciation. Would mental measurements give a similar result?

Professor Kidd, in a paper four years ago, mentioned the fact that the timbre of the voice tended to deteriorate in South Africa. Is there any weakening of the intellectual fibre? Are our sons better mentally than ourselves, or worse? South Africa has produced no great poet, writer, artist or inventor. Neither, indeed, has any country under the Southern Cross. Are the stars in their courses fighting against us? Or is it that the climate is too generous and too alluring? Gibbon, Scott, Wordsworth, Carlyle, and Stevenson were undistinguished at school and college. It required the stimulus of new and hard conditions to awake their powers and intellectual energies. Is it because conditions have been too soft in South Africa that there are no Robert Louis Stevensons here? Great success means sacrifice. Is youth disinclined to pay the price—unwilling to scorn delights and live laborious days—too content with the trivial round, the common task?

It would be folly to predict the result of what such comparative mental tests would be. But if the answers to such questions as I have asked were to be of such a nature as not to flatter our national pride, then a certain amount of immigration to this country would be an intellectual necessity, whether it were an economic one or not.

I have dealt with only a very few of the developments which the educational to-morrow may bring forth If this subject were thrown open for discussion at this meeting, every one present would have some new educational proposal to make. Mr. Leslie would propose, as he did on Tuesday, that all schools in South Africa should be fitted up with simple meteorological instruments, and all boys taught to read them. Good! Professor Young would approve, as he did on Wednesday, of instruction in the simple rocks and minerals being given in the schools of South Africa. Again, good! Professor Macfadyen, who is sure to have been ruminating on the psychology of the mob during his enforced stay further west last week, might suggest to us that the educational psychologists, having done a good deal of work on the subject of the individual child, might, with advantage, turn to the study of the psychology of the mass. After all, children are taught in masses, more or less, and usually more than less, large. The Union Astronomer might not press for star-knowledge in the schools, but I have heard him advocate a simplified form of our English spelling as one of the most pressing of educational reforms. I believe that the demand for spelling reform will grow in strength year by year, although its accomplishment may not be seen by the present generation. South

African teachers know the handicap which our chaotic spelling places on the children of the country. Canada and India must feel the same difficulty. The simplification of English spelling is a factor in the Empire's growth which will have to be seriously considered some day.

This address is meant to be suggestive rather than exhaustive. The old Chinese philosopher Confucius used to say that when he showed his students three corners of a subject, he left them to find the fourth for themselves. I have shown you one corner of the subject. I leave you to think about the other three. In conclusion, if the Union Parliament and the Provincial Councils of South Africa—and I hope that primary and secondary education will long remain under the jurisdiction of the latter—decide wisely and well in regard to the educational problems awaiting solution here, we shall be entitled to look forward not without hope and confidence to the educational to-morrow. I wish we could say, however, in the language of Romeo:—

> "Night's candles are burnt out, and jocund day
> Stands tiptoe on the misty mountain tops."

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND IRRIGATION.

TUESDAY, JULY 8.

1. Address by J. H. VON HAFE, Mem. A.C.E. (Port), President of the Section.
2. Star positions and galactic co-ordinates. By R. T. A. INNES, F.R.A.S., F.R.S.E.
3. A plea for the more exact measurement of rainfall. By F FLOWERS, F.R.G.S., F.R.A.S.

WEDNESDAY, JULY 9.

4. Data for the study of the climate of Lourenço Marques. By Lieut. A. D'A. TEIXEIRA.
5. The measurement of air, with special reference to compressors. By C. JANSEN.
6. The Hydrographer's Department of the British Admiralty. By H. PIM, B.A.

FRIDAY, JULY 11.

7. Notes on (*a*) the geometrical and legal cadastre of immovable property in the Province of Mozambique; and (*b*) the possible application of radio-telegraphy to expeditious geodesy. By Colonel P. L. DE BELLEGARDE DA SILVA.
8. Determination of the latitude and longitude of the pillar of the transit instrument of the Campos Rodrigues Observatory. By Lieut. A. D'A. TEIXEIRA.
9. Cosmological hypotheses. By R. T. A. INNES, F.R.A.S., F.R.S.E.
10. A few notes on water divining. By W. INGHAM, M.I.C.E., M.I.M.E.

SECTION B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY, AND GEOGRAPHY.

TUESDAY, JULY 8.

1. The bearing of recent discoveries of early tertiary shells near Trinidad Island and in Brazil on hypothetical land routes between South America and Africa. By Miss C. J. MAURY, Ph.D.

WEDNESDAY, JULY 9.

2. Address by Prof. R. B. YOUNG, M.A., D.Sc., F.R.S.E., F.G.S., President of the Section.
3. On a meteorite from N'Kandhla District, Zululand. By Prof. G. H. STANLEY, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.

SATURDAY, JULY 12.

4. Quinonoid oxidation products of dianisidine. By J. MOIR, M.A., D.Sc.
5. Chemical composition of rain in the Union of South Africa. By C. F. JURITZ, M.A., D.Sc., F.I.C.

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

FRIDAY, JULY 11.

1. Notes on coffee growing. By F. DE MEIRELLES.

SATURDAY, JULY 12.

2. Address by A. L. M. BONN, C.E., President of the Section.
3. The relation of sewage flow to water supply. By W. J. DAVENPORT.
4. A nematode worm in the tomato. By Prof. H. A. WAGER, A.R.C.S.
5. *Jubæopsis Caffra* Becc.—a new genus of Palmæ from Pondoland. By Prof. R. MARLOTH, M.A., Ph.D.
6. Observations on the development of the planula in a certain plumularian hydroid. By Prof. E. WARREN, D.Sc.
7. Health conditions on the Isthmus of Panama. By S. EVANS.
8. The sugar industry in Mozambique. By J. MUNRO.
9. The sanitary state of the stock of the Lourenço Marques District. By Lieut. J. B. BOTELHO.
10. Notes on the distribution and character of reptiles and amphibians in South Africa. By J. HEWITT, B.A.

SECTION D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

WEDNESDAY, JULY 9.

1. The Phallus cult among the Bantu. By Rev. J. A. WINTER.

FRIDAY, JULY 11.

2. Address by J. A. FOOTE, F.G.S., F.E.I.S., President of the Section.
3. The condition of the natives of Delagoa Bay in the sixteenth century according to early Portuguese documents. By Rev. H. A. JUNOD.
4. A decimal coinage for South Africa. By Prof. W. A. MACFADYEN, M.A., LL.D.

SATURDAY, JULY 12.

5. The Trade Schools in the Transvaal. By W. J. HORNE, A.M.I.C.E.
6. The relation of High Schools to the University Technical College By W. J. HORNE, A.M.I.C.E.
7. On extraneous education. By H. L. LAKE.
8. The Humour of estranged Indo-German cognates. By Rev. W. A. NORTON.

Sir. W. F. HELY-HUTCHINSON.

SIR W. F. HELY-HUTCHINSON.

G.C.M.G., M.A., LL.D.

(*Born 22nd August*, 1849. *Died 23rd September*, 1913.)

The decease of the Right Hon. Sir Walter Francis Hely-Hutchinson, which occurred at Peterborough on the 23rd September, just a month after the completion of his sixty-fourth year, causes a gap in the hitherto unbroken series of distinguished men who have occupied the Presidential chair of the South African Association for the Advancement of Science.

Sir Walter was the second son of the fourth Earl of Donoughmore, and was born in Dublin on the 22nd August, 1849. He was educated first at Cheam School, and subsequently at Harrow. He then entered Trinity College, Cambridge, whence he graduated, and was afterwards called to the bar at the Inner Temple. In 1874 the Hon. W. F. Hely-Hutchinson, as he was then styled, entered the diplomatic service as an attaché on the staff of Sir Hercules Robinson (afterwards Lord Rosmead), and proceeded in that capacity to Fiji. Sir Hercules was at the time Governor of New South Wales, and Mr. Hely-Hutchinson was appointed as his Private Secretary for Fiji affairs, a post which he vacated in 1875 in order to assume the more important duties of Private Secretary for New South Wales affairs. At the age of 28 he was offered and accepted the Colonial Secretaryship of Barbadoes. Six years later, after a successful term of office in the West Indies, Mr. Hely-Hutchinson became Chief Secretary to the Government of Malta, and in the following year (1884) he was promoted to the position of Lieutenant-Governor of the island. In 1888 he was created a Knight Commander of the Order of St. Michael and St. George, and in 1889 Sir Walter Hely-Hutchinson was transferred, as Governor, to the Windward Islands. After the lapse of four years he was appointed Governor of Natal, inaugurating Responsible Government in that Colony, and, two years after his arrival, effecting the annexation of the Trans-Pongola territories. It was during his tenure of office in Natal that his services were further recognised by promotion to the Grand Cross of St. Michael and St. George in 1897, on the occasion of Queen Victoria's Diamond Jubilee. In 1901 Lord Milner, until then Governor of the Cape Colony, as well as High Commissioner for South Africa, relinquished the former post, and proceeded to the Transvaal as Governor of that Colony, then recently annexed to the British Crown. It was on Lord Milner's strong recommendation that Sir Walter Hely-Hutchinson succeeded him as Governor of the Cape of Good Hope, and he discharged the functions of that high office with conspicuous tact during a time when the most delicate handling was essential. His term of residence in the Government House at Cape Town covered a transition period, the nature of which could scarcely have been anticipated at its commencement. When that period was entered upon, the country was being torn asunder by warfare and bitterness: at its termination the Union of South Africa was just on the eve of inauguration, and the enthusiastic send-off that Sir Walter received from men of all shades of political opinion, just before his final departure from South Africa, after seventeen years of gubernatorial service in the country, was the best possible proof of the wisdom and skill that had characterised his administration during those troublous years.

Sir Walter had made it his definite purpose to exercise moderation to all men, and to carry amity into every circle whither he went, and it is difficult to judge whether his tactful interest, as a townsman, in the welfare of the agriculturist, or the facility with which he, as an Englishman, familiarised himself with the language and habits of the other dominant race in South Africa, did more to win for him the confidence and esteem of those who, not many years previously, had sympathised, passively or actively, with the forces arrayed against his Sovereign and country. It may also be said with truth that he took the utmost pains to make himself acquainted with every portion of the country that he was appointed to govern, with every phase of its resources and industries, with every class of its inhabitants. It has been well remarked that "the country folk especially liked the entire absence of frigidity or formality that marked his progresses through the Colony." "My ambition," Sir Walter said, shortly after taking office here, "is to get at the hearts of the people, and when the time comes for me to depart, I shall be happy if I can feel that you will remember me as a friend." That was the feeling which animated him consistently through his occupancy of the Cape Governorship, and he remained true to it during the few subsequent years of his life, as every possible occasion testified. Presiding over a meeting of the Royal Society of Arts in May, 1912, when a lecture on the subject of "Colonial Vine Culture" was being delivered by Mr. A. H. Burgoyne, M.P., Sir Walter rather warmly and at some length expressed his dissent from some of the lecturer's observations. He hoped that Mr. Burgoyne would excuse him when he said that if he had been to South Africa, he would have expressed himself rather differently about the Dutch farmers. . . . . When discussing South African agriculture, it might be well to begin by leaving off calling the Dutch farmers ignorant and indolent, because that was a mistake. There were many of them, no doubt, still open to the charge, but the number was steadily diminishing, and there were amongst the Dutch farmers men who were not less progressive in their methods than the most progressive Britishers. . . . He felt bound to say, in justice to the South African wine farmers of to-day, that the presentation of the case with regard to the South African wine industry in the paper was scarcely fair to them, and he attributed that, not in any sense to original sin on the part of the author of the paper, but to the fact that he had never been to South Africa to see for himself. . . . He had lived in South Africa for seventeen years, and he knew the failings of the Dutch farmers and also their virtues, and they deserved encouragement rather than blame.

The continued interest in South Africa and its doings which Sir Water evinced on the occasion just alluded to remained with him to the end. It is well known that up to his death he was a Director of the Standard Bank of South Africa, and one of his very last public appearances was at a meeting of the Royal Colonial Institute on the 13th June, 1913, when, presiding at a lecture on "the Plumage Bill in relation to the British Empire," he took the opportunity of referring to the pleasure with which he had on more than one occasion visited the farm of one of the pioneers of ostrich-breeding in South Africa, Mr. Oscar Evans, and had inspected the produce of the birds on the farm.

The South African Association for the Advancement of Science enjoyed the privilege of having Sir Walter Hely-Hutchinson as its President during the year of its meeting at Grahamstown, 1908, and in his Presidential Address, on that occasion, he clearly demonstrated that in making himself acquainted with the various details of scientific progress in South Africa, since the days of La Caille and Lichtenstein, he had exercised the same thoroughness that characterised all that he undertook in his official life. The main subject of Sir Walter's address, on that occasion, was the efforts of science in the matter of combating disease, an appropriate theme in view of the fact that at that meeting the first award of the South Africa Medal—for achievement and promise in scientific research in South Africa—was made to Dr. Arnold Theiler, then Veterinary Bacteriologist to the Transvaal Government, in recognition of his work in connection with diseases enzoötic in South Africa. The close acquaintance that Sir Walter then showed with the details of contemporary scientific advance in the sub-continent, was a revelation even to those who were quite aware of his deep interest in all the phases of the country's progress, and after that it was no surprise to find him lamenting that so few of the scientific investigators now working in South Africa were men born in the country, and urging that it was the obvious duty of South Africa to afford many more adequate facilities in the direction of providing for the training of its own scientific men. In one of the closing paragraphs of the presidential address occur some sentences which claim a special interest in view of the decision, at the following year's meeting, to issue the Association's Annual Report of its Proceedings thenceforward in monthly issues, under the title of THE SOUTH AFRICAN JOURNAL OF SCIENCE. Sir Walter had been referring to the useful objects which the Association might serve in co-ordinating the many and diverse factors that, in independence of each other, were working in the interests of scientific advancement. He laid down that the greatest impulse to that advancement would be derived from co-operation and union.

Take, for instance [he continued] the question of scientific publications. Scientific papers appear in the publications of various and diverse scientific societies and institutions in South Africa, and here and there in various Agricultural Journals: many are buried in blue-books, if not mummified in manuscript, and lie (like Mendel's report, which was communicated to the Brünn Society in 1865, and was lost to view until 1901), unnoticed and unread, on dusty shelves. But there is no such thing in South Africa as a South African Journal of Science, which might serve as a common channel of communication between the scientific workers throughout South Africa, and between them and the general public. It has been suggested to me that the foundation of such a journal, which is obviously desirable, would be possible, and that there is no reason why it should not be successful, if managed on the proper lines. It has occurred to me, too, in the course of preparing this address, that we ought to possess, and to publish from time to time (perhaps in the Journal) a summary record of the names and work of those who have devoted themselves, or are devoting themselves, to scientific investigation in South Africa. . . . In the matter of scientific development this is relatively a young country: but we are making history in South Africa, in scientific as in other matters: and a summary record of scientific work, kept up to date from year to year by this Association, would be an exceedingly useful work of reference when the time comes to write it. Admission to the record, if entrance to it were, as it should be, carefully guarded by those entrusted with the framing of it, would no doubt be eagerly desired: and the record itself would be not only a pledge of the moral support which the Association is desirous of affording to the advancement of science, but a considerable step in the direction of systematising the work of scientific enquiry.

In these days, when one finds that, in some phases of scientific work, union is even less close than at the time of the South African Association's Grahamstown meeting, when it is, moreover, asserted that co-operation and co-ordination in such work are unnecessary, when it is declared that best results are achieved when the workers operate as discrete units, the closing words of Sir Walter's presidential address may well be recalled.

There is reason to believe [he said] that in the matter of scientific enquiry in South Africa there is, and has been, a considerable amount of duplication, over-lapping, and therefore waste of effort—of repetition of experiments which would have been unnecessary had the experimenters been in closer touch with each other—had they been working as parts of one organisation. We hear a great deal in these days of closer union: and whatever branch of policy or administration be brought under discussion, ... one conclusion is always arrived at:—"Under some form of closer union, these things could be better arranged." People differ about what form closer union should take. Some differ, even, as to whether it is possible at all; but the conclusion is always the same. We may say the same thing about scientific investigation. I do not say what form closer union, as regards scientific investigation, should take. I will not even commit myself to the statement that it is possible. But I think you will all agree with me that, under some form of closer union amongst scientific organisations, scientific enquiry in South Africa could undoubtedly be carried on more economically and with less waste of effort, than is possible under existing conditions. By promoting closer union and co-operation in scientific matters, the Association will, to quote the words of its own Constitution, "give a more systematic direction to scientific enquiry," and will thus do much towards affording to scientific enquiry in South Africa that "stronger impulse" which, by its Constitution, it has undertaken, and bound itself, to provide.

Shortly after his retirement, Sir Walter was admitted to the honour of Privy Councillorship, in recognition of his eminent services to the Empire, particularly while Governor of the Cape Colony; and, although it may be foreign to the scope of this publication to refer to those services in detail, the eulogium passed upon the departing Governor by the late Mr. Sauer, on the occasion of his public farewell, may nevertheless be recalled. "It was not possible," the late Minister of Justice remarked, "to value too highly the strictly constitutional part which the Governor had played in this country."

It may not be generally known that, during his occupation of Government House at Cape Town, Sir Walter went to considerable trouble in getting together as complete a series of portraits in oils as could be secured, of all former Governors of the Cape Colony, from the time of its first settlement. In order to fill up the gaps in that series the services of artists here and in Europe were requisitioned, and these were supplied with the most authentic contemporary prints or other pictures that it was possible to furnish for the execution of the commissions entrusted to them. The result was that a most interesting and invaluable historical collection has been gained for the country.

JUBÆOPSIS CAFFRA BECC.: A NEW GENUS OF PALMAE FROM PONDOLAND.

By Prof. Rudolf Marloth, M.A., Ph.D.

Some years ago, Mr. Charles Ross, then Conservator of Forests at Umtata, reported the occurrence of a palm which was quite different from the two known species growing in our south-eastern coast belt, *viz.*, *Phœnix reclinata* and *Hyphæne crinita*. Some fruits of this palm were sent to Kew, and considered (possibly) to belong to *Cocos Yatay*, a native of the Argentine and Southern Brazil. Nothing further was ascertained at the time.

As artificial introduction was out of the question, and as the palm occurs only in close proximity to the sea, it appeared not impossible that, originally, ocean currents might have brought the seeds to our shores. The matter appeared of great scientific interest, for the genus *Cocos* is, apart from the widely spread Coco palm, entirely American; hence I collected as much information concerning it as possible. Mr. Ross states, in a letter, that the palm occurs only at the estuaries near the mouths of the Umsikaba and Umtentu Rivers, and at both localities only on the northern bank, the rivers flowing here nearly due east. It grows in isolated clumps, and occupies the nearly horizontal rock terraces (Table Mountain sandstone), which form the shore at this part of the coast, but not more than 10 to 30 feet above the water's edge.

The locality is very much out of the way, and difficult of access, but with the assistance of the present Conservator of Forests at Umtata, Mr. P. T. Doran, I finally succeeded in obtaining leaves, a young spadix and some spikes of young fruit, as well as ripe fruits. The material did not agree with the description of the genus *Cocos*, nor of *C. Yatay* in particular, and the director of Kew Gardens, to whom I forwarded a complete set, passed it on to a specialist, *viz.*, Professor Beccari, at Florence. This author replied, that there was no question about its being a true *Cocoinée*, but that it represented a new genus, which he named *Jubæopsis*, and the species *J. caffra*.

Close to the sea the plants are low and bushy, but a little further in, the stem reaches a height of 20 feet, with leaves 10 to 15 feet, and panicles up to 5 feet long. Each branch of the panicle carries 30 to 40 twigs, which are thickly covered with clusters of fruits. The ripe fruit is orange yellow, 1½ inches in diameter, with a scanty fibrous pericarp; the stone is nearly globular, 1 1-5 inch. in diameter, the longitudinal section slightly conical in its lower half; 1-seeded, and the weight 12 to 14 grammes. The three germinating holes are arranged near the equator of the stone, not near the base as in *Cocos*. The nearly allied *Jubæa*, which comprises a single species (Chili), has an elongated, somewhat 3-sided stone. The endosperm is hollow, of a sweetish taste, resembling that of the coco-nut; the embryo is lateral.

The Native name of the palm is "inkomba," while that of *Phœnix reclinata* is "lisundu."

A curious fact in connection with this palm is mentioned by Professor Beccari, *viz.*, that there is an illustration in "Martius, Hist. Nat. Palmarum" (plate 164) which is supposed to represent *Phœnix reclinata*, but obviously belongs to another species. Up to the time of receiving my material that illustration had been a puzzle to him, as no such palm was known, but now he recognised that it is evidently our plant. Nothing, however, is known about the original from which the drawing was made. Some collector must have sent specimens to Europe before. Was it, perhaps, J. F. Drège? He visited the neighbourhood of both localities in 1832, but in the list of his collections from Pondoland no other palm, besides the two common kinds, is mentioned.

Jubæopsis caffra is another addition to the fairly long list of phyto-geographical problems which South Africa offers, for, as far as known, and apart from the Coco palm, it is the only representative of the sub-tribe in Africa, and its nearest ally, *Jubæa spectabilis*, the only species of that genus, inhabits the West Coast of South America (Chili).

As this is such a rare and highly interesting plant, it would be very desirable that it should be soon introduced into cultivation, and I hope that the Durban garden, as well as the new National Botanic Garden at Kirstenbosch, will see to that without delay.

A New Oil-yielding Tree from Lourenco Marques.—In the *Kew Bulletin*, 1913, No. 4, p. 131, it is announced that a tree which grows in profusion in the Lourenco Marques district has been identified as belonging to an undescribed species of *Balanites* (*Simarubaceæ*). It produces a fruit whose kernel is highly oleaginous, yielding at least 60 per cent. of a fine oil perfectly suitable for alimentary, lubricating or manufacturing purposes. The species is described under the name *Balanites Maughamii*. In the Madanda forest the tree is known by the native name of *Manduro*. It is doubted whether the fruit will prove economically capable of export, as the kernel is enclosed in a thick fibrous shell, which would, moreover, first have to be extracted from the sugary pulp surrounding it. The oil is a clear, yellow liquid, without pronounced taste or smell.

STAR POSITIONS AND GALACTIC CO-ORDINATES.

By Robert T. A. Innes, F.R.A.S.

"The Galactic circle, the great circle to which the course of the Via Lactea most nearly conforms. Every subject has its technical or conventional terms, by whose use circumlocution is avoided and ideas rendered definite. This circle is to sidereal what the invariable ecliptic is to planetary astronomy,—a plane of ultimate reference, the ground-plane of the sidereal system."—Sir J. Herschel, "Outlines of Astronomy," 1849, p. 533.

In nearly every case concerning the motions of the heavenly bodies, the astronomer has to refer their places to the centre of the Sun; so that if an observer could be heliocentric, much labour of reduction would be saved. Let us try and imagine how a heliocentric observer, with all our notions upon astronomy, would start to work. His first object would be to form a catalogue of the stars, and to do so, he would have to decide on the planes of reference to which their places should be referred. If a terrestrial friend should suggest that the plane of the Earth's equator should be the fundamental plane, and that the direction of the intersection of the Earth's orbit with its equator should be the initial point, I think our heliocentric astronomer would be surprised. He might say: "but both the Earth's orbit and its equator are changing constantly, and the stars are virtually fixed; would I not by choosing such co-ordinates involve myself in endless calculations? Why should I not choose some plane and starting point nearly invariable and related in some way to the stars?" The terrestrial astronomer could only reply that his predecessors used the Earth's equator, etc., and that the theory of meridian instruments which they used was based on the fact that the Earth rotates. But what, the heliocentric astronomer might ask, has the Earth's rotation to do with the places of the stars; would not the stars still be in their places if the Earth ceased to rotate? Why not fix the places of your stars by photography? It gives results more precise than any meridian instrument, and from these precise places, you may, if you wish, find out the positions of the Earth's equator and orbit; but do not mix your ideas, and put the cart before the horse!

How is it that sidereal astronomy has got so involved? I think the difficulty grew in this way: Precise astronomy commenced about 1750. It is interesting to note that the oldest catalogue that the astronomer keeps on his working shelf is for the epoch 1750, and was compiled from Lacaille's observations made in Strand Street, Capetown, with a ½-inch telescope. The other star catalogues between 1750 and 1800 are due to the labours of Bradley, Mayer, and Lalande. But the work of these four astronomers is remarkable in this, that although they made the observations, they did not reduce them. The prison-house of variable right ascensions and declinations was not yet ready. But early in the nineteenth century, Bessel got all into shipshape order. Bessel's aptitude for all the problems of spherical astronomy was marvellous, so that to a subject which seemed unwieldy in its clumsiness, he managed to fit formulas of—when the complexity of the subject is considered—remarkable neatness. The relief was so great that astronomers accepted the fetters gleefully. Bessel's star-reduction numbers, which are published in every astronomical ephemeris, provide for the aberration of light, nutation in latitude and longitude, and the precession of the equinoxes. Thus encouraged, astronomers soon reduced the observations of Lacaille, Bradley, Mayer, and Lalande to mean epochs. So long as the stars concerned are not very near the poles of the rotating sky and the period does not exceed one century, the precession formulæ are not too unwieldy, one has to calculate for both right ascension and declination the first term of the precession, which will be multiplied by t the time elapsed, then the secular variation which is to be multiplied by $t^2/200$, then the third term of the precession, which will be multiplied by t^3. It is true that for many thousands of stars these precessional terms are already calculated, and all that remains is for the user of a catalogue to do the multiplications by t, $t^2/200$ and t^3. But the labour of making all these calculations is prodigious, and it is all done to impress an imaginary motion to the fixed stars. This motion makes it difficult to compare the places of stars in different catalogues. Thus we have in catalogues the following positions of ε Orion:—

Catalogue.	Epoch.	R. A. h.	m.	s.	Dec.		
Lalande	1800	5	26	3.66	−1°	20′	27.2″
Brit. Assoc.	1850	5	28	36.22	−1	18	6.5
Cape	1900	5	31	8.36	−1	15	56.5

indicating change in one century of

R.A. + 5m. 4.70s. Dec. + 4′ 30.7″.

whereas the real movement of the star in that time has only been 11.66″ in all,—the rest is fictitious.

The use of the moving or equatorial co-ordinates of Right Ascension and Declination is inevitable for some purposes, such as in determining the places of the Sun, the interior planets Mercury and Venus, and the clock-stars; for finding with an equatorial telescope, rough equatorial co-ordinates such as can be read off a good star map by inspection are all that are required. Why should we, therefore, impose moving co-ordinates on millions of fixed stars because we require moving co-ordinates for the Sun and a few planets and clock stars?

I think that the reason astronomers have kept to moving co-ordinates was a belief that the use of Galactic Co-ordinates, to coin a term suggested not only by the nature of the problem, but by Sir John Herschel, would lead to formulæ of even greater complexity than those given by Bessel. When I proposed the use of Galactic Co-ordinates, a well-known astronomer wrote me that the idea was attractive, but that no one would look further unless numerical examples showing how it worked in practice were forthcoming. I must confess than when I took up this challenge I was not too confident that the formulæ would work; in the result I was agreeably surprised,—the resulting expressions even in the most disadvantageous cases are hardly longer than the old methods, and in all others they are shorter and sometimes very much shorter. If this was the only gain, it would be considerable, but the real gain is behind this, the positions furnished by the Galactic Co-ordinates are final, comparisons betwixt star catalogues will become immediate. To work out a proper motion of a star to-day is hours, if not days, of work, because of the fictitious movements impressed upon it; with galactic co-ordinates, the comparison will be the work of minutes, and will, moreover, yield the proper motion referred to its natural plane.

One cannot but regret that in planning the great *Carte-du-Ciel* the advantages of a proper system of co-ordinates were ignored. Let us look at the difficulty which the system adopted leads to. To take, as an example, the Cape *Carte-du-Ciel* Catalogue, we learn from Mr. Hough's last report that it will fill eleven quarto volumes and give the positions of about 990,000 stars in all. At the same rate the complete sky *Carte-du-Ciel* catalogues will furnish the places of some 13,500,000 stars. These are all to be referred to the mean equator and mean equinox of 1900. If the catalogue is repeated, as is the implied intention in another century (or less as I hope), and it is referred to its mean epoch, any comparison between the two catalogues will be extremely laborious because the effect of precession on the so-called standard co-ordinates is complex. But let us assume that instead of 13½ million stars there are only 8 million catalogued, and that each star can be effectively compared in ten minutes of time, then the complete comparison will occupy one man's full time for 555 years, and at the moderate salary of £200, cost £110,000. I fear that there is a danger here in that the *Carte-du-Ciel* scheme is strangling itself so far as useful work goes by adding so enormously to its load of inertia. Had the places been referred to the galactic system by the use of galactic plate centres and secular co-ordinates, comparisons would be practically instantaneous. There is, however, a saving clause: when the *Carte-du-Ciel* scheme was started in the 1880-1890's, astronomers tacitly assumed (forgetting Proctor's work) that each star moved on its own—was an individuality distinct from its neighbouring stars—an assumption engendered by the known motions of the brighter stars then most studied; to-day it is known that stars are travelling in communities, and that the number of these communities is not large, that they, perhaps, can be counted on the fingers of one hand, but it would not matter if there were 1,000 communities—it is much easier to deal with 1,000 communities than with 13,500,000 individuals; and it is also known that the number of large or erratic proper motion stars is very restrained. Hence, the real value of the *Carte-du-Ciel* consists in its photographs or their enlargements; in fact, in the *Carte-du-Ciel* and not in the places of stars derived from it. Examination of these *Cartes* taken at different dates by means of superposition and projection in an enlarging lantern or by a blink-apparatus (as made by Messrs. Zeiss) will at a glance discriminate those stars which are moving "out of community"; measures of these and of *a few* of those moving "in community" will give all the information as to these motions which is required. By this means, instead of measuring on an average 300 stars per square degree, about eight or nine will suffice. The saving from this point of view alone is forty-fold.

A superficial criticism is that the galactic plane is not rigidly marked on the sky. But is the equator? The former is defined by the galactic latitudes of the stars at the chosen epoch, and at later epochs by such latitudes as will reduce the totality of proper motions (freed from the effect of motion of the solar system) to a minimum. To this plane must be referred the equator and equinox of the Earth, and not vice-versa. In the future, star places will be determined solely by photography, but to-day we are in a transition period and one of rivalry. But where the ultimate victory will be is not uncertain. If we look over Boss's Preliminary Star Catalogue, we see that with hundreds of observations spread over a century, we may hope to know such a well observed star's place as determined with meridian instrument with an accuracy of about $\pm$ 0.05″ at the centre of gravity of the observations or of 0.1″ forty years afterwards. Professor Kapteyn, in measuring photographs of the Hyades Group of Stars (Groningen Publications, No. 14), finds an accuracy as great from one set of plates, whilst Mr. F. Slocum, in measuring the parallax of Nova Gemini (2), finds a probable error of $\pm$ 0.007″ from observations spread over less than one year. It might be objected that the photographic measures are differential measures, which are always more accurate than absolute measures, but it is probable that these differential photographic measures can be continued around the sky in belts and the triangulations closed with all possible accuracy. At the present time Professor H. H. Turner is trying various methods of finding the absolute places of stars by photography at the University Observatory at Oxford. The results so far obtained are encouraging, but as might be expected with any new method, various difficulties arise and have to be combated. It is, however, quite doubtful if the probable error of a well-observed meridian star above given + 0.05″ means anything, because, after all, it depends on the position of the equinox, a very elusive point indeed.

I have laid the advantage of using Galactic Co-ordinates before astronomers in Circulars Nos. 2, 5 and 6, issued by the Union Observatory. In Circular No. 2 the necessary formulæ are developed, and tables given for the conversion of mean equatorial co-ordinates to invariable galactic co-ordinates for any year from 1750 to 1950, with a special table for the conversion of true equatorial co-ordinates to invariable galactic co-ordinates or *vice-versa* for the current year 1913. The processes are illustrated by numerical examples. The most thorough investigation of the position of the Galactic Plane was made by Newcomb, and published in 1904 under the title "*On the position of the Galactic and other Principal Planes towards which the Stars tend to crowd.*" Unfortunately the principal galactic plane cannot be found very precisely because the Milky Way is a very irregular aggregation of stars, throwing out wisps and branches, whilst the zone of brightest stars is considerably inclined to it. Newcomb gives the following poles:—

	R.A.	Dec.
Galactic Plane (omitting branch)	192.8°	+ 27.2°
Galactic Plane (including branch)	191.1	26.8
Plane of fifth type stars	190.9	26.7

It is known that stars of the fifth type (bright line spectra) are all close to the principal plane, but their number is small. It has further been assumed that the solar system is in the principal plane. But it is not a matter of great importance if the assumed position of the plane is in error so long as it is nearly correct, as any small error can easily be allowed for when the progress of astronomy requires. The total change in many thousands of years will certainly be less than the change in all the present star-catalogues every fifty years caused by the fictitious precession of the stars. Besides the position of the plane, it is necessary to adopt a departure point from which longitudes are to be counted, and it is obvious that this must be a fixed point. The point actually chosen is that one which in this age will make the longitude of the apex of solar motion,—the direction towards which the Sun is moving—equal to 0°. This point is chosen because a considerable portion of the proper motions of the stars is actually due to the solar motion through space, and it renders the effect of this motion in a uniform manner, in that generally all proper motions so far as they are caused by the Sun's motion, tend towards 180° of galactic longitude. Here, again, a compromise has had to be made, because the apex of solar motion depends on the class of stars to which it is referred. I have adopted for 1900 the position of the apex recommended by Dr. Campbell, of the Lick Observatory, namely, R.A. 18h. Dec. + 30°, and for the plane, Newcomb's determination including the branch, so that we have

Ascending node
$281° \ 6' \ 0.00'' + 4413.57'' \, T - 6.88'' \, T^2 + 0.186'' \, T^3$
Inclination
$63 \ 12 \ 0.00 + 1967.18 \, T - 4.56 \, T^2 - 0.145 \, T^3$
Departure Point
$23 \ 35 \ 27.26 + 432.40 \, T + 22.46 \, T^2 - 0.128 \, T^3$

in which T indicates solar centuries after 1900, assuming as correct Newcomb's variations of the Earth's equator and orbit.

In Circular No. 5 the advantages of using a fixed system of co-ordinates in planetary theories is insisted on, and for this fixed system there is no reason why the Galactic system should not be used. If anything, the simplifications which would thus be introduced into the planetary theories, are more considerable than those already dealt with. At its simplest, the motions of planets and comets are complicated, but this complication is vastly increased by adding on to their motions—both in their orbits and of their orbits—other imaginary motions, as is done at present.

In Circular No. 6 it is shown that if even a precise daily ephemeries of a star in equatorial co-ordinates is required—which appears to be the most unfavourable case for the use of galactic co-ordinates—one can be easily and rapidly computed without any knowledge of the star's imaginary mean right ascension and declination. As an example, an ephemeris of ε Orion is computed for the current year (1913).

Astronomers have been quite aware of the awkwardness of referring the stars and planets to rapidly-shifting planes, and some attempts to get over the chief difficulties have been made. Thus the late Dr. Ristenpart proposed that the equinox should be changed every 25 years, and he would call 1875, 1900, 1925, etc., normal equinoxes. He has published tables for the normal equinox of 1925. His idea would save some work, but not much—it is, in short, only a palliative. The astronomical ephemerides do something in the same direction. As an example, I will deal with the issue for 1915 of the celebrated *Connaissance des Temps*, which, as it proudly boasts, is the oldest astronomical almanac now published, as it first appeared in 1679, and has never suffered an interruption; besides this, it has always been brought up to date so punctually that it might also claim to be the youngest. For the Sun, the *Connaissance des Temps* furnishes the longitude and latitude for date, and for the mean equinoxes and ecliptics of 1915 and 1920—three where one would do. Similarly for the planets the heliocentric co-ordinates are referred to the Earth's true equinox and ecliptic of date and the mean equinox and ecliptic of 1920. For 732 minor planets the Gaussian Constants and their variations are given. It seems illogical to speak of constants varying—they really do not do so—nevertheless, 4,392 annual variations are specially computed for 1915. If galactic co-ordinates had been introduced, it is only three annual variations that would have been required—a saving of 4,389 out of 4,392. Lastly, for the stars the elements of reduction are given for the mean equinox and equator of 1915, and also for 1920. And when one has got to 1920, the labour of Sisyphus will still go on, but the mountain gets a little steeper each time.

DICOMA ANOMALA.—The *Pharmaceutical Journal*, No. 2,587, p. 694, contains a communication from Messrs. Tutin and Naunton, of the Wellcome Chemical Research Laboratories, London, in regard to their investigation of the plant *Dicoma anomala* Sond. belonging to the Compositæ. Smith, in his "South African Materia Medica," refers to it as possessing a reputed medicinal value, the powdered root being administered in cold water as a remedy for colic. The leaves are intensely bitter. The authors extracted from the plant a colourless crystalline glucoside, possessing the formula $C_{39}H_{58}O_{15}$, as far as could be ascertained, for the quantity available did not permit of its composition being definitely established. This glucoside was obtained from the water-soluble portion of an alcoholic extract of the entire air-dried plant. From the portion of the extract which was insoluble in water, and which formed a resinous mass, an amorphous alkaloid was obtained in small quantity, the hydrochloride of which was a brownish amorphous substance, and nothing definite was obtained therefrom. The resin yielded Hentriacontane, palmitic, stearic, and other acids, and a phytosterol of composition $C_{28}H_{46}O$, differing in composition from the more commonly occurring members of that class, and apparently a lower homologue of stigmasterol.

UTILITARIANISM AND RESEARCH.—Prof. E. H. Griffiths, F.R.S., in his presidential address to the Educational section of the British Association, emphasised the practical value, to the working-man, of scientific research. The price of his meat, he pointed out, was closely connected with refrigeration methods founded on Joule and Thomson's researches; the purity of his beer was similarly connected with Pasteur's work. The collier owes his safety to Sir Humphry Davy, the driver of the electric tram his position to Faraday. The steel-worker is under obligation to Bessemer and Nasmyth for employment, the telegraphist to Volta and Wheatstone, the wireless operator to Hertz. The wounded soldier has the bullet extracted by the aid of Röntgen, the sailor achieves his "landfall" by help of mathematicians and astronomers; his compass and sounding line are due to Kelvin, his bright beacon lights to Tyndall. Practically all wage-earners are under obligation to Lister. If voters realised that their security, comfort and health are the fruits of scientific research, those in authority, instead of being indifferent to, or opposing research, would enthusiastically encourage it. First educate the man in the street, and then, hardest task of all, the legislator may possibly be educated.

ROOT KNOT IN THE TOMATO.

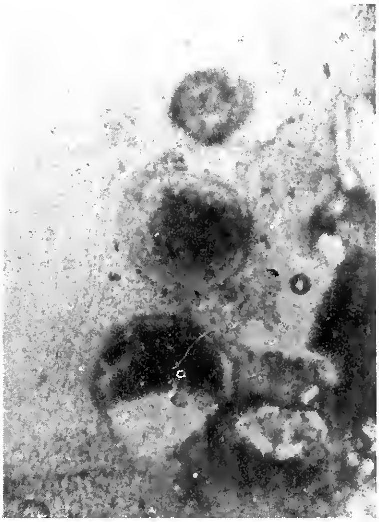
By Professor HORACE ATHELSTAN WAGER, A.R.C.Sc.

The life history of the Nematode worm *Heterodera radicale* causing this disease in America has been fully worked out by Ernest Bessey, but the results of my own observations on a similar disease in the Transvaal—notably in the Tomato—appear to differ somewhat markedly from his account, so that I am doubtful if the Transvaal species is quite the same. It has been thought that the worm has been introduced into South Africa from America, but it is more probable that the worm is indigenous, as it has been found on uncleared and uncultivated land. However, it is easy to see how the worm could be disseminated if once introduced, as small quantities of soil containing the worm are easily carried from one place to another by the hoofs of animals, cart-wheels, etc. The list of infected plants in America contains now over 500 names, whereas the South African species appears to show preference for only a few hosts, having a reluctance to attack others. I have grown likely hosts quite close to badly-infected Tomato plants without the slightest trace of infection appearing. In the Transvaal it forms a most destructive pest on Tobacco, it being impossible to grow Tobacco in some districts. It is practically impossible to cure or prevent the disease, at any rate without great expense. The worm evidently lives in the soil, and enters the root, causing the disease, which shows itself on the ærial portions of the plant at any time, but usually just as the fruit is ripening. Pathologically, however, I do not consider it as a disease, but as an animal pest which so interferes with the work of the root as to finally kill the plant. The symptoms of the attack in the Tomato appear to be as follows:—The whole plant becomes covered with a soft down of small white hairs, especially on the young shoots and young fruits, giving the plant a whitish appearance not unlike that due to a mildew fungus. The young shoots soon become stunted, the leaves begin to curl and shrivel up, and the fruit ripens very slowly. The plant eventually comes to consist of bare stems with a few green fruits still attached.

The significance of the white down on the leaves appears to be explained by an effort of the plant to correlate the transpiration with the lessened amount of moisture absorbed by the attacked roots. The roots of most of the attacked plants are found to be beset with numerous swellings, probably true galls. These vary in size from about 1 mm. on the small rootlets to large warty continuations on the thicker roots. At first they are hard, but soon they begin to rot, and become soft and pulpy. Some attacked plants show no galls, although the presence of the worm in the root can be demonstrated. The plants do not seem at all able to offer any resistance after once being attacked, as the cutting back of the plants never seems to invigorate them. The worm itself is threadlike, white, slightly flattened, and varies in length from about 300 to 500 μ, and shows fine cuticular rings. The oral end is slightly tapering and rounded, but the tail end tapers to a sharp hyaline point. The American species is given as being over 1 mm. in length and the tail end rounded. I have found no signs of moulting as described for the American species. In this species there is therefore no stage that can be considered as a larval stage. There are no spines on the tail—which is perfectly smooth—so that identification is rather difficult, and there is no definite bend in the tail to distinguish the male. There is apparently no difference between the male and female in the young stage, but a difference soon appears, probably after fertilisation has taken place. The female is then seen to be wider, with more granular contents, a more blunt tail, and shows the genital pore in the middle. It then takes up a permanent position in the root, and the gall swellings made of parenchyma are produced by the plant. It slowly changes its shape, becoming wider and wider, and finally flask-shaped, the tissue of the gall being dissolved or absorbed to make room for it. In this way the gall has scattered through it small spherical spaces made of the female bodies. These spaces can be seen with the naked eye as small whitish circular patches of about $\frac{1}{2}$ mm. in diameter when a gall is cut across. There is no definite lining to the spaces, but a more or less dense rind of parenchyma is found around each. Occasionally a clear lining can be seen around a young space, which is probably the wall of the female body, but this soon disappears.

The neck of the worm also gradually disappears and eggs begin to make their appearance in the rounded portion until each space

1



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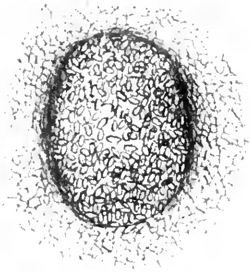

4

1. Root of tomato showing gall formation. 2 and 3. Photomicrographs of t.s. of gall, showing nests of eggs. 4. Section of gall, showing eggs.

Prof. H. A. WAGER.—Root Knot in the Tomato.

becomes a nest of very numerous eggs. There is thus no laying of eggs at the rate of 10 to 15 per day as described in the American species. The eggs are oval at both ends, with straight sides, and about 70 to 80 μ long, never 90 μ, and about two and a half times longer than wide. I have never found any slightly curved. At first they show granular contents with a clear cell wall, but soon the young worm can be seen coiled up inside, each worm having three bends. In most Nematodes of this type this condition is the larval stage, the egg having developed a kind of mouth at one end, but in this worm, as stated above, there appears to be no larval stage, the eggs developing directly into the young worms. All the eggs hatch at about the same time, so that some nests show a squirming mass of young worms. After hatching, the worms appear to increase very little in size, and certainly no moulting stages have been observed. At this stage the gall begins to rot away, so that the young worms and probably eggs themselves are set free into the neighbouring parenchyma and soil, and in this way other plants may become infected. It is possible that the worms actually live in the soil as well as in the plant, and only enter the plant for hatching or breeding purposes. The swellings on the roots would thus be true galls. Most of the worms seen in a gall would therefore have been bred on the plant, and more galls are produced by further breeding. The galls are probably not produced until the females begin to take up their permanent positions. That is why some infected plants have no galls on the roots. Infection obviously takes place in the first instance from the soil, so that the eggs and even the worms themselves must have great powers of endurance. I have had some infected plants under observation which I have just kept alive through the winter. I have repeatedly found the worm present on the roots but no sign of galls. It is difficult to decide upon the kind of injury effected by the worm, as I have many plants in the last stages of attack without any sign of galls. From infected roots kept in water for three weeks living worms have been obtained, as also after repeated drying and wetting. I have had the pest under observation now for nearly two years, and have not yet succeeded in infecting other plants, although the pest has been recorded from South Africa as occurring on Celery, Lettuce, Radish, Potato, and some others.

WESTPHAL'S COMET.—The periodic comet first discovered by Westphal, in 1852, was found on September 26th by Delavan at La Plata, and was then about the eighth magnitude Its perihelion occurs on November 26th, and on December 3rd its right ascension will be 20 h. 38′ 16″, and its north declination 42° 33′. That is to say, it will be in the neighbourhood of *a* Cgyni, moving in a northerly direction. It is expected to be faintly visible to the naked eye at perihelion. The period of revolution of this comet is 61.12 years.

THE RELATION OF HIGH SCHOOLS TO THE UNIVERSITY TECHNICAL COLLEGE.

By William James Horne, A.M.I.C.E.

The necessity for brevity in the title of a paper may cause the title I have chosen for this one to be slightly misleading. I wish to urge the necessity for expanding the science side of the high school in the Transvaal to cover something more than merely the preparation of the pupil for a pass in science at matriculation. I want to suggest that the existing pronounced trend of the education and culture given in these schools towards the literary and legal professions should be paralleled by an equally pronounced trend towards the engineering profession and those professions allied to it.

I am moved to this mainly through a paper by Mr. Norman Harrison, Chief Engineer to the General Post Office, read before the South African Institute of Electrical Engineers early this year, in which a most pessimistic note was struck, as far as the ability of the South African young man to take entire charge of any engineering scheme of some magnitude is concerned. His main point was that rarely in this country does the engineer take his proper place at the head of the business; that he is usually there purely in the capacity of a technical adviser, whilst some other officer controls who has no technical knowledge whatever; that, in fact, "the engineer is lacking in business capacity"—in other words, "he is lacking in the commercial application of scientific knowledge." He goes on to say, with reference to facilities offered by certain Government Departments to a few selected youths, that he is afraid that

> the general and commercial education of these boys is not such as will tend to bring the matter to a successful issue, having in mind that we are aiming at providing the engineers of the future. No doubt many of these boys have received a very fair education, some may be exceptionally well trained along technical lines; but I am very doubtful that they have received that broad and liberal training which should underlie the technical education of every professional man.

As the considered opinion of a highly-placed engineer, it appears to me worthy of profound attention, as reflecting a certain amount of experience gained in this country. Here I may digress to point out that engineers, as a body, appear singularly loth to bring forward their experience in such matters, probably because the magnitude and intricacy of their own profession engenders a healthy respect for the, to them unknown, difficulties of the teaching profession; a frame of mind to which the attention of many amateur educationists might well be drawn. Thus, I am unacquainted with any South African papers on this subject between the one I am now citing and the address of Professor Orr, given, nearly five years ago, as President of the then Transvaal Institute of Mechanical Engineers, in which he dealt in optimistic vein with the training of the future engineer in the technical college of University rank and in the commercial works. To that part of the training I do not refer, except briefly: I wish to confine my remarks to the "general education"—to the foundation for that "broad and liberal training" to which Mr. Harrison has referred.

It is necessary, for the sake of the uninitiated, to be clear as to what is *not* implied in the main when the term "engineer" is used by a professional expert: it does not mean the trade of engine-driving nor that of a tradesman working in the fitting and erecting shops of an engineering works; the first is an engine-driver, and the second is a fitter or engineer's mechanic. Again, the switch-board attendant in an electric power station is not an electrical engineer. A plumber is not a sanitary engineer, nor is a builder an architect. The steel-worker erecting the steel work of bridges and re-inforced concrete buildings is not a civil engineer any more than is the mason building the stone dam of a reservoir. The confusion in the lay mind, which, as a rule, does not distinguish between the profession and the trade branches into which it has come to be divided, is probably due to the fact that it is necessary for the professional engineer to have spent a certain number of years at the practice of the trade: this is exceedingly necessary in the mechanical and electrical engineering professions and, to a less extent, in the profession of a civil engineer. In this respect the engineering profession differs from the profession of an architect, who is not usually expected to have worked at the trade of builder.

The engineer, broadly speaking, is required

> to design the organisation, determine the policy, select the personnel, control the finance and supervise the work done in his business.

This means organising efficiency, a commercial grip on affairs, the ability and tact to deal with one's fellow men in every social grade, together with the highest training in the technics of his profession. The function of the University technical college is the training in technics; if its atmosphere is right, it will continue to call forth those personal attributes which are specially necessary to the success of the engineer as a professional man, and the foundation for which must have been laid in the engineer-student's school life. It is here that the high school plays a most important part, with responsibilities as great as those in connection with the preliminary training for any other learned profession. Sir J. J. Thompson has ably summarised what is required in the education of an engineer; it

> ought to be so framed as to develop those qualities which will make him in the best sense of the word a man of the world; to make him a man of wide sympathies and interests. These qualities are more likely to develop by a training which includes a considerable study of literature than one which is severely restricted to scientific or technical subjects.

There are other claims for literary studies proper; it is advantageous that the engineer should discern not only what is commercially possible, but what is artistically impossible; that cheapness and nastiness often go hand-in-hand. Also cultural studies which prevent a man being a prig keep him likewise from becoming a beast; the rational enjoyment of leisure is of importance to the engineer, since he is often lonely in a distant country with a vicious climate; the man who can master a good book is master of himself. Thus the higher technical education must not, in practice, no matter how good it may be in theory, aim at producing a finished and specialised animal instead of a plastic, well-informed and broad-minded man. It is no more possible to produce a useful specialist in turbines, wireless telegraphy, or any other branch of engineering at the age of 22 than it is to produce a first-class brain, ear, or eye specialist. The latter would be counted ludicrous, but the former is often expected.

It is doubtful whether a successful engineering education for a community can ever be adequately covered by any set programme or syllabus. Within certain limits the man of superior ability and the necessary common sense, who essays to earn his livelihood in one or other branch of the engineering profession, will do so, no matter how poor or how unorthodox his preliminary training may have been. Given sufficient incentive, the world will always produce its Stephensons, Watts, Trevithicks, Kelvins, Nasmyths, Ericssons, Corlisses, Simenses and Holleys. We can, however, widen the limits of possibility and remove the handicap of an insufficient educational foundation by providing some better scheme than has hitherto obtained. There is another very cogent reason for all this, and one which did not exist in the days of these earlier inventors whom I have named, that is, international competition. A colonial possession is more open to the clever foreigner than the older countries. Thus, if it be desirable that we train our own young men ourselves for the highest posts that the engineering profession has to offer, it is essential that both high school and university technical college should keep educational pace with not only British institutions but with Continental ones in addition.

The warning has been sounded by engineers themselves in no uncertain way. In November, 1903, the Institute of Civil Engineers, London, appointed a special committee "To consider and report . . . as to the best method of training . . . Engineers." A summary of the recommendations made by that Committee, as far as concerns the preliminary or preparatory education necessary for engineers, is given later on.* Again, we have another warning in the recommendations of the Imperial Conference on Technical Instruction held at Berlin in 1910. We

* Report: Education and Training of Engineers. Proceedings: Institute of Civil Engineers. Volume CLXVI, part iv, 1905-1906, page 159.

have practical warnings all around us: how is it that our best telephone systems are of Swedish origin? Why is our best motor-car engine of Continental make? What is the reason for the fact that the best mathematical treatises on steelwork for buildings and the new system of re-inforced concrete are by German and Norwegian engineers?

Mr. Dooley, philosopher, answers, "it is education that makes the nation"; let us get to the necessary education. The high school must increase the breadth and depth of its curriculum in order to allow the University technical college to maintain its proper status among the highest technical institutions of other countries. Before I go on to consider how a beginning in this direction can be made in South Africa, let me refer to an attitude of mind very common to us. I again quote Professor Sir J. J. Thomson:—

The training that is wanted is one that will train the boy to think about things, one that will train him so that he will get the whole weight of his mind upon the problem he is tackling. If he has got this power, then it is not a matter of primary importance as to what may have been the nature of the studies by which he has attained it. A boy who has this power is far more likely to make a good engineer, even though his training has been wholly classical, than one without it, even though he has studied the whole gamut of sciences.

The attitude of mind to which I refer is that the classical education already existing is sufficient for our purpose. Such an argument, of course, ignores Professor Thomson's preliminary hypothesis about the existence of the power to think about things: also it would make no provision for the brain without a bent to classics, and which might be groping in the dark for expression; again, it groups the brilliant and the mediocre together, probably with more harm to classics than to technics. The better plan is to give a boy a general education mainly literary up to certain age—the age really depends upon the boy—watch him closely when this time arrives, and then continue his education according to his bent. It, therefore, follows that an applied mathematics and science side must be added to the present high school system. Such an addition is indicated in the following resolution of the Conference on Technical Education called by the Minister for Education, the Honourable F. S. Malan, in 1911, at Pretoria:—

That . . . . in the opinion of this Conference the main entrance to a technical university course should be through the science side of the ordinary high school or equivalent institution.*

I have now to quote the highest British authority I know concerning the preparatory education of the engineer—the Institution of Civil Engineers, England—from the report of their Committee upon this subject:—

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*Blue Book No. U.G. 2/12. "Conference on Technical, Industrial and Commercial Education held at Pretoria."

Recommentations in respect of Preparatory Education:—

1. It is desirable that a boy intended for the Engineering Profession should, before leaving school and commencing to specialize, have attained a standard of education equivalent to that required by the Institution Studentship Examinations; and that he should not commence his special training until he is about 17 years of age.
2. A leaving examination for secondary schools, similar in character to those already existing in Scotland and in Wales, is desirable throughout the United Kingdom. It is desirable to have a standard such that it could be accepted by the Institution as equivalent to the Studentship Examination, and by the Universities and Colleges as equivalent to a Matriculation Examination.
3. Advanced teaching of History and Geography, with instruction and practice in Essay-writing and in Précis-writing, should be included in the ordinary school curriculum; and the instruction in English subjects should include at least an introduction to English Literature.
4. Greek should not be required, but an elementary knowledge of Latin is desirable. The study of Latin should, however, be discontinued during the last two years of attendance at school, or after the standard required for the leaving certificate has been attained. Modern languages, especially French and German, should be studied, and should be taught colloquially or in such a way as to give the pupils a practical knowledge of each language, sufficient to enable them to study its literature and to converse in it with some degree of facility.
5. Instruction in Mathematics should be given by methods differing considerably from those usually adopted in the teaching of this subject merely as an intellectual exercise. The geometrical side of Mathematics should be fostered, and before they leave school, boys should be conversant with the use of logarithms, and with at least the elements of trigonometry, including the solution of triangles. It is also of importance that instruction in practical arithmetic should be carried further than has been generally the case hitherto, with the object especially of encouraging the use of contracted methods and operations in mental arithmetic; and of encouraging also the expression of results with only such a degree of (numerical) precision as is consistent with the known degree of certainty of the data on which they are or may be supposed to be based.
6. It is preferable that boys should attain at school a general knowledge of elementary Physics and Chemistry, or what is sometimes called "Natural Philosophy," rather than that they should pursue in detail some particular department of science.
7. Special attention should be given to drawing; the instruction should include ordinary Geometrical Drawing with orthographic projection, Curve-drawing, Freehand-drawing, and Practical Mensuration.
8. Work in the nature of handicraft, such as Carpentry or Turning, or elementary field-surveying, may be encouraged as a recreation, but should not be required as a school exercise.
9. It appears to be impossible, in the general curriculum of school work, to include advantageously time for instruction in such a subject as Surveying, which has been suggested.

The Committee recommend that this scheme of Preparatory Education should be officially communicated to the Board of Education and widely circulated amongst those engaged in the conduct of Secondary Schools and Engineering Colleges, in order that future schemes of tuition of youths who contemplate entry into the Engineering profession may be guided thereby. The Committee are of opinion that if this course is taken it would assist in overcoming one great difficulty now universally felt in Institutions in which applied science is taught. At present a considerable proportion of students enter technical institutions ill-prepared, and at least one year has to be devoted to instruction which ought to be secured beforehand. Proper preparation is essential if students are to derive full benefit from special instruction in applied science. Professors and teachers ought not to be required to undertake subjects that should be taught elsewhere, but should be left free to devote themselves to scientific and technical instruction, which is their real work.*

You will see from the foregoing that a strong literary course in the education of the future engineer is insisted upon. I have already referred to the old dictum that "readynge maketh a full manne." There is a utilitarian use also: the ability to write reports and to use words in the right connection. Mr. Harrison, in his paper which I quoted in the beginning, laments the inability of the average engineer in this connection.

How many engineers are there to-day, who are technically expert, but who find the compilation of a report a most difficult and laborious matter; some of them find it an impossibility to perform, and do not hesitate to say so. . . . . It is not exactly literary style that is necessary, although this has its value, but the perfect appreciation of any interpretations that may be made under subsequent circumstances.

My experience tallies with Mr. Harrison's in this matter of reports from engineers; and I venture to give here two extracts from such an one:—

(*a*) Unslaked lime absorbed water with sluggish avidity and with an absence of necessary chemical evolution and combustion . . . .

(*b*) From chemical assays the constituent parts disclose no tangible chemical combination tantamount to the attributes incorporated in a good hydraulic limestone. . . .

A more meaningless jumble could scarcely be imagined, but I shall refrain from further remark on these extracts, except to say that these were not compiled by an educated Kaffir, but by a British-born engineer.

I pass on to consider the requirements indicated in the teaching of mathematics. This study must not be merely an intellectual exercise, it must be taught as a tool; thus, we have the elements of trigonometry, logarithms and practical mathematics with geometrical treatment asked for. Now, provision is made in the code for trigonometry or a branch of applied mathematics as optional subjects, and I think that these should at once be made compulsory in the science side of each high school. I need not detail exactly what subjects would constitute the literary side and what the science side; that can be left to the principals of the schools concerned. We do not force subjects upon the head-masters of these schools, and rightly so. He has to be satisfied before he introduces them that they are (*a*) generally cultural and educative, (*b*) that there is a demand for them. In other words, there must be an educated public opinion willing to realise the difficulties and the requirements of an engineering education before innovations, which appear to be departures from previous practice, can be in-

* Proceedings of the Institution of Civil Engineers, Volume CLXVI part iv, 1905-1906.

troduced. There is, however, one subject which should be introduced in addition to these I have mentioned, and that is manual training in woodwork and in metalwork. "A boy at school should be trained in a scientific habit of mind, which is, after all, nothing but organised and directed common sense." Manual work does this by the objective nature of the training it gives. There is much misunderstanding, and it must be pointed out that the modern conception of manual training workshops attached to primary and high schools is that they are constructive laboratories in which the scientific habit of accuracy may be acquired. That is to say, they are not looked upon as tool-rooms where anything may be made in the amateur method, from a packing case to a bookshelf for a bedroom, as has been the case in some instances in this country. As "a secondary course . . . is more specifically and definitely related to the pupil's future occupation," manual training workshops should be provided in both woodwork and metalwork at every secondary and high school as well as at primary schools, in order to provide the necessary guidance for those boys with constructive inventive genius, leading them towards a professional training through the technical college of university rank.

We have now to see how the matters in hand can be adapted to South African conditions: and here it must be remembered that the length and direction of the next educational step is predetermined by the number and length of the previous ones. Thus, with reference to the preparatory work at present included in the curriculum of the university technical college, and which it is desirable should make way for the highest technical work, I do not think that these technical colleges could drop their present first year engineering courses for some time to come without seriously affecting several well-meaning and hard-working students. There appears to be no reason, however, why the high school course and the first year technical college course should not overlap until a better educational state has arisen. At the South African College, Cape Town, the first year engineering course consists of :—

English, Dutch, Mathematics, Mechanics, Chemistry, Physics, Geometrical and Freehand Drawing, Workshop Practice,

while at the South African School of Mines and Technology, Johannesburg, we have :—

Mathematics, Applied Mathematics, Physics, Heat, Sound, Light, Electricity, Inorganic Chemistry, Geology and Mineralogy, Graphics, Workshop Practice.

Now, these being merely lists of the names of subjects, it is not fair to make comparisons between the courses without studying the syllabuses in each subject advanced by each institution. We may say at once that languages should have no place in the engineering curriculum of the university technical college. The ability to write a clear report in either languages of the Union, and without orthographical and other errors, must be acquired in the public school: it is a waste of time otherwise. Again, the inclusion of a course in geology and mineralogy in a first year engineering course is a doubtful matter: its use to a future electrical engineer, for example, is problematical. Also Heat, Sound, Light and Electricity are branches of physics, and, it may be reasonably expected, are included under the term physics in the South African College course. The same may apply to mathematics, which will certainly include some applied and practical mathematics. Chemistry, of course, means inorganic chemistry, and graphics is a newer name for the old subject, the geometrical drawing necessary to the engineer.

Thus, the two courses at these colleges may be assumed to be similar, if we except the two languages from the one, and geology and mineralogy from the other.

We are now able to suggest subjects for the final year of the high school course for those pupils intending to enter the university technical college; these are:—

Both languages of Union.
French or German.
Mathematics, pure and applied, including practical Mathematics, with graphical treatment, Logarithms and Trigonometry.
General Elementary Science (*i.e.*, the elements of physics and chemistry).
History and Geography, with special reference to Commercial and Industrial development.
Précis and Essay writing.
Geometrical Drawing and the Elements of Mechanical Drawing and Graphical calculation.
Manual Training (*i.e.*, the elements of workshop practice).

To those interested I would recommend the following two "Special Reports" issued by the Board of Education, London, as illustrating the trend desired in the teaching—No. 12, "Mathematics with relation to Engineering Work in Schools," and No. 1, "Higher Mathematics for the Classical Sixth Form"—both of which are papers that have been prepared for the International Commission on the teaching of Mathematics.

The object of this paper is to promote a greater educational efficiency by placing the schoolmaster in a position of preparedness to give a considered judgment upon the broader issues involved in the organisation of curricula and methods adapted to a preparatory training for the professional engineer of the future. I have endeavoured to do this by drawing attention to the fact that there is a unanimous demand for that organisation on the part of many responsible engineers. The "what to teach" and "why" has been given; the "how to teach" must be left to the schoolmaster. If teachers cannot become professionally articulate in this direction, I am afraid that the question will be decided by amateur or professional organisers without their guidance, and consequently without the best results. The complaint is that the standard of the first year course at the university technical college is generally too low: it is suggested that this can be remedied by the high schools giving a better preparation to the future student. If this is not done, the lad himself will find a way by cramming, which, though not quite useless, is much inferior to a systematic course of study.

The theory of modern economics is built up under the influences produced by the introduction of steam power through the potent agencies of the steam railroad, steam navigation and the use of steam power in industrial operations. Under industrial operations, I include the great means for transportation and intercommunication comprised in railways, telegraphs and telephones, in addition to the manufacture and distribution of products involving the application of power, mechanical or electrical, as well as the distribution, whether by pipe or by wire, of that power itself.

It would be folly to assert, therefore, that further developments in economic theory are not largely dependent on those industrial changes which are continually produced by the inventive genius of the great body of engineers. The engineers precipitate these affairs on the world by their inventions; in return, these affairs are the support of the engineering profession: thus, it is the duty of engineers to do their share in moulding their various economic creatures so that these creatures may reach the maximum usefulness to society. That is, the engineer has a public responsibility as great, if not greater, than that of the theologian, the physician and the legal pleader.

Thus, the engineering profession can justly claim a right to equal consideration in the curricula of the high school. I would ask, therefore, that the schoolmaster should not continue to practise his profession aloof from the ordinary engineering affairs of the world, that he discontinue considering his work as being more confined to study and investigation from a distance, that he should apply his knowledge to assist in the re-organisation of engineering education, if possible by meeting a responsible body of engineers.

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Address by Professor Dugald C. Jackson, Proceedings of the American Institute of Electrical Engineers, Vol. XXX, part No. 8.

Board of Education. Special Reports on Education Subjects. H.M. Stationery Office, London.

No. 1. "Higher Mathematics for the Classical Sixth Form," 1911, price 1d.

No. 2. "Mathematics with relation to Engineering Work in Schools," 1912, price 2d.

CURE FOR SLEEPING SICKNESS.—M. Danyez, in a paper recently presented to the Academy of Sciences, points out the advantage, in treating trypanosomiasis, of using several medicaments, no one singly being energetic enough to effect a cure. Thus, in trypanosomiasis occasioned by the spirilla of Rhodesia, very remarkable results have followed upon minute doses of arseno-benzol and silver nitrate. A single injection of one-twentieth of a mgrm. has cured a mouse; similarly rabbits have been cured by single injections of five mgrms.

TRANSACTIONS OF SOCIETIES.

SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Thursday, May 15th: J. W. Kirkland, President, in the chair.—"Water Power plants; with special reference to the Belvedere Power plant, Pilgrim's Rest, Transvaal": W. **Elsdon-Dew.** The author traced the development of electric power transmission in the Pilgrim's Rest District from 1890 up to 1910, when the Belvedere Power scheme was decided on. The water race and power station, completed in July, 1911, were described. The intake is situated on the Blyde River, above the Dientje Falls, which are 120 feet in height. The whole water race was designed for a flow of 160 cubic feet per second at a velocity of two to three feet per second. From the gates the waterway passes through an intake tunnel 445 feet in length through solid rock. Three other tunnels are subsequently traversed, the longest being 1,090 feet in length. The power line, which is 19 miles in length, traverses broken country for five miles after leaving the power house, varying about 800 feet in altitude in that distance.

Thursday, June 26th: J. W. Kirkland, President, in the chair.—"Notes on the construction of the Victoria Falls Power Company's 80,000-volt station at Vereeniging": R. B. **Canning.** A detailed description of the new power station at Vereeniging, comprising notes on the water supply, method of handling coal, the boiler plant with economisers and superheaters, the boiler feed system, the steam ranges, steam and electrically driven auxiliaries, the main turbo-generators, and the switch gear.

Thursday, September 18th: Prof W. Buchanan, B.Sc., A.R.C.S., M.I.E.E., Vice-President, in the chair:—"Notes on electric furnaces, with special reference to an induction furnace": Dr. W. **Glucksmann.** After referring shortly to the three different classes of arc furnaces and to the resistance furnaces in use at present, the author proceeded to describe in detail Gassie's induction furnace recently installed at St. Jacques, France, and concluded with some general remarks on the efficiency of electric furnaces.

S.A. Institution of Engineers.—Friday, May 16th: W. Calder, Vice-President, in the chair.—"The manufacture of cement:" E. **Davidson.** The properties and applications of Portland cement were briefly sketched, and details were given of improvements in the burning of the raw material and with regard to the preparation of the latter for the kiln.—"Notes on the theory of centrifugal pumps and ventilating fans": A. S. **Ostreicher.** A technical paper in which the subject was treated mathematically, with geometrical illustrations.

(Kimberley Branch), Thursday, May 26th: J. Harbottle, Chairman of the Branch, in the chair.—"Central Power station working, with special reference to De Beers Central Power Station:" G. M. **Robertson.** A fully-detailed description of the equipment and work of the Central Power Station.

Saturday, August 16th: W. Calder, President, in the chair.—Presidential address: W. **Calder.** Reference was made to some of the problems in connection with the mining industry that are still awaiting solution. Amongst these are the question of cheaper working costs, the economic centralisation of mining work, the sanitary conditions underground, the instability resulting from large worked-out open spaces, the need of systematic underground sorting, the air consumption of rock drills, the conservation and use of water, and the electrification of mining plants.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, May 17th: W. R. Dowling, M.I.M.M., President, in the chair.—"Vacuum filtration at the Victoria Mill of the Waihi Gold Mining Company, New Zealand": W. **Macdonald.** A general description was given of the plant, which has been in operation since the beginning of 1908. The vacuum pumps, which are of the double acting type, are eight in number, the motive power being a 200 h.p. Crossley gas engine. An outline was added showing the general conditions of the milling and treatment plant governing the production and character of the slime pulp. An account of the routine work of the plant was given, and the efficiency of the filtration process and of the extraction and recovery of the last traces of gold and silver bearing solution was discussed.

Saturday, June 21st: W. R. Dowling, M.I.M.M., President, in the chair—."Notes on the assay of Mine Samples" R. **Dures.** The assay of samples sent up from working faces of mines was discussed, and some of the errors occurring in the manipulation of these assays were pointed out. Details were given of a variety of tests showing the effects on assay results of (1) coarse and fine grinding, (2) varying the amounts of charcoal and of other components of the charge, (3) careful cleaning of the beads before weighing, (4) duplicating the assays, (5) inadequate heating of the muffle, (6) cupeling the gold with silver.

South African Society of Civil Engineers.—Wednesday, June 11th: F. E. Kanthack, M.I.C.E., President, in the chair..—"New station yards at Germiston and Braamfontein": H. H. **Elliott.** Works in connection with the provision of new railway stations and yards at Germiston and Braamfontein have been recently completed, and as the alterations and additions were on a scale larger than any that had been previously undertaken at any station in the Union, particulars of the works were given.

Wednesday, July 9th: T. W. Perry, M.I.Mech.E., in the chair.—"Roads in their relation to the development of the country": W. **Craig.** The author's remarks were virtually confined to the Cape Province, in which roads are classed as (1) Main roads, (2) Divisional roads, and (3) Farm roads. The Government exercises no control over either the Divisional or farm roads, and very little over the main roads. In the development of the country, road construction and maintenance should, in the author's opinion, be undertaken by the Government, and handed over to the Local Authorities only when these are in an assured position to carry out their duties efficiently. Indiscriminate handing over by Government to Divisional Councils of all road control has proved such action to be premature.—"Note on staggered and squared rail joints as applied to railway tracks": A. J. **Beaton.** The term "staggered" is applied by trackmen to broken or unsquared joints of the rails in the permanent way. Considerable doubt exists regarding the relative merits of the staggered and square joints systems of laying rails. These were discussed by the author, who concluded that the use of staggered joints is undesirable for reasons of (1) expense, (2) lack of additional stability to the track, and (3) detriment to smooth track riding.

Wednesday, August 13th: A. D. Tudhope, M.I.C.E., Vice-President, in the chair.—"Some notes on a modern Spanish irrigation canal": F. E. **Kanthack.** A description, based on the author's inspection, of the State canal of Aragon and Catalonia.

Royal Society of South Africa.—Wednesday, July 16th: Dr. L. Peringuey, F.E.S., F.Z.S., President, in the chair.—"On some Fossil Fishes from the diamond-bearing pipes of Kimberley": Dr. R. **Broom.** Three new types of Palæoniscid fishes now preserved in the McGregor Museum, Kimberley, were described. For these the author erects two new genera—*Disichthys* and *Pelcichthys*—and three new species—*Acrolepis addamisi*, *Disichthys Kimberleyensis*, and *Pelcichthys Kimberleyensis*. The fossils occur in sandstone taken from the Wesselton and De Beers Mines, and from the absence of conspicuous sandstones in the Ecca beds of the vicinity, and the occurrence in another slab of *Chelyoposaurus williamsi*, they are in all probability of Beaufort age.—"On the daily range of atmospheric potential gradient at Bloemfontein and the influence of dust storms": W. A. D. **Rudge.** An account of observations at Bloemfontein between July and December, 1912, with a Bendorff recording electrometer. The values of the potential gradient at hourly intervals were given for the whole period, and curves showing the daily range of the potential gradient for selected cases. The normal curves are similar to those taken in other parts of the world, but those for dusty days show great differences. On very dusty days there was a very strong negative potential gradient amounting to thousands of volts per metre. This is caused by the clouds of fine siliceous dust raised by the wind. A negative potential gradient was never recorded unless dust was blowing or rain falling. The rain which fell during the period under observation was invariably negatively charged.—"Further magnetic observations in South Africa": Prof. J. C. **Beattie.** The results of observations in various parts of South Africa during 1910-13. The observations were mainly carried out in the Western Transvaal, British Bechuanaland, and Bushman land.—"Magnetic Maps of the Western and Northern parts of the Union of South Africa and of Great Namaqualand for the epoch 1st July, 1908": Prof. J. C. **Beattie.** The maps show the true isogonics, the true isoclinals, and the true lines of equal horizontal intensity for the above region.—"Note on Clebsch's Theorem": Dr. T. **Muir.**

Wednesday, August 20th: Dr. J. K. E. Halm, Ph. D., F.R.S.E., Vice-President, in the chair.—"On the significance of the position of the genital apertures in Hirudinea": Prof. E. J. **Goddard.** The position of the genital pores is considered to be identical in all leeches, with two doubtful exceptions. It is concluded that the ancestral stock, from which the Hirudinea arose, must have been oligochaetan and aquatic in nature, with a body of 33 or 35 somites, and provided with setae similar to those of aquatic oligochaeta, such as Lumbriculidæ and Phreodrilidæ.—"On a

Phreodrilid from Sneeuw Kop, Wellington, South Africa": Prof. E. J. **Goddard.** A new form, discovered on the Wellington Mountains, was described by the author.—"Notes on spodumene from Namaqualand": G. C. **Scully.** and A. R. E. **Walker.** A lithia-bearing mineral collected near Jackal's Water, Steinkopf. From optical and other physical characters the authors refer this mineral to the species spodumene.

Wednesday, September 17th: Dr. L. Peringuey, F.E.S., F.Z.S., President, in the chair.—"On the interpretation of the electro-cardiogram": Prof. W. A. **Jolly.** The author has arrived at an explanation of the various features of the curve, based upon experiments on the isolated tortoise heart.—"A contribution to our knowledge of the anatomy of the chamaeleon": The Hon. P. A. **Methuen** and J. **Hewitt.** The authors conclude that the most generalised and probably most primitive forms are the genera *Brookesia* and *Rhamphoteon*, whilst the viviparous small chamaeleons of the *pumilus* group are the most primitive in the genus Chamaeleon; for these latter species, *pumilus* and allies, the authors revive the old generic name *Lophosaura* of Gray. The family has probably spread from a centre of origin situated in that portion of the Ethiopian region of which there now remains two separated components, Madagascar and the Cape Province of Sclater.—"Note on the pollination of *Encephalartos Altensteinii* (Kaffir Bread Tree)" Prof. R. **Marloth.** The insect on which the transport of the pollen from the male cone to the female cone of *Encephalartos Altensteinii* and *E. villosus* depends is *Antliarrhinus Zamiae*. The female insect pollinates the ovules while moving about between them for the purpose of depositing its eggs. Although according to Dr. Rattray's observations, some, most, or all the seeds of a cone are thus destroyed by the grubs of the insect, the visits of the insect are nevertheless essential to the plant, for without them no seeds would be formed at all. There are only three species of *Antliarrhinus* known, and the genus is, as far as observed, entirely confined to Eastern Cape Province.

Cape Chemical Society.—Friday, September 19th: Prof. R. Marloth, M.A., Ph.D., President, in the chair.—"Note on the methods of determination of nicotin in tobacco and tobacco extracts": Prof. P. D. **Hahn.** The method prescribed by Uhlex results in discrepancies which make the percentages of nicotin appear far larger than the amounts actually present. This is evidently due to distillation in the steam of proteid compounds which are subsequently calculated as nicotin.—"Preliminary note on soil investigations in the Olifants River Valley, Van Rhynsdorp Division": Dr. C. F. **Juritz.** The author described the nature of the country traversed in a flying soil survey, with particular attention to the indigenous vegetation. Tables showing (1) percentages of plant food, (2) proportions of brack salts, and (3) results of mechanical analysis of about 60 soils were given.

NEW BOOKS.

Pratt, Ambrose.—*The Real South Africa.* 8vo. pp. xix, 282. Maps and illustrations. London: Holden & Hardingham, 1913. 24 oz., 10s. 6d.

O'Niel, Rev. J—*A grammar of the Sindebele dialect of Zulu.* 12mo., pp. xii, 177. London: Simpkin, Marshall, Hamilton, Kent & Co., 1913. 8 oz., 7s. 6d.

Lyne, R. N.—*Mozambique: its agricultural development.* 8vo., pp. 352. Map and illus. London: T. Fisher Unwin, 1913. 26 oz., 12s. 6d.

Pettman, Rev. C.—*Africanderisms: a glossary of South Afriian colloquial words and phrases, and of place and other names.* Royal 8vo., pp. xvii, 579. London: Longmans, Green & Co., 1913. 32 oz., 12s. 6d.

HISTORY OF EARLY PORTUGUESE DISCOVERIES AND EXPLORATION IN AFRICA.

By Salomon Seruya.

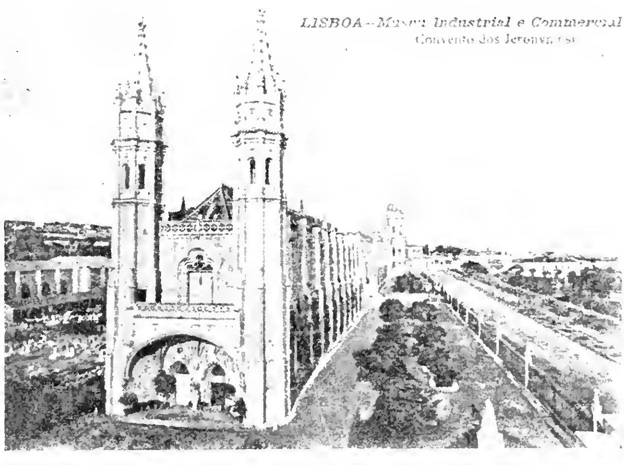
(*Evening Discourse delivered in the Colonial Hall, Lourenço Marques, on Friday, July 11th, 1913. Illustrated by lantern slides.*)

" Portugal does not forget that she was the first power to raise the veil of mystery which covered Central Africa." These were the introductory words of the address of the President of the French Geographical Society to Sir H. M. Stanley, when he presented the Society's Gold Medal to the great explorer on the 28th June, 1878.

Well, ladies and gentlemen, Portugal does not forget, either, that her sons were the first to set foot on the shores of South and East Africa, and were thus the chief agents in the general development of the world which followed their discoveries.

It is because Portugal does not forget her work of past centuries that I venture to address to the members of the South African Association for the Advancement of Science, on this their first visit to Portuguese soil, a relation of the doings of our ancestors in Africa.

It would, perhaps, be more becoming if I gave this Association a scientific dissertation. But our programme calls this a popular lecture, and so I avail myself of this in order to hide my ignorance in matters of science, and, I hope, that when I



Jeronymos Monastery.

(now the Industrial and Commercial Museum), erected in Lisbon in commemoration of the Portuguese discoveries.

have given a simple and abridged review of the travels and lives of some of those who transformed the world in the fourteenth and fifteenth centuries, you will forgive the pride of the Portuguese, who are rather inclined to recall their history when opportunity offers.

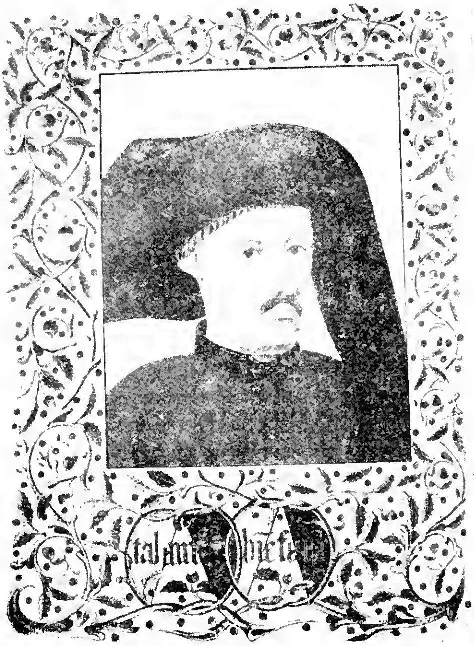
I have used portraits of the men whom I shall refer to, taken from old engravings, to illustrate my remarks.

I have also done my best to obtain copies of old paintings and etchings of the landing of explorers at the various harbours and of their reception by the native tribes and Arab rulers. Valuable and abundant literature of this kind certainly exists, but unfortunately I have been unable to procure the desired material within the short time at my disposal. It is also but fair to mention that I have gathered some of my notes from early Portuguese works as well as from Dr. M'Call Theal's excellent "History of South Africa."

When, in the beginning of the fourteenth century, Portugal, by the initiative and will of one man, sent her navigators across the ocean in search of new countries, and gradually became the greatest maritime power of the time, the Atlantic was looked upon by Europe as an insuperable barrier, in front of which the ambition and greed of mankind had to stop. Hercules' Columns, as ancient history called the two promontories on either side of the Straits of Gibraltar, were the limit of the Greek hero's marvellous deeds. Nothing, westward of these Columns, was known to Antiquity. The Phœnicians, whose enterprise and commerce were so great, did not know more than the European and African shores of the Mediterranean, and, although they passed through the Straits of Gibraltar, they never went any further than Cadiz. The Canary Islands, called in former days the Fortunate and Atlantic Islands, were so little known that for a long time they were held to be a myth like Solomon's Land of Ophir which, even at the present date, still remains a subject of controversy. It was common belief that the earth was divided into five zones, only two of which, the temperate zones, were habitable. The others were not accessible because of the intense cold prevailing therein in the south and of the intense heat in the middle zone.

Ignorance and superstition went hand in hand to frighten the boldest in any attempt to explore the African waters. The greater activity of the waves and winds round the capes of North Western Africa, which were after all nothing but a natural phenomena, was regarded as a sure sign of the inhospitality of the South Atlantic waters. The belief was so current that one of the first African capes was called "Cape No," thus indicating that Nature and Providence had combined there to tell mankind: "No, you shall not go further." The man who disbelieved the tradition and determined to unveil the secrets of the sea was the Infante Dom Henrique, better known as Henry the Navigator, fifth son of King John I of Portugal, and of Queen

Philippa of Lancaster, a sister of King Henry IV of England. Having fought the battles of Portugal against the Moors in North Africa, this great Prince realised that he could render his country better service in a different field, and soon retired



PRINCE HENRY THE NAVIGATOR.

into his estates at Sagres, in the South of Portugal. There he founded the school where mathematics, cosmography and nautics were taught, where astronomical observations applicable to navigation were made, and hydrographic charts were drawn, where instruments for the observation of the sun and the stars were manufactured, and particular attention was devoted to improving naval construction.

From the Sagres School came the seamen who, under Dom Henrique's personal direction, discovered a number of islands, amongst which were Madeira and the Azores, and it was owing to his initiative, and with his monetary assistance, that companies were formed for the settlement of the discovered lands. Let me recall the interesting fact that the Prince himself selected the first colonists of Madeira, that he provided them with vines and sugar cane brought from Cyprus and Sicily, and that within twenty-five years of its discovery the island was able to maintain not only the natives, but also a Portuguese population of eight hundred souls, and was exporting more than 500 tons of sugar per annum.

The Prince's activities were the subject of bitter attacks on the part of the Court. It was contended, among other things, that it was criminal to distract good and strong men from the war against the Moors and to send them to certain death over the terribly stormy seas; that no profit could be derived from the unknown lands which could not possibly be anything else but uninhabitable and burning areas, similar to the deserts of North Africa; that if indeed those lands could offer any advantage, the Romans and the Phœnicians would not have failed to attempt that kind of exploration, and the very fact that they had not done so was a sure proof of the vanity of the scheme.

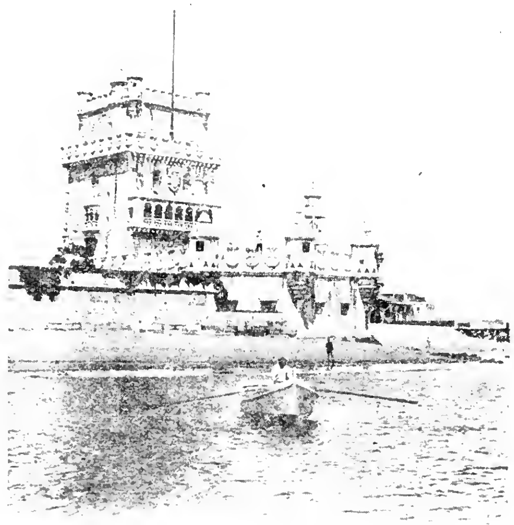
Such criticisms did not abate the Prince's courage, nor, fortunately, did they carry weight with the King, and when Dom Henrique died in 1460, after forty years of continuous and strenuous work, the whole of the West Coast of Africa down to Sierra Leone had been discovered, and the way was open for those skilful navigators, who astonished and revolutionised Europe by taking the fleets of the Kings of Portugal to the remotest parts of the world.

Not much work was done for about twenty years after the Infante's death. Portugal was too busy with the conquests in Mauretania and the war with Castille to be able to equip any considerable exploring expedition. It was not until 1481, when King John II ascended the throne, that full advantage was taken of the rich seed sown by the Infante. King John, whom we rightly call the Perfect Prince, was fully alive to the vastness and greatness of his uncle's ideals and schemes, and realised what their execution would mean for his country and for the world's progress.

His officers went further south along the West Coast and discovered Guinea and the Congo River. Their dealings with the inhabitants of those lands were so friendly that they brought back to Lisbon some natives with a request from the Congo King that he might be supplied with ministers of religion, teachers in the art of reading and writing, mechanics, agricultural labourers, bakers, etc., while some of the members of the expedition remained behind in order to explore the interior. "Further south," however, was King John's constant aim, and in 1486 a fleet, under Bartholomeu Dias, left the Tagus in search of the Southern Cape. This expedition is styled by a distinguished geographer as the "most delicate and difficult undertaking attempted in modern times."

Navigation was then beginning to be made somewhat easier owing to the results achieved by the mathematicians kept at Court, whom the King constantly pressed for new observations and new inventions. They prepared the pilot's declination tables and greatly improved the measurement of the altitude of the sun by means of the astrolabe. The ablest of these scientists were Rodrigo, Joseph Hebrew and Martin Behaim, of Nuremberg. They rendered the world a great service. Their names and their work may justly be said to be immortal, as subsequent navigators were no longer compelled to follow the coast line, and were able to risk taking their ships into the high seas, their course then being shorter and less dangerous.

The King's orders to Dias were that he should continue the exploration of the coast of Africa as far south as he could, and ascertain whether or no the African seas offered the much coveted unbroken ocean route to India. This Dias unknowingly did, for he doubled the Cape of Good Hope, and landed on an uninhabited island in Algoa Bay. He and his officers had a



THE BELEM TOWER, AT THE MOUTH OF THE TAGUS

suspicion that the great problem was solved, for as far as the eye could reach, the shore stretched east and west and, unless they were in a deep bay, an open sea must necessarily lie before them. Fate, however, would not give Dias the glory of the great feat which was in store for another. His men complained that their supply of food was running short, and they insisted on returning, whereupon Dias asked them to sign a document to that effect. He obtained from them consent to sail two or three days further east, and so they reached the mouth of a river, which they named the Infante, after the second officer in command; this river is probably what we know to-day as the Kowie. The expedition then turned back, and then the great headland was discovered and named the Stormy Cape because of the heavy weather encountered.

Dias reached Lisbon in December, 1487, after an absence of nearly seventeen months. He was well received by the King, to whom he gave a full account of his voyage. As he mentioned the difficult crossing of the Stormy Cape, King John directed that it should henceforward be known as the Cape of Good Hope, as he conceived a great idea of the results of Dias's discovery, and entertained a great hope that the scheme in view would soon be accomplished.

BARTHOLOMEU DIAS.

I may mention here incidentally a bitter disappointment which befell King John II in the midst of his efforts to enlarge the field of discoveries. A man came to Portugal with the promise of magnificent discoveries in the western extremity of the Atlantic. This man, a native of Genoa, had travelled a great deal in the Levant. Rumour went that he had settled in Madeira where, one day, he received in his home the dying pilot of a wrecked French ship, who told him of an unknown continent across the ocean. King John did not take this man seriously and rejected his proposals. So did other European Powers until after seven years of untold striving and rebuffs the Genoese succeeded in getting Queen Elizabeth of Spain to equip three ships, which he led across the Atlantic in search of the New World. Some time later, these ships anchored in front of the City of Lisbon, and Christopher Columbus informed King John that he had discovered America for the Spanish Crown.

King John died in 1495, and was succeeded by King Manoel I, under whose reign Portugal knew her most glorious and prosperous times. This remarkable Monarch soon brought to completion the preparations which had been begun by his predecessor for the equipment of a second fleet to continue Dias's unfinished work. In July, 1497, four vessels left the Tagus, the flagship *San Gabriel*, piloted by Pedro d' Alemquer, who had taken part in Dias's former expedition, the *San Rafael*, the *Berrio* and a storeship, all under the supreme command of Vasco da Gama. The number of men on board these four ships was not more than one hundred and seventy, soldiers and sailors together.

KING MANOEL I.

The gloomy stories told by Dias and his companions of the inhospitable seas of the Cape of Good Hope had filled the people of Portugal with terror. Shipwrecks were the foremost topic of conversation, and it was the firm belief both of those who bade them farewell in the Lisbon harbour and of da Gama's men that they would never return alive. Their terror became more acute when they approached the Cape of Good Hope waters, about five months later. It was apparently a bad season, and although some writers contend that fine weather prevailed, reliable Portuguese historians assert that heavy storms were met with. This circumstance, coupled with the legendary treachery of the Cape, led the crews to mutiny on several occasions. Had it not been for da Gama's prudence and firmness, the whole expedition would certainly have failed. On the 22nd of November the Commander had the joy of doubling the dreaded Cape safely with all his ships. Milder winds were encountered, and a few days later the fleet reached Mossel Bay, where da Gama decided to drop anchor, so as to give his men a rest, and to procure fresh provisions. Friendly relations were at first established with the natives, who gladly exchanged fresh eatables and some live sheep for beads and other low price articles brought in da Gama's ships, which astonished these simple people. But as some altercations occurred between the Hottentots and his

VASCO DA GAMA.

men with regard to the exchange of curios, da Gama suspected treachery and moved to another anchorage, where he decided to abandon the storeship, as there was no further need for her. Everything was transferred to the other vessels and she was burned, whereupon the three ships proceeded on their course eastward, keeping close to the land, which was observed to improve constantly in appearance. On the 25th of December, the country then in sight was named Natal by da Gama in honour of the day which was being celebrated on board his vessels. Our Durban friends have erected at the Point a small but dainty monument to the leader of the first Europeans who saw the country they live in. It was he who gave it the pretty name it has kept to this day, and will probably always retain, and I am only sorry that Natal's example was not followed in other parts of the South African continent, particularly in this Province of Mozambique, where not a single monument is to be found in memory of the great man or of his followers.

In January, 1498, da Gama reached the mouth of a river, which he named the River of the Kings, and which was subsequently called the Copper River on account of the quantity of that metal found in use by the natives. It is to-day the well-known Limpopo.

The navigators were then becoming rather disheartened as they found everywhere only the most miserable people, whose languages could not be understood, and whose treachery was constantly feared. It was not until they reached Quelimane, about the end of January, that they began to entertain hopes of a better turn of things. There they found black inhabitants, it is true, but some of them were of an olive shade, better clothed, and these understood a few Arabic words, which clearly indicated the vicinity of white people. In fact, the Portuguese succeeded in understanding from the natives that, if they went further, they would come across white people who had ships almost like theirs.

Da Gama took the tidings as a good omen that he would soon be in possession of information, which would help him to reach India. He remained some time at Quelimane in order to clean, recaulk, and generally to better the condition of his vessels, and also partly because scurvy had appeared among his men in a very bad form.

When, a few days later, the fleet reached Mozambique, da Gama learnt that this place carried on a considerable trade with India. The Island belonged to the Kingdom of Ki'wa and its Governor, Zakoeja, an enemy to Christians, paid a visit in State to the Portuguese Commander and promised to supply him with two pilots, who would take the fleet to India. Mischief and treason, however, were contemplated by the Governor. Da Gama kept him under close observation during the whole of the conversation and noticed some hesitation in his answers, which led him to doubt the man's sincerity. In spite of that courtesies and presents were mutually exchanged, entertainments took place at which the Arabs went so far as to break their law and drink Portuguese wine, and ultimately the two pilots were sent on board. But they soon deserted the ships and hostilities began, a shower of arrows being poured into the Portuguese vessels. Da Gama retorted with a few cannon shots, which killed four men, amongst whom was one of the runaway pilots, who died by the side of the Governor. Zakoeja, in terror, notified his readiness to yield to all da Gama's demands. The latter contented himself with accepting the services of another pilot, and set sail on the 13th of March. The pilot took the ships amidst some islets, where they ran into great dangers, but paid dearly for his treason. Da Gama had him flogged so severely that for a long time afterwards the spot was known as "The Islands of the Flogged."

The pilot then promised to take the fleet to Kilwa, the capital of the kingdom, a rich and busy city said to be inhabited by some Christians. In doing this he expected to be avenged there, as messengers had been sent with the report of the events at Mozambique, and his hope was that preparations were being made at Kilwa for a hot reception of the Portuguese. Strong currents prevailing, his scheme failed, and the fleet put up at Mombassa, and later at Melinde. A most friendly intercourse was at once established between da Gama and the ruler of the latter place, who felt proud of being visited by the emissary of a mighty monarch of distant lands. A pledge of peace and friendship was entered into, which was mutually observed ever afterwards. When da Gama arrived at Melinde, four Indian vessels were in port, manned partly by Christian Hindoos and partly by Mahommedans, who showed great joy at the sight of the strange navigators. They gave da Gama useful information, and one of their crew, by name Cana, a native of Guzerat, and a skilful pilot, undertook to conduct the fleet to India.

It is contended by some writers that da Gama learnt from those Hindoos a new manner of taking the altitude of the sun, and how to use the compass. It is said that da Gama's astrolabe, which he showed them, did not astonish those men in any way, and that, on the contrary, they showed him much more perfect instruments, which, they asserted, were commonly used by the Arabs in the Red Sea, and by all the other people who visited the Indian Ocean. But although the opinion has been freely expressed that the knowledge of the compass came to Europe from India, it is by no means a certainty that the Portuguese transmitted that knowledge to the European nations. The real origin of the compass is lost in the obscurity of time, and can only be a matter of conjecture. It is interesting to note that some writers give the Neapolitan Flavio Melpha the credit for its invention, two hundred years before the first Portuguese expeditions, whereas Guyat de Provins, a French poet of the twelfth century, says that the instrument was known in his time, and found its birth in France. Others claim it for England, others for China, while many believe that the instrument was first made use of by the Venetians, who went to India and China through the Red Sea.

Da Gama left Melinde on the 24th of April, and on the 24th of May, 1498, he reached Calicut, in India, having thus accomplished the dream of the Infante Dom Henrique, and attained the object for which Portugal had striven so long, and for which King Manoel had exacted so many sacrifices from his country. Da Gama returned to Portugal with 55 men out of a crew of 170.

The doings of Vasco da Gama and of his successors in India form a magnificent page of history which, however, cannot find its place here if I am to abide by my subject.

While King John II was sending out Bartholomeu Dias by sea in search of the Cape of Good Hope, his emissaries were also doing very interesting work on land. It was then believed that a certain powerful Christian King called Prester John lived in the interior of Africa. King John II had a keen desire to enter into communication with this ruler, sure as he was that Prester John would assist in the discovery of an overland route to the East Coast of Africa, and thence to India, and also in the opening up to the Portuguese of the routes through which Oriental spices and wares were conveyed. A native who came to Portugal told the King that there resided in the interior of Africa a certain potentiate by name O'gano, who had jurisdiction over all the neighbouring tribes, the rulers whereof he invested with the royal insignia, consisting of a cane, which was the emblem of the sceptre, a sort of a helmet in guise of the crown, and a brass cross. Their ambassadors, when visiting O'gano's Court, never saw the monarch, but were permitted to see only one of his feet, which they kissed in religious devotion. Before they left, a brass cross was placed round their necks, an act which freed them from all servitude and entitled them to rank with the nobility. Narratives of this kind naturally impressed King John's mind and confirmed his idea that great things could be achieved if he could only get into touch with the Native rulers of the interior. In fact, he thought O'gana who distributed brass crosses, could be nobody else but the much talked of Christian King, Prester John. So he sent out Pedro da Covilham, who, after a most extraordinary voyage through Naples, Cairo, Aden and Sofala, ultimately penetrated into O'gano's states. The ruler's real name was Escander (a corruption of Alexander) and his land was called Abyssinia. To him Covilham handed King John's letters and a chart of the Portuguese explorations. But Covilham was never allowed to return to Portugal. He apparently got married and left descendants, for the chronicles of 1559 report that a certain European called Alvaro da Costa Covilham resided in the Abyssinian Empire. In all probability, this man was a son of King John's messenger.

Let me also mention the name of Goncalo Eanes, whom King John sent up the Senegal River, and successfully reached Timbuctu. He was therefore the first European to visit the city which for many centuries afterwards remained, and perhaps still is, a mysterious place.

In 1500 a second expedition, consisting of thirteen vessels, was sent to India under Pedro Alvares Cabral. Keeping far to the westward, to avoid the calms usually met with on the coast of Guinea, to his surprise he discovered a country unheard of before, the mainland of South America, Brazil, which was subsequently annexed and colonised by Portugal, with the success of which that great State is now a vivid proof. He sailed again towards the Cape, in the neighbourhood of which he lost four vessels in a tornado. One was under the command of Bartholomeu Dias. Is it not a strange irony of fate that this man should have found his grave on the spot he had discovered, and which he himself had described as being so deadly?

Two years later, in 1502, John da Nova discovered St. Helena. No efforts were made to colonise this island, but, in later years, a Portuguese called Lopes acclimatised there some domestic animals, such as pigs, goats, rabbits, partridges, etc., and made some plantations.

PEDRO ALVARES CABRAL.

The following year, on his way to India, Antonio de Saldanha landed and fought the Natives in a bay in the vicinity of the Cape of Good Hope, which bay still retains his name.

In the course of the years 1505 and 1507 the East and West coasts of Madagascar were discovered and explored by Tristao da Cunha, and by Ruy Pereira and Fernando Soares, who gave the island the name of St. Lawrence. The first captain's name is well known to us, on account of the islands which he was the first to sight, and of which some interesting news has been published recently in the South African newspapers. He was the man who, a few years later, visited Rome, at the head of a brilliant embassy from King Manoel to Pope Leo X. Rich presents from India and Africa were sent to show the Pontiff the importance of the trade which had been opened up with those continents.

Among the presents, it is perhaps interesting to note, was an elephant, an animal which had not been seen in the Papal City since the days of the Roman Empire. This fact greatly contributed to bring to Rome a huge crowd eager to witness the arrival of the ambassadors of the country which was doing so much for the expansion of the Christian faith, and who were the bearers of such wonderful specimens of the wealth of the Orient.

Portuguese settlement in East and West Africa went on steadily, as the subsequent expeditions to India required the establishment of refreshment stations, and men were left at the various ports, to see to the needs of the fleets and to open up commerce with the interior. Important commercial centres sprang up at Loanda and Benguella, in Angola, and at Mozambique and Sofala in this territory. A great portion of the interior, as well as the whole of the coast belt, was gradually explored by Portuguese officials and traders.

In 1545, Dom Joao de Castro, one of the most distinguished Governors of India, reported to the King the recent discovery of the bay and rivers of the Lagoa by a man called Lourenzo Marques, and the following year the King, in reply, sent instructions for a closer investigation of the discovery. King Manoel apparently had more faith than the succeeding generations in the destiny of this town, since this place remained for centuries undeveloped, and it is only in recent years that it has attained sufficient comfort to attract the members of the South African Association for the Advancement of Science!

Portuguese penetration and settlement in Africa has been steady and consistent. When, during the first portion of the seventeenth century, the wars with England and Holland deprived her of her Indian Empire, Portugal remained in Africa. If her African dominions do not show a degree of development and wealth equal to those of other powers, the reason is easily traceable to the small population and limited financial capacity of the Mother Country. In spite of that, the work of the Portuguese will leave its mark for all time in all branches of human activity. They have rendered gigantic service to science by their nautical discoveries, and by their gift of a new geography to the world. They have augmented the world's wealth by opening up new channels of commerce. In Africa in particular, they were faced with enormously large tribes extremely superstitious and tenacious in their habits as well as in their hatred of any innovation. Christianity has made many converts in Africa: it has, perhaps, not made a single civilised man who will adopt our customs and mode of living, so much so that a celebrated statesman once expressed the fear that Africa would for ever be the eternal abode of barbarism. Nevertheless, the Portuguese were the first to attempt to civilise the African Natives, and the greatest share in whatever has been achieved to this day is undoubtedly theirs. They claim that with reason, as they also claim with equal reason a great part in the European colonisation of this country, where they have displayed much activity and enterprise in the cause of science and civilisation. This entitles them to a prominent place in Africa, quite apart from the rights bequeathed to them by the deeds of their navigators and warriors, which are looked upon nowadays as only a brilliant romance.

LUIZ DE CAMOENS,
the poet of the Portuguese epic of Africa and India.

Of those heroic times the remembrance has been immortalised by the great poet Luiz de Camoens in his Lusiad.

MICROBE OF HYDROPHOBIA.—Prof. Hideyo Nogushi claims to have discovered the microbe of hydrophobia, and gives a description thereof in the *Bulletin* of the Rockefeller Institute. In this connection Prof. Metchnikoff, of the Pasteur Institute, makes the following remarks: " Nogushi has made a discovery of great importance. His note, hastily published as it was, is in some respects brief and obscure, but the strict control that is exercised at the Rockefeller Institute, as well as the personality of Nogushi himself, are sufficient safeguards that this is an authentic discovery, and that it will mark an epoch in the history of bacteriology. The culture of the hydrophobia protozoa may permit of the preparation of a serum or vaccine of far higher activity than the spinal preparations now employed for inoculation against rabies, and probably the lengthy and painful treatment of twenty injections will be much shortened."

A PLEA FOR THE EXACT MEASUREMENT OF RAINFALL.

By Frank Flowers, C.E., F.R.A.S., F.R.G.S.

The detailed study of rainfall should be a national question in every civilized country, and the economic importance of it is so tremendous that there is no need for an apology in introducing a paper, which has for its purpose a brief consideration of the method of rainfall measurements.

It is unnecessary here to dilate on the influence of rainfall upon climate and then upon immobile and mobile life. Its importance upon the water supply to towns is apparent. Many industrial concerns depend upon a favourable rainfall. Besides, the character of its occurrence determines the safety of life and property, the formation of dongas and a host of other considerations into which the subject enters.

From the day, in 1662, when Sir Christopher Wren first designed the rain-gauge, little was done in the British Isles until 1860 to establish a co-ordinated system of rainfall observations. Since the latter date, however, an organized body of observers has been working, and a large amount of valuable information has thus been secured. In South Africa, for many years past, the Cape and Natal Provinces have been attending to this national necessity, while in the Transvaal we are just celebrating the tenth anniversary of the establishment of its Meteorological Observatory. The success achieved by the latter institution during the past decade is a matter of gratification to all interested in the subject of climate. Its Annual Reports, which have been regularly issued in the past, have been much appreciated and of considerable value. It is hoped that the new Union Department of Meteorology will continue the excellent practice.

In countries where the characteristic rainfalls are slow and continuous, and where the total annual precipitation is such as to adequately replenish both natural and artificial reservoirs the question of the exact measurement of rainfall is not so imperative and the ordinary gauges of the "Snowden" or Indian pattern give sufficient data upon which to design hydraulic schemes. In the zone of torrential rainfalls, however, it is contended that the ordinary gauge does not give sufficient information, and that the automatic instruments possess many advantages over the older forms.

For the agriculturist, in areas where the characteristic rainfall is torrential, the determination of the ratio of beneficial to non-beneficial rainfalls of the total annual precipitation is a subject of great importance, while to the engineer a knowledge of the intensity of rainfalls, the area covered by same, and the run-off for any particular locality is absolutely necessary for the correct designing of public and private works.

The British standard unit of rainfall is taken as the number of inches precipitated per hour, and the run-off is calculated in cubic feet per second from any given catchment area; consequently, the more clearly the rainfall measurement shows the

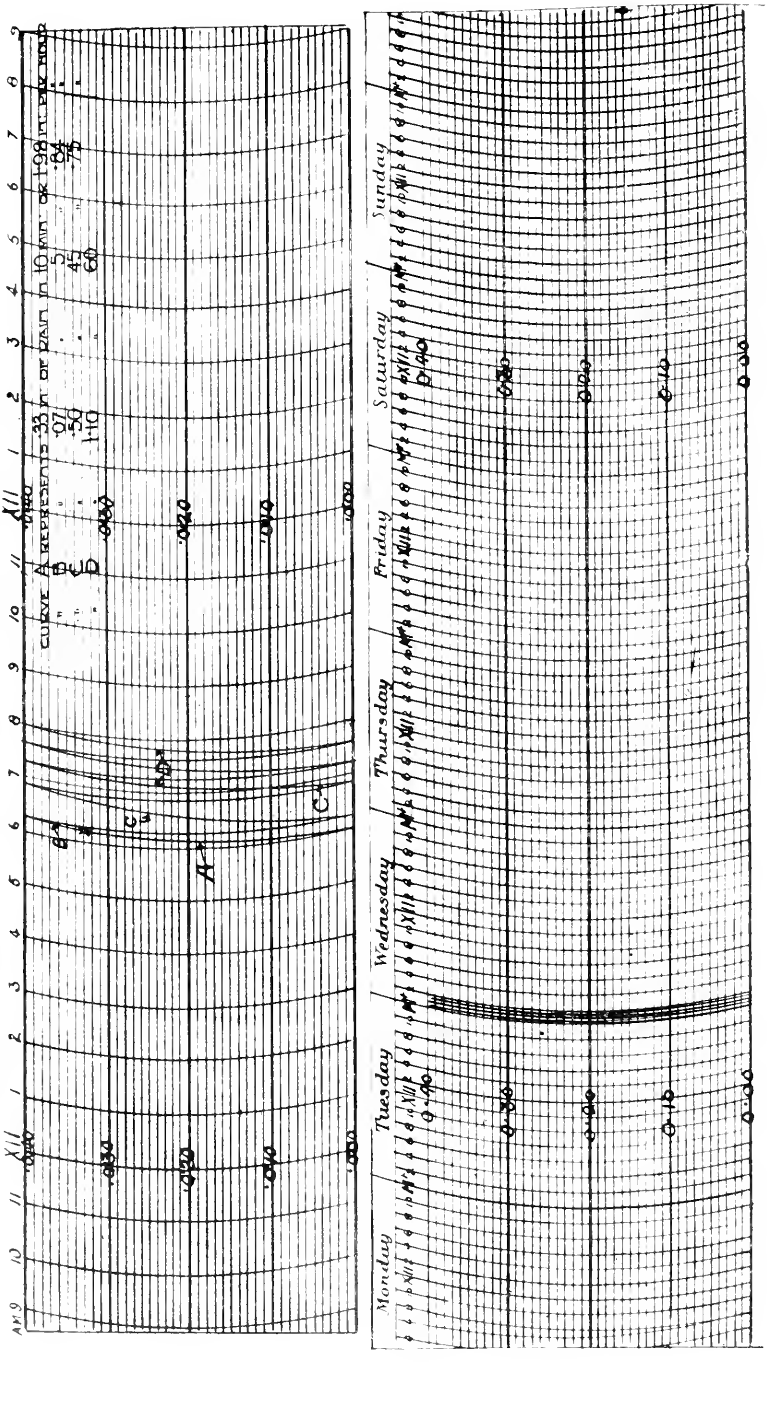


DIAGRAM COMPARING THE RECORD OF A RAINFALL ON A 24-HOUR CHART WITH A SIMILAR RAINFALL RECORDED ON A WEEKLY CHART AS MEASURED BY AN AUTOMATIC RAIN GAUGE.

relation of rainfall to time—*viz.*, intensity—the more valuable become such data.

In the Transvaal it is not uncommon to receive a precipitation of one-third of an inch in fifteen minutes, without further rain for the twenty-four hours; hence, by the ordinary rain-gauge measurement, which is read once a day, such a shower would be credited as a day's rain, and would suggest, without further explanation, a beneficial rainfall, but by the automatic gauge the chart would show the true character of the rainfall.

The soil obviously takes a much longer time to absorb rain than the latter takes to fall; consequently, one-third of an inch precipitated during twenty-four hours is much more beneficial to the country than one-third of an inch in fifteen minutes, which represents an intensity of 1.32 inch per hour. For these reasons the automatic rain gauge is much more valuable for a correct study of rainfall than the ordinary gauge, and when calibrated occasionally with some standard instrument, gives far more reliable data, because of the elimination of the personal equation

At present time, in the Transvaal Province, there are over 600 ordinary gauges of the "Indian" pattern in use. Of the automatic rain gauges there are some forty whose charts are divided into two-hour sections, and are changed every week. One automatic instrument (and one only, as far as can be ascertained) of the same type, whose chart is changed every twenty-four hours and whose sections read for single hours.; and there is also one Halliwell Automatic Rain Gauge. The former are manufactured by Richards, of France.

The Halliwell gauge is an extremely useful instrument, for the reason that its charts are large, and, consequently, the marking is easily read to single minutes. Its fine adjustment, too, ensures maximum accuracy in working; but it requires handling by trained men, and, as the chart has to be changed every twelve hours, renders the instrument only suitable for important meteorological stations.

The simplicity in construction and management of the 8-day and 24-hour auto gauge by Richards recommend them for more extensive use; both instruments are identical, except that the clock gearing is adjusted for one or the other period of charts. and the cost is practically the same.

The only advantage that can be urged for adopting the weekly geared instrument, in preference to the daily one, is the time saved in attendance; this, however, is a small matter, and is mainly a question of habit.

On the other hand, the weekly chart has an important disadvantage, and that is, if the pen has to travel more than once per hour up the chart—*viz.*, to record a rainfall greater than 0.40 inches per hour—then it is almost impossible to obtain even an approximate idea of the character of such rainfall from the chart, because the pen markings overlap and obliterate each other, whereas the markings on the twenty-four-hour chart can easily be read by means of a tracing cloth template to every five-minute period. And, since the object sought in all these observations, automatically determined, is that the data should approach as near as possible to the unit of measurement used in their practical application, the twenty-four-hour chart is therefore preferable to the weekly one, and doubtless many of the eight-day instruments in possession of the Government could be converted to the twenty-four-hour type by a simple adjustment of the clockwork.

By the kindness of the Town Engineer of Johannesburg—Mr. G. S. Burt-Andrews, M.I.C.E.—the writer has been permitted to discuss the performances of the two types of instruments belonging to his department.

Until recently the 24-hour Richards Auto-gauge was stationed at the Klipspruit Sewerage Farm, which is 7.4 miles south-west of the 8-day Auto-gauge at the Burghersdorp Pipe Yard, Johannesburg. The altitude of the former is 5413 M.S.L., and the latter is 5460, or a difference of 237 feet in vertical height, each instrument being 4 feet above the surrounding ground, and in open positions.

Unfortunately it is only possible to take the period of 1909-13 into consideration, and a large number of charts have been studied. The larger chart gauge being stationed at Klipspruit, the data therefrom is put forward with greater confidence than the weekly chart of the Burghersdorp instrument. In both cases, however, the results are only *indicative* not conclusive; not only the period is small, but the comparison is made on different charts. Notwithstanding, however, it is claimed that these indications are important and justify the larger use of the 24-hour Auto-gauge, and the more exact measurement of rainfall.

For the period under review, rain fell at Klipspruit for 594 hours in 231 days, giving a total precipitation of 75.19 inches during the period, of which 16.16 inches fell in 620 minutes, *viz*: 21.49% of the total rainfall fell in 1.75% of the total time. Further, it was found that for the season 1910-11, there were 18 falls of rain, which lasted from 0 to 1 hour, 24 from 1 to 2 hours, 11 from 2 to 3 hours, 6 from 3 to 4, 4 from 4 to 5, 6 from 5 to 6, 4 from 6 to 7, 3 from 7 to 8, 1 from 8 to 9, 3 from 9 to 10, 1 from 10 to 11, 1 from 13 to 14, and 1 from 15 to 16 hours of continuous rain; while for the season 1911-12, it was found that the number of showers in duration of 0 to 1 hour was 20, 1 to 2 hours 25, 2 to 3 hours 11, 3 to 4 hours 1, 5 to 6 hours 1, 5 to 7 hours 1, and 10 to 11 hours 1.

It was further noticed that rains of 2 hours and less in duration contained spurts or spasmodic turns of intense fall, where a few minutes of such rain dominated the rainfall for the period. By combining these rains as against the 83 days of rain for the season 1910-11, and the 68 days of rain for 1911-12, we get 57.6% of non-beneficial rainfall for the two seasons.

In this connection it is interesting to note that this determination is in close agreement with one made by Mr. H. E.

Wood, M.Sc., of the Union Observatory. In his paper on "The Intensity Distribution of Rainfall over the Witwatersrand," abstracted in the Natal Report (1907) of this Association, he says:—

> A further comparison table shows that only 20 per cent. of the Transvaal rainfall falls in what may be classified as light, directly beneficial showers, against, roughly, 50 per cent. of the English rainfall; whilst about 60 per cent. of the Transvaal rain falls in heavy showers against only 25 per cent. of the English rainfall. It is, therefore, inferred that the greater part of the Transvaal rainfall is not directly beneficial to the soil, and, unless conserved, is lost to the Colony.

The Burghersdorp weekly charts show that rain fell for 322 hours in 144 days during the same period, producing a total precipitation of 63.55 inches, of which 9.22 inches fell in 207 minutes, *viz.*, 14.5 of the total precipitation in 1% of the total time. A sample of both charts is annexed hereto, on each a two-hour continuous rainfall of similar intensity has been marked. On the 24-hour chart it is a simple matter to determine the character of the fall for every five minutes, but on the weekly chart it is very difficult to do more than tell the total precipitation for the period. Obviously, therefore, the 24-hour chart is of a greater practical value than the weekly one. Although both instruments above referred to have not been calibrated with any standard instrument, the figures stated herein may be accepted as sufficiently accurate for the purpose of this paper.

In advocating the more extensive use of the 24-hour auto-rain gauge, it should be noted that the ordinary gauge has to be read once every day, so that no extra work is entailed upon observers by substituting an auto for the ordinary gauge, and as already pointed out, the instrument is so simple in management that no difficulty should be experienced in its continuous working, while, on the other hand, charts give better information at headquarters than the ordinary cards.

Finally, a field of investigation lies in the direction of determination determining such problems as:—

(*a*) What intensity of rainfall may be rated as non-beneficial to the soil for a given catchment. (It is recognised that this question is governed by many factors; still, it is confidently expected that such an investigation would result in the establishment of some useful standard.)

(*b*) What intensity of rainfall may be regarded as phenomenal, the disastrous results of which are often referred to as an "Act of God."

(*c*) What intensity of rainfall should a designing engineer provide for in schemes to deal with flood water, and at the same time keep within reasonable economic bounds.

These and many other questions are continually presenting themselves whenever the problem of the control of stormwater is being dealt with, and, as Mr. F. E. Kanthack, M.I.C.E. pointed out in his address to the First South African Irrigation Congress, in 1909, that generalisation in rainfall is not much use for practical purposes; this is undoubtedly true, not only for the Irrigation Engineer, but in every department of engineering into which the question enters.

When it is considered that large sums of money have been spent in the past—and much of it on guess work—and that still larger sums have to be spent in the future for accommodating the rainfall in South Africa, the author, after years of personal contact with the problem, is of opinion that what is required is a more exact measurement of rainfall in every district in South Africa.

LIGHTNING CONDUCTORS AT ST. PAUL'S CATHEDRAL.—The recent installation of new lightning conductors at St. Paul's led to the discovery that a portion of one of the original iron bar conductors, which was erected under the superintendence of Benjamin Franklin himself about 140 years ago, was still in position and in a good state of preservation. When lightning conductors were originally employed, they were termed "Franklin rods," and a warm controversy arose at the time as to whether they should terminate in points or balls. King George III was a firm believer in ball terminals, and the advocacy of points by the President of the Royal Society brought about his resignation.

AMPHIBIAN POISON.—Prof. J. Arthur Thomson writes, in a recent number of *Knowledge*: "It is well known that the defenceless amphibians—toads, frogs, newts, salamanders, and the like—are protected by a poisonous secretion formed by skin glands. The phrynin of the toad has been often experimented with, and is a powerful poison. Madame Phisalix has recently found that injections of a modification of amphibian poison will immunise an animal, *e.g.*, rabbit or guinea-pig, against a strong dose of the same poison. This is what might have been expected from analogous cases. But the further point is of much interest—that animals immunised against amphibian poison are also immunised against the poison of the viper."

VOLCANIC DUST AND CLIMATIC CHANGE.—In a paper published in the *Bulletin of the Mount Weather Observatory*, VI [1] 1-34, Prof. W. J. Humphreys discusses the various factors in the production of climatic change, and particularly the profound changes resulting in the glaciation of the ice-ages. He considers that the presence of volcanic dust in the upper atmosphere, is an important factor, which decreases the intensity of solar radiation in the lower atmosphere, and therefore the temperature of the earth. An effect such as this he traces back as far as 1750. These changes of temperature, though small in absolute magnitude, are of great importance, seeing that a variation of only 1.26° F. has been known to delay the maturing of the Mauritius sugar cane crop by a whole year.

ON THE DEVELOPMENT OF THE PLANULA IN A CERTAIN SPECIES OF PLUMULARIA.

By Prof. Ernest Warren, D.Sc.

The present brief paper on the peculiar mode of development of the planula in a hydroid constitutes a summary of a more detailed account with plates, which will be published at a later date in the "Annals of the Natal Museum."

The species of hydroid is probably new, and was found in January, 1911, on an oyster shell in a rock-pool just north of the mouth of the St. John's River, Pondoland.

The hydroid has a creeping hydrorhiza, which sends upwards pinnate stems about ⅜ inch in height. The hydrocaulus in the region of the pinnæ consists of only hydrothecate internodes, which carry a median sub-calycine nematophore and a pair of supra-calycine nematophores. The pinnæ are peculiarly short, and carry, as a rule, only two hydrothecæ. The pinnæ arise alternately on the right and left; there is a basal non-thecate internode articulating with a slight protuberance of the hydrocaulus internode, then follows a somewhat short, non-thecate internode with a median nematophore, then a thecate internode with a median sub-calycine and paired supra-calycine nematophores, followed by a non-thecate joint, and terminally there is a second thecate internode. The pinnæ usually bear a short pinnule which arises on the distal edge seated on a slight prominence springing just above the first theca. The pinnule carries only one hydrotheca.

The gonothecæ, both male and female, are frequently borne on the same pinnate stem. The female gonothecæ spring from a spot just below the hydrotheca of the main stem, and on one side of the sub-calycine nematophore. Frequently three or four of such gonothecæ arise in succeeding internodes, the oldest and largest being the proximal one.

The male gonothecæ arise on the more proximal pinnæ just below the proximal theca.

Here, as in other hydroids, which bear the sexual organs of both sexes, it may be noticed that the female organs are carried on the main axis where the available nutritive supply would be greater, while the male organs are borne in places where the nutritive supplies are smaller.

This fact is suggestive that the determination of sex is at least partly dependent on the amount of available nutriment.

The male gonotheca is small, and consists of an elongated theca with a well-marked "covering plate" at the apex. Inside there is a blastostyle carrying a sperm-mass.

The female gonotheca when mature is broadly ovate. When young the covering plate (*Deckenplatte*) is very marked. Later the gonotheca becomes inflated and encloses a median narrow blastostyle bearing one egg at its extremity. There is a large rounded operculum at the distal surface. The female gonotheca is markedly flattened in a plane at right angles to the antero-posterior median vertical plane passing through the main-axis. It bears near its base a pair of lateral nematophores.

We have now to describe in greater detail the origin of the egg, the growth of the female gonotheca and egg, and the development of the embryo.

The amount of the material available was fairly considerable. The specimens were fixed carefully in warm, corrosive sublimate and acetic acid solution, and stained with Delafield Hæmotoxylin followed by Orange. Some six pinnate stems with female gonophores were sectioned in different planes, and owing to the fact that the gonophores in succeeding internodes of the main stem were in different conditions of growth, all stages of development would seem to be present.

Notwithstanding this fact, the youngest ovum that could be identified was already in the endoderm, and was situated just below the sub-calycine nematophore. Presumably, according to August Weismann, and from analogy with observations on other hydroids, the ova first arose in the ectoderm and then migrated into the endoderm, but they were not definitely located in the outer layer, although carefully searched for. The ovum is small, measuring about 14 μ in diameter, and is surrounded by ordinary endoderm cells. The presence of the ovum causes a slight swelling projecting into the lumen of the internode.

The ectoderm immediately above the area where the ovum is imbedded in the endoderm, early becomes slightly modified in that the cells are more columnar and somewhat taller than the ordinary ectoderm cells. The chitinous perisarc situated just above is become markedly thinner, apparently through being dissolved by the subjacent ectoderm.

In the next stage the plate of ectoderm grows out into an ovoid swelling, which is covered by a very delicate layer of perisarc continuous with the general perisarc. The endoderm follows the ectoderm, and the whole structure is the beginning of the female gonotheca. The portion of endoderm carrying the ovum passes into the gonotheca at the time of its formation, and becomes located on one side of it. The diameter of the egg has increased to 17 μ

By this time the mesoglea between the ectoderm and the area of endoderm in which the ovum occurs becomes thin and evanescent. At the same time the ovum gradually becomes separated from the endoderm, and the ectoderm around becomes modified and forms a kind of cap over it. This cap may be regarded as representing a rudimentary gonophore.

The distal portion of ectoderm of the young gonotheca consists of columnar cells with pear-shaped, coarsely granular cells wedged between. This is the beginning of the "covering plate." The endoderm with the cœlenteron expands distally and becomes somewhat T-shaped. The ovum has now entered the ectoderm, and the covering cap becomes divisible into an inner columnar layer in immediate contact with the ovum, and an outer layer of flat cells. The ectoderm at the sides of the gonotheca gradually contracts away from the chitinous layer. The diameter of the ovum is now about 20 μ.

The gonotheca continues to expand and the egg grows slightly (diameter about 23 μ); no obvious yolk is passed into it. The covering cap of ectoderm cells of two layers, which probably represents a rudimentary gonophore, also grows. A delicate mesoglea layer appears in this region, and the endoderm cells on which the ovum is seated are granular and stain more readily than the remainder of the endoderm.

The gonotheca expands further, and the distal plate of tall columnar cells and granular cells begins to secrete a thicker layer of perisarc; this is the beginning of the operculum. The blastostyle, except in the region of the operculum, is quite separated from the chitinous layer of the gonotheca and lies in the mid-axis. The cap of two layers of ectoderm around the ovum grows and becomes separated from the ovum, so that there is formed a distinct space above the egg.

The egg is probably fertilized at this stage, and presumably after such fertilization it secretes a kind of vitelline membrane, which is thicker on the outer side than on the inner side. The endoderm becomes slightly pushed out into a blunt process consisting of narrow granular cells, and the egg is seated on this out-pushing. The ovum reaches a diameter of about 34 μ.

The gonotheca now grows to its full size, and the cells of the covering plate and of the endoderm become attenuated and thin. The space between the egg and the ectoderm layers representing the gonophore increases in size. The vitelline membrane becomes thicker. The operculum consists of thicker perisarc than the rest of the gonotheca, and its edge is sharply marked off from the surrounding thinner portion below. The gonotheca has now assumed its definite form and size and further growth does not occur; its greatest width is about 0.48 *mm.* and length 0.89 *mm.*

At a somewhat later stage the outermost gonophore layer of the cells disappears, and the inner layer of cubical or columnar cells breaks up to form an irregular cluster around the ovum. The covering plate of ectoderm cells below the operculum and the endoderm layer become still more attenuated, and will shortly disappear. The outpushing of endoderm becomes rather more pronounced, and the cells remain granular and actively living. The egg does not grow, the protoplasm is finely granular, and there is a large nucleus with nucleolus. There is still a pronounced membrane around the egg: it is less obvious in the inner side against the granular cells of the endodermal outpushing. There is no obvious mesoglea separating the egg from the endoderm.

In the next stage considerable changes have taken place in that the whole of the "covering plate" of ectoderm and also the upper horizontal limbs of the T-shaped endoderm have entirely disappeared. The out-pushing of endoderm has grown upwards and has pushed the egg, together with the surrounding cells derived from the breaking up of the columnar ectoderm cells of the rudimentary gonophore, into a more or less central position in close contact with the operculum. The membrane around the ovum becomes less distinct.

Subsequently the ovum becomes quite central at the apex of the gonotheca, and is closely surrounded by the tissue derived from the rudimentary gonophore. The endoderm is now in the form of two symmetrically placed lateral lobes, one being formed from the endodermal out-pushing and the other is the end of the main axis of the endoderm of the blastostyle. The egg is seated symmetrically between the two lobes. The ovum segments and a rounded cluster of about 16 loosely attached blastomeres is formed. The endoderm immediately under the young embryo consists of taller and more granular cells than those of the rest of the endoderm of the blastostyle.

The number of blastomeres increases, and they become smaller. A segmentation cavity soon appears, and this is not central but occurs nearer to the apex of the gonotheca, so that below the embryo is two or three cells in thickness, while above, it is mostly only one cell thick.

The embryo is now being obviously supplied with nourishment by the cells in which it is embedded. The diameter of the embryo is $2\frac{1}{2}$ times that of the original ovum, which was never swollen with yolk. The embryo continues to expand, and the segmentation cavity increases in size. A differentiation in the cells of the embryo now becomes evident in the lower side, where an inner layer of flattened cells can be seen. This layer lines the segmentation cavity on the lower half only. It would appear to arise rather by differentiation than by delamination. The cells around the embryo constitute a kind of placental feeding tissue, and the tissue between the embryo and the endoderm appears to be the most active portion in the transfer of nourishment. Here some of the cells are rounded or stellate, and they were doubtless amœboid.

The embryo begins to sink further into the gonotheca, and becomes more widely separated from the apex. The embryo has assumed a pear-shaped outline, and the two lobes of endoderm grow upwards around it, followed by the ectoderm. The cells of this ectoderm are very elongated and extended to the walls of the gonotheca. The ectoderm between the embryo and the lobes of endoderm retains the same characters as before, and doubtless it carries nourishment from the endoderm to the embryo. The inner flat layer of cells of the embryo, which constitutes the beginning of the endoderm, is still confined to the lower half or two-thirds of the embryo.

The embryo continues to grow, and the cells of which it is composed increase greatly in number, but their size remains the same as before. The endoderm of the embryo is continued right round and becomes more than one cell thick. The ectoderm is also mostly two or three cells in thickness. The cells of the ectoderm and endoderm differ but little from each other in appearance, but the endoderm cells are perhaps a little flatter. There is, however, a fairly sharp line of division (an incipient mesoglea) between the two layers. Whether the endoderm arises as a definite splitting off of the ectoderm (delamination) or by a gradual differentiation of the innermost cells cannot be clearly seen, but the difference between the two methods of origin is probably so small that it may be regarded as an artificial distinction which cannot be fully distinguished in any individual case of development.

The outermost cells of the ectoderm of the embryo are not sharply marked off from the placental tissue. The cells of this tissue come into the most intimate connection with the embryo.

The embryo still further increases in size and pushes itself into a more central position in the gonotheca. The cœlenteron is very extensive, and the wall of the embryo is comparatively very thin. This wall is thinnest along the flattened sides of the gonotheca, and here it consists of a single layer of ectoderm and endoderm cells, and is closely squeezed against the perisarc.

Above, below and laterally, the wall is considerably thicker, and both the ectoderm and the endoderm are several cells in thickness. Thus in section parallel to the plane of flattening of the gonotheca the planula is quite thick walled.

The material has not permitted an examination of a later stage, but it is probable that the planula in the above condition is nearly ready to break out of the gonotheca, for the gonotheca that was immediately below, and therefore slightly older, was empty and the operculum gone, doubtless through the bursting out of the planula.

Here, then, we have an interesting case of the nourishing of the developing embryo. In the majority of Invertebrates the egg is charged with enough food or yolk-material to enable development to proceed sufficiently far until the young creature can feed and provide itself with food. In this hydroid the egg remains quite small and is never provided with yolk, but it segments, and development takes place in a kind of placental maternal tissue, which supplies the embryo with food during the whole development. This placental tissue arises as a modification of an outgrowth of the ectoderm of the blastostyle. This outgrowth, as we have seen, forms a kind of cap over the young ovum, and doubtless may be regarded as representing a rudimentary gonophore.

THE BEARING OF RECENT DISCOVERIES OF EARLY TERTIARY SHELLS, NEAR TRINIDAD ISLAND AND IN BRAZIL, ON HYPOTHETICAL LAND ROUTES BETWEEN SOUTH AMERICA AND AFRICA.

By Carlotta Joaquina Maury, Ph.D.

It was my good fortune lately to be sent as palæontologist of a geological expedition in charge of Mr. Arthur C. Veatch, and under the auspices of the General Asphalt Company of Philadelphia, to Trinidad Island and Eastern Venezuela. We obtained fossils ranging from Cretaceous to Quaternary; but the interest centred around those of early Eocene age. For true basal Eocene fossils had never before been found in that region or anywhere in the Antilles. Moreover, this Eocene fauna formed a perfect link between the basal Eocene of the southern United States and that of the Pernambuco beds of Brazil, the age of which had previously not been determined.

The Eocene fossils were discovered by Mr. Veatch and several of the other gentlemen of the expedition, on Soldado Rock, an islet 117 feet high, lying in the Gulf of Paria near the Serpent's Mouth, just west of the south-western extremity of Trinidad.

The lowest of the fossiliferous beds on this rock is an extremely hard greyish to reddish limestone. Lithologically it is exactly like the basal Eocene formations at Ripley, Mississippi; Fort Gaines, Georgia; and Clayton, Alabama. And this resemblance becomes most striking when fragments of the Soldado rock contain shells of the same species as those of the Gulf States. Indeed, it was most fortunate that, although a very large proportion of the Soldado forms were new, there were also such very characteristic North American lower Eocene species as *Venericardia planicosta*, *Levifusus pagoda*, *Latirus tortilis*, *Calyptraphorus velatus* var. *compressus*, and *Turritella mortoni*. Very happily, mingled with these were characteristic Pernambuco forms as *Callista megrathiana*, *Chione paraensis* and *Cucullæa harttii*, all of which had never before been found outside of the State of Pernambuco.

Thus I was able to correlate both the Soldado beds and those of Pernambuco as basal Eocene equivalent to the Midway stage of Alabama*.

The uppermost fossiliferous bed on Soldado contained fossils that were mostly new, but *Ostrea thirsæ*, *Fusoficula juvenis*, and *Modiola alabamensis*, and even the aspect of the new species indicated a Lignitic Eocene age corresponding to the Nanafalayan stage of Alabama.

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* For complete descriptions, see Maury: "Palaeontology of Trinidad." *Jour. Acad. Nat Sci.*, Philadelphia, 2nd series, Vol. XV, pp. 25-112, 1913.

Great stress has been laid by many writers on the resemblances of South American fossils to those of contemporaneous times of the Old World. Relationships have been established between the South American faunas and those of France, Spain, Malta, Morocco, Egypt, South Africa, and India; but until Dr. Derby's work on the Palæozoics of Brazil little was said of the faunal relationships of the two Americas. It fact, it was thought that hardly any mingling had occurred between the species of these adjacent continents.

But this discovery of lower Eocene forms on Soldado Rock awakened my belief in the very close kinship of the North and South American Tertiary life. This view was strengthened by the previous discoveries of Dr. Heilprin and Dr. Dall that the Antillean Oligocene has a close relationship with that of Florida

Nor are these kinships limited to the Tertiary. They existed in the Palæozoic and now exist in the present, as a glance at the accompanying table will show:—

RELATED FAUNAS OF THE AMERICAS.

Geologic Age	*South America*	*North America.*
RECENT AND QUATERNARY.	Molluscan and coral faunas northward from the La Plata.	Molluscan and coral faunas southward from Cape Hatteras.
OLIGOCENE.	Upper Oligocene faunas of Cumana (Venezuela), Trinidad and Jamaica.	Upper Oligocene of Florida (Tampa silex bed and Chipola marls).
	Lower Oligocene faunas of San Fernando and Manzanilla Trinidad.	Lower Oligocene of Vicksburg, Mississippi.
EOCENE.	Lignitic fauna of Soldado Rock.	Lignitic fauna of the Gulf States.
	Midway fauna of Soldado and Pernambuco.	Midway fauna of the Gulf States.
CRETACEOUS.	Cretaceous faunas of Venezuela and Colombia.	Cretaceous of the South-Western United States and Mexico.
CARBONIFEROUS.	Faunas of the Amazonian Valley in Brazil, Bolivia, and Peru.	Coal Measures of the Western United States (More than half the species being identical).
DEVONIAN.	Erere fauna of Brazil.	Onondaga fauna of the United States.
	Maecuru fauna of Brazil.	Oriskany of Alabama.
	Brazilian and Venezuelan Silurian faunas (Upper formation).	Niagaran of the United States.
	Brazilian Silurian faunas (Lower formation).	Clinton and Richmond faunas of the United States.

It appears as if,—just as the present molluscan and coral faunas of the Gulf coast of the United States came originally from the coast of Brazil, as Dr. Dall and Dr. Verrill have shown—so the Tertiary marine invertebrate faunas of the Gulf States probably originated in the Brazilian and Antillean waters.

On the other hand, various recent researches have shown as regards the supposed affinities of the Antillean and South American Cretaceous, Eocene, and Oligocene invertebrate faunas to those of South-Western Europe and Northern Africa and India, that although there are very few species in common, and others bearing resemblances, yet the evolution of the faunas on the two sides of the Atlantic was distinct. The species common to both coasts were in some cases pelagic, as the South American Cretaceous Ammonite, *Pulchellia*, which occurs in Colombia and neighbouring countries, and in the Alps, Roumania, and Asia. In other cases as *Venericardia planicosta*, we can easily suppose the molluscs to have crossed *via* the Greenland-Spitzbergen route, especially when we recall the sub-tropical climate prevailing in those high latitudes during the early Tertiaries. Or these species may have been of northern origin and migrated down the east and west coasts of the Atlantic. Some of the resemblances have been found to be parallelisms of development, merely responses to similar environments, and not specific identities. Moreover, in a number of cases species identified years ago with those of the eastern hemisphere have turned out later when more material was obtained, not to be precisely the same. For example, in 1887 Dr. C. A. White, in his fine monograph on Brazilian fossils* identified a *Turritella* from the Rio Maria Farinha beds, Pernambuco, as *Turritella elicita* described by Stoliczka from the Cretaceous of Southern India†. Since then Professor G. D. Harris has monographed the Alabama Midway‡, and now it is clear that the true identity of the Brazilian *Turritella* is not with the Indian species, but with Conrad's *Turritella humerosa*, characteristic of the North American Lower Eocene.

There is, however, a *Turritella* in the lowest fossiliferous bed on Soldado, which is extremely close to Stoliczka's shell, differing mainly in its less slender form, and I have named it *elicitatoides*. But Dr. Dall once pointed out to me an interesting fact shown by the rich and exquisitely preserved Florida Oligocene shells, namely, that in successive horizons there often come repetitions of certain types of sculpture. Now this must indicate a ready response to similar external conditions, a repetition of physical conditions causing a repetition of sculpture. And it would seem likely that the resemblance between the Soldado and Indian shells should be explained in this way.

Those who advocate the relationships between the South

* "Arch. do Museu Nac. do Rio de Janeiro" (1887), pp. 162-163, pl. XVIII, figs 6, 7.

† "Pal. Indica, Geol. Surv. India," Vol. II, p. 221, pl. XIV, fig. 3, 1868.

‡ "Bull. American Palaeontology," Vol. I.

American and Antillean Tertiary faunas with those of Northern Africa, and South-Western Europe, and Asia usually postulate either a mid-Atlantic route passing north-east and east from Trinidad to North Africa and South Europe, or a South Atlantic route *via* northward extensions of Antarctica.

The mid-Atlantic route is thought to have been first a continent (virtually Atlantis) becoming later, through subsidence, a chain of islands which, according to some authors (as Dr. Guppy, of Trinidad) existed into middle or even late Tertiary times.

The crystalline highlands of Brazil and Guiana are looked upon as ruins of the western extremity of this continent, while the eastern remnants are Madeira and the Canary Islands.

Some writers of brilliant imagination, but not geologists, as Donnelly and Jules Verne, have endeavoured to prove from Greek and Egyptian traditions of a vanished continent to the westward of Northern Africa, that Atlantis existed during the Human period and was the scene of a splendid ancient civilization. But, as I need not say, its existence since man has been upon the earth is to be looked upon only as a charming fairy tale. Moreover, its existence at any period is not supported by evidence given by the floor of the Atlantic for some of the profound deeps now lie in its pathway.

Yet it is not impossible that there was a limited land mass not transoceanic, lying to the north and east of northern South America, which supplied rock *débris* for building up the Palæozoics of Brazil and oldest rocks of Trinidad, for they appear according to Katzer and others to have been formed of material derived from the eastward. We can more readily believe this, because the presence of deep sea genera of Foraminifera in Antillean formations indicates that this area has been subjected to very unusual changes of level.

The South Atlantic route *via* extensions of Antarctica appears somewhat more probable because of the configuration of the ocean floor in that region. It was first advocated by Sir Joseph Hooker, in 1847, to explain the distribution of flowering. plants. Evidence in its favour was later set forth by Beddard, Moore, Spencer Ameghino, Hatcher and Ortmann, and, in 1900, Dr. Osborn reconstructed Antarctica by elevation to the three thousand and forty meter sounding line. This connected the Antarctic continent with South America, Australia and New Zealand, but not with Africa.

This evidence furnished by the oceanic floor against an Antarctic connection of South America and Africa was strengthened in the following year by the results of Ortmann's study of the fossil shells and mammals of Patagonia. He found their resemblance to certain forms of New Zealand and Australia to be so close as to be regarded by him as an indication of a former connection of South America with Australia, *but not with Africa.*

Finally, in 1910,* Dr. Osborn abandoned as a matter of imperfect record the theory of an Antarctic land connection even between South America and Australia.

He now believes that the greater part of the animals and plants of the Southern Continent are of northern origin, and that the evidence advanced for Antarctic connections is probably explainable through distribution from the north.

Of the South American mammals, Dr. Osborn remarks,† "There is no satisfactory evidence of connection at any time with the mammalian life of Africa except in the very late Pliocene times, through migration by way of North America."

It was a delight to find that these conclusions of Dr. Osborn, reached from a study of the vertebrates, should so harmonize with my own, based on the invertebrates.

In conclusion, we may say that our present knowledge indicates: (1) that the early Tertiary molluscan and mammalian faunas of South America were closely akin to those of North America: and (2) that the evidence furnished by both the molluscs and land vertebrates of South America is against the existence of Tertiary or Cretaceous land bridges to Africa.

TRANSACTIONS OF SOCIETIES.

Royal Society of South Africa.—Wednesday, October 15th: Dr. L. Péringuey, F.E.S., F.Z.S., President, in the chair.—"A new mimicry plant (*Mesembrianthemum lapideforme*)": Prof. R. **Marloth.** In summer the plant consists only of two fleshy bodies (the leaves), which are half buried in the sand. Each leaf is shaped like a tetrahedron, with blunt edges and angles, and brownish-red in colour ilke the angular fragments of stone among which the plant grows. It is consequently most difficult to detect even in localities where its occurrence is known. In spring the plant produces two flowers, one at each side, which are joined to the parent plant by a very thin connection. The ripe seed vessel is consequently easily detached at this spot and can be carried away by the wind—a mode of dispersal unique among the nearly 400 species of the genus *Mesembrianthemum.* "On an experimental modification of Van der Waal's equation": J. P. **Dalton.** The *a* of Van der Waals's equation is considered to be a function of the temperature only, and the *b* to be independent of the temperature. The function is then determined for a typical normal substance (isopentane) from the experimental isothermals. The modified vapour pressure curve is found to represent experimental results for both normal and abnormal substances much more closely than the original. The new values agree well with the Van der Waals vapour pressure formula, and the modified equation is used with quite satisfactory results for the calculation of latent heats and also for obtaining the curve of inversion of the specific heat of saturated vapours.—"Barometric variability at Kimberley and elsewhere": Dr. J. R. **Sutton** An attempt to determine working constants which shall represent the "cyclonic activity" at various places in South Africa and such other places outside as have available information regarding the barometer. Tables are given showing the monthly mean constants, with maximum and minimum values, or barometric variability. One deduction is that the "equinoctial gales," so far as barometric changes can represent them, have no existence in fact.

* "The Age of Mammals," p. 80.

† *Op. Cit.* p. 78.

Geological Society of South Africa.—Monday, June 30th: Mr. H. S. Harger, Vice-President, in the chair.—"The Bushman's River cretaceous rocks": Prof. E. H. L. **Schwarz.** The author recently examined the Wood Beds (Lower Cretaceous) of the Bushman's River, where *Anthodon serrarius* was discovered by Atherstone over fifty years ago. The result of the examination was the discovery of a large bone, estimated to have been quite five feet long, which would give about twelve feet for the length of the hind leg. At the base of the Wood Beds are brown sandy beds, and above red marls, both containing great logs of petrified wood, probably *Araucarias*, up to 18 in. diameter. Near Woodbury is the alum cave whence the mineral bushmanite is obtained, the cave having been formed by the weathering of the unconformity between the Witteberg quartzites and the Enon conglomerate. As a natural occurrence the chemical combination of this mineral, a magnesia-manganese alum, is unique in the world.—"The geology of Katanga and Northern Rhodesia—an outline of the geology of South Central Africa": F. E. **Studt.** The author described (1) the sequence and general characteristics of the rock systems of Katanga and Northern Rhodesia, and gave an outline of the tectonic geology of that portion of the African continent, covering an area twice that of the British Isles; (2) He showed that the rock systems recognised in South Africa cover the greater part of Equatorial and South Central Africa, having similar lithological characters and geological sequence; (3) He indicated the general distribution and relative age of the large areas of subsidence which occur in Equatorial and South Central Africa; and (4) he summarised generally the conclusions arrived at. Structurally he divided Equatorial and Southern Africa into the following regions: (*a*) the *Congo-Angola-Kalahari Region*, distinguished by the presence, in almost undisturbed condition, of the Transvaal system and the Waterberg System, and almost completely surrounded by rocks of the Swazi system; (*b*) the *Katanga-Rhodesia-Transvaal Region*, characterised by the presence of the Transvaal and Waterberg formations, very much disturbed by granitic intrusion; (*c*) the *Cape Region* a country of folded and mountainous nature, covered by the apparent equivalents of the Transvaal and Waterberg Systems; (*d*) the *Karroo Region*, the large and high plateau whose southern part was continously immersed in the Karroo Sea; (*e*) the *East African Region*—that part of the Continent east of Lake Graben, from which the Transvaal and Waterberg formations are almost entirely absent. The region is almost wholly granitic, schistose and volcanic, and is characterised by an extension of the subsidences, accompanied by powerful volcanic activity, from the Katanga-Rhodesia Region; (*f*) the *Coastal Belts*, narrow zones in which Cretaceous and Tertiary post-Karroo deposits have been laid down. Incidentally, the author pointed out the resemblance of the subsided areas, which extend apparently over 2,000 miles, from the Zambesi-Luangwa graben into Abyssinia, to the Martian canals, and suggested that, if those canals really exist, these long subsidences afford an explanation of them.

Monday, September 8th: A. L. Hall, B.A., F.G.S., President, in the chair.—"The cassiterite lodes of Leeuwpoort; the paragenesis of the lode-forming minerals": D. P. **McDonald.** Cassiterite is very widely distributed throughout the area, but development has been concentrated on five occurrences, and these were fully dealt with by the author, and the minerals occurring in the lodes described. The ore bodies result almost entirely from the replacement of the quartzites by those minerals: these replacements were each shortly discussed. Conclusions as to the order of succession of the lode-forming minerals were stated, and the processes by which the tin ore was mineralised from the granite of the Bushveld Complex indicated.—"Notes on the tin deposits of Embabaan and Forbes Reef in Swaziland": A. L. **Hall.** The localities mentioned constitute the two main tin-bearing districts of northern Swaziland. Practically the whole of the tin recovered from the Embabaan workings occurs in the form of loose crystals of cassiterite, no definite lodes *in situ* being visible. The source of this cassiterite is undoubtedly the pegmatites belonging to the older granite formation. At Forbes Reef, 14 miles north of Embabaan, there are two modes of occurrence: these may be referred to as in granite and in schist. The Forbes Reef deposits consist entirely of reef tin, and they are probably genetically connected with the intrusion of the granite into the schists. This mode of occurrence is unusual, and suggests the economic possibilities of beds of schists in close proximity to intrusive granite.—"The terraces of Eerste River at Stellenbosch": Prof. S. J. **Shand.** Along a certain part of its course the river is bounded by flat alluvial terraces, horizontal in a direction at right angles to the river course, but inclining constantly downstream. The author examined into the conditions under which a silt-charged river may deposit part of its load, and found it chiefly in the confluence, within a small area, of a number of torrential streams. When once the alluvium had been deposited, the river commenced to remove some of the deposit and to establish a new level at a horizon 27 feet lower. Still later, part of this second terrace was carried away, and a third level, six feet lower, established. The present flood level is 12 feet below this. The inference is the elevation of the surrounding area within recent times by not more than 50 feet, involving the previous submergence of the isthmus connecting the Cape Peninsula with the mainland and the separation of the Peninsula itself into a pair of islands by means of a strait connecting Chapman's Bay with Fish Hoek.

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HEALTH CONDITIONS ON THE ISTHMUS OF PANAMA.

By Samuel Evans.

Count Ferdinand de Lesseps failed in his efforts to construct a canal across the Isthmus of Panama chiefly because of the high mortality among the workers, and that notwithstanding a lavish expenditure on hospitals and on medical attention. The Americans acquired the right to make the Panama Canal by a Treaty which was ratified on February 26th, 1904, but it was not until near the end of 1905 that the authorities in Washington fully realised that the completion of the undertaking would depend on the successful solution of the health problem. The sanitation work on the Canal Zone was placed under the direction of a member of the United States Army Medical Corps, Colonel Gorgas, who had already distinguished himself as Chief Sanitary Officer of Havana.

In the 1903 edition of the *West India Pilot,* the Panama Canal District is described as "one of the hottest, wettest, and most feverish regions in existence." Sir William Osler in "Man's Redemption of Man," states that "For centuries the Isthmus had been the white man's grave." In an address delivered before the Los Angeles Chamber of Commerce in June, 1911, Colonel Gorgas said:—

> The present railroad across the Isthmus was under construction from 1850 to 1855. During this period the mortality was so great that several times construction had to stop because the labouring force had died or were sick. No statistics were retained concerning this period, so we can judge of conditions only from individual instances. At one time the construction company imported one thousand negroes from the West Coast of Africa, and within six months these had all died off. At another time, for the same reasons, they brought over one thousand Chinamen and within six months these had all died off.

Under the first French Panama Canal Company the work was at its maximum from 1881 to 1889. In January, 1886, the company had in its employ on the Isthmus 14,605 negroes and 670 Europeans, making a total of 15,275 men. Colonel Gorgas, in the address from which I have just quoted, states:

> From the best information which I can get, and which I consider accurate, I believe the French lost 22,189 labourers by death from 1881 to 1889. This would give a rate of something over 240 per thousand per year. I think it due to the French to say that we could not have done a bit better than they, if we had known no more of the cause of these Tropical diseases than they did. . . . . We ourselves, with an average force of 33,000 men, in nearly the same length of time, have lost less than 4,000.

Colonel Gorgas gives a number of instances to illustrate the deadly character of the Isthmus of Panama at that time, so far as Europeans were concerned:

The first French Director, M. Dingler, came to the Isthmus with his wife and three children. At the end of the first six months all had died of yellow fever except himself. One of the French engineers, who was still on the Isthmus when we first arrived, stated that he came over with a party of seventeen young Frenchmen. In a month they had all died of yellow fever except himself. The Superintendent of the railroad brought to the Isthmus his three sisters; within a month they had all died of yellow fever. The Mother Superior of the Sisters nursing in Ancon Hospital told me that she had come out with twenty-four Sisters. Within a few years twenty-one had died.

M. Bunau Varilla, writing of the busiest period when the Canal was under French control, states:

Out of each 100 individuals who arrived on the Isthmus it is not an exaggeration to say that on an average not more than 20 were able to keep at their posts in the construction camp.

Referring to the fact that under the French practically all the manual labour was done by negroes, M. Bunau Varilla writes:

Death within three months was almost certain for white labourers on the Canal works.

Now let us see what has taken place on the Isthmus under the Americans. Colonel Gorgas went to the Panama in June, 1904. Owing, however, to red tape and official delays, he was not able to accomplish much during the first year. Mr. W. F. Johnson in "Four Centuries of the Panama Canal," writes:

It took many weeks to get mosquito netting for the windows of the Canal office buildings, and then not enough was supplied, and in the meantime some of the most valuable men of the staff were prostrated by the bites of malarial mosquitoes. The Chief Sanitary Officer wanted netting for all the official buildings in the Canal Zone. This request was refused as extravagant and unnecessary. Then he asked for at least enough to enclose the verandahs of the hospitals. This, too, was refused, and he was told that there was no need of enclosing more than half the verandahs, and that even then a part of the space should be solidly boarded up instead of screened.

However, the Chief Sanitary Officer persisted; he gradually overcame all opposition. By the end of 1905 yellow fever had been entirely suppressed, and since the end of 1907 the Isthmian Canal Sanitation Department has shown results which are probably unparalleled in the history of human achievement.

I do not think I can better convey an impression of the improvement in the health conditions effected under the American Administration than by means of the following table, which gives the disease death-rate per thousand per annum among the Canal employés from the beginning of 1906 until the end of last year:—

Year.	Europeans.	Negroes.	Total.
1906	12.35	45.52	38.98
1907	10.92	29.61	24.53
1908	7.27	9.24	8.68
1909	6.43	7.91	7.55
1910	4.92	8.39	7.50
1911	5.88	8.21	7.65
1912	4.62	6.9	6.37

The average number of workers was:—

Year.		Europeans.		Negroes.		Total.
1906	...	5,264	...	21,441	...	26,705
1912	...	12,553	...	38,340	...	50,893

I have taken 1906 as a starting point because that is the first year for which I have been able to obtain detailed statistics.

I may mention that the last case of yellow fever originating on the Canal Zone was in November, 1905.

In 1912 there were living on the Canal Zone, which is in the Tropics, 4,502 white women and children from the United States, and the mortality from disease amongst them was at the rate of 5.55 per thousand per annum, a record which compares favourably with the mortality rates of women and children in many European health resorts.

Colonel Gorgas attributes the phenomenal success of the Isthmian Canal Sanitation Department to

> The great discoveries in Tropical medicine made during the time between the coming of the French to the Isthmus and the coming of ourselves.

Colonel Gorgas's policy appears to be based mainly on the following discoveries:—

1. In 1898 Sir Ronald Ross proved that malaria is caused by a parasite which is transmitted through the agency of a mosquito belonging to the genus *anopheles* or other closely related genera.
2. In 1900 and 1901 a Board composed of four surgeons of the United States Army Medical Corps conducted a series of experiments in Cuba, which proved conclusively that the virus of yellow fever is conveyed from one person to another by the mosquito *stegomyia calopus* and in no other way, excepting by experimental injections.
3. In 1898 Dr. Simmonds claimed to have proved that plague was spread by fleas from plague infected rats. This claim was not finally accepted by medical men until 1905. In 1902 and 1903 Dr. D. J. Verjbitski, by a series of experiments, showed that plague could be communicated to healthy men and animals by bugs as well as by fleas.
4. In 1900 the United States Government published an abstract of a report by the Commission which investigated the origin and spread of typhoid fever in the United States Military Camps during the Spanish War. One of the conclusions of the Commission was that "flies undoubtedly serve as carriers of infection." Previous to the publication of the Commission's Report, Dr. L. O. Howard, Chief Entomologist of the United States Department of Agriculture, had warned the American public that the common house fly was in all probability a disseminator of typhoid fever.

Lieutenant-Colonel Macpherson, of the Royal Army Medical Corps, who visited the Panama in March, 1908, stated in a paper read before the United Services Medical Society, July 1st, 1908, that there had been a considerable incidence of enteric fever in the labour camps on the Canal Zone, and that

Much practical attention is being paid to the prevention of its spread by flies and other insects. The association between flies and disease became very prominent in connection with the American camps in Florida in 1898. Since then the United States medical authorities have made considerable progress in measures for getting rid of flies in connection with habitations and camps, special attention being paid to preventing them having access to latrines and food. On the Canal Zone all latrines, no matter of what form, are made fly-proof.

Most of the measures adopted by Colonel Gorgas were specifically designed with a view to suppressing yellow fever, malaria, plague, and other insect-borne diseases by—

(*a*) Killing insects and vermin.

(*b*) Eliminating or destroying their breeding places.

(*c*) Making it as difficult as possible for them to get at infected matter and at human beings.

Such in broad outline are the distinctive features of Colonel Gorgas's system of sanitation.

The Hon. Joseph Baynes, of Natal, has initiated and is the champion in South Africa of a somewhat similar policy as regards animal diseases. Dipping does for animals what Colonel Gorgas's system does for human beings—it prevents the spread of disease by insects. In both cases, professional men have been slow to accept the results and to act upon them. In 1910, at my suggestion, a circular was sent to each of the managers of the Rand Mines-Eckstein Group of companies, instructing them to take steps to deal with flies in the compounds, but I believe very little has been done, owing, no doubt, to the fact that many of the mine doctors are not convinced that flies are a serious danger to health.

So far as I know, Khartoum is the only place besides the Panama where the health authorities have concentrated attention on preventing insects from spreading disease. Dr. Balfour, Director of the Wellcome Research Laboratories, and also Medical Officer of Health of Khartoum, has distributed among the inhabitants a "Handbook on Sanitation," which is intended to make the public "conversant with the main lines of sanitary policy which are followed in the city." Nearly the whole of the Handbook is devoted to the reduction and elimination of insects and vermin—mosquitoes, flies, sand flies, bed bugs, rats, etc. The consequence is that Khartoum, like the Canal Zone, is not only almost mosquito-less, but also nearly fly-less, and the results are equally gratifying, the death rate for the two years ended 30th September last being under ten per thousand per annum.

The saving of human and animal life which has followed the adoption of Colonel Gorgas's system in the Panama and of dipping in South Africa points to the conclusion that we have hitherto greatly under-estimated the extent and character of the mischief done by insects.

It is now recognised that dipping helps to keep in good health not only cattle and sheep, but also horses, mules, donkeys and dogs.

The improvement of the health conditions on the Panama Canal is not confined to any particular race or to any particular disease. As a matter of fact it is most marked in two wholly unexpected directions:—

(1) With negroes who are supposed to be largely immune from Tropical diseases, and

(2) In the case of pneumonia, which is not ordinarily considered as being a Tropical disease or insect borne.

It would probably surprise most people to hear that in the days of the French Canal companies, and also in the first years under the Americans:—

(*a*) The death rate among the negro workers was much heavier than among the European employés, and that

(*b*) The principal cause of the high mortality of the negroes was pneumonia, as is the case with the Kaffirs on the mines of the Transvaal and of Southern Rhodesia.

By the end of 1907 Colonel Gorgas had brought his measures for preventing the spread of disease by insects to a high state of perfection. In nearly every one of the monthly bulletins for that year is reported the completion of some important item in the plan of campaign against insects and vermin. Before the commencement of 1908 the houses of practically all the Americans working on the Canal had been screened and made vermin proof and provided with water closets in place of the pail system. An examination of the table giving the mortality rates from the beginning of 1906 to the end of last year shows that the reduction in the death rates of the employés coincide in a remarkable manner with the maturing of the plans of the Isthmian Canal Sanitation Department. Further, that table points to the conclusion that the improvement effected is permanent in character. An idea of the extent and bearing of this improvement can be gathered from the following comparisons of the disease death rates of 1906 with those of 1912:—

Mortality from Diseases per thousand per annum among the employés of the Isthmian Canal Commission and the Panama Railroad Company.

A.—EUROPEANS.

	1906.	1912.	Reduction in 1912.
Pneumonia	3.61	.24	3.37
Malaria	2.85	.48	2.37
Typhoid and other intestinal diseases	2.09	.08	2.01
Meningitis	.38	.08	.30
Other Diseases	3.42	3.74	+.32
Total	12.35	4.62	7.73

B.—NEGROES.

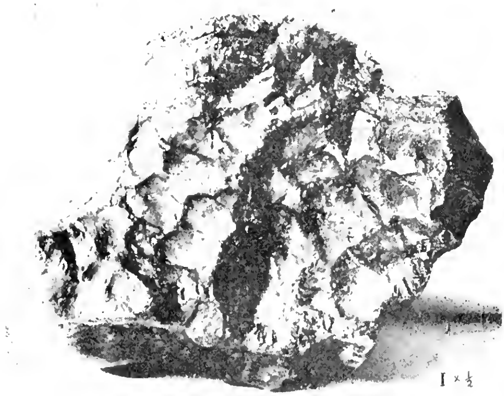
	1906.	1912.	Reduction in 1912.
Pneumonia	18.46	1.41	17.05
Malaria	9.74	.21	9.53
Typhoid and other intestinal diseases	4.66	.29	4.37
Meningitis	1.16	.26	.90
Other Diseases	11.50	4.77	6.73
Total	45.52	6.94	38.58

C.—TOTAL FORCE.

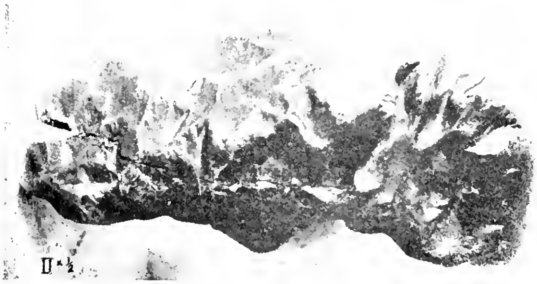
	1906.	1912.	Reduction in 1912.
Pneumonia	15.54	1.12	14.42
Malaria	8.39	.27	8.12
Typhoid and other intestinal diseases	4.16	.24	3.92
Meningitis	1.01	.20	.81
Other Diseases	9.88	4.54	5.34
Total	38.98	6.37	32.61

Had the mortality rates of 1906 among the employés of the Isthmian Canal Commission and the Panama Railroad Company prevailed last year, about 1600 additional deaths would have taken place; and there would, no doubt, have been a large number of additional deaths among the families of the employés and the other residents on the Canal Zone. I consider that we are justified in concluding that most of these lives were saved in precisely the same way as animal life is saved in South Africa—by preventing insects from spreading disease.

ETIOLOGY OF CANCER.—At the International Medical Congress held a few months ago, Dr. Freund, of Vienna, announced the discovery that there usually exists in normal blood a fatty acid possessing the power of destroying cancer cells. In cases of cancer the blood was found to lack this fatty acid, but, on the other hand, contained a substance which had the property of destroying the acid which would normally destroy the cancer-cells. Dr. Freund believes that when cancer tumours develop in the body the normally present fatty acid must have previously disappeared from or diminished in the blood.



I × ½



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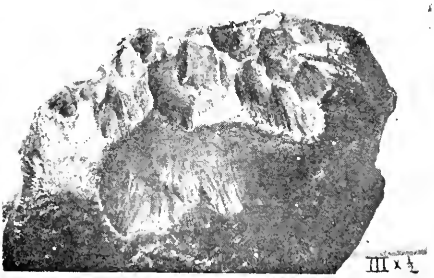


III × ½

Prof. G. H. Stanley.—The N'kandhla Meteorite.

ON A METEORITE FROM N'KANDHLA DISTRICT, ZULULAND.

By Prof. George Hardy Stanley, A.R.S.M., F.I.C.

(Plates 4-7.)

This meteorite was observed to fall on the 1st of August, 1912, and is therefore of quite exceptional interest, as, of the large number of this variety which have been found, less than a dozen have been actually seen to fall, and, of course, others have been seen without having been subsequently found.

The phenomena accompanying the fall call for no special comment, as there appears to be no material difference between the observations reported in the present instance and those recorded in connection with other falls.

Briefly, the first occurrence noted was the usual sound of an explosion, which naturally attracted attention over a considerable area, and on looking up into the sky, a rapidly moving body was seen, which left a spiral trail of smoke and at the same time appeared to produce a rumbling or crackling sound.

It is not clear that only one was afterwards found, though I have only been able to definitely locate one; there may have been two or three, but the one which forms the subject of this communication fell near the junction of the Buffalo and Tugela rivers, on the Pokinyoni hill, in the N'kandhla district, within a few yards of a native woman.

The accounts are somewhat in conflict as to the direction in which the meteorite travelled, but it was probably towards the South-East.

The time of its appearance is variously given as from 10 a.m. to 1.30 p.m., but the latter appears to be the correct statement, affidavits and other statements in connection with the fall are appended.

It is of interest to note that two other meteorites were seen at not very distant dates; one on June 2nd was observed at places as far apart as Grahamstown, Malmesbury, Port Nolloth, Potchefstroom, Standerton, and many intermediate places; another on August 6th at Umtata, Tembuland, but in neither case was the actual fall, if any, observed.

This meteorite weighs nearly 38 pounds, and consists almost entirely of nickel-iron alloy; it is therefore classed as a siderite.

It is coated with a skin of magnetic oxide exhibiting flow lines, and shows also a profusion of "thumb marks."

The external appearance is shown by the accompanying photographs 1, 2 and 3 (Plate 4), which are about one-fourth actual size linear. It shows several cracks (the largest being very apparent in No. 2), the edges of which are mostly quite sharp and the metal inside quite bright, both of which circumstances indicate that the metal was cold when the cracking occurred, *i.e.*, most probably at the moment of impact with the boulder which it struck on falling.

In at least one place, however, the edges of a crack show signs of fusion, being in fact rounded, and oxide penetrates into the crack; possibly this side was foremost (*brust-seite*), and therefore hot immediately before impact, the other sides being cold, or possibly this was a previously formed crack.

It is inconceivable that a body of such irregular form would be always oriented in the same direction during its passage through the air, and indeed the lines of flow indicate that different sides have been foremost at different times.

Not only oxide, but metal, has been caused to flow and form well marked "lips" in several places, generally at the rear edges of grooves or "thumb marks" as seen in photo 3. A cross section through one of these lips is also shown very well in the photo of the etched slice No. 6 (Plate 5), and may also be shown diagrammatically as below.

Apparently it struck a somewhat glancing blow and shows deformation due to impact, *i.e.*, indentations and striæ at several places. At the chief point of impact the metal became (or was already) sufficiently heated to reoxidise, and shows a blue oxide film where a small piece has cracked off. Yet as a whole it was not sufficiently hot to scorch the dried grass on to which it rebounded after the impact.

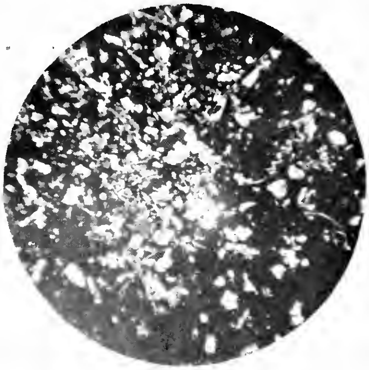
While not excessively hard, the metal of which it is composed is extremely tough, so that it was found to be impossible to obtain samples for chemical analysis by drilling. Shavings were therefore removed from a corner by a shaping machine for this purpose; this had the advantage of leaving a flat surface from which a slice could be cut without removing an excessive quantity of the meteorite.

Preliminary experiments showed that although it was composed almost entirely of metal, some of its constituents were very differently soluble in various solvents, particularly in dilute acid.

All the sawdust obtained in cutting the section was boiled in dilute sulphuric acid till all action appeared to cease. After the treatment 1.6 % of a dark grey residue, with apparent metallic particles, was left.

On heating this in air to redness it glowed, increased in weight, and became brown in colour. It was then boiled with strong hydrochloric acid, and still left a slight insoluble residue

IV



V

VI

VII

Prof. G. H. Stanley.—The N'kandhla Meteorite.

which showed, on examination, the presence of a trace of platinum.*

The hydrochloric acid solution was found to contain a trace of copper, and (expressed on the original 1.6 %, insoluble residue) about 50 % iron and 30 % nickel; the small quantity did not allow of a more exact determination.

Five grams of the shavings were treated with dilute sulphuric acid for twelve hours; the black insoluble portion remaining was filtered off, dried and weighed and found to constitute 5.8 %. It consisted chiefly of heavy metallic flaky particles with some few floating black ones; all magnetic, and the metallic looking ones tough and malleable. The appearance of these is shown in photo No. 4 (Plate 5).

Of this, .1 gram was boiled with dilute hydrochloric and sulphuric acids, and the solution decanted off.

There was still a heavy insoluble residue, consisting chiefly of light grey, strongly magnetic particles of metallic appearance, shown in photo No. 5, with a few light, black particles, and fewer still minute transparent ones, one or two of which were found to be isotropic.

The amount of this insoluble residue was only .64 % of the original sample. It was extremely brittle and easily powdered, but even in the state of fine powder was scarcely attacked by hot concentrated nitric acid; it was, however, easily soluble in aqua regia, leaving no apparent residue.

It was found to consist of iron, nickel, and phosphorus, the proportions present being:—Iron 53.2 %, Nickel 23.3 %, Phosphorus 8.9 %, which indicates that it was probably largely composed of schreibersite, the iron-nickel phosphide.

The other portion of the relatively insoluble 5.8 %, *i.e.*, 5.16 % contained 65.9 % Iron and 33.1 % Nickel (corresponding very nearly to the composition of Fe_2Ni†), while the easily soluble original portion, i.e., 94.2 %, contained 9.50 % Nickel and 90.30 % Iron.

By calculation this gives the total Iron as 88.94 % and Nickel 10.89 %. Direct determination of Iron and Nickel in a fresh portion, completely dissolved in hydrochloric and nitric acids gave Iron 89.28 % and Nickel 10.68 %.

Other portions were used for the determination of other possible constituents, the complete analytical results being as follows:—

Iron	89.28 %.
Nickel	10.68 %.
Silicon	.004 %.
Sulphur	trace.
Carbon	.030 %.

* The colour reaction with potassium iodide was used.

† This corresponds to Catherinine, which, according to M. de Mauroy, is not found associated with other alloys.

Phosphorus	.057 %.
Aluminium	trace.
Magnesium	trace.
Platinum	trace.
Chlorine	trace.
Manganese	not detected.
Cobalt	not detected.
Chromium..	not detected.

Obviously, with a body of such heterogenous structure, it would be almost impossible to obtain an accurate sample of the whole from one place only, and the above results may not therefore represent accurately the composition of the whole body.

For the examination of the internal structure, a small slice (27 × 20 mm) was cut from the corner where the sample had been taken, ground flat, taking precautions against overheating, and finely polished.

At this stage the crystalline structure became apparent, owing to the varying hardness of the several constituents, but it was developed further by a brief immersion in dilute nitric acid, as usual in metallographic investigations of the internal structure of steels. It then presented the appearance shown in photograph No. 6.

When examined under the microscope and its appearance compared with published descriptions of other meteorites, some difficulty was experienced in identifying the various constituents, but this was found to be largely due to the use of vertical illumination instead of oblique. The difference produced in the appearance in this manner is shown in photos No. 7 (oblique) and 8 (vertical), the dark constituent (taenite?) in one becoming the white constituent in the other.

Photograph No. 6 was taken with oblique illumination. The long "bars" or "beams" which make up the greater portion of the area of the section appear from their colour and structure to be most probably "kamacite," of lengths from about 2 to 8 mm, and widths in the neighbourhood of 1 mm (exceptionally .5 and 1.5 mm).

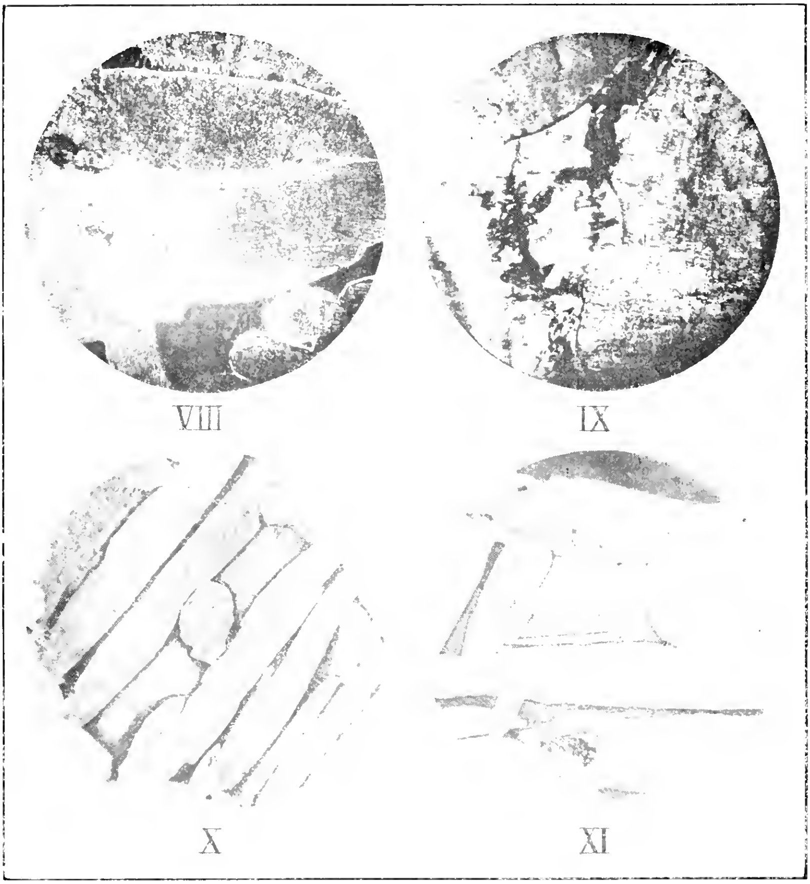
Surrounding these almost completely in nearly every case are what appear to "combs" of taenite," and in between are "fields" apparently of "plessite."

The names given and used here are in accord with most of the descriptions of structures, and some of the compositions, given by different authors in the limited literature of the subject available in Johannesburg.

But with regard to the chemical compositions there appear to be conflicting views.

Kamacite is variously stated to be a solid solution with 6 to 7 % Nickel, and a chemical compound $Te_{14}Ni$ (Nickel 7 %).

Taenite similarly is given as a solid solution containing 15 to 35 % Nickel, and also as a compound F_6Ni (Nickel 15 %),



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and Plessite, a eutectic or eutectoid betkeen kamacite and plessite, and as a compound $F_{10}Ni$ (Nickel 9.5 %).

I have, therefore, assigned names with considerable hesitation and in accord, as already stated, with the structure rather than with the chemical composition.

While they may serve for the present description, they must be regarded as subject to revision.

The nature of the section corresponds, I think, to " medium octahedrite." Comparatively little of any accessory constituent is apparent, but there are several small isolated patches of a hard, bright, white constituent, apparently brittle, since it appears often cracked and broken, occurring generally in the centre of a large bar of kamacite. These can be seen in photograph No. 6, and several of the other photos, and photograph No. 9 (Plate 6) shows an enlarged view of one such occurrence (× 170 diameters*). (The black patches are simply depressions more or less filled with the polishing material). They are chiefly of long drawn out form of length up to 3 mm, and width about .3 mm, and show angular outlines.

They appear to be the brittle constituent separated by acid treatment, probably " schreibersite."

At the edges of some of them, little excrescences of rust became visible after a few days' exposure to the atmosphere, possibly due to specks of " lawrencite," a trace of chlorine having been detected.

Even on examination of the section by the unaided eye, a band of different appearance to the rest is seen down one side—which originally was at the outside of the meteorite—varying in thickness from about 2 mm, where a " lip " is evident, down to zero. Photograph No. 10 (× 18) shows an enlarged view of a portion of this (and indeed of every constituent of the meteorite), and it will be noted that a banded or zoned structure is apparent, indicating probably that this outer layer has been fused, or at least caused to become plastic, and flow, so that it has lost all trace of its former structure. The line of division between the crystalline and altered structure is quite sharp.

The same photo also shows a curious inter-penetration of kamacite, one small bar apparently piercing another.

The kamacite appears to be very well defined wherever it occurs. This is seen, for instance, in photograph No. 11, where every bar, though of irregular shape, has quite sharp outlines. Under higher power (× 170) its structure is shown in photograph No. 12.

The dark lamellae between the bars, apparently " taenite,' on the other hand, are only sharply defined on both sides when between two nearly adjacent bars of kamacite

When the kamacite is some little distance apart, leaving

* The magnifications are those of the original photos, which for purposes of reproduction have been reduced to two thirds.

room for a field of "plessite," the taenite appears to merge into the latter, as seen in photo 11.

Taenite has been stated to be a solid solution of iron in a Nickel, containing 13 to 35 per cent. Nickel, and according to this, the difficultly soluble portion, photo 4, may be regarded as taenite; this, however, is in conflict with the statement of another authority that Taenite is Te_6Ni.

Under high power (×170) and vertical illumination (photo 13) this constituent is seen as white bands between two kamacite bars, but whenever it broadens out a dark constituent appears in the centre, as is well shown in the photo and wherever it enlarges so as to become of sufficient size to be apparent at lower powers, or to the naked eye, they apparently constitute the fields of plessite.

This plessite is of the greatest interest. Apparently the kamacite crystallised first, the mother liquor became continually richer in nickel, and finally caught between two nearly approaching faces, solidified as taenite. But when more space was left and a cell formed, the material enclosed in the cell would not be sufficiently rich in nickel to crystallise as taenite, and further segregation would occur.

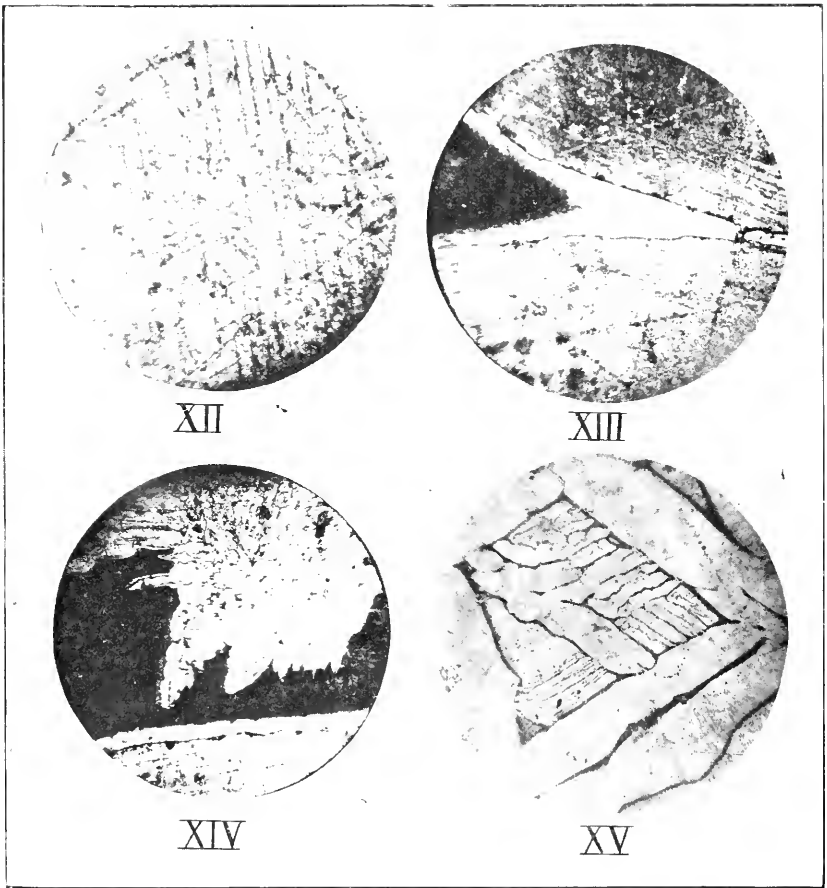
The amount of segregation and nature of the resulting structure would vary with the size of the cell, and consequent composition of the mother liquor entrapped, and this appears to be the reason for the variable appearance presented by the "plessite" fields in different cases.

This difference in appearance has, of course, been noted by other observers in other meteorites, such terms as "dark plessite" and "light plessite," "plessite with metallic sheen," etc., etc., having having been used, but I have not seen any accounts of the examination of plessite fields under high powers.

In the present specimen, to the unaided eye, the small fields of plessite are dark, and as the size increases, the centre becomes lighter, till, with the larger fields, the plessite appears to consist of a light area with a peculiar orientated metallic sheen.

Under high power (× 170), each plessite area, dark or light, is seen to be surrounded by a thin line of "taenite," inside that occurs a zone of a dark constituent (photograph No. 13), resembling in structure pearlite, *i.e.*, it shows a true eutectic structure of alternating plates; in the small areas this makes up the whole section, but as the size increases the centre shows segregation till in the largest areas only a comparatively narrow zone of dark eutectic is seen inside the taenite, the whole interior being occupied by a crystalline aggregate resembling very much, on a microscopic scale, the macroscopic structure of the meteorite as a whole.

This is shown in photograph No. 14, and it appears probable that these small crystals are also of kamacite surrounded by taenite, the taenite, however, being relatively more abundant than in the whole meteorite.



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Photograph No. 15 (× 18) shows this is an extreme case, a new system of kamacite crystallisation having started inside the cell, leaving smaller cells of plessite.

In conclusion, I have pleasure in acknowledging the great assistance rendered by Mr. M. T. Murray in the preparation of the photographs.

Appendix.

Affidavits.

Branch Court. Ensingabantu. N'kandhla District, the 11th October, 1912.

Before me—T. A. Jackson.
Magistrate. N'khandhla district.

Appeared: Chief Mapoyisa, Ntuli tribe, N'kandhla district, who, being duly cautioned, and having made the declaration required by law,

States:

I was at my kraal at the Ekulela stream near the Tugela, and shortly after noon, I heard a loud explosion overhead, and looked up and saw what appeared to be smoke It came from the direction of Helpmakaar, apparently, *i.e.*, from a northerly direction, and appeared to go south towards the sea. It travelled like smoke, with a spiral motion, accompanied by a rumbling sound.

It seemed to pass over the Qudeni point, and disappeared. All that we could see was a trail of smoke; there was no fire accompanying it.

I was first attracted by the sound as of thunder, and then looked up and saw what I have described. Afterwards I heard that a lump had dropped near where a woman named Dedisa was gathering firewood. Dedisa is my sister, who married Matanjana, and is living at the Nsunguza stream, a tributary of the Buffalo river, just over the boundary in Nqutu district.

That is all I know.

Mapoyisa—his X mark.

Read over, interpreted and adhered to before me.

(Signed) T. A. Jackson,
Magistrate, N'kandhla.

Appeared: Dedisa, wife of Matanjana, Chief Ngwoni, Nqutu district.

States:

I was cutting grass near my kraal, and was in a stooping position, when I heard a loud explosion. Then all the hillside was filled with a deafening sound, which continually grew louder until I heard a sound as of something striking the ground. I saw stones flying all around me, and I threw myself down on my face in a great fright. I did not know what was happening, and thought that it was a visitation from Almighty God. At last I got up and attempted to run, but my strength failed, and I fell down again. I got up and staggered home, and told the people at home. The thing that struck the ground struck it within about five yards of where I was.

I have never been back near the spot, as I am too frightened to do so. I cannot say anything more as I was in too great a fright. The noise was deafening, and it seemed as though the whole hillside was tottering and falling. I did not even see the thing that struck the ground; I was too frightened to go and look at it.

Dedisa—her X mark.

Read over, etc., etc.

Appeared: Matanjana ka Mpunzi, Chief Ngwoni.

States:

I live between the Mlambomunzo and Nsunguza streams, tributaries to the Buffalo River, in Nqutu district, quite near the boundary between that and N'kandhla district. I was away at the Umhlatuzi on the day that the meteorite was seen. I heard a great noise like a cannon being fired, and on looking up into the sky, I saw what appeared to be a spiral column of smoke following a round looking object. It appeared to come from South-West to North-East, but I am not sure of the direction. It was about a week later that I returned home, and I then heard that something had fallen near where my wife was cutting grass. I then went to look at the spot, and found that a hole had been made in the ground about a yard across and two feet deep. All the stones there were smashed to pieces and scattered all around.

The boys Sihau and Mahoyana tell me that they went at once to see it, when they heard my wife's story. They say it was a lump somewhat resembling lead. It had rebounded out of the hole a few yards.

Matanyana—his X mark.

Read over, etc., etc.

Statement of Zacaria Dhladhla, Native catechist at Qudeni, in regard to the meteorite which fell at Qudeni on the 1st August, 1912.

The meteorite struck a hard, blue, whinstone boulder about two feet in diameter fair in the centre I should say, and crushed this into dust and small fragments, there being very few pieces left of it bigger than two inches square.

The depression in the ground was about two feet in diameter and about nine inches deep, and concussion so great as to loosen the boulders in the neighbourhood for distance of about fifteen feet radius, and several of these in the close proximity of the impact, jumped out of their places and rolled down the hill a little distance.

I could find no fragments of the meteor, which appeared too tough to break, though it had cracks caused by the impact I think.

The dust from the collision went up the hill, but the large pieces of the crushed stone spread in all directions round the hollow in the ground, which at the spot is nearly all rock with very little soil, and is principally vertical schist, with white quartz and whinstone.

As far as I can gather, the meteor came down nearly vertical, though in a slanting direction towards north, striking the southern slope of the hill at right angles to it, as it did not rebound, but only rolled down the hill about 12 feet from where it struck. It could not have been very hot, as the old dry grass where it fell, was not singed. While in the air nothing was visible except a little smoke following its course, but some natives say it was bright like a star, and had a tail like a comet, followed by a line of smoke.

(Signed) G. M. Gunderson,
for Zacaria Dhladhla.

Extract from Circular No. 3, 1912, November 26th, of the Union Observatory.

Mr. Brandon, the Magistrate at Mpofana, supplies the following addttional remarks:—

At 1.30 p.m., I was sitting in my house after lunch, when I heard a sound as of crackling wood.

I rushed out, thinking the house was on fire, and saw all the natives pointing to the sky.

Looking up, I saw a long line of smoke across the sky from West to East, which soon disappeared.

The sergeant of police came to my house a few minutes afterwards saying he had been on the hill for a walk, and had heard a huge explosion, and feared a disaster at one of the Natal coal mines.

We could get no particulars for some days, but about a week afterwards I heard that a meteorite had fallen on the Pokinyoni hill in the N'kandhla district of Zululand, about 18 miles from here.

Dr. R. Broome.—"Dr. Robert Broome, the authority on South African palaeontology," says *Science* of October 31st, "is visiting America for a year of scientific research, especially upon the ancient vertebrates of the Permian period. He has accepted a temporary appointment upon the staff of the American Museum of Natural History for this purpose, and has brought with him his private collection of South African Permian reptiles."

NOTICIA SOBRE A CULTURA DO CAFÉ

Por Francisco de Meirelles.

O café é uma planta da familia das Rubiaceas e oriunda da Abyssinia. As suas especies são numerosas e as mais interessantes segundo H. Jumelle debaixo do ponto de vista pratico são: a *Coffea Arabica,* a *Coffea Liberica* e a *Coffea Stnophilla.*

Coffea Arabica.

E expontanea na costa oriental da Africa Portugueza, encontrando-se no estado selvagem, e é um arbusto que não vae alem de 5 a 6 metros de altura. O verdadeiro typo da *Coffea Arabica* é o café vulgarmente conhecido por *Moka*; as folhas são oppostas, glabras, ovaes e as flores são brancas e reunidas em pequenos grupos nas axillas.

As principaes variedades da *Coffea Arabica* são. café do Brasil, S. Thomé, Java, Jamaica, etc., etc.

Clima.

São variadissimas as opiniões, sobre qual será o melhor clima para o café—uns dizem que elle prefere as regiões altas do que as baixas, como acontece por exemplo no sul da India e na Venezuela, aonde as plantações vão alem de 2:000 metros de altitude. No Brasil, a partir de 600 metros até 1:000 de altitude, colhem-se os melhores cafés; de 200 metros para baixo, são os cafés de inferior qualidade. As temperaturas entre 15° a 25° são as mais favoraveis e as que melhor lhe convem. Acima de 25° a cultura é perigosa e necessario se torna abrigá-la para a defender do calor. Diz Raoul que "as regiões onde o café vive melhor se acham nas montanhas da zona intertropical, a uma elevação correspondente ás condições thermicas das regiões comprehendidas entre o 20° de latitude norte e o 23° 30′ de latitude sul." Outros autores, segundo Jumelle, dão como altitude média, entre 6° a 12° de latitude, 1:000 a 1:800 metros.

De 10° para baixo, o café, embora com elle haja todos os cuidados não poderá resistir.

Estudadas, pois, as temperaturas e as altitudes mais convenientes ao café, vejamos agora as chuvas. Como toda a gente sabe, o café aprecia terrenos aonde a humidade lhe não falte. Elle agradece-a e corresponde no crescimento, que dia para dia apresenta, com as regas que se lhe dã. E, na opinião de alguns autores, elle deseja uma atmosphera moderadamente humida e uma frescura constante do solo.

E, não será de estranhar que em certas regiões aonde abunda o café, elle se não apresenta no mais exuberante vigor, porque as condições climatericas são de excellente ordem, como acontece na India, Ceylão, Brasil, etc., aonde as chuvas annuaes vão de $2^m.50$ a $3^m.75$.

E, sendo o café uma planta de raiz pivotante, se a sua cultura for feita num terreno fofo e permeavel, a colheita fornecerá dados para se avaliar se, sim ou não, o solo será causa principal para uma boa acclimatação numa dada e determinada região!

Em minha opinião, não serão os terrenos a causa principal na sua acclimatação, porque estes corrigem-se. Deve-se attender em especial ás condições climatericas, factores principaes para uma boa cultura. Poderemos, é facto, construir abrigos, e preparar sebes que o recatem dos ventos fortes, apropriando-lhe irrigações que ao terreno deem humidade. O que não poderemos, é dar-lhe calor, elemento indispensavel á vida e que, sem elle, a planta não resiste.

Cultura.

Foi em 1908 que pela primeira vez experimentei uma cultura de café na circumscripção de Marracuene. Era o café da Jamaica que ia experimentar. Foi este semeado em pequenos vazos de papel, cheios de terra, previamente preparada e escolhida; a constitutição d'ella devia aproximadamente ser arenohumifera.

Em cada vaso foi disposto um grão de café, regado moderadamente, foram os vazos collocados numa estufa de caniço e capim, sujeitando-os todos os dias a uma exposição ao sol de duas horas. E era conveniente não os expôr mais, porque o mês era perigoso—dezembro. Desde o 15.° dia começou a germinação que se prolongou quasi por um mês, verificando-se depois que a percentagem dos não germinados era relativamente pequena—de 214 grãos germinaram 183. Não é de estranhar que isto acontecesse porque as sementes já traziam longa viagem e, embora admiravelmente acondicionadas, como é mister da casa Vilmorin Andrieux, de Paris, nada mais facil que uma ou outra se resentisse. Dois meses depois, em fevereiro, soffriam a transplantação para latas de petroleo que tambem foram cheias com a mesma terra, não tendo nenhuma d'ellas morrido com esta operação. E foi nessa occasião que admirei como agradeciam as regas que se lhe administravam. Já então collocadas numa estufa, somente feita de caniço, que diexava coar uns raios de sol não muito violentos, em poucos meses, fizeram-se umas plantas dignas de se admirar pelo viçoso colorido de suas folhas.

Notei apenas entre quatro ou cinco, uma especie de ferrugem que lhes manchava e murchava as folhas, e que creio ser o que na America se chama, como diz Jumelle, " mancha de hierro " devido ao *Stiblum flavidum*.

Houve duas mais cujas folhas embraqueceram, ignorando qual a causa, morrendo tamben. As atacadas de ferrugem foram pulverizadas com a solução conhecida por " Paris Green," mas sem resultados efficazes.

E um anno depois, eram plantadas definitivamente em local previamente abrigado e preparado. Escolheu-se o terreno junto de uma pequena mata, aonde cresciam umas acacias. As plantas foram collocadas de 4 × 4 metros e abrigadas por pequenos toros de madeira encastellados—covas largas e fundas e bem estrumadas. O café não estranhou e, embora lentamente, começou desenvolvendo-se. Regas, o mais frequente, conforme as condições o permittiam. Dezoito meses depois as plantas em media apresentavam 1,10 de altura e algumas frutificavam.

O grão, pelo menos os que vi, não tinha degenerado; era perfeitamente igual á semente mãe.

Actualmente, na Estação Experimental do Umbeluzi trabalha-se numa pequena plantação de café de S. Thomé, cujas plantas, em numero de 800, abrigadas em estufas de caniço que lhe permittem a entrada dos raios solares, apresentam um aspecto soberbo. O terreno, escolhido com todo o cuidado, receberá a plantação em quinconcio. Nada poderei dizer d'esta variedade porque a já vim encontrar nas condições em que actualmente se apresenta. Dirijo a mesma plantação e só depois d'ella feita é que poderei colher elementos que mais tarde me autorizem a emittir a minha opinião.

Doenças do Cafe.

Infelizmente são variadissimas, e, na maioria dos casos, perniciosas para a planta. Ha a distinguir as doenças causadas por insectos, como é a *Xylotrechus quadrupes*. Segundo Jumelle, é a femea que perfura a planta até á medula, dividindo-a em galerias aonde deposita os ovos. A *Cemiostoma Caffeella*, produzida por uma larva que se enrosca nas folhas. As doenças causadas por um persevejo, "Bug," e d'ahi as doenças a que os plantadores inglezes, segundo o mesmo autor, dão o nome "Black bug" (*Lecanium nigrum*) e o "Green bug" (*Lecanium veride*).

Estes insectos atacam as hastes e muitas vezes vão até á raiz. Ha a seguir as doenças causadas por cryptomagas, como a *Hemileia vastatrix*, que é um cogumelo.

Os tratamentos a applicar são varios, citando-se entre os melhores: a calda bordeleza, a terebinthina, o petroleo e o sabão em soluções.

E perante tantas doenças e outras causas ainda hoje desconhecidas que atacam o café, poz-se já em pratica em varios paises a enxertia para a multiplicação de hybridos interessantes. Assim, por exemplo, ha hoje productos de uns "Stenophilla" com um Liberia que, segundo opinião dos plantadores, resiste muito mais a qualquer doença. A enxertia é feita antes da planta ser plantada, num vazo convenientemente preparado para não soffrer quando da plantação definitiva. É a enxertia de fenda, a escolhida.

Cafe de Inhambane.

Na provincia de Moçambique, o café mais conhecido pelo seu typo e *bouquet* especiaes, é com certeza o café de Inhambane

É um pequeno arbusto com a folha pequena glabra, oval, tendo a pagina superior de um verde brilhante

As flores reunem-se em pequenos ramos junto da axilla das folhas; o seu grão é extremamente pequeno, medindo em média 4 a 5 millimetros de comprido.

O café de Inhambane é excellente para lotar com outros; o seu aroma e sabor, completamente differente dos outros, levou já alguem a affirmar que elle não possuia cafeina.

No norte do districto de Inhambane, principalmente nas circumscripções de Panga e Massinga, encontram-se frequentes traços mais ou menos numerosos de cafezeiros incultos e que a maioria dos indigenas derruba quando amanha as suas machambas. O seu rendimento, conforme tive occasião de verificar numa propriedade de um agricultor, regula entre 200 grammas por cada planta. Dadas as suas condições de resistencia, parece-me que é uma cultura que deve remunerar o agricultor a que ella se dedique.

Uma plantação regular em quincuncio terá por hectare 663 plantas que renderão aproximadamente 1:326 kilogrammas de café. Em Inhambane, o preço oscilla entre 300 e 400 réis o kilo, como algumas vezes tive a occasião de verificar.

Mas deixemo-nos de optimismos e contêmo-lo já em 200 réis o kilogramma.

Renderá pois um hectare 265$200 réis. Qual será o preço do amanho de um hectare? Não poderá ir alem de 60$000 réis: accrescentemos mais a decorticagem, transporte, direitos aduaneiros que arbitraremos em 80$000 réis. Vê-se pois que ha uma despesa, valorizando o café muito por baixo, de 140$000 réis por hectare e um rendimento de 125$200 réis!

Será talvez, dirá quem me ler, uma phantasia algo extravagante, este meu calculo.

Eu falo do café de Inhambane aonde a mão d'obra por ora é relativamente barata: cuidada e tratada convenientemente, é de presumir que o agricultor que a ella se dedique se não arruine. Se attendermos tambem ás condições meteorologicas, veremos igualmente que a planta resiste ás mais variadas mudanças de temperatura: é frequentissimo nesta quadra do anno um thermometro de relva accusar 3° abaixo de zero—é verificar os graphicos dos thermometros registradores que accusam altas e baixas deveras interessantes. Elle resiste á ausencia das chuvas que se fazem sentir com uma irregularidade assustadôra, para quem da terra vive e nella empregou os seus capitaes; e, como exemplo frisante, apresento este: desde o primeiro de janeiro do corrente anno as chuvas caidas no Umbeluzi aonde ha um nucleo de agricultores illustrados e uma Estação Exprimental do Governo, apenas se registaram 96 millimetros!

E se compararmos a altura annual das chuvas, como acontece no Brasil, India e outros paizes, aonde ellas attingem 3 metros e mais, com as que cairam este anno e o anno transacto, poderemos affirmar sem receio, que o café de Inhambane é uma cultura na qual se pode arriscar capitaes.

Não aconselharei a ninguem nesta provincia que metta hombros, sem previamente estudar e ter fundos capitalizados, a uma plantação de café de outras variedades que por ora são desconhecidas nesta provincia.

Sobre o café de Inhambane, não teria duvida alguma em arriscar capitaes desde que a cultura fosse modelar, e para isso bastava a boa vontade e a persistencia de quem a dirigisse.

Não é transcendente, e hoje, com as aperfeiçoadissimas alfaias agricolas que na sua maioria estão ao alcance de todo o agricultor, e os magnificos apparelhos para o decorticar, a empresa não seria grande, que qualquer a não pudesse levar a bom fim.

E ao encerrar aqui estas ligeiras notas sobre o café, haja quem me ler de corrigir as muitas dificiencias e lacunas que ellas conteem, porque, sendo o mais obscuro funccionario da Repartição de Agricultura d'esta provincia, não caberia em meu animo a louca vaidade de exhibir-me num trabalho de tanta responsabilidade, quando é certo que não era a mim, mas sim a outrem, que tal competia.

(TRANSLATION.)

NOTES ON COFFEE GROWING.

By Francisco de Meirelles.

Coffee is a plant of the Rubiaceae family, a native of Abyssinia. Its species are numerous, and according to H. Jumelle the most interesting ones from a practical point of view are: *Coffea Arabica*, *Coffea Liberica*, and *Coffea Stnophilla*.

The *Coffea Arabica* is indigenous to the Portuguese East Coast of Africa, where it is found wild. It is a shrub which does not atttain a height of more than 5 to 6 metres. The true type of *Coffea Arabica* is the coffee generally known as Mocha, and its leaves are opposite, glabrous, oval, and the flowers are white and in small clusters at the axils.

The principal varieties of *Coffea Arabica* are the Brazil, São Thomé, Java, Jamaica, etc.

Climate.

Opinions differ considerably as to the best climate suitable for Coffee, Some say that it prefers high to low lands, as, for instance, in Southern India and in Venezuela, where the plantations exceed an altitude of 2,000 metres. In Brazil the best grades of coffee are gathered at altitudes varying from 600 to 1,000 metres. Coffee grown below 200 metres is of an inferior grade. The most suitable temperature is between 15 and 25 degrees Centigrade. Cultivation above 25 degrees is risky, and it then becomes necessary to shelter the plant in order to protect it from the heat. Raoul says that the regions where Coffee thrives better are those in the mountains of the intertropical zone at a height corresponding to the thermic conditions of the regions lying between parallels 20° North and 23° 30′ South. Other writers, however, according to Jumelle, give the average altitude, between latitudes 6 and 12 degrees, as 1,000 to 1,800 metres.

Below 10° Centigrade, coffee, however careful the treatment may be, cannot resist the conditions.

Temperature and altitude best suited to Coffee having been ascertained, let us now consider the question of rainfall. As everyone knows, Coffee loves a soil where there is no want of humidity. The plant benefits much thereby and corresponds in its daily development to the watering given to it. In the opinion of some writers it requires a moderately moist atmosphere and constant coolness of the soil. In certain regions where Coffee is found in abundance it is not surprising that it shows itself in a most exuberant condition, seeing that the climatic conditions are excellent, as in the case of India, Ceylon, Brazil, etc., where the annual rainfall rises from 2.5 to 3.75 metres.

Coffee having a tap root, if its cultivation is made in soft and pervious ground the crops will furnish sufficient data to ascertain whether or not the soil is mainly responsible for its satisfactory acclimatization in a particular region.

In my opinion, however, the soil is not the principal factor of acclimatization, for the soil can be corrected. One must pay attention especially to the climatic conditions—the main factors in satisfactory cultivation. Of course, we might build shelters and provide hedges to guard the plant against strong winds, and irrigate the soil so as to render it moist, but we cannot give it heat, and this is indispensable to the life of the plant, which cannot do without it.

Cultivation.

In 1908 I experimented for the first time in the cultivation of Coffee in the sub-district of Marracuene. I tried Jamaica Coffee. This was sown in small paper pots filled with earth previously prepared and selected. The earth was approximately a humus-sandy soil.

One Coffee bean was placed in each pot and was moderately watered. The pots were placed in a green-house made of reeds and straw, and were exposed to the sun during two hours every day. It would have been risky to have exposed them any longer as the month (December) was a dangerous one. Germination commenced on the 15th day and extended over a period of nearly one month. It was later ascertained that the percentage of non-germinating seeds had been comparatively small; out of 214 beans 183 sprouted. This should cause no surprise, as the seed had travelled a long way, and while the packing was excellent, as is usually the case with Messrs. Vilmorin Andrieux, of Paris, it was not strange to find that a few beans had been affected thereby. Two months later, in February, they were transplanted to paraffin tins filled with the same kind of earth, and none perished as a result of this operation. It was just at this time that I was able to appreciate how they benefited from the watering administered. Placed in a greenhouse made of reeds only, through which a few not too violent sunrays were allowed to filter, the plants became in a few months worthy of admiration for the luxuriant colour of the leaves.

I noticed that in four or five plants only a kind of rust stained the leaves and made them wither. I believed it to be what according to Jumelle is called in America "mancha de hierro," and is due to the *Stilbum Flavidum*.

The leaves of two other plants bleached through some cause unknown to me. Those affected by rust were sprayed with Paris Green, but no satisfactory results ensued.

One year later they were definitely planted in a previously sheltered and prepared site. The place chosen lay close to a thicket of acacias. The plants were placed at a distance of 4 metres from each other and protected by small wooden stumps with wide, deep ditches well manured. The plants did not feel the change, and they commenced to develop, though slowly. Watering was administered as frequently as conditions required. Eighteen months later the plants showed an average height of 1.10 metres, and some were bearing fruit.

The beans, at least those I saw, had not degenerated, and were perfectly equal to the mother seed.

At present a small plantation of São Thomé Coffee is being made at the Umbeluzi Experimental Farm. There are 800 plants sheltered in greenhouses made of reeds, which permit of the sun passing through, and they have a superb appearance. The site for the plantation was very carefully selected, and will receive the plants in quincunx. I am unable to express an opinion concerning this variety, as I found it already in its present condition. I am now superintending the plantation, but not until it is made shall I be able to gather sufficient data to form an opinion.

Diseases of the Coffee Plant.

Unfortunately there is a great variety of diseases, these being in most cases pernicious to the plant. First come those which are caused by insects, such as *Xilotresus quadrupes*. According to Jumelle it is the female that bores into the plant down to the medulla, where, dividing it into galleries, it deposits the eggs. *Cemiostoma Caffeella* is caused by a larva which wraps itself up in the leaves. Some diseases are caused by a bug, such as those which, according to the same writer, are called by English planters "Black bug" (*Lecanium nigrum*) and "Green bug" (*Lecanium veride*). These insects attack the stems and often get down to the roots. Next come those diseases caused by cryptogamia, such as the fungus *Hemileia vastatrix*.

There are various ways of combating these diseases, and the best treatments recommended include: Bordeaux mixture, turpentine, petroleum, and soap solutions.

In view of so many diseases and several other still unknown causes which attack the coffee plant, grafting has been resorted to in various countries for the purpose of producing interesting hybrids. Thus we find now, for instance, the products of Stenophilla with Liberia, which, in the opinion of planters, will offer far more resistance to disease. Grafting is made before planting in a conveniently prepared pot, so that the plant will not suffer from the effects of transplanting. The system preferred is cleft-grafting.

Inhambane Coffee.

On account of its particular type and bouquet, Inhambane Coffee is undoubtedly the best known Coffee in the Province of Mozambique.

It is a small shrub with oval, glabrous leaves of a brilliant green on the upper side.

The flowers gather in clusters near the axils of the leaves. The beans are extremely small, and measure an average length of 4 to 5 millimetres.

Inhambane Coffee is excellent for blending purposes, and its aroma and flavour, which are totally different from any other kind, have led many to state that it contains no Caffein.

In the Northern portion of the Inhambane District, more especially in the sub-districts of Panga and Massinga, one frequently comes across more or less numerous traces of uncultivated coffee plants which the majority of the Natives pull down when tilling their gardens. I had an opportunity to verify, in a private farm, that the crops average about 200 grammes per plant. In view of its resisting properties, I am of opinion that its cultivation will handsomely repay those who undertake it.

A plantation in quincunx should, as a rule, have 663 plants per hectare, which will yield about 1,326 kilogrammes of coffee. Prices at Inhambane vary from 300 to 400 réis per kilo, as I often had the opportunity of ascertaining.

Putting aside, however, any optimistic views, let us quote the price as low as 200 réis per kilogramme. One hectare will thus yield 265,200 réis. What will be the cost of tilling per hectare? It cannot be far beyond 60,000 réis. Let us now add the cost of decortication, transport, and Customs dues, which we may reckon at 80,000 réis. Thus we have an expenditure of 140,000 réis, and if we take the value of the coffee at a very low figure, there would remain a profit of 125,000 réis.

To the mind of readers this might appear too extravagant a fancy on my part, but I am referring to Inhambane Coffee, where labour is still comparatively cheap. Provided the cultivation is properly looked after, one can safely say that the planter will not be ruined! As to meteorological conditions, one sees that this plant resists most successfully the most varied changes of temperature. It is not at all infrequent for a grass thermometer to record 3 degrees below zero—one need only examine the diagrams of the registering thermometers, which show really interesting oscillations. The plant stands the drought, which occurs with an irregularity that is most alarming to those who make their living out of the soil. The following is a striking illustration. From the 1st January of the current year the rainfall at Umbeluzi, where there is to be found a nucleus of trained agriculturists and at Government Experimental Farm, was only 96 millimetres (3.74 inches). If we compare the annual rainfall in Brazil, India, and other countries where it often reaches as high as 3 metres, and sometimes more, with our rainfall in this and the previous year, we can safely assert that Inhambane Coffee warrants the investment of capital.

I should never advise anyone who has not previousuly studied the cultivation of Coffee and does not possess sufficient capital, to go in for other varieties that are not yet well known locally.

I should not mind putting money in Inhambane Coffee, provided the cultivation was carried on in a thorough way, and this can easily be accomplished by means of an attentive and persevering management. The undertaking is by no means an exceedingly difficult one, and now that such perfect agricultural implements can always be procured at prices well within the reach of all farmers, and with splendid decortication machinery available, anybody could make Coffee cultivation a success.

In concluding these hurried notes on Coffee, I shall expect whoever reads them to be indulgent to their defects. Being one of the least important officials in the Agricultural Department of this Province I do not put myself forward as an expert in a work of so much responsibility.

AGRICULTURAL SCIENCE.—Two books, which have recently issued from the press in connection with Messrs. Charles Griffin and Co.'s series of technological handbooks, claim a more than merely passing reference. An era of agricultural renaissance is, we trust, opening up for South Africa—an era of which probably no more than the beginnings have as yet been seen. To take full advantage of this time of agricultural opportunity, South Africa will need all the energy of mind and all the energy of body that men can put into practice. And it is necessary, also, that many South Africans not *directly* connected with agriculture should have an intelligent grasp of agriculture's needs and capabilities. To these as well as to the embryo farmer Messrs. Griffin's two publications are bound to be of much assistance and interest. Mr. Herbert Ingle's handbook on Elementary Agricultural Chemistry* should interest them because the author spent some years in South Africa as Chief Chemist in the Transvaal Department of Agriculture, and is therefore in a position to illustrate some of his teachings by means of examples drawn from this country. The need of local colouring in some text books locally used is often felt, because of the diversity of conditions that separate between South Africa and some of the countries more highly organised as to their systems both of technical education and of intensive cultivation. Such a need, in respect of zoology, for instance, was met in Professor Gilchrist's book on "South African Zoology." Mr. Ingle's handbook, however, does not aim at being distinctively South African, and so the author is in no sense to be blamed because that pronounced colouring is not as prominent as in Dr. Gilchrist's book: on the other hand, though less pronounced, the touches of South African colouring are by no means absent. In a way, Mr Ingle almost seems to apologise for putting in these touches: he thought it advisable, he says, to give some account of the products of tropical agriculture, "because the book was prepared while the author was in touch with many of the crops and agricultural practices of South Africa"; and again, the references to the composition as well as to the amount of ash constituents in the food of animals are defended on the ground that though not felt to be of much importance in Europe, where diet is varied, their importance is considerable "in such countries as South Africa, where the usual food of draught animals is composed almost entirely of cereals." Now many a South African student of agricultural science will think that these apologiae are supererogatory: rather would he wish that more of the illustrations apologised for had been given. Amongst those quoted are noticed a few results of investigations of rain made at Pretoria, some analyses of veld soil and ant heap soil from Christiana, an ascription to the supposed presence of sodium carbonate in many South African streams of the muddy condition of their waters, a reference to a South African practice of screening plants from the early morning sun, several analyses of South African fodders, a more detailed mention of Lounsbury's Cape experiments on tick-destruction, the use of lime and sulphur dips at the Cape, and last, though not least, the Cape weights and measures. Those who study a book like this because of the *general* agricultural chemical information contained in it—and they, doubtless, make up by far the greater number of its readers—will find, in addition to a few dozen

* Ingle, Herbert, B.Sc., F.I.C., F.C.S., *Elementary Agricultural Chemistry*. Crown 8vo., pp. ix, 250. 2nd ed. London: C. Griffin & Co., Ltd., 1913. 4s. 6d.

pages outlining modern chemical principles, chapters dealing with the atmosphere, the soil, natural waters, crops, manures, stock feeding and dairying, and also one mainly devoted to insecticides and fungicides. Altogether Mr. Ingle's handbook is the nearest approach to a South African handbook of agricultural chemistry that has yet appeared in print.

Professor Löhnis, in his laboratory handbook on Agricultural Bacteriology,† has, it is true, no South African illustrations to put forward, one obvious reason being that in South Africa agricultural bacteriology is still uninvestigated. This remark does not apply to veterinary bacteriology, which scarcely falls within the ground covered by the author. Moreover, the object of the book is to impart instruction in laboratory practice. It claims our attention for the important reason that the study of agricultural bacteriology in this land cannot be set about too soon in downright earnest, and it is quite time that a thorough and general interest were aroused in this branch of science. The bacteriology of foods, dairy products, manures and soils requires to be understood with far greater clearness than the prevalent hazy notions allow of—notions so hazy, indeed, that bacteriology, chemistry and pharmacy are apt to become agglomerated, in the minds even of those who have to set the pace, into one mass of vague ideas, to the inexpressible detriment of South Africa's agricultural industry. Bacteriology is a relatively new science, and agricultural bacteriology one of its more recent aspects, hence it is not only in South Africa that the bacteriology of agriculture has not been as widely studied as necessity demands; indeed, Professor Löhnis points to the abundance of literature on bacteriology for *medical* students, and in connection with the *brewery* industries, while a laboratory book on methods of practical *agricultural* bacteriology has been lacking. The author, therefore, designed his work specially for students of agriculture, in order to fill this gap. He devotes the first five dozen pages to a general introduction to the subject of agricultural bacteriology and to experiments in order to induce familiarity with bacteriological technique, but the main part of the book consists of three sections, namely, on dairy bacteriology, the bacteriology of manures, and soil bacteriology. While every farmer need not be an expert bacteriologist, the dairyman and the agriculturist will be far better equipped for their work if they have books in handy form like that of Professor Löhnis, available for reference, for its character is such that many in South Africa whose student days are over, and had not the opportunities of studying the bacteriology of agriculture which scientific advance has put within the reach of

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† Löhnis, Prof. Dr. F., *Laboratory methods in Agricultural Bacteriology*. Translated by W. Stevenson and J. Hunter Smith. Crown 8vo., pp. xi, 136. London: C. Griffin & Co., Ltd, 1913. 4s. 6d.

the new generation, will do both themselves and the country service by acquiring intelligent comprehension of the principles on which the agricultural bacteriological methods described by Professor Löhnis are founded.

THE PSYCHIC LIFE OF THE THONGA TRIBE.—On page 175 of the previous volume reference was made to the Rev. H. A. Junod's book on "Social Life amongst the Thonga people." A second volume, having for its main subject the psychic life of the same tribe, has now been published. This book, like its predecessor, is divided into three sections, one of which deals with agriculture and industries amongst the Thonga, and the second with the tribe's literary and artistic life. These two sections occupy the first half of the book, the remainder being devoted to Thonga religion and superstitions. These three heads, however, scarcely afford an idea of the complexity of the tribal life as delineated by M. Junod with an ability that carries conviction as to his right to speak authoritatively. The wealth of detail in which the work abounds, combined with its comprehensive width of range, together constitute a striking testimony to the author's large and almost unique experience of Thonga customs, and to the ethnographic value of the facts recorded by him. Those facts are marshalled in the manner characteristic of the scientist who recounts the results of his exhaustive studies. The section of the book dealing with Thonga agriculture naturally divides up into two chapters. The first of these, beginning with a brief description of the soil, and of Thonga customs in regard to land tenure, passes on to the subject of grain, vegetable and fruit culture, and general agricultural practice. The author wisely disclaims the idea of a sharp demarcation of what he calls the psychic life, seeing that grain-threshing and horticulture have each their distinctive taboos. Such a taboo, for instance, is connected with the planting of new or foreign trees, including mangoes, oranges, etc. Other aspects of Thonga agriculture discussed—with regard to which the author contributes a great store of information—are the preparation of foodstuffs, the breeding of stock, the chase, and the piscatorial art. A few pages on alcoholism and its concomitant vices are also interposed, and then one becomes interested to learn that, amongst the culinary dainties of the Thonga, caterpillars, locusts, and white ants are universally appreciated. The features of Thonga industries described include costume, dwelling-places, and various small appliances, such as pottery-ware, basket-work, carved wooden utensils, and metal-work. The author proceeds to introduce his readers to the niceties of the Thonga grammar, and this, after a brief excursus on the tribe's literary faculties, leads on to a chapter on the proverbs, riddles, and enigmas of the Thonga. The reader next makes acquaintance with Thonga poetry (lyric, epic, satiric, and dramatic); then follows a most interesting and exhaustively illustrated account of the native folk-lore, and this, in turn, is succeeded by a chapter on Thonga music and musical instruments. Nearly a dozen pages of staff notation sufficiently illustrate the former, and M. Junod asserts that the Thonga are familiar with both major and minor modes, while accidentals and the chromatic scale present no serious difficulties—nor, to judge from some of the illustrations given, do consecutive fifths. In discussing shortly, at the close of the second section of this book, the problem of Native Education, the author makes it a cardinal principle that such education must be bi-lingual: the teaching of vernacular reading and writing he declares to be the basis of the whole edifice, but in the ever-increasing intercourse with white people he sees a need for knowledge of Portuguese, English, or Dutch, and accordingly he proposes a division of native primary education into three stages: (1) The vernacular stage, (2) a mixed or transition stage, and (3) a European stage, during the last of which one or other of the three European languages mentioned should, as far as possible, be employed as the medium of instruction. In that portion of his book wherein he describes the Psychic life proper, consideration is first of all given by the author to Thonga conceptions of the world and its origin, and to their ideas of cosmology, physiography, meteorology, and biology. By an easy transition this passes over to the native conceptions regarding man as embracing body and soul, and from these again to the Thonga religion, which is ancestrolatry of a purely spiritistic type, that is to say, idolatry and fetishism are absent. The religion, though non-moral, is not immoral, and coupled therewith is a conception of Heaven—a term with which is associated a dim idea, not only of uninhabited locality, but also of impersonal, though active power. Magic rites amongst the Thonga people possess several more or less distinct phases, some beneficent, others the reverse. Medical practices belong to the former category; less exclusively so is the treatment of demoniac possession, while witchcraft is met with both in the form of white and black magic, the latter being decidedly maleficent. The concluding portion of the chapter on magic is concerned with divination, the object of which is to provide guidance and direction in regard to the future, under perplexing circumstances, by means of such expedients as presages and divinatory bones. The fourth and final chapter of the book deals with some of the restraints put upon the people: these are the taboos and moral restraints. The origin of the taboos is generally inexplicable, but when a taboo has been proclaimed and then transgressed, condign punishment is thought to be averted from the transgressor by the drugs of the medicine-man. As for moral restraints, M. Junod comes to the conclusion that, if Bantu religion is non-moral so also Bantu morality is non-religious, nor can a man even so much as feel himself guilty of a crime which he has committed if he has not been convicted thereof. In his concluding sentences the author, having in view a long list of the vices of civilisation (which list he tells over categorically), expresses fear for the extinction of the tribe unless these influences be checked, and so he makes an appeal to Education to provide the enlightenment of mind, and to Christianity to lead the weak and carnal Bantu to its own ideal, as the people's only salvation from the annihilation which he otherwise considers inevitable.

INTERNATIONAL ELECTRICAL AND ENGINEERING CONGRESSES.—The International Electrical Congress is to be held at San Francisco from September 13th to 18th, 1915, under the auspices of the American Institute of Electrical Engineers, by authority of the International Electrotechnical Commission, and during the Panama Pacific International Exposition. The deliberations of the Congress will be divided among twelve sections, which will deal exclusively with electricity and electrical practice. The International Engineering Congress will be held at San Francisco during the week immediately following the Electrical Congress. The Engineering Congress is supported by the Societies of Civil, Mechanical, and Marine Engineers, and by the Institutes of Mining and Electrical Engineers, as well as by the prominent Pacific Coast engineers who are actively engaged in organising it. This Congress will deal with engineering in a general sense, electrical engineering subjects being limited to one of its eleven sections.

INTERNATIONAL CONGRESS OF TROPICAL AGRICULTURE.—The International Association for Tropical Agriculture has decided to hold an International Congress in London during June, 1914, and all countries interested in Tropical Agriculture and Forestry are invited to participate therein. The principal object of the Congress is the discussion of ways and means of improving agriculture in the Tropics, and thereby increasing the production of the numerous food-stuffs and industrial raw materials derived from tropical countries. The Congress is to be held in the Imperial Institute, South Kensington, London, S.W., and communications intended for submission thereto may be made in English, French, German, or Italian, but the general language of the Congress will be English. The following subjects for papers and discussion are suggested:—Technical education and research in tropical agriculture, Labour organisation and supply in tropical countries, Scientific problems of rubber production, Methods of developing cotton cultivation in new countries, Problems of fibre production, Agricultural credit banks, Agriculture in arid regions, Problems in tropical hygiene and preventive medicine, Problems relating to tropical agriculture and forestry, The cultivation and production of rubber, cotton and fibres, cereals and other foodstuffs, tobacco, tea, cocoanuts, other agricultural products, and forest products, Plant diseases and pests affecting tropical agriculture.

TRANSACTIONS OF SOCIETIES.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, August 16th: A. Richardson, M.I.M.M., President, in the chair.—Presidential address: A. **Richardson.** The training and work of the mine surveyor were shortly reviewed, and a syllabus of subjects requiring closer attention on the part of students of surveying and assistants on the mines suggested.—"Mining copper ores at Messina": J. A. **Woodburn.** Ancient copper workings, extending over a considerable area, exist at Messina, near the Limpopo, in the Northern Transvaal. Of these three distinct lodes are at present being worked. These lodes and their development were described and illustrated, and the methods of stoping, stope-filling, sinking and ventilating the shafts, sorting the ore and milling shortly explained.

Saturday, September 20th: A. Richardson, M.I.M.M., President, in the chair.—"The determination of the acidity or alkalinity of waters": Dr. J. **Moir.** Tables of 54 indicators and the effects produced on them were submitted in connection with which the author called attention to the misleading conclusions as to acidity of mine water or alkalinity of town water that may be drawn if filtrations are performed with indicators of a wrong class.—"The Sand-filling of mines": Dr. W. A. **Caldecott** and O.P. **Powell.** The general considerations relating to sand-filling were discussed; the methods in actual employment on certain mines at the present time were described, and details given of their cost.—"A system of keeping mine and mill accounts, costs and metallurgical records": M. W. **Maclachlan.** An outline of a system of centralisation of work in preparing mine operating costs, records and general accounts, as personally installed and supervised at a group of mines in Mexico.—"Ventilation of the mines of the Rand: The problem of obtaining healthier conditions": G. H. **Blenkinsop.** The author discussed shortly the underground conditions on the Rand, with the enquiry why a system of ventilation, which fulfils practically all needs in Europe, fails to attain the desired result on the Rand. In reply to this enquiry, the much higher daily mean temperature, and susceptibility to pulmonary complaints owing to high altitude, are placed foremost. The author proposes to substitute a blower method for fan ventilation in the mines, maintaining that the blowers would introduce constant supplies of fresh air, whereas fans neither lower the temperature of the mine air nor diminish its impurity.

Saturday, October 18th: A. Richardson, M.I.M.M., President, in the chair.—"Electric blasting": W. **Cullen,** T. **Donaldson,** and W. **Waters.** The endeavour of the authors was to show that the beneficial effects of electric blasting are not so much along the line of obtaining better blasting results as in bringing about improved health conditions for all underground workers. It diminishes the dust and smoke inseparable from the safety fuse; it removes the danger of premature explosions, and it is more economical than the safety fuse to the extent of £2 per 1,000 shots. The authors proceeded to describe a series of underground experiments carried on at the Meyer and Charlton mine, and concluded with details of the appliances required for electric blasting.

Saturday, November 16th: A. Richardson, M.I.M.M., President, in the chair.—"The natural soda deposits of Africa; with some notes on the alkali trade": J. **Watson.** Short descriptions were given of the soda lakes of Egypt, German East Africa, and Magadi, British East Africa. The author then proceeded to a more detailed account of the soda-pan at Zoutpan, 25 miles north of Pretoria, in connection with the working of which the South African Alkali Limited Liability Company has recently been formed. In this connection the establishment of a new South African industry was advocated and lines of operation suggested.—"Explosives in hand and machine labour stopes": T. D. **Delpart.** The author pointed out that notwithstanding the advantages which machine-holes for blasting have over hand-labour holes, a greater quantity of explosives is required in order to break a ton of reef in machine stopes than in hand-labour stopes.

The reasons of this were discussed and suggestions made for lowering the cost of explosives per ton of reef broken.—"The effect of charcoal in gold-bearing cyanide solutions, with reference to the precipitation of gold": M. **Green.** It was found that equal weights of finely crushed wood charcoal, agitated with gold-bearing cyanide solutions of equal strength, for lengths of time varying from three to 18 hours, in each case precipitated identical quantities of gold. It was also found that freshly-ignited wood charcoal precipitated 90 per cent. of the gold contained in a stock cyanide solution, while similar charcoal, after six months' exposure, precipitated only 50 per cent.; also that sugar charcoal obtained by heating sugar in closed retorts precipitated 62 per cent. of the gold, sugar charcoal prepared by treatment with sulphuric acid failed to precipitate any gold whatever. Discussing the underlying principles of the effect of charcoal in cyaniding, the author concluded that charcoal does not stop the passage of a dissolved substance through it by means of an osmotic effect, but that its power as a precipitant of gold from aurocyanide solution is due to occluded gases, loosely held gases having little or no influence. It appears to be mainly carbon monoxide that is responsible for the power of charcoal thus to precipitate gold.

South African Society of Civil Engineers.—Wednesday, September 10th: A. D. Tudhope, M.I.C.E., Vice-President, in the chair.—"The water supply of Kingwilliamstown": T. G. **Caink** The water is obtained from a catchment area of about 9,300 acres, consisting of forest-clad mountains rising to between 3,000 and 4,000 feet above the dam. Rain gauges near the top and bottom of the catchment area show 16-year averages of respectively 74 and 37 inches of rain per annum. The water shows a remarkable absence of silt, even after severe storms, and has no trace of the brown colour characteristic of Western Province rivers. The run-off from the catchment area amounted to 4,968 million gallons in 1911 and 1,080 million gallons in 1912. The dam is curvilinear on the middle portion, with a straight length on either side. Detailed descriptions of the construction of the dam, reservoir and pipe line were given by the author. The water, on reaching the town, passes through "Candy" filters, and the monthly consumption during 1912, by a population slightly over 9,000, of whom about 3,400 are natives, averaged close on thirteen million gallons.—"Notes on the casting and driving of reinforced concrete piles": H. A. **Fuhr.** A description of the operations involved in the construction of the Tyumie River Bridge, Alice, Victoria East, Cape.

Wednesday, October 8th: G. T. Nicholson, M.I.C.E., Vice-President, in the chair.—"The Stockton tunnel": A. **Colman.** The tunnel is on the Natal main line, between Mooi River and Estcourt, and constitutes a deviation whereby the high watershed, previously crossed by a deep open cutting at an altitude of 5,300 feet, is reduced in elevation to 4,080 feet, and the ruling gradients of 1 in 30 have been eased to 1 in 65, at a cost of half a mile of tunnel and a deviation two miles to the west.

South African Institution of Engineers.—Saturday, October 11th: Mr. W. Calder, President, in the chair.—"Air consumption and maintenance costs of rock drills": E. G. **Izod,** and E. J. **Laschinger.** Greater economy in the use of compressed air for transmission of power was urged. Air power is mainly used for actuating rock-drills, and on an average twice as much compressed air is used on a development shift as on a stoping shift. That large savings in the air-power bill of the mines may be effected is shown by the fact that in one group of mines, a saving of over one shilling per machine shift in the air power cost as between January and December, 1912, was brought about; in other words, there had been a saving of 1,205,038 air units, notwithstanding an increase in the number of rock-drill shifts during the same period from 73,926 to 78,545. With regard to maintenance, there had been a saving comparing January with December, of 51 shillings on every 52 machine shifts worked. Suggestions were made as to the lines along which such savings might be effected.

Saturday, November 8th: Mr. W. Calder, President, in the chair.—"Ventilation of Mines": W. **Pile.** The author insisted on the absolute necessity that a free and continuous supply of fresh air should be equally and efficiently distributed throughout each mine. He compared the "naturally" with the "mechanically" ventilated mines, and with those where a combination of "natural" ventilation with fans was employed. "Natural" ventilation he regarded as unreliable, and as the flow of air can be more easily induced than forced, fans would be more efficient if placed at the top of the upcast shafts. The system of blowers is not commended, as the forcing of air down a mine would raise its temperature, while the air itself, coming from the travelling roads would be impure and heated. The construction of large airways was suggested, and the constitution of a Ventilation Board, composed of practical men, in respect of each mining district.

Geological Society of South Africa.—Monday, November 17th: Dr. E. T. Mellor in the chair.—"Notes on a form of black diamond from the Premier Mine": D. P. **Macdonald** Specimens of this rather peculiar variety of diamond have been found distributed throughout the part of the pipe now being worked, and were not confined to any one locality in the mine. The largest piece weighs 104 carats. The physical characters of the diamond were described, as well as the effects noticed on heating fragments and powder under different conditions. The appearances, both of the diamond powder and of the sections under the microscope were described: throughout the specimens there is transparent carbon, but in mass the diamond is opaque, because of the density of the opaque particles scattered throughout its substance. In the muffle furnace the diamonds yielded a yellowish-brown ash, to the extent of 3 per cent. This ash was physically, microscopically, and chemically examined. The results observed were detailed, and the nature of the black carbon enclosed in the diamond discussed.

Rhodesia Scientific Association.—Wednesday, December 24th: Mr. H. B. Maufe, B.A., F.G.S., in the chair.—"The Mosquito Plague, and the necessity for eliminating the nuisance from the town": D. E. H. **Strong.** An account of the life-history of the mosquito was given, and the best means of securing its destruction discussed.

NEW BOOKS.

Fraser, Donald.—*Winning a primitive people: Sixteen years' work among the warlike tribe of the Ngoni and the Senga and Timbuka peoples of Central Africa.* 8 × 5 in., pp. 320. Maps and illus. London: Seeley, Service & Co., 1914. 5s.

Worsfold, S. N. Basil.—*The reconstruction of the new Colonies under Lord Milner.* 8vo. (2 vols.), pp. vi, 376, 429. London: Kegan Paul, Trench, Trübner & Co., 1913. 48 oz. 25s.

Markham, Violet R.—*The South African Scene.* 8vo., pp. vii, 450. London: Smith, Elder & Co., 1913. 24 oz. 7s. 6d.

Tremearne, Major A. J. N.—*Some Austral-African notes and anecdotes.* 9 × 5½ in. pp. xii, 215. Illus. London: Bate, Sons & Danielsson, 1913. 7s. 6d.

Macdonald, Dr, W.—*The conquest of the desert.* 9 × 5½ in., pp. xii, 197. Maps and illus. London: T. Werner Laurie, 1913. 7s. 6d.

THE PHALLUS CULT AMONGST THE BANTU; PARTICULARLY THE BAPEDI OF EASTERN TRANSVAAL.

By Rev. Johannes August Winter.

The following is a translation of a manuscript written by a native minister, Martinus Sebusane, on the subject of the *Koma*, or circumcision. It was revised by the native minister, J. Mphole. The pamphlet has been translated by me, and I have added my explanations. Many authors, amongst almost every nation, have written essays about the Phallus Cult, as one of the oldest Cults, nay, by many it has been spoken of as the very first religious Cult of men. In one of the back-numbers of the *Religious Psychology*—one of the best German periodicals dealing with religion and psychology in their relations to each other—many German, French, and English writers about the Phallus Cult are referred to. Some go so far as to make out that the Cross (Christian and others) was originally a symbol of this Cult.

The following is only a small contribution, useful to men who study and are interested in the scientific researches regarding original religion, especially the sacred rites of the aborigines of South Africa.

That the mystery of germinating life should draw the attention of simple human beings, and lead them into the belief in an unseen supernatural power, we can easily understand. The golden bull, the Apis Cult, amongst many other historical facts, prove it. In how far the Old Testament Circumcision has been influenced by this Egyptian Cult, is difficult to say. I dare say, however, that the following about the old Circumcision amongst our natives will induce the reader to think that this most sacred and most secret mysterious law is nothing but the Phallus Cult, or, at least, a remnant of it. The very symbols of breeding (*sit venia verbo!*) are praised in the hymns used throughout, from early to late, during this most sacred season of our natives. The very hymn is a Cult. All Cults have it.

Translation.

Koma is the name of the congregation of those going to be circumcised, of those who henceforth are no more to be seen or to have intercourse with those at home. The name means Mystery (Secret), it indicates also a very great matter of the highest importance. *Go bolla*—the word for what is going to be done—means: to go out.

The beginning of the Koma.—The young uncircumcised boys inform all their family connections, that they are going

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go uela (to fall in). They take off every kind of dress that they have been wearing before. The cattle are taken out, not allowed to be milked in the morning. In the evening they are milked in this way: The two preceding boys, those lately circumcised, thrash each other with long, heavy lathes of a special kind of shrub (*moretloa*). It is a sham-fight, the winners to have the right to milk.* All women and girls must grind grain. Lots of sweet milk-porridge is cooked, to be eaten next morning. Early next day all come together at the *Kgoro*.† A number of the most brave warriors distribute the porridge into the hands of the boys, thrashing them cruelly, calling out: *Dikgomo*! (The cattle!)‡ This ceremony is to teach them to be brave in war.‖ The boys, who, afraid of this severe thrashing, run away leaving their porridge, are called with that most ugly, indecent name *Mapshega*.§

After this they go out into the field, to have their hair cut, to do away with all childishness.¶ At sun-down all return to the Chief's fire and council place, where they eat and sleep, after walking round the kraal singing. They are not allowed to eat porridge, but must eat unground boiled grain mixed with soil. This food also, like everything else, has its special name. In fact, during this time nearly everything has another name, not the common words. This bad, dirty food is a symbol, to indicate: You are going to become men, who will marry wives who will cook nice, clean porridge for you. The songs all have the point to despise the boyish and childish state and to praise manhood.

The next day very early all go out into a lonely desert place. An old man is chosen by the Chief to perform the work of circumcising, in the same way as described in Genesis xvii. The præputium is cut off. All boys have to sit on a flat stone, all on the same stone, called *Setlalo*. All boys, who either themselves or through their mother, have some blemish on their character or family-name (*e.g.*, immorality, an adulteress as mother, etc.), are not allowed on this stone *Setlalo*, but must be circumcised on another stone called by the infamous name *tlaba*. The first boys operated on are those who are chosen to suffer before their Chief (son of their Chief); they are called *Malekadigale* (the triers). Then comes the highest in rank, then those of lesser rank, down to the lowest and poorest (servants and those taken as children

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* A certain number of years, generally from three to five, intervene between the *komas*. When natives wish to tell their age, they say: We are of such and such a *koma*. Each *koma* has, and keeps, its name.

† Fire- or council-place near mouth of cattle kraal.

‡ I have known natives who regard their cattle as something holy, who actually ask buyers: "Are cattle a thing to be sold?"

‖ No kraal is regarded as defeated, the cattle of which are not taken.

§ Men suffering from diarrhœa.

¶ The proper hair-cutting designating the different tribes, is done when the time of the circumcision—generally three months—is over.

from defeated kraals). A water-melon is cut, pieces of which may be sucked by those suffering from faintness because of loss of blood. When all is over they are told the old formula: *Seo ki Tiroane-tiroa-magongoana magoshi a go fela ba diriloe seo.* meaning: "All chiefs and all men of all times have been marked by this mark." Now they are called *Madikana* (the hidden ones). No eye is allowed to look upon them, except those who have formerly gone through this process. Women and *Mashiboro* (uncircumcised) must run away whenever they hear the special songs and hymns, singing which they roam over berg and dale. The elder boys (last and second last before these) now commence to thrash each other, as also the freshlings, with cruel big rods. Hymns and songs, fixed from the oldest times, in praise of manliness, in praise of the female parts—exceedingly indecent—are now sung from early to late during their ceaseless excursion from sunrise to sunset.

After the operation, skins or blankets are cut into broad strips reaching from hip to knee, and called *Motshabelo.* The thin lines to keep these must be so tied that nothing of them can be seen. Their name is *Kgoyana*, which means: "What is hidden must not be seen!"

The first thing to be done after the circumcision is this: The elder boys must hurry to the place, the most sacred place of their home, the sleeping and eating place, called *Mpato.* This is a kind of kraal, made of big branches freshly cut, with two openings, one for the old circumcised and one for this year's boys. Any of the latter entering by the other opening is mercilessly killed (even now). As soon as the elder boys arrive, after the ceremony, they start kindling the "holy fire," never by matches, but always by rubbing two sticks (one of hard, one of soft wood) till a flame appears. This fire must never be allowed to die out during the three months, day or night. During rain they cover it as best they can. This is the only fire to be used by them, no second fire or firebrand otherwise taken may be used. When the *Madikana* are brought there, everybody is shown his own sitting, kneeling, and sleeping place, in the same rank and order in which they have been circumcised. They are ordered to sleep on their back with widely spread out legs, taking great care that no blood touches any other part of their bodies. Only the ruling Chief's eldest son is allowed to use a blanket in the night. Before sleeping they are allowed only to kneel, but not to sit. Plenty of food is given them; in fact, they are purposely fattened like pigs, because it is a shame to bring them back to their home in a meagre condition. The porridge is cut with sticks by the elder boys and given into their open hands. On the day of New Moon no food at all is eaten—it is a fast-day. If during the eating a boy coughs, all eating is at once stopped. All teaching is thrashed into them. The greatest amount of thrashing is accompanied by: "Obey your Chief." They are taught to regard him* as their God. Whenever they see a Chief they must all kneel down, clapping their hands and shouting the necessary greeting: *Moriba*, and looking down as if not worthy to look at him. All men, meeting them, must also be greeted in nearly the same way. Certain fixed formulæ are used, for this greeting as well as for the answers from the men. The men usually answer the following: *Tsikana, ea rara ea matenoa, ka tipa madi a falala, ba ri: ga se madi ao ki malakapetla madi a basadi a bo-mmaoenu li dikgaitshedi.*" Which sentence signifies that they are not to think too much of their blood, it being only blood like those of women, their mothers and sisters. After some days they are given some feathers (ostrich or pigeons) and driven into a pool of water to wash and soften the wounds. All this is accompanied by thrashings. When the sores are healed, there commences their eternal roaming round about, under chosen leaders, accompanied by elder boys with rods. Then they are compelled to sing all their old hymns and songs, all kinds of manners and customs being also thrashed into them, all that a man could and should do, especially in relation to women. They are often thrashed on the soles of their naked feet, with the words: "A man ought to have shoes" (sandals). Further thrashing: "Always obey your father, never obey your mother." Before eating, morning and evening, they receive lashes on their fingers: "A man does not eat with unclean hands," compelling them to wash their hands. They receive lashes on the tips of all fingers of their left hands joined together, to teach them how to commence using the female parts. With a hot burning rod they are thrashed between the parts of their posteriors,†to teach them cleanliness there, and not to use open places or near their homes for defilement. Good and bad teachings are strangely mixed! An instance of a good one: An elder boy says to the *Madikana*, "I am going to sleep with a girl or woman"—then all must cry out: *Matsoèra*!‡ spitting out before him, as before a nasty filthy thing. When crossing footpaths, where women usually go or have just passed, all cry out the same bad word. It seems to be impressed upon them, both the use of women, and at the same time to despise all women as a lower, unclean class. Another teaching is called: *Mogano*. They receive cruel wounds in their neck, to teach them to have done with all impudence, disrespect and disobedience, in fact, to teach them humility before elders. Uncircumcised boys are called *Mashiboro*, which means: quarrelsome, disrespectful ones. Another cruel practice with their fingers, to teach them no longer to steal milk, when milking goats, is called: *Go amusha dipudi*."

Besides these cruel and often immoral and indecent lessons, they have to roam about in the hills to catch game, or to cut poles for the Chief's use, or other work done for the Chief.

* Who is often called the *Poo*, the bull of their home.

† They call it: *Go roka*, to sew.

‡ An infamous word.

Always in the afternoon, when approaching their *Mpato*, the elders cry out: *Tsoai la ntsoetsoe.*"* Whereupon the *Madikani* have to answer: *Mafefo!*† In connection with this they are instructed to make use also of a dead brother's wife, to obtain children for the dead brother.

When the time is near to bring them back to the home-kraal, the men make an image of a naked man from soft wood. Before this all must kneel down and with bent heads greet it with the name of one of their old famous Chiefs. Images of game are also made round it, coloured with clay, lime, coal and ochre. Then this special *Mpato* is given the name by which it will always be known, *e.g.*, *Matooba* (that of Chief Sekukuni), *Masoene*, *Manala*, *Magasa*, *Makoa*. Every boy now also gets his own new name. Before leaving they build two little stone-heaps with the image of a hyæna made of clay (and also coloured like one), called *Piri*. This the new men destroy. Then all the men sing and dance in praise of the new men, holding long rods upwards, no more to thrash—called: *Naka tsha koma* (horns of the *koma*).

After this all are well washed, the hair cut, fresh loin-bands put on (either from klipspringers or sheep), their bodies are well greased and rubbed in with *Letsuku*,‡ a last heavy thrashing is given with the shout: *Bonna ki byo!* (This is to be a man)—and with tremendous shouting, dancing, and singing in the afternoon, they are at last brought home to their kraal—as men.

All things used during those months are burnt down. The boys are strictly forbidden to look back at them and at the place, when they go home.

Now they are men. They have been told, that from now, they will be judged as men, no more like children.

One or two experiences added by the Translator.

Years ago, long before the war—when that splendid Paramount Chief Kgolokoe was ruling the Sekukuni country, and I was at my station under the Eastern Precipices of the Lolu Mountains—one day a messenger from the Chief came to inform me of the death of Selatole, the Chief's brother. On the afternoon of the next day I went up with my few men, who had black bands round their arms, driving up also a black ox from me, according to the usual way of friendly Chiefs to show their sorrow. When on top of the Mountain, an *Induna*, sent by the Chief, asked me not to use my usual bridle-path, but to go by another on the left side. When asked: 'Why?" he said: "Our *Koma* is on this path, and nobody can use it." I became very angry, and said: "Never in my life have I turned out of my way

* Sweet salt—meaning soon to be able to use women.
† A cry of astonished wonder.
‡ A yellow-brown ochre from burnt slate with iron particles.

because of Satan's festivals."* I flatly refused, and, although late and already dark, I preferred to go home down the bad kloof, but allowed my men and the ox to go on by the other path. Early next morning a messenger arrived, saying: "The Chief is deeply sorry for my turning back, and also that he could not accept an ox given with averted head." But I still refused. A week passed. Many Chiefs going up and returning passed my house. At last a Christian Chief, whom I had baptised, also returned, and gave me a message from Chief Kgolokoe, that, if I would inform him of the day and time of my coming, he would arrange with the headman of the *Koma*, to hide the boys in the long grass, so that I may use my usual bridle path. The very next day I went. I saw the *Koma*-boys from afar lying down in the grass. The Chief received me very kindly. I found my ox still alive, and, after the customary inquiries into the sickness and death, and expressions of my sorrow, I handed it over. In answer, I had a beautiful black ox, which I ordered to be killed. The kraal was under a low hill, on top of which the *Mpato* of the *Koma* was. We heard the continual singing of the boys. Knowing that when a friendly Chief visits the Capital, they often let these boys have a quiet rest, I told the Chief to send word up, and let them rest. After a little while there was a loud shout, *Reke-reke boroko*, of thanks, and so they were allowed a rest.

When, not very long ago, I visited Mr. Haigh, at a store at Sekukuni's kraal, at the bottom of the hill, on which the *Mpato* was, Mr. Haigh told me that his horse went astray, and that it was very likely somewhere half way up the hill. Upon my saying: "Why don't you go and fetch it?" he said: "That would be as much as my life is worth."

Once, in 1888, I had the pleasure and honour to receive our then Administrator, Sir Owen Lanyon, at my house. In our talk we also touched upon the *Koma*, and the possibility or impossibility of the Government having some supervision over these secret proceedings, during which boys are often killed and nobody allowed to talk of it. Neither then nor later, up to the present day even, could the Government in any way obtain any right to interfere. I mention this only to show how secret this half cult half custom is kept, being the very backbone of our Natives' national life.

SYNTHETIC MILK.—A factory is about to be established in Liverpool for the manufacture of synthetic milk from soya beans and other ingredients. The ground beans will be treated with a small proportion of sodium phosphate, and just brought to the boil with water. After addition of sesame oil, milk sugar, and salt, the milky liquor will be filtered and sold to dealers at 2d. per quart.

* I regard this *koma* as the heathen baptism, although Livingstone says that he found nothing to find fault with in it.

THE CONDITION OF THE NATIVES OF SOUTH-EAST AFRICA IN THE SIXTEENTH CENTURY, ACCORDING TO THE EARLY PORTUGUESE DOCUMENTS.

By Rev. Henri A. Junod

What is the origin of the South African Bantu, and, if this cannot be discovered, what are, at least, the influences which have brought about the peculiar features of their social and psychic life, their customs, their special ideas, their characteristic rites? Did they borrow them from other people, or are these customs absolutely underived? What is, in one word, the secret of their past?

If we consult the Natives themselves on these questions, on which every student of mankind would be very glad to get a trustworthy answer, we must confess that the information they give is very unsatisfactory. They still remember vaguely some historical events which happened a hundred years ago. They have kept the memory of political changes and of migrations which took place from 200 to 400 years ago. They possess the genealogies of chiefs of their clans which number eight to twelve names, and which may reach somewhat further back in the past. But legendary traits are mingled with the historical facts, and, when asked about their origin, they either say: "We do not know," or they answer by the well-known story of the reed and the chameleon. This is pure myth.*

The Portuguese displayed considerable activity in this part of the world during the sixteenth century. Have they not left documents which would supplement this scanty Native information? In a review of the first volume of the book just referred to, the *Lourenço Marques Guardian* put forth some hypotheses on the origin of the Delagoa Bay Natives, and expressed the wish that I should go to Lisbon and there study the Portuguese archives, so as to throw more light on the question. It happens, in fact, that I have lately had the opportunity of staying in Portugal for two months, and I tried to find those precious documents. Owing to the courtesy of the directors of the Geographical Society, I had access to their fine library, but I came to the conclusion that sixteenth century documents on the Natives of South Africa are very few. The best report dealing with our tribes is certainly the book of the Dominican brother João dos Santos, *Ethiopia oriental e varias historias de cousas notaveis do Orient*, printed in Evora in 1609, in which he describes what he saw in Sofala and Tete. Is this work, in which the splendours of the Monomotapa kingdom are revealed, entirely trustworthy? It is hard to say. As it deals rather with Central than with Southern Africa, and as Dr. Theal in his book, *The Portuguese in East Africa*, has sufficiently made it known to modern readers,

* Compare my work on "The Life of a South African Tribe," Vol. II, p. 326-328.

I did not spend much time in studying it. The Decades of João de Barros and of Diogo de Couto also contain much interesting material, but they relate military feats accomplished by the Portuguese in India and East Africa rather than ethnographical facts. The most interesting documents which I met with are the reports of four shipwrecks which occurred on the coast of Natal and Delagoa Bay between 1550 and 1598, which were incorporated by Gomes de Brito in his *Historia tragicomaritima*, published in 1736 in ten volumes. This extensive work was reproduced in 1904 in the *Bibliotheca de classicos portuguezes*, and the wrecks which interest us more directly are described in Vols. I, IV and V of that edition. I have found since then that these stories were reproduced in Vols. I and II of the Records of South East Africa, published by the Cape Government. The Portuguese text is given, together with the English translation, and one may be thankful that these records, written without any preconceived idea in the most genuine and simple way, historical documents of the best type, have thus been put within the reach of the South African public.

The same collection contains letters of two Jesuit Brethren who made an attempt to convert the Natives in the neighbourhood of Inhambane in 1560-1562. These letters coming from men whose first object was to influence the minds and hearts of the Natives and who stayed amongst them a certain time, trying to understand them, have even more value than the records of the shipwrecks for the solution of the question which I have put in the beginning.

I confess that all these documents are not absolutely new, but they have not yet been studied with a sufficient knowledge of the Natives of to-day, and they certainly contain most precious details on the condition of the Black tribes of South East Africa 300 to 350 years ago. Shall we find in them glimpses of a further past? This remains to be seen.

In the first part of this paper, I intend giving the contents of the documents on which our study bears and a short resumé of the doings of their heroes; then, we shall extract from them what information they contain about the Natives of these prehistoric times, more particularly about those of Delagoa Bay, who played quite a prominent part in these tragic events.

PART I. THE DOCUMENTS.

Delagoa Bay was discovered in the beginning of the 16th century by Antonio de Campo, the captain of one of the ships which composed the second fleet of Vasco da Gama. It was only in 1554 that two Portuguese of Mozambique, Lourenço Marques and Antonio Caldeira undertook an exploration in the country round it. They were very successful. Having penerated into the interior by a river which reaches the sea on the 25° South latitude (evidently the Limpopo) they found the Natives disposed to sell copper, "which they had in abundance"; they also saw a great many elephants, and the Blacks sold them tusks on very favourable conditions. For some beads worth three vintens (three pence) they could get ivory worth 100 cruzades (which means in the present currency about £7) Lourenço Marques sent a request to the Vice Rey of India, Dom João de Castro, who forwarded it to the King of Portugal, Dom João III, and the King gave orders to provide the explorer with a ship loaded with goods for barter in the Bay. This was the beginning of regular commercial transactions between the Portuguese of Mozambique and the Natives of these regions. Each year a "pangaio," *viz.*, a boat made of planks sewn together, went to Delagoa; the sailors stayed in the little uninhabited Elephant Island (which D. de Couto calls Sentimuro) for months, feeling themselves there better protected against any possible attack and visiting the interior as far as they could, following the rivers; they exchanged their goods, which consisted of beads of iron, and stuff, against ivory and occasionally amber. Later on, in 1580, the pagaio came only every second year. A regular traffic was also started with Inhambane in 1550 to 1590.

These facts must be known in order that one may understand that, for those rescued from the wrecked ships, the Bay of Lourenço Marques or Rio de Santo Espirito was the great hope of salvation. It was also called Bahia de Alagoa, the Bay of the Lake, because the Portuguese believed that one or two of the rivers flowing into it came from a big lake in the interior, that from which flowed also the Nile to the North and the Zambesi or Cuama to the West.

1. *The Galleon S. João.*

This was the richest of all the ships that had yet left India for Portugal. Her cargo was said to be worth one conto of gold. One can guess the importance of the galleon by the fact that the crew and passengers numbered about 600 souls, 200 Portuguese and 300 to 400 slaves. She was wrecked on the coast somewhere on 31° S.; 40 Portuguese and 60 slaves died, and the 500 persons remaining, amongst them some women of the best families of Portugal, succeeded in saving only very little of their goods and a portion of their provision of rice. Their journey to Delagoa Bay has been told by an anonymous writer, who obtained the particulars from the "guardian" of the ship, Alvarao Fernandes. The captain, Manuel Souza, took the lead; he had with him his wife, Dona Leonora, and his uncle, Panteleon de Sá. They decided to follow the border of the sea, and started on the 7th of July. The distance to be covered was 181 leagues in a direct line; but they travelled more than 300 leagues, owing to the difficulty of the road. The first month they lived very poorly on their rice; later on, they began to buy some food from the Natives, but it seems that they did not know how to deal properly with them; they often had to fight with them in order to open their way; they endured untold sufferings from hunger, still more from thirst, living on fruit of the veld, on shells and fish of the sea. More than 300 died on the road. After three months they reached the Bay. The chronicler says:

> They then met with a Kaffir, master of two villages, an old man who seemed to them of good condition, to be well disposed, and who proved himself to be such by the hospitality which they received from him; he told them not to go further, but to settle with him, and that he would do his best to help them. indeed, this country was poor in means of subsistence, not that it could not produce them, but because the Kaffirs were people who only sowed very few seeds and ate nothing but the beasts which they killed.

This man was the chief of Inhaca to whom Lourenço Marques had given the surname of Garcia de Sa, the name of the commander of Malacca, because his features were somewhat like those of that official. He tried to keep the party near him, telling them that on the Northern side of the Bay, there was a chief with whom he was fighting, a great robber who would certainly do them harm. The Portuguese, wishing to show their gratitude for the kind reception received from the Inhaca chief, consented to help him to subjugate another petty chief, six leagues to the South, who had revolted against him. So Pantaleon de Sá and twenty white men accompanied the 500 warriors of the native king and defeated his enemy, bringing back all his cattle as a prize. The Portuguese still numbered 120. But they insisted on going forward. They crossed a river (one now called the Maputo River), and with great difficulty a second one (Tembe and Umbelozi). But, during the crossing, Manuel de Souza lost patience and, with his spear, he threatened the Natives, who were to take the white men over in canoes. His companions told him to take care, that this action would bring disaster on the whole party. But he was out of his senses. His reason was giving way under the burden of his responsibilities and the greatness of his sufferings. They all crossed the river, but on the other side (which is the present Matjolo country), the native chief compelled them to give up their guns, saying his people would not dare to stay with white men as long as these had these frightful engines in their possession; then he scattered them all over the land, and when they were totally unable to defend themselves, the Kaffirs robbed them of everything they possessed. They stripped them of their clothes. For a time Manuel de Souza and his wife were spared this disgrace, but they had to submit to it after all. Dona Leonora, who was a *fidalga* (a person of noble extraction), after having behaved in an admirable way all through the journey, was so grieved by this shameful treatment and the death of her child, which then took place, that she died miserably. Her husband buried her and fled to the bush, half mad. Then he disappeared., probably eaten by wild beasts. His rings were found later on in a forest of the Mpfumu country, and the chief showed them to the Portuguese who visited him. Most of the companions of M. de Souza met the same fate. The ship for Delagoa Bay had already returned to Mozambique. The one which came in 1553 found eight Portuguese still living and seventeen slaves, who were brought back to that town on May 25th, 1553. The narrative of the terrible loss of the San João is well written and most touching, but not being by a witness, it contains very little information on the Natives, no names at all; so it is of no great use for our purpose.

2. *The San Bento* (*St. Benoit*), 1554.

The story of this wreck, on the contrary, is most interesting, as it was written by Manuel de Mesquita Perestrello, a well educated man who was one of the passengers. The ship contained about 400 persons, and 322 were rescued, 98 Portuguese and 224 slaves. They had managed to save a gun, twelve loads of ammunition, and many spears. They came on shore at about the same place as the San João, and also followed the road by the border of the sea. But they had very few goods for barter, and thus suffered terribly from hunger. Their captain, F. de Alvares Cabral, died when crossing Santa Luzia River; they wandered fourteen days round a bay, which they called Rio dos Medôas de Ouro, and which must be Kosi Bay, and lost not less than twenty persons during that time. A tribe of robbers attacked them in these regions: some shots from the only gun saved made such a wonderful impression that as the chronicler says,

> When they heard the noise, it was as if devils had jumped on them; they scattered and fled so quickly that they disappeared in a minute.

But fighting with Natives was dangerous for them as it cut short any supply of food they might have obtained from them. A terrible famine began to decimate them. Perestrello describes it in the following words:—

> Some of us were forced to eat their own boots . . . . and if someone found a bone of a wild beast quite dry, as white as snow, they ate it, reducing it to charcoal as if it were a real treat. All were looking at the veld to see if they could discover any herb, bone or insect . . . . and if one of these things appeared before them, they all ran to take it and often they quarrelled, friend with friend, relative with relative, for a locust, or an insect, or a caterpillar. After having walked three days doing this, we reached a hill where they were many wild onions; though we suspected them of being poisonous, we took them and made our meal of them, and it pleased Our Lord that they did not harm us.

Four sailors were then sent forward to inform the captain of the ship in Delagoa Bay of the presence of this party, if perchance the ship had not yet returned to Mozambique. Dying of hunger they killed a native on their way and ate him. This did not prepare a nice reception for the party coming behind. They had one day to fight in the same circumstances as the soldiers of Leonidas:—

> The Kaffirs attacked us, throwing so many assegais at us that all the air was full of a cloud of them.

The fight lasted two hours and, if they escaped, it was only owing to their gun which struck the Natives with terror and cleared the way. Another time, one of the enemy having been killed with the assegai, the whole party discussed if they would not eat him to relieve the pangs of hunger.

According to what was whispered it was not the first time that the misfortunes of this journey had pushed some to taste human flesh. But the captain did not consent to it, saying that, should the news scatter, that we eat natives, these would flee before us to the end of the world and would persecute us with much more hatred.

They were at their worst, when happily a messenger came from the chief of Inhaca; he had heard of them and offered them hospitality, saying that he was the brother of the White men who frequently came to the Bay, and to whom he sold much ivory in exchange for beads (contas). This was a great relief. The Inhaca subjects consented to sell produce for money which the Natives further South had always refused. Those who reached the Bay were fifty-six Portuguese and six slaves. They had travelled for 72 days and covered 300 leagues.

What a miserable life they led in Inhaca's country for five months, decimated by hunger and leopards, covered with vermin, obliged to cut wood, to carry water for the Natives in order to receive some food and save their lives. The report of Perestrello describes it in most touching terms. At last, in November, 1554, Perestrello, who was settled in the island of Inhaca, one day saw a sail on the sea, a ship; he fell on his knees, blessing God for His mercy; this was salvation. But of all the party, only twenty Portuguese and three slaves succeeded in reaching Mozambique. The story of Perestrello is full of charm and of interesting remarks. As he remained five months at the Bay, he was able to see much of the Natives, and his report contains many precious details about the subject which interests us.

3. *The San Thomé.*

Thirty-five years later, in 1589, another ship was lost in the neighbourhood of Delagoa Bay. This was the *San Thomé*, whose captain was Dom Paolo de Lima. On March 22nd, she was wrecked on the shore of the Terra dos Fumos, the country of the smokes, so named by the Portuguese narrators because, when passing near it, they always noticed much smoke, a proof that it was thickly populated.* Ninety-six persons were saved. In this ship travelled also Diogo de Couto, the author of the Decades, one of the principal historians of that time. He wrote the record of the year 1611. This is also the work of a witness and not of an ordinary individual, but of a practised writer, of a man who took an interest in the land and its inhabitants, and possessed a real gift of observation.

The country of Fumos is on $27\frac{1}{2}°$ south latitude; it is the present Amatongaland, only 50 leagues distant from Lourenço

* One must not confound the Terra dos Fumos with the country of Fumo or Vumo or Rumo on the North of the Bay. *Fumos*, in the first case, is the Portuguese word for smoke, in the second the name of a native chief, or, rather, clan, as will be seen later on.

Marques. So the rescue of the party seemed to be an easy thing. However, the travellers had any amount of difficulties in reaching the kraal of Inhaca. There they heard that the Mozambique ship had left the Bay ten days before. The chief who behaved very well towards the unfortunate Portuguese led them at their request to the Island Setimuro, where they found more than fifty huts built by the traders There they settled, but as the ship had gone, most of the sailors crossed the Bay in two boats which they found there, wishing to continue their journey to the North and to send larger vessels from Inhambane or Sofala to save the thirty-six who had remained behind. The two boats were separated from each other by a terrible hurricane. The smaller one found the mouth of the Manhiça (Nkomati) River,* reached the capital of the chief of Manhiça, and had the good fortune to find there Jeronymo de Leitaõ, the master of the Mozambique ship, whose pangaio had been wrecked near the Rio do Ouro (Limpopo), and who had taken a refuge near the Manhiça chief. Jeronymo immediately sent a letter to Sofala to ask for help, and the whole party crossed the Bay and joined the others at Manhica. The second boat was wrecked not far from the mouth of the Limpopo, but the men were saved and well received by the chief Inhapula, who gave them guides to go to Inhambane. They reached their destination, passing through different clans whose names Couto quotes carefully, thus giving us a precious account of the tribes between Lourenço Marques and Inhambane. Having found no help in this last port, they went on to Sofala. When they reached that place, a pangaio had already sailed to rescue Paolo de Lima and his party. But the old man died before that ship came. The report of Couto ends here; he does not say how many others left their bones on the shores of Delagoa Bay and how many returned to Mozambique.

4. *The San Alberto.*

This was the last of the four wrecks. It took place in 1593, four years after that of the *San Thomé.* The ship had 347 passengers on board, 163 Portuguese and 194 slaves. She went ashore on the Natal coast, in the same region as the *San João* and the *San Bento.* But the story of the rescue of the party is wonderful. It illustrates the old Greek proverb, "An army of deer commanded by a lion is stronger than an army of lions commanded by a deer." The captain of the party, Nuna Velho Pereira, was a man full of courage, of wisdom, and of personal

* The story as told by Diogo de Couto is almost impossible to understand in its actual form, as the manuscript was evidently altered. In its second half the word "Inhaca" is regularly employed instead of "Manhiça," and "Manhiça" instead of "Inhaca." . . . . As "Inhaca" is south and "Manhiça" north of the Bay, this error makes the movements of the party absolutely incomprehensible. Having discovered the mistake, which was committed probably by the printers later on, I have been able to restore the original text, and the whole story becomes quite clear.

force, who succeeded in saving 182 persons out of 285 who reached the shore. The voyage lasted three months, and covered more than 500 leagues. Having heard of the awful difficulties met by the *San João* and *San Bento's* crews, Pereira decided to travel inland and not along the coast, trusting that he would find more means of subsistence, and that the rivers would be easier to cross. His expectations were partially fulfilled. But what helped him most was the kindness united with firmness which he always showed to the natives, preventing his people from plundering the plantations, paying regularly for all that he bought by means of bits of copper and iron, adorning children and women with ordinary beads or beads of crystal taken from rosaries, which had happily come to the shore after the wreck, etc. Nuna Velho Pereira did so well that the Natives of Zululand said the white men were just like the black, and differed only from them in their colour. In some places, they kissed the Portuguese on their faces and accompanied them dancing and singing. How different from the dreadful experiences of the earlier parties. So his journey was a kind of triumphal crossing of all Caffraria (as the Portuguese called this coast) with almost no fighting; he bought a great number of cattle, which the party took with them, eating them when they had to cross deserts. They still had nineteen with them when they reached Inhaça; they had the good luck to find there the traders' ship, which only came every second year. Most of the party could embark in it for Mozambique.

The story of the wreck was written by João Baptista Lavanha, "Cosmografomór de Sua Magestade," in 1614, from a detailed account by the pilot of the ship. It contains the names of most of the petty chiefs which the party found from 32° south latitude up to Inhaça Island, and this list is most valuable.

Though the subject of this paper is the condition of the Natives in the 16th century, and not that of the Portuguese of that time, I will not proceed further without insisting on the strong religious faith which animated and comforted these men through the horrors of their peregrinations. The anonymous chronicler of the wreck of the *San João* says his aim in telling this story was to teach the men who travel on the sea to recommend themselves constantly to God and to the Virgin that she should pray for them all. In their order of march throughout the country they generally put in front a priest or the pilot carrying the crucifix. In all their misfortunes, they saw the finger of God, a punishment for their bad deeds. Relating the terrible journey round Kosi Bay, Perestrello says:

No doubt, if someone had seen us, from the top of these hills (may he be one of the savages living in the midst of these inhabited mountains) marching naked, without boots, weary and strangers, lost, and in awful necessity, feeding on raw herbs, of which even we did not find enough for our needs, he would have thought we had gravely sinned against God, because, if our sins had been small, His mercy would not have allowed such heavy punishment to fall on such miserable bodies. . . . . Having given up all hope of escaping from those marshes by human power, we resolved to have recourse to the Divine One. So, having all fallen on our knees, in prayer, we asked Our Lady by her holy Conception to obtain for us from her glorious Son another miracle similar to that which He made for the Children of Israel when they left Egypt and passed the Red Sea . . . . . that we might that same day find a way through the marsh which seemed impossible to cross, and there, owing to her guidance, we found the way through to the other side. Having witnessed such an evident miracle, we again bent our knees, promising to make a pilgrimage to Nossa Senhora de Guadeloupa and a solemn missa . . . . . and, in order to show us clearly by whose hand this work had been done, and that the manna of the desert would not be wanting, we found many cocoa nuts on wild palm trees, etc.

Perestrello certainly was a mystic, a mystic of the right sort; Lavanha is more matter of fact. He says he has written his report to give useful indications to the sailors who may fall into similar misfortune. However, in his story also, the religious fervour is not wanting. See what Nuna Velho Pereira, the distinguished Captain of the rescued party did when taking leave of the Chief Gamabela, on 27° South Latitude, a few days before reaching the end of his travels:

We were all thankful for the kind welcome received from this Kaffir; and he himself was no less pleased to have offered it to us. So he asked Nuna Velho to give him something which he might keep in remembrance of him and of all the Portuguese accompanying him. Nuna Velho answered that he would act according to the request, and would give him the most precious treasure which was in the world. So taking the cross which was hanging on his chest, and taking off his hat, he raised his eyes to Heaven and with great devotion kissed it; then he gave it to the Portuguese who were near him, who performed the same ceremony, and to the chief, saying this was the sacred token of his friendship, and that he ought to show it the same respect as he had seen our people do. The barbarian took it and kissed it with the same reverence, putting it to his eyes; so did all the Natives. And seeing this, Nuna Velho ordered the carpenter to make a cross from the branch of a tree. It was made and was eight palms in length. Nuna Velho handed it to Gamabela, telling him that on such a tree the Author of Life had overcome death by his own death, that it was the remedy against death, the health of the sick and that by the power of this sign the great Emperors had won victories. . . So that the chief ought to put the cross on his hut and every morning, when leaving his hut, he ought to show respect to this cross by kissing it, and to adore it on his knees, asking help of it with confidence when health was failing amongst his subjects or when rain was wanting for his gardens. . . . With these words he gave this royal trophy and unique glory of Christianity to the headman, who took it on his shoulders, and with his men, who numbered about 500, he went to his village to do what Nuna Velho had told him. In this way the Holy Cross was planted by this virtuous noble man in the very midst of Caffraria, centre of the heathenism over which to-day it is triumphant. . . . May God Our Lord be pleased to enlighten the minds of these poor heathens, so that holding firmly that trustworthy Cross which remained amongst them, they may be saved from perdition and from the blindness in which they live.

Is not the religious candour of these men most touching? Of course, the hope of saving Native tribes from the power of heathenism by a mere substitution of the catholic rites for those of the animistic religion was most childish, and we know that other and more spiritual methods are needed to reach such an end. However, there was an evident earnestness in those men of old, and their faith gave them strength and hope in their terrible journeys.

The same can certainly be said of the Jesuit Fathers who undertook to convert the Kalanga tribe, located thirty leagues to the South-West of Inhambane, and who wrote the letters to which I alluded. A son of the Chief of that tribe had gone to Mozambique, and, after having been received with great honours, he had been converted there and baptised. He therefore asked the Portuguese to send missionaries to his home. The request was agreed to, and Goncalo da Silveira, a nobleman of Portugal, started in 1560, from Goa, with another brother, André Fernandez, to found the mission. They had great success; at least, they thought they had, because in the seven weeks of their stay at Otongwe, the capital of the chief Gamba, they baptized 450 persons, the chief, his sons, his wives, etc. Gonçalo, leaving the kraal after these few weeks, was most enthusiastic and hopeful. Alas! The good Fathers had considered as true conversion what was merely external adhesion to a doctrine very imperfectly understood. Fernandez, who had remained on the spot, very soon noticed it. The Black Christians did not abandon a single one of their superstitions, and, when warned by their missionary that the old animistic practices were inconsistent with their new faith, the Chief and his men rebuked him, left him all by himself, even threatened him, and the mission ended miserably after two years, leaving absolutely no trace. We shall see directly what customs and ideas Fernandez discovered amongst these strange converts.

PART II.—WHAT THESE DOCUMENTS TEACH US ABOUT THE NATIVES OF SOUTH-EAST AFRICA.

1. *The names of the sixteenth century tribes compared with those of to-day.*

First of all, what were the tribes inhabiting the South-East Coast of Africa in those times? According to Dr. Theal:

> In all the region traversed by the crews of the wrecked ships, not a single tribe is mentioned of the same name as any one still existing now;

and the Cape historiographer adds:

> It would serve no useful purpose to give the names of the tribes round Delagoa Bay and further north, as placed on record by the Portuguese writers, for, even if these names were accurate at the time, the communities that bore them have long since ceased to exist and never did anything to merit a place in history.

I am sorry to contradict the distinguished gentleman to whom we owe so much excellent work on South African history, but these assertions do not correspond to the facts. For convenience of discussion, let us consider first the Delagoa tribes, then those South of the Bay, and, thirdly, those North of Delagoa.

As regards the tribes round Delagoa Bay, with which I am best acquainted, the situation was almost exactly the same in 1550 as it was before the Gungunyana war. We possess three descriptions of the Bay, descriptions containing names: the first, of Perestrello (Hist. trag.-mar. I, p. 130); the second, of Diogo de Couto (IV, p. 100); the third, of Lavanha (V, p. 82). They mention five chiefs inhabiting the borders of the Bay, two on the Southern side, and three on the Northern side—Vumo, Lebombo and Manhiça. Let us consider these names.

The name of "Inhaca" (Nyaka), the old friend of the Portuguese, is well known up to this day, being applied especially to the island which lies to the East of the Bay. In former times, the kingdom of this Chief extended much further South. He is one of those who were deprived of their dominion by the growth of the Maputju clan, to which we shall refer directly. The Maputju defeated Mutlhobotahomu, the descendant of Nyaka, but this tribe still exists, though it has lost its independence, and "those of Nyaka" (*ba-ka-Nyaka*) still greet each other by saying: "*Shawan, Nyaka*";" I greet you, Nyaka."

Zembe is evidently the actual *Tembe*, a clan which has played a great part in the history of the Bay, especially in the Anglo-Portuguese contest about the possession of the country. (See the Memoirs concerning the arbitration of President MacMahon, in 1873). Why the old Portuguese writers spell Zembe instead of Tembe I cannot explain. This is probably a mistake made by Perestrello, and adopted later on by Lavanha.*

The name "Tembe" applies in a special way to the ancient Chief who is considered as having founded the royal family, but also to all his descendants, by whom it is used as a kind of family name; it has also become the name of the river Tembe, called by the Natives *Mi-Tembe* (*viz.*, daughter of Tembe, as rivers are considered as feminine by these tribes.†

On the Northern side we find mentioned *Rumo* (I, p. 130; IV, p. 102), or *Vumo* (IV, p. 103), or *Fumo* (V, p. 83), evidently Mpfumo, the most celebrated of the Delagoa little kingdoms, which ceased to exist as an independent clan after the war of 1894. *Mena Lebombo* is probably Libombo, who was one of the first invaders of the Nondwane country on the Western border of the estuary of the Nkomati. This word *Mena*, put by Perestrello before Lebombo, means: I, myself. The chronicler may have heard that Chief tell his name by saying: "*Hi mena Lebombo*"; "I am Lebombo"; and he believed this *Mena* to be a part of the name. Lebombo was first located in the Lebombo hills.

Manhiça is well known up to this day, and the "*ba-ka-*

* Diogo de Couto does not mention this name.

† "The Life of a South African Tribe," II, p. 301.

Manyisa" form one of the most numerous clans of the Ba-Ronga.*

If we consider the map of the country as it is to-day, we see that two or three names are wanting in these three descriptions: Maputju (Maputo), Matjolo (Matolla), and Mazwaya (Magaia); but we can very well account for this want; in fact, these three clans are of modern origin. The Maputju and Matjolo are younger branches of the Tembe and Mpfumo royal families, which severed themselves from the main branch and made themselves independent in relatively modern times. Maputju was the younger brother of Muhari, the fourth Chief in the Tembe genealogy, and he managed to found his own kingdom, probably in the course of the eighteenth century, conquering Nyaka, Buyingane, and many others, probably destroying the Makomata mentioned by Diogo de Couto, with their Chief Viragune (?.. a name which does not sound much like Bantu). The Magaia, or more correctly pronounced *Mazwaya*, emigrated from the Lebombo hills after Mena Lebombo overcame this latter Chief, as well as the primitive inhabitants (the Mahlangana, Honwana and Nkumba), and extended over both banks of the Lower Nkomati, probably encroaching on the territory of Manhiça. One of the first chiefs quoted in the Mazwaya genealogy is Ngomana. This name is also encountered in the description of Diogo de Couto under the form Angomanes, and is applied to a chief living in a locality whose description well answers to the old abode of the Mazwaya clan in the Lebombo hills.

My conclusion is that in the middle of the sixteenth century the Native population round Delagoa Bay was composed almost

* As regards the names given by the Portuguese chroniclers to rivers, there are many difficulties in these reports. When coming from the South, the first river met is that now called the Maputo, and the second is the Tembe. Strange to say, the two chroniclers of the XVIth century who mention the river Tembe, Perestrello and Lavanha, apply that name to the first river, "that which separates the country of Inhaca from that of Zembe." The first river is also called by Lavanha Mclengana. There is, not far from the mouth of the Maputo River, a hill still called Nkelengen, and this is probably the origin of Mclengana. Diogo de Couto calls the Maputo River Belingane, saying that this is also the name of a kingdom. No doubt this is Buyingane, name of a chief who was located near the mouth of the river and who was conquered by the Maputju, but whose clan still exists in the same conditions as that of Nyaka. The country is still called Ka Buyingane.

To the second river, the Mitembe, Diogo de Couto and Lavanha apply the name of Anzete, or Ansate. This seems to me to be a corruption of the word Usutu or Lisutu (Umzuti on the Portuguese map of 1873) which is the old name of one of the branches of the Maputo River, the other being the Lipongolo. I believe there has been a confusion made by the chroniclers between these two rivers. As regards the Manyisa River, there is no doubt about its identification. It is the Nkomati of to-day; but Natives do not call it by that name in this part of its course; they call it Morako (hence the name Morakwen, Marracuéne). They may have termed it "*nambu wa ka Manyisa*," *viz.*, the river flowing in the Manyisa country, and the chroniclers have mistaken this expression for the name of the river itself.

of the same elements as to-day, and that the Native traditions account perfectly for all the changes that have taken place. Thus it is not true to say that these communities "have long since ceased to exist." It is also an error to pretend that they "have done nothing worth mentioning in the history of South Africa." For a long time before the European or Asiatic traders occupied the high land of South Africa, the tribes round Delagoa Bay acted as intermediaries between the White merchants and the tribes of the interior; the Mpfumo clan, especially, was known as a clan of merchants; large caravans were organised to carry clothing, beads, and other goods to Gazaland, to the Northern Transvaal, even to Zululand, and, in this way, these Natives really contributed to the civilisation of the country.

Let us pass now to the tribes South of Delagoa Bay, in the country now called Caffraria proper, Natal, Zululand, Amatongaland. In the report of Lavanha we find an extensive list of names of chiefs, or, rather, of headmen, through whose territory the party of San Alberto made its way. I reproduce it here with the Portuguese orthography, which is, of course, very defective, as these old chroniclers had no idea of the special Bantu sounds: so I add to these names their translation into what seems to have been their real pronunciation:

From 33° to 32° South Latitude we meet with the Tizombe clan, the Chiefs Luspance (Lusiphansi?) and Ubabu. From 32° to 31°, Inhancoza (Nyana-we-nkosi), Vibo. From 31° to 30°, Inhancunha (Nyankunya); Ospidanhama (Usipidanyama); Moxangala (Umshangala) mountains; Catine (Katini). From 30° to 29°: Inhanze; Mabomborucassobelo; Mocongolo (Umkongelo). From 29° to 28°: Mutangalu river; Gogambapolo; Gimbacucumba; Uquine Inhana (Ukinyane), near the Tugela River, called Uchugel. From 28° to 27°: Panjana; Malangana; Gamabela, Bambe. Further North begins the kingdom of Inhaca.

To these chiefs Diogo de Couto adds the following, in Amatongaland: Macalapapa, near the Santa Luzia Bay, and the Macomato tribe, with a chief called by him Viragune, between Mocalapapa and Inhaca.

I have not been able to identify those names with any still existing, except that of the river Uchugel, evidently the Tugela. The other river mentioned—Mutangala—is, according to Theal's supposition, the actual Umzimkulu; the Mashangale mountains would be the Ingele. It may be that some student of Native history dwelling in those countries will be able to find traces of some other words of the list. However, should this attempt prove unsuccessful, we should not wonder at the disappearance of those names, as we know what frightful disturbances the military raids of Chaka caused in the whole territory of Natal and Zululand from 1812 to 1820. This sanguinary despot destroyed, or amalgamated, hundreds of clans under his cruel rule. In Bird's "Annals of Natal," I have found a list of 93 tribes which were living in Natal during the pre-Chaka period. However, I have not met any of Lavanha's names amongst them. It must be remarked that these were names of petty headmen, and not of clans, as is the case with those of the chiefs of Delagoa Bay Natives; so they may have been lost more easily.*

On the other hand, it is evident that the population of Natal and Zululand was very similar to that of to-day, and that the language spoken was already the actual Zulu-Xosa. This is proved by the many words reported by Lavanha (*e.g.*, ancosse, *inkosi*; inhancosa, *nyena-we nkósi*; sinkoa, *isinkwa*, bread); there were already many dialects of the same tongue, if we can rely on the information of the chronicler, who says:—

> The language is almost the same all through Caffraria and the difference between them (the dialects) is similar to that existing in the languages of Italy or between the common idioms of Spain.

The third region crossed by the shipwrecked men of the sixteenth century extends from the Limpopo to Inhambane. Diogo de Couto mentions the following tribes as having been met on the way by the travellers: Near the mouth of the Limpopo, on the Western shore, the kingdom of *Inhapule*; on the other side of the river, the *Manuça*. On the coast further North, the kingdom of *Inhaboze*, reaching the river called *Inharingue*. On this river were five other chiefs: *Panda, Monhibene, Javara, Gamba, Mokumba*; further on, they reached the river of Inhabane. We stop here, and do not follow them further North, to Sofala. Though I have never visited this part of the country myself, I have easily identified most of these names by questioning Natives coming from the region. Inhapule is evidently *Nyapure*, the name by which Natives still designate the country round the mouth of the Limpopo. This name is found on all the maps under the form of Inhampura. As is the case with Nyaka, the

* The only name which Theal proposes to correlate with an actual tribe is Bambe, as quoted by Diogo de Couto (IV, p. 100) and Lavanha (V, p. 76). He identifies it with the Abambo tribe, which he supposes to have come from the Zambesi between 1570 and 1593 and to have settled between the Umbelosi and the Umkumazi rivers and shortly afterwards to have broken up into numerous fragments amongst which were the Amazizi in the upper Tugela valley and the Amahlubi on the Buffalo river. Theal describes this horde as having devastated all the territory between the Zambesi and the Limpopo, only sparing boys and women who were incorporated in this mass. I do not know from what sources Theal draws all this information. It is true that the party of the *San Alberto* found the Natives to the South-West of Delagoa Bay in a certain state of unrest. Nuna Velho, before reaching Inhaca, thirty leagues from the Bay, met with a treacherous attempt on the part of a headman called Bembe to rob him of one of his cows. This occurred not far from Santa Luzia Bay; but it was by no means an attack by a powerful invading tribe. It is true that this "Ancosse" was an usurper, reigning by terror; however, the identification of this Bambe with the great Abambo tribe seems very doubtful. Moreover Perestrello, already in 1554, mentions a tribe of robbers in the same neighbourhood. Diogo de Couto in 1589 places the Vambe tribe further South, and says it occupies the great part of Natal. These are contradictory statements, and it seems to me difficult to prove any real relation between this Bambe and the supposed migration of the Abambo.

tribe no longer exists as independent, but the clan of Nyapure is still living, "these of Nyapure"; and they are saluted thus: "Good morning, Nyapure!" The same can be said of Inhaboze and Manuça. "Those of Manuse" have lost their self-governing condition, but people bearing that family or clan name are met with on the Eastern border of the Limpopo. The river Inharingue is the actual well-known *Inyarrime* lagoon, in the midst of the country of the so-called Ba-Chopi, and most of the little kingdoms here mentioned still exist. Gamba, the Mokalanga invader who was baptised by Gonçalvo da Silveira, is certainly the *Gwambe* clan whose chief Khugunu (Cogune) is one of the most important amongst the Chopi. Mocumba is probably *Nkumbi*, his neighbour, and these two clans seem to inhabit exactly the same tract of country where the Portuguese found them in the sixteenth century. Panda, still called by that name in the Portuguese orthography, but in reality Pande, is settled further North, directly westwards of Inhambane. Javara is either *Zavalla* or *Zavora*. Monhibene alone is unknown to my informants As regards Inhambane, it is naturally the *Inhambane* of to-day, or more correctly pronounced *Nyembane*. It was already the name of a country round the Bay, not of a chief, though a chief of that name must, no doubt have lived there in former times.

The ethnology of the country between the Limpopo and Inhambane is rather complicated. We meet now with three main ethnic or linguistic elements in that region: (1) The *Ba-Lengi*, more commonly called *Ba-Chopi* (wrongly spelt "M'chopes" on certain maps); *viz.*, "those who are transfixed with weapons" (as their country was the favourite hunting, or, rather, raiding ground of Gungunyana); they occupy the border of the sea in the southern part of the region. (2) The Tonga-Nyembane*; *viz.*, the tribe round Inhambane who speak a peculiar language, the Gitonga. (3) The Ba-Tswa, who are but a branch of the big Hlengwe group which belongs to the Thonga-Shangaan tribe. When inquiring into the past of these various clans, we find that many of them emigrated from the Nyai or Kalanga groups, countries in the South of Rhodesia. There are Malalanga amongst the Ba-Tswa, *viz.*, the clans of Khambane and Makwakwa called by the common name of Nwanati. The clan of Gamba, or Gwambe, also came from the North, and its emigration took place during the reign of the father of the chief whom Silveira baptised, *viz.*, in the beginning of the sixteenth century. This Kalanga origin is proved by some Native words quoted by the Jesuit fathers in their letters Fernandez reports the following song as having been sung a great many times in Otongwe, the capital of Gamba:

Gombe zuca na virato ambuze capana virate,

* I propose, for the sake of clearness, to call the tribe near Inhambane, Tonga-Nyembane, to distinguish them from the Thonga-Shangaan (Thonga with an aspirated h) who occupy all the district of Lourenço-Marques and part of that of Inhambane.

Which he translates by:

> The ox has leather to make sandals, the goat has no leather to make sandals.

Gombe might be Nwombe, a word which Tonga-Nyembane use to say ox. But the Banyai also employ it and the word mbuze, or mbudzi, for goat, is not Tonga, but distinctly Nyai; the Tonga and the Chopi say phongo. Again the word Muzimo (Mudzimo), which the missionaries found meaning the spirits of the departed, is Nyai. Strange to say, to-day the Gwambe clan speaks the regular Chopi language. This fact is most interesting to note. It confirms the supposition to which I was led when inquiring into the past history of those tribes, *viz.*, as a rule, in this part of the world, the immigrating clans lose their idioms and adopt those of the primitive inhabitants in the course of time. Consequently, the languages which we find in these regions are the oldest monuments of human activity. Tribes and clans may have come and gone: the language has remained, whatever fluctuations and changes it may have undergone. Though it may form many dialects, it keeps its identity throughout the ages. Thus the study of the language helps to penetrate more deeply into the past than any other study.

Let us draw the following consequence of this rule regarding the Delagoa tribes. Diogo de Couto, speaking of the inhabitants of the Lebombo hills, says:

> The people of these forests speak the same language as the Vumo and the Anzete, their neighbours, and are all, men as well as women, of such a size that they seem giants.

The Vumo and the Anzetes are the Mpfumo and Tembe clans. According to all the traditions, the Mpfumo came from Zululand and the Tembe from the Makalanga country.* If the report is true, in 1580 already, they had both adopted the language of the Bay, the Ronga which is a dialect of the Thonga-Shangaan. If it is so, their arrival in the country must have taken place a long time before that date, as such a change of language cannot be accomplished in one generation. (The Ba-Ngoni of Gungunyane have still more or less preserved their idiom eighty years after their invasion of 1820-1830). This argument, which seems decisive, leads us to assert that the Tembe and Mpfumo clans were already settled in Delagoa Bay in 1450 (perhaps 1350), and that, before that date, the primitive population already spoke a language akin to the Ronga of to-day. I do not think any scientifically accurate statement can be made regarding Natives of South-Eastern Africa reaching further back in the past than this.

2. *Political and Social Life.*

If the Natives of 350 years ago were nearly the same tribes as to-day, were they very different as regards their form of gov-

* See "The Life of a South African Tribe." I, p. 21-23.

ernment and their degree of civilisation? Diogo de Couto seems to establish a great difference between the tribes round the Bay, including the Vambe of Natal and those further South, in the Southern part of Natal and Caffraria. The chiefs of the first were "kings" reigning over an extended area, mustering as many as 500 warriors, and this description also applies to the Inhambane clans, whilst the Caffrarian ones were only "ancosses" (*izinkosi*), headmen, heads and lords of three, four, five villages. Perestrello gives a similar account, saying that these Caffrarian Natives "do not go far from the place where they were born, and from the neighbourhood of the huts where they were created and die." For that reason they were unable to guide the party more than two days, and lost their way. This difference is also noted by Lavanha. He found a "captain of Inhaca," *viz.*, an induna, who had dispossessed an "ancosse," Gimbacucumba, on the southern border of the Tugela (V, p. 57), and he promised him to plead his cause when he should reach Inhaca's kraal. The Delagoa Natives were raiding as far as Zululand and further South in those times, whilst the reverse took place since the nineteenth century, after the rise of Chaka, as one knows. In fact, though Perestrello complains of the scarcity of food in the land of Inhaca, he describes the capital of this king as being quite an important place.

It is not wanting in a certain polity and order of Government, for it is large and contains many people, with its squares and streets not very complicated, surrounded with a fence of very hard branches, high enough and well closed, with three or four openings at the convenient places.

This description perfectly answers to the "*ntsindja*," or capital of the Ronga chiefs some years ago, when they had still retained their full power.*

The same disintegrating influences acted then as now on the clans, *viz.*, younger brothers and sons of reigning chiefs wanted to make themselves independent and to found new political bodies. The son of Inhaca had tried to do so, but failed (V, p. 82). The chief used to place sub-chiefs in the remote places of his kingdom; thus, the sister of Inhaca was reigning in that capacity in the South of the country (V, p. 77). He had counsellors, called by the chroniclers "Capitão" and "Majorial." Moreover, these petty kingdoms lived in perpetual warfare with each other, and the tribes South of the Bay were hereditary foes of the Mpfumo chief (I, p. 133), on the Northern shore. This feud has persisted to the present day, and was one of the notable features in the war of 1894.

The social customs have not been studied with much care by our chroniclers; however, what they say regarding them is sufficient to show that they were the same as now. The Kaffirs were polygamists. Lavanha tells how the Chief Ubabu proudly

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* *Cf.* "The Life of a South African Tribe," I. p. 392, illustration of the Tembe capital..

showed him his 200 oxen, his 200 sheep, his seven wives, and his numerous children. "They are very sensual, and have as many wives as they can afford, being very jealous about them." That polygamy was founded on *lobola* (cattle marriage), and that the wife bought was the property of the clan which purchased her, is proved by the fact that the missionaries of Gamba noticed with horror that their new converts inherited the widows of their dead relatives, and took them as wives, a custom which is one of the characteristic features of the social law of the South African Bantus.

Lavanha tells that all the clans south of 29° South Latitude were circumcised, and the Jesuit Fathers assert that the Tonga-Nyembane had the same custom, whilst the Makalanga were uncircumcised. When inquiring from those Tonga about the origin of the rite, they were told it was taught to the Natives by "a Moor of rank who came to these parts." This information is interesting, as it throws some light on the question of the origin of circumcision amongst the South African tribes. The Chopi and Tonga-Nyembane still circumcise the lads to-day, but they are convinced that this custom is their own, and deny that it has been introduced by strangers. The fact that Caffrarians, South of 29°, in a region not yet visited by the Arabs, followed the same rite, is altogether against the hypothesis of a semitic origin. Suppose, however, that the first idea came from the Arabs, the circumcision initiation, as it is now practised in South Africa and in many other parts of the Dark Continent, bears the Bantu character so strongly, that it can be said to have been thoroughly adapted to the circumstances and to the genius of these animistic tribes.

(3) *State of Civilisation.*

The *weapons* used by the Natives of the sixteenth century were already made of *iron*. In addition to the knobkerries, our chronicles mention "azagaias." Perestrello noticed them as far as 32° S. They were seen all through Caffraria, Natal and Zululand by his followers. The Gamba Natives had "bows, arrows and small assegais." Amongst the Tizombe, Lavanha also noticed hatchets of the typical South African form, which he describes as follows:—"They are like an edge fixed into a stick, and with it they also cut trees and carve dishes." Natives also used ox-hide shields.

The presence of assegais proves that Natives knew iron and even had great quantities of that metal at their disposal. Where did they procure it? They eagerly bought pieces of iron and nails from the crews of the wrecked ships, and the Portuguese so well knew the value attached to iron by Natives that those of the *San Thomé* and of the *San Alberto* burnt their wrecks in order to extract all what they could of the iron employed in the construction of the ships. Nuno Velho even ordered his men to destroy what they could not take with them in order not to depreciate the valuable metal as a means of exchange. But it is evident that these few wrecks did not provide all the clans with their assegais. In Amatongaland the Natives possessed so many of them that, according to the highly coloured narrative of Perestrello, for two hours these assegais formed a cloud in the air! The South African Bantu must have known the art of metallurgy already in those remote times. So the iron foundries still met with in the Northern Transvaal are not a modern imitation of white methods.

Copper was also plentiful, at least on the borders of the Limpopo, and very much appreciated. It was used in the manufacture of large bracelets, of which the Inhaca chief wore many on his arms. No doubt these ornaments were also of Native make; the copper proceeded perhaps from the Palaora mine in Zoutpansberg, where certain Basuto have mined the ore extensively up to our times. On the other hand, *gold* and *silver* were quite unknown (V. p. 27); at any rate the *Sao Alberto* crew did not see any trace of them. This corresponds with the fact that there exist no indigenous words in the Thonga-Shangaan language to designate these two precious metals, whilst iron and copper are called *nsimbi* and *nsuku*, two typical Bantu words.

Implements appear to have been few: pots dried by the rays of the sun, wooden dishes are mentioned amongst the Tizombe. But basket work of the present type, which is evidently primitive, must have been present everywhere.

The *huts* had already their present round form, the two present patterns having been duly noticed by the *San Alberto* crew: the bee-hive hut of the Zulu (*redondas e baixas*, V. 21), and the hut provided with a wall and conical roof (*como as nossas choupanas de vinha*—"similar to our huts in the vineyards"), which is met with first at Inhaca's sister's village and is the typical dwelling of the Thonga-Shangaan. I found no description of Gama's huts. The villages were circular, surrounded by a fence (V. 21) with the cattle inside the enclosure.

The agricultural customs were also nearly on the same level as three centuries later, before the introduction of new and improved seeds. Perestrello was surprised to see the Inhaca people cultivating so little ground:

> The people of these parts, he says, live in forests, naked, without law, without custom, without clothing, and have no other wants which may induce them to gather provisions and keep the surplus which they may obtain in favourable times for times of scarcity. They live on roots and herbs which the bush provides, and sometimes on the flesh of elephants and hippopotami, without thinking of tilling the ground by the products of which they all live, chiefs as well as subjects.

This description, which is not very clear, does not prove that the Inhaca people did not cultivate fields, as they ate Kafir corn, but that they did so on a very small scale; so when a troop of sixty or seventy white people arrived amongst them they were not prepared for that eventuality which it was impossible to foresee, and the poor Portuguese suffered bitterly from hunger.

If we carefully study the Reports, we see that, in fact, the Natives possessed most of their present cereals. The most widespread was a grain called *nachenim* or *nachani*, or *nechinim* (a word, the origin or which I am unable to trace; it seems to be an Indian word); this grain is a seed similar to mustard, from which they make cakes (I. 136, 184; V. 51, 30° Lat. S.); it is called milho and alpistre by the Portuguese (I. 136), and is said to be the best means of subsistence of the land. It is of that cereal that the Inhaca king measured a certain quantity to each of his guests. No doubt this is the actual Kafir corn or millet. Perestrello also mentions a "milho zaburro" (I.88), and Lavanha another cereal called ameixoeira (V, 50); it is, if I am not mistaken, the Sorghum*; Nuno Velho found a vegetable called "jugo" in Natal (this is a kind of pea), and the "gergelim"; the travellers sometimes obtained beans, which were plentiful near Inhambane. Fernandez, in his tiresome journey to Gamba, enjoyed them immensely, and noticed that each pod contained sixteen beans. They are extensively cultivated to-day by the Thonga-Shangaan under the name of "timbawen." It seems that the country round Inhambane was more advanced as regards agriculture than any other on the coast, as we find also mentioned there "grains which grow beneath the ground," either the Kafir pea or the monkey nut.

The millet and sorghum were also prepared under the form of beer, which Lavanha calls "pombe," ecidently the *byala* or *tjwala* of which the Natives are so fond all over South Africa. This is a food as well as a beverage. The culinary customs were the same as to-day.

Caffraria and Natal were full of *oxen*. Nuno Velho counted as many as 100 at Luspance, and 200 at Ubabu (32° S.) He managed to buy some all along his journey. They were plentiful in the Inhaca island. Lavanha says about the Caffrarian cattle:

> Their meat is fat, tender and savoury; they are big; most of them are without horns (mocho) and the greater part are oxen,† which constitute the riches of the people; they sustain themselves on the milk and the butter made of it."

The Capridæ also were abundant, mostly sheep in Caffraria and Zululand (120 at Luspance, 200 at Ubabu), some of a large size and of the race of Ormuz; in Inhaca there were principally goats (I. 110; V. 82). Fowls are often mentioned at the same place, and amongst the Gamba people who "possess an abundance of cattle, large hens and fat cows, but few goats and sheep."

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* The word "ameixoeira," or "mexoeira," nowadays designates the small grey kaffir corn in Lourenço Marques. There must have been a confusion of terms in the Reports. Moreover, the chroniclers seem to consider these names as indigenous, which I believe is a mistake.

† The travellers noticed with amazement in one of the kraals an ox with four horns, two ordinary ones and two others under them pointing backwards; another ox had three horns proceeding from one which divided itself into three at the distance of one palm from the head (V. 58).

Hunting seems to have been more developed near Inhambane than in Delagoa Bay. Fernandez gives a vivid account of the manner in which Gamba men succeeded in killing elephants. The hunting party numbered as many as 150 men, and, after having forced the beasts into a narrow passage in the forest, tried to wound the legs so that the elephants would fall under the weight of their own bodies.

The way of *dressing* of all these tribes has not been clearly described by the travellers. The Natives are represented as naked in Caffraria (I. 76), and in Inhaca's country (I. 137). Lavanha, on the contrary, asserts that the Tizombe put on a coat of ox-hide with the hair outside, and, as regards the Inhambane clans, in 1560 already the women at Gamba's Court had adopted cotton clothing adorned with beads twisted together. This description exactly answers to the short skirts worn by all the Thonga-Shangaan women in the interior. The national costume, however, worn by common people, consisted of skins or strips of bark, and they already manufactured blankets by sowing together pieces of the bark of the *mphama* fig-tree. These blankets, which are remarkably strong, are called *ntjalu*. The taste for *ornaments* was very great, and was the real incentive for commercial transactions. Beads of Indian make, of red clay, were met by the shipwrecked men as far as 32° S. Father Fernandez minutely describes the horns which Gamba men made by twisting their hair in such a way "that the head was no longer to be seen." Some wore as many as ten of them! This seemed rather a worldly fashion to the missionary, and he asks one of his friends to forward to him a picture of the last judgment representing devils provided with horns in order to show his converts that this is altogether an infernal custom! I have not heard of any clan still practising this curious treatment of the hair.

(4) *The Psychic Life.*

Is it possible to get some glimpses of the mental life of the South African Bantus of the sixteenth century from these Reports? Occasional visitors, not knowing the language, are apt to make the greatest mistakes on such a subject. However, I discovered a few illusions in them which take a special interest when put in relation with what we actually know of Bantu rites and ideas. There are, of course, many more in the letters of the missionaries.

As regards the *moral character* of the race, it was so plain as to be at once detected. The curious mixture of generosity and selfishness, of good humour and of treachery, of mildness and of cruelty, which is still noticed in native morals, appears clearly in the relations they had with their first visitors. Fernandez puts one of these contrasts of the Bantu character in the following pleasing and apt way: "Though so poor, they are very proud, and each of them is a king of the woods!" In some cases they treated their unfortunate guests very badly. The way in which the Mpfumo people robbed Manuel de Souza and his wife is most disgusting. But we must not forget that he was coming as a friend of Inhaca, the hereditary foe of Mpfumo, and that he had substantially helped that chief in a battle with another chief. Moreover, the party was proceeding with arms, fighting and sometimes killing the Natives, and the behaviour of Souza himself had been very imprudent. It seems to us very hard and offensive that these black people dared to deprive a Portuguese lady like Dona Laura of all her clothing; but remember that, on the question of modesty, they had not the slightest idea of the offence they were committing, as a little bit of clothing is quite sufficient in their opinion to answer all the exigencies of decency. In other cases, the hostility shown was the direct outcome of an attack on the part of the poor wrecked people who did not know how to behave. I recall only the crime of anthropophagy committed by some of the *San Thomé's* party. On the other hand, one cannot help admiring the kindness shown by the Inhaca chief to the four caravans; their presence was a heavy burden for his people who had such scanty resources. He did not forget to work for his own interests and taxed them to the utmost; however, he showed himself a friend in need. As regards Nuno Velho of the *San Alberto*, he had almost no difficulty with all the tribes through which he passed, and this seems to be owing to the perfect atttitude he adopted towards the Natives; he always was just and good, preventing his people from robbing the least object, himself adorning the women and the children with the bits of coral or of crystal he paid for his purchases, treating black people as men. In the meantime, he was very firm and did not lose any occasion of asserting his prestige. So, when he killed a cow, he always did so by shooting it with a gun, and he called the Natives to witness the wonderful effect of his arms. They sometimes ran away, but he took them by the arm and reassured them. He would have made a perfect Native Commissioner!

The Portuguese saw very little of the *religion* of the Natives. Lavanha says:

> They are very wild (*brutos*) and do not adore anything, so they received our holy Christian law with great easiness. They believe that Heaven is another world similar to the world we live in, inhabited by other people who by running about cause the thunderstorms and by making water cause the rain.

This testimony is very short indeed, and one could hardly accept it as a trustworthy résumé of the subject. But when reading carefully our documents, we find traces of the two great sets of religious institutions, which a deeper study reveals amongst these tribes, *viz.*, the ancestor worship and the idea of Heaven.

The *ancestor worship*. The pilot of the *San Alberto* directly after the wreck saw the chief Luspance going with another

Native to the place where the sheep he had given to Nuna Velho had been skinned. He ordered this man (who was no doubt the priest of the family) to take some half digested grass in the bowels of the animal, and he threw it into the sea with words of thanksgiving, "for having brought Portuguese to his land as he expected great gain from them." Now, this is exactly the rite which takes place in most of the sacrifices of South African Bantu. This grass is called *psanyi* in Thonga, and its importance is fully shown in my description of Thonga Ancestrolatry.* The habit of throwing *psanyi* into the sea is practised exactly in the same way amongst some Thonga. It is an invocation to the spirits of the ancestor, who are buried near the sea, and are more or less confounded with the impersonal power of the sea itself, this rite showing the transition between a purely ancestrolatric and a naturist sacrifice.†

It is natural that the travellers had no opportunity of witnessing many manifestations of the ancestor worship, as they are generally purely private acts of the family life. Even the Jesuit fathers did not notice the details of it. They, however, heard Gamba people speak about "Muzimo," spirits which come at night to ask for food and they give them food and drink, placing it at the foot of a big green tree." These Muzimo are certainly the Manes, the spirits of the departed. Besides these Fernandez speaks of "Umbe" as being the name of God in the tribe. This Umbe is probably Mumbi, the Creator, or rather the "Former" of the world, from the root *ku bumba*, to make pots, a root very widespread in the Bantu languages. This God is often confounded with the *Sky* and the *Sun*, and Natives have a number of curious ideas about him which constitute what I called their deistic notion.

According to the Reports, White men are called by the Natives Sons of the Sun, "because they are white like the sun." Heaven is inhabited by mysterious beings which cause the thunderstorms and rain. This is almost the same superstition as that of the "balungwane" still met with amongst the Thonga-Shangaan; *balungwane*, little men who are said to inhabit heaven and look down to us. When they see a man walking on earth they sometimes discuss who he is. If not agreeing, they spit on the traveller; he looks to the sky to see where this unexpected drop of rain comes from; they then see his face, and thus they know him‡.

The fact that these mythical beings are called *balungwana*, diminutive of *balungo*, the name given to White people in Zulu and Thonga is interesting to note, and shows that the meaning of the word *balungo* might have been precisely: people of heaven.

The rescued people of the *San Thomé* having left a few sick Portuguese in the village of the chief of Inhampula, this man

* *Cf. op. cit.*, Vol. II, p. 361-385.
† Vol. II, p. 299.
‡ See *op. cit.*, Vol. II, p. 405.

called the other members of the party and ordered them to remove the patients immediately, "because," said he, "the Natives did not want to see any people dying there, as the sun would be angry with them, and would not allow the rain to fall on the earth, and so there would be no fruit nor means of subsistence for the whole year." "They said so," adds Diogo de Couto, "because they believed that the Portuguese are sons of the sun, as they are white and fair" (IV. p. 122). The same superstition reigned at Inhaca, where the Portuguese had to bury their dead secretly. In the same way when Paolo de Lima and others died in Manhica, the Natives did not allow them to be buried in their ground; their graves had to be dug near the river. This is one of the most curious taboos of these tribes. They believe that Heaven (rather than the sun) is offended if any one dying an unnatural death is buried in dry ground. It would be more correct to say: If anyone dies having not been lawfully incorporated with the tribe by special rites: children dying before the ceremony of "tying the cotton string" (see Vol. I., p. 54), twins, and also strangers, as they may bear this objectionable character which irritates Heaven and brings the malediction on the land.

Thus the great taboos are not a new thing amongst our tribes. The same can be said of the sexual taboos and of the taboos of death. Natives of the Northern part of Natal hearing from the Portuguese that the cross they wore was such a sacred thing, kissed it as they saw the White people do, and asked them afterwards if they were allowed to have relations with their wives after they had received this holy sign. This is quite in keeping with the sexual taboos of Native initiation (V. 65). Lavanha reports that, at the death of a member of a kraal, they all break their huts into pieces and build in another place, believing that when one of the neighbours or relatives has died, everything will go wrong in the village (V. 21). This is the great law consequent to the taboo of death still observed in our days.

If the taboo superstitions were the same as to-day amongst the Natives of South Africa, their *magic* seems to have been also quite similar. Divination is practised amongst the Gamba people by casting lots with small shells stuck at the back with the wax of black wasps, and this consultation takes place in cases of disease and death. The Thonga-Shangaan of our days also use shells for the purpose, shells mixed with astragalus bones and various stones; certainly the system is the same. However, divination by the examination of the intestines of fowls and mice which Fernandez reports as common amongst the Gamba is no longer resorted to in these tribes, as far as I know.

Smelling out witches was of common occurrence. All the practices of witchcraft were known, and the accused were tried by the "*mondjo*" ordeal (called *motro*), *viz.*, by drinking a poisonous drug. I find, however, no traces of the exorcism of so-called possessed persons by drum-beating in our documents. The disease of possession was perhaps not yet known, as this kind of nervous trouble seems to spread as an epidemic in certain times and under certain circumstances only.

The comparison might be pushed farther, but this rapid survey is quite sufficient to prove that in the middle of the sixteenth century the Natives of South-East Africa, especially those of the shores of Delagoa Bay, were grouped in a manner very similar to that of to-day, three centuries later; they had the same customs, the same character, very nearly the same degree of civilisation.

That condition, according to all probability, was already an *ancient state of things*, at any rate nothing proves that it was of recent origin, and the unity of language, as already pointed out, proves that there had been no great change in the population of the country for a long time. The tribes lived in relative peace, and the migrations had not the sanguinary character of the Zulu raids of the last century: Gamba, the Mokalanga invader, was respected and estimated by his Tonga neighbours.

My conclusion is that we must be very prudent when we try to make hypotheses on the remote past of the South African tribes. Native traditions are of no avail, as we saw; comparison of the names of the tribes is delusory, as these names often are mere nicknames, or have not the same signification, or are merely designations of cardinal points, and mean, consequently, people of the East (Ba-Ronga), of the North (Ba-kalanga), etc.* The study of the language does not help much more, if really the emigrating clans adopt more or less completely the dialect of the people they subjugate, the men marrying the women of the land, and the women are always the best preservers of the language, at least amongst the uncivilised. Dialectic differences occasionally may help to trace the origin of certain clans. For all these reasons I ask to be allowed to remain sceptical when I see splendid maps showing the road which our tribes have followed since the time they severed from the Ur-Bantu stem till they reached their present abode. The Bantu tribes of South Africa are very, very old; their peculiar rites I am convinced, especially the belief in Heaven, are really primitive and not modern importations. This was the conclusion of my study of the life of a South African tribe.† I am glad to have found in these precious documents a confirmation of that impression.

* Thus, as regards the name Ba-Tonga.—There is a large tribe bearing that name on the Zambesi, in Northern Rhodesia, a much smaller group near Inhambane, the Tonga-Nyembane group, and the Thonga-Shangaan, of Delagoa Bay, the Zoutpansberg and Gazaland; but this similarity of name is no proof at all of a common origin or of special relations between these various tribes. Thonga, in Delagoa Bay, seems to be only the Zulu pronunciation of Ronga, the name of the clans round the Bay, and Ronga means East or dawn. They are the people of the East—for their Western neighbours! *Kalanga* means North, or at any rate, for the Ronga, Bakalanga people are the tribes of the North, irrespective of their origin, they say that their kinsmen of Khosen (Cossine or Magude) speak the Shikalanga, *viz.*, the language of the Ba-kalanga.

† Vol. II, p. 535.

TRANSACTIONS OF SOCIETIES.

South African Institute of Electrical Engineers.—Thursday, November 20th: Mr. B. Price, Vice-President, in the chair.—"Railless Electric Traction": J. W. **Westwood.** A short technical description of the various systems, including also the general problem of railless traction, with statements of comparative costs.—"Electrification of Railways": Prof. W. **Buchanan.** An examination into the probable advantages to be gained by electrifying existing steam railways, and a comparison of the relative merits of different available electrical systems. In considering the relative merits of steam and electricity as applied to railways, the author discussed (1) cost of operation, (2) reliability of service, and (3) convenience to the general travelling public. In the second part of the paper the relative merits and defects of alternating as compared with continuous electricity were considered; in the former case the single and three phase systems were compared, and in the direct current the low and high voltage systems.

Thursday, December 18th: Prof. W. Buchanan, B.Sc., A.R.C.S., M.I.E.E., Vice-President, in the chair.—The Electrical Testing Work of a large Power Company": T. F. **Whimster.** The work of an electrical testing department was described under the following heads: (1) examination, adjustment, and maintenance of electrical protective apparatus (2) testing and repairs of electricity meters (3) testing and upkeep of electrical measuring instruments, (4) tests on generators, transformers, etc., including efficiency and temperature tests, (5) electrical testing of samples of tapes, insulators, oils, etc., (6) experimental work entailing use of the oscillograph, (7) standards and sub-standards.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, December 13th: A. Richardson, M.I.M.M., President, in the chair.—"The solubility of iodine in sodium iodide solution": H. W. **Gill.** The author has demonstrated (1) that the proportion of iodine dissolved is directly proportional to the concentration of the sodium iodide solution, (2) that a solution containing 1.5 per cent. of sodium iodide will dissolve sufficient iodine to prepare a decinormal solution, and (3) that the compound $NaI_3 + 2H_2O$ probably exists in the iodine-sodium iodide solution.—"The Union Patents Bill": A. L. **Spoor.** and W. E. **John.** A general review of the draft Bill prepared by a Commission appointed by the Government of the Union, and a critical discussion of some of its chief features.

NEW BOOKS.

McKee, W. M.—*South African Sheep and Wool.* 8½ × 5½ in., pp. 326. Illus. Cape Town: T. Maskew Miller. 1913. 12s. 6d.

Cameron, Charlotte.—*A Woman's winter in Africa: a 26,000 miles Journey.* 8vo., pp. 403. Maps and illus. London: Stanley Paul & Co. 1913. 42 oz. 10s. 6d.

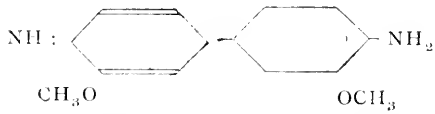
Johnston, Sir H. H.—*Pioneers in South Africa.* 8vo., pp. vii, 316. Illus. London: Blackie & Son. 1914. 32 oz. 6s.

QUINONOID OXIDATION PRODUCTS OF DIANISIDINE, AND THEIR POLYMERISATION.

By James Moir, M.A., D.Sc.

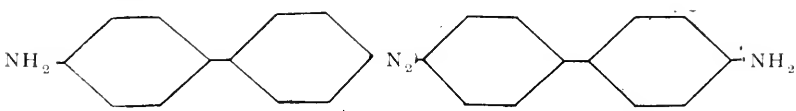
Previous work on the formation of quinonediimines is represented by Willstætter and Pfannenstiel's work on oxidation of phenylenediamine.* In the diphenyl series the chief references are: Willstætter and Kalb†, whose papers deal with the oxidation of benzidine and its methyl derivatives to coloured substances which the authors consider to be quinonoid: see also the present author's work on "diphenoquinone-diimine" and its 3-3′-dimethyl derivative, and on their quinhydrones‡; "Oxidation-products of benzidine"||; also "New derivatives of diphenoquinone.§

The present work deals with certain beautiful and comparatively stable substances analogous to the above, obtained by mild oxidation of dianisidine (3-3′ dimethoxy-benzidine). One of these is undoubtedly a quinhydrone, and will be termed *dianisiminoquinhydrone*, to indicate that it is a compound of the unknown 3-3′-dimethoxy-diphenoquinone-diimine with dianisidine; and its formula may be written in monomolecular form by making *one* only of the benzene-rings quinonoid. (This is merely to save space, since it involves writing a trivalent carbon-atom. This formula is:



The basal idea in this is, I think, the same as what is meant by certain German writers in using the term *meriquinone*, but I, personally, see no advantage in abandoning the term quinhydrone.

As regards the corresponding quinonediimine, I shall bring forward evidence to show that, when formed, it immediately polymerises to an azodye. This behaviour was suspected in the case of Willstaetter's "dipheno-quinone-diimine," which I now consider to have the formula



This is perfectly analogous to the behaviour of ordinary quinonediimine, which in contact with water apparently polymerises to azoaniline

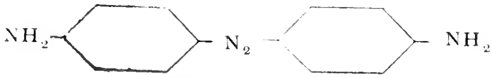
* *Berichte*, 1904, p. 4605; see also *Ber.*, 1894, p. 480; 1904, pp. 1494 and 2906.

† *Berichte*, 1904, p. 3761, and 1905, p. 1232.

‡ "Benzidine Chromate," Proc. C.S., Lond.

|| Trans Roy. Soc. S.Afr., 1912, p. 205.

§ Rept. S.A. Assn. for Adv. of Sc., Bulawayo, 1911, p. 253



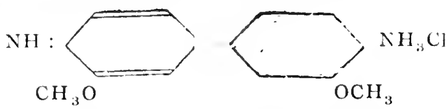
and a higher polymer $C_{18}H_{18}N_6$. I consider, therefore, that no true quinonediimine of the diphenyl-series has yet been prepared, although several quinhydronic substances (so-called "benzidine chromate," and the green oxidation products of dimethyl and tetramethylbenzidine, etc.) are known, and the present paper deals with a new and comparatively stable member of the quinhydrone class.

A. *Salts of Dianisimino-quinhydrone.*—The chloride is very easily obtained by dissolving dianisidine in excess of dilute hydrochloric acid at not over 25°, and suddenly adding a slight excess (over the theory) of strong ferric chloride solution. The mixture becomes immediately deep blood-red, and the quinhydronic chloride almost immediately crystallises out in deep-indigo microscopic needles, quite black in the liquid, and completely opaque under the microscope. Great excess of ferric chloride, or too high a temperature, lead to an impure product: otherwise the reaction is nearly quantitative. The presence of strong acid prevents the separation of the indigo compound (which is the *mono*-hydrochloride*, and is soluble in strong acids to a deep blood-red colour, still visible in a dilution of 1 part in a million, presumably due to a diacid salt).

The preparation is washed on a Buchner funnel until iron is removed and the substance begins to dissolve with a greenish-blue colour: further washing leads to partial hydrolysis: an olive-green coloration of the washings is seen when the free acid is almost gone, this being a mixture of the blood-red and blue-green colorations of the diacid and monacid salts respectively. For analysis, the substance was dried over sulphuric acid in vacuo. 0.2390 gram reduced by standard stannous chloride in presence of hydrochloric acid, and back-titrated by iodine used 0.0477 Sn in the reduction = 19.95%.

0.1810 treated with silver nitrate excess and boiled to destruction with concentrated nitric acid gave silver chloride, which was weighed as Ag after reduction: Ag = 0.0805: hence HCl in substance = 15.0%. Iron impurity in filtrate found 1% = 1.9% HCl as $FeCl_3$, therefore corrected HCl in substance = 13.1%. By removing tin from the reduction-liquor by sulphuretted hydrogen and adding ammonia the reduction product was obtained, and was pure dianisidine (*m.p.* 137°).

Dianisiminoquinhydrone monohydrochloride.—



= $C_{28}H_{32}O_4N_4Cl_2$ on the official formulation requires HCl = 13.1%, Sn for reduction to dianisidine = 21.3%.

* This is on the C_{14} formula.

A more basic salt of lighter purple colour and with copper-coloured metallic lustre is obtainable by using sodium acetate after the addition of $FeCl_3$ in the preparation, or by operating on a diluted alcoholic solution of dianisidine (the base) with nearly neutral $FeCl_3$. This variety is very slimy and unfilterable, and is best freed from iron by washing with very dilute acetic acid, in which it is practically insoluble: it gives a bright bluish-green colour when rubbed on a white surface so as to give a thin layer. The coloration given by concentrated sulphuric acid with both of these hydrochlorides is garnet-red, which is orange when diluted, and quite stable even on great dilution.

The parent substance from the action of $FeCl_3$ on benzidine, *dipheniminoquinhydrone*, gives a pure orange colour.*

The most remarkable property of these blue salts should be mentioned here, *viz.*, the isomeric change induced by alkalis. Any alkali, even tap water, produces a chestnut-brown precipitate of an insoluble base which on treating with acids gives salts entirely different from the above quinhydronic salts: with very dilute acids the solutions of the new salts are brownish orange: stronger acids give olive-green solutions: still more acid gives a wine-red colour: quite strong acids give an intense and beautiful crimson purple: on drying up an acid solution of the chestnut base, these colours appear in rings edging the vessel. In the solid state the HCl-compound of the isomerised chestnut base is dull olive and almost without lustre. Concentrated sulphuric acid gives an intense crimson-purple shade with traces of the isomeric base. The crude chestnut base melts easily and contains free dianisidine which can be removed by hot dilute alcohol, and the undissolved base, which melts at about 220° (not sharp) and should be *dianisiminoquinone*, is in reality a polymer thereof of azo-dye nature, *viz.*, $NH_2.C_6H_3OMe.C_6H_3OMe.N{:}N.C_6H_3OMe.C_6H_3.OMe.NH_2$.

This follows from the fact that the substance is difficult to reduce by hot stannous chloride and then yields dianisidine, whereas the original quinhydronic substance is immediately reduced in the cold.

(2) *Hydrobromide of the quinhydrone.*—15 grams dianisidine in excess of cold 1% HBr solution is treated with 30 cc *liquor ferri perchlor. fort. B.P.* previously mixed with 100 grams of potassium bromide in saturated solution. The purple hydrobromide is filtered off after standing twenty minutes (not longer), and being well crystallized, can be properly washed out, if only small quantities of wash water are used at a time, since hydrolysis occurs as the acid is removed. The quinhydronic hydrobromide forms a magnificent purple paste with brilliant copper lustre on rubbing: it is *blue-green* by transmitted light, but in mass the coppery lustre causes it to appear purple. The solution in slightly acid water is blood-red, and on dilution greenish blue. In absolutely neutral water the colour is at first dull red, after some time changing through olive to green, the latter stage being

* See Trans. Roy. Soc. S. Afr., p. 209.

micro-crystalline—presumably the basic salts as in the case of the HCl and HNO_3 salts. Tap water liberates the isomerised chestnut base $C_{28}H_{28}O_4N_4$, from which boiling water extracts the dianisidine which accompanies it.

A specimen dried in vacuo gave the following analyses:
0.2605 used 0.0398 Sn for reduction = 15.25%.
0.3210 gave 0.1125 Ag = 26.3% HBr. On correcting for trace of potassium bromide ash, these figures become Sn = 15.4, HBr = 25.6.

$C_{28}H_{32}O_4N_4Br_2$ requires Sn = 18.4, HBr = 25.0

The reduction product was again pure dianisidine.

On soaking a weighed quantity in conc. ammonia and finally washing out with dilute soda, and finally with warm water, it yielded 71.7% of crude chestnut base, and the washings contained a trace of dianisidine.

Thus 71.7 base + 26.3 HBr = 98.0 is accounted for, the amount of base (mixture of $C_{28}H_{28}O_4N_4$ and dianisidine) agreeing with above formulation. On percolation with cold alcohol about 48 % of the original was left undissolved: (*m.p.* 190-210°), being the crude polymerised diimine $C_{28}H_{28}O_4N_4$.

3. *Basic Nitrate of the quinhydrone.*—This is much less soluble than the above salts, consequently an almost quantitative yield is obtained when dianisidine in excess of 5% HNO_3 is treated with ferric nitrate. It can be completely freed from iron by washing, and forms a black-violet paste, soluble in acids to a deep blood-red solution: a trace gives an intense garnet coloration in concentrated sulphuric acid. Owing to this intense colour the substance could be used as its own indicator in titrating it with stannous chloride, after dissolving in warm dilute hydrochloric acid. 0.1370 dried in vacuo used 10.7cc stannous chloride (1cc = 0.00274 Sn) to disappearance of red colour. Sn for reduction = 21.4% of substance. Titration of a specimen dried in the steam-bath left a proportion of violet azo-dye unreduced and gave Sn = 15.3%: so that some degree of isomerisation occurs on heating.

$C_{28}H_{31}O_4N_4(NO_3)$ requires Sn = 21.7%: it thus seems to be a basic nitrate analogous to the basic hydrochloride above described.

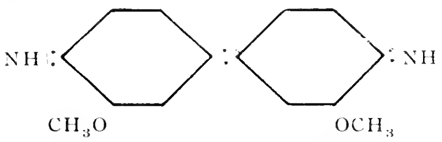
4. *Quinhydronic sulphate.*—From action of ferric chloride on dianisidine in very dilute H_2SO_4 at 30°. The almost black precipitate obtained on standing is the sulphate, and is quite insoluble in dilute sulphuric acid, though on washing it commences to dissolve to a blood-red solution: inky-violet paste almost black on drying in vacuo, which treatment alters it to some extent, as the dried substance gives a purple shade in conc. H_2SO_4 due to the polymer (see below). On reduction with stannous chloride the liquor was brown, and was found to give a black precipitate with iodine (so deep as to mask the starch endpoint) which was used as the endpoint of the back-titration. 0.2400 used 0.0456 Sn for reduction, and filtrate worked up with Barium

chloride gave 0.0840 $BaSO_4$. Sn = 19.0%, H_2SO_4 = 14.7%. $C_{28}H_{32}O_4N_4(SO_4)$ requires Sn = 20.4, H_2SO_4 = 16.8%, but the specimen consisted partly of the sulphate of the isomeric base (the polymer) as a result of drying at too high a temperature.

5. *Bichromate.*—This is the dimethoxy-derivative of the so-called "benzidine chromate" investigated by the author,* and like it, is somewhat indefinite, being either quinonoid or quinhydronic according to circumstances. The specimen analysed was obtained by working at 30° and adding an excess of potassium dichromate solution to the blood-red mother liquors from the hydrochloride preparation: a voluminous blue slime is obtained, which was washed out and dried at 90°. It forms a black violet cake which deflagrates on heating or on touching with concentrated sulphuric acid. It was therefore analysed by boiling with hydrochloric acid and precipitating chromic hydrate. 0.611 gave 0.183 Cr_2O_3 = 30.0%.

$C_{28}H_{30}O_4N_4.2H_2Cr_2O_7$ requires Cr_2O_3 = 33%, which is sufficiently near to the experimental result for the case of a compound of this indefinite character.

B. *Investigation of the brown isomeric base* (polymerised dimethoxy-diphenoquinonediimine).—This is best prepared from *undried* specimens of the quinhydrone salts by treating with ammonia, filtering and washing with dilute soda (when it becomes rather lighter in colour), and finally with pure water. The product is brick-red on drying, and melts easily, being partly composed of free dianisidine and partly of "polymerised dianisiminoquinone." Titration with $SnCl_2$ used 19% Sn, so that rather less than half is the "quinone." Most of the dianisidine can be extracted by hot 70% alcohol. After this treatment the undissolved brown substance (dried at 90°) used 29% Sn for reduction and melted at 150-175°. Another quantity of gummy impurity was removed by digestion in acetone and washing. The insoluble dark brick-red melted at 220-240°, and on reduction by stannous chloride used Sn = 48.4% of substance: no ash was left on burning it.



or the polymeric azo-dye formula $C_{28}H_{28}O_4N_4$ requires

Sn = 49.2%.

It is fairly soluble in benzene, chloroform and similar solvents.

A portion was dissolved in hot dilute acid and precipitated with ammonia, and this procedure repeated until the aqueous filtrate contained no dianisidine (as tested by rendering just acid and adding $FeCl_3$). The "quinone," thus completely freed from

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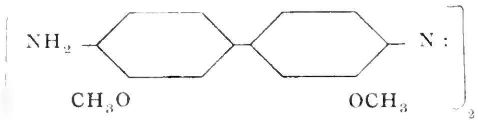
* Proc. C.S., London *l.c.*, and Trans. R.S.S.Afr.

dianisidine, was reduced by $SnCl_2$, and the tin removed from the diluted solution by H_2S. On concentrating somewhat, adding ammonia, and cooling, the reduction product came out in hair-like needles and glistening scales melting at 133° and 137° respectively: both varieties were dianisidine, which thus appears to be dimorphous. No other reduction-product could be obtained.

All attempts to regenerate the blood-red quinhydronic salts from the "quinone" have failed. The basic salts of the above "quinone" are olive, both solid and in solution, and the acid salts intense purple. With concentrated sulphuric acid the base and the salts give an intense bluish purple even in the minutest traces, as in the case of coeruliignone. It is thus probable that the "quinone" does not possess the simple quinone-diimine structure, but instead the isomeric polymerised form:



viz., the *tetramethoxyl*-derivative of the *azo-xenylamine* (4-4′ *diamino-azobisdiphenyl*) obtained by the author from "benzidine chromate."* Both the alternative formulæ agree with the formation of dianisidine by reduction. On the one hand the properties of the substance are stictly analogous to Willstaetter's "diphenoquinone-diimine," and, on the other hand, the substance is quite stable, does not lose ammonia, and has all the properties of an azo-dye, so that the arguments apply to Willstaetter's compound as well as to the present one: and my opinion is that both have the dimolecular formula, and are aminoazo-dyes. The only difficulty is that the supposed isomeric change of the quinone-diimine is apparently instantaneous. Even in the most dilute solution the quinhydronic salts give with ammonia a red precipitate of the above base (the dianisidine simultaneously formed remaining in solution), and no sign of an intermediate true quinone-diimine can be detected.

The colour changes of an acid solution of this base, $C_{28}H_{28}O_4N_4$, on evaporation are interesting. The brownish-green solution in very dilute hydrochloric acid changes to pink, bright reddish purple and dull blue, forming rings on the edge of the vessel which change colour as the steam passes and repasses, with quite remarkable effect.

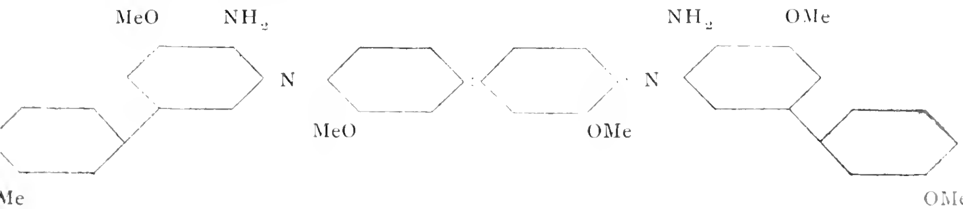
The bichromate of this base is an insoluble brown precipitate, quite different from the blue quinhydronic bichromate.

On drying the hydrochloride of the base $C_{28}H_{28}O_4N_4$ (obtained by evaporation) at 105°, it undergoes a further partial change, for on extraction with water, a brown insoluble is left which gives a *royal-blue* coloration with sulphuric or strong hydrochloric acid. This is also formed if the hydrochloride is

* *Loc. cit.*

allowed to stand for a week in presence of acid, and is probably a demethylated derivative of the diimine: the black precipitate formed is the almost insoluble hydrochloride of the demethylated compound, and only gives the blue coloration on dilution and heating. Another bye product is obtained on boiling the quinhydronic salts with acid water for some time: a black slimy precipitate is got which gives only a dirty olive coloration with sulphuric acid, and was therefore not investigated.

Following Willstaetter, I attempted to make the true quinonediimine from dianisidine in chloroform with lead dioxide. The product was mainly the brown base $C_{28}H_{28}O_4N_4$ (*m.p.* 220-225°), along with a small quantity of a higher polymer, very sparingly soluble in all solvents, of chocolate colour, and giving a pure blue coloration to sulphuric acid (m.p. 245°). From the analogy of Bandrowski's work on polymerisation of quinonediimine to $C_{18}H_{18}N_6$,* this sparingly soluble substance is probably $C_{42}H_{42}O_6N_6$, *viz.*:



Organic Chemistry is nowadays so specialised that there is nothing left in it of interest from the mental point of view—except filling up cracks in the plaster of the edifice. For example, the new substance I describe is about the 120th known isomer of the formula $C_{14}H_{14}O_2N_2$, so I cannot imagine anyone taking a real interest in investigating ordinary colourless substances under circumstances such as these. It is the great intrinsic beauty of the substances which I describe, and the interesting problem of the cause of the multiplex colour-changes which alone attract me to work at this field, despite the manifest special difficulties of doing organic work in South Africa without satisfactory appliances.

DELAVAN'S COMET.—A new comet, 1913*f*, was discovered at La Plata by M. Delavan on December 17th, ten months before perihelion, which will be reached on October 4th. The comet will probably be a grand naked-eye object, for even Halley's comet was not discovered until eight months before perihelion, and was then only of the 16th magnitude, whereas that of Delavan's at discovery was 10½. On March 29th it will be near λ Ceti, *viz.*, 2h. 56m. R.A. and 8° 55′ N.D.

* *Ber.* 1894, p. 480.

CHEMICAL COMPOSITION OF RAIN IN THE UNION OF SOUTH AFRICA.

By Charles Frederick Juritz, M.A., D.Sc., F.I.C.

In a paper by N. H. J. Miller, Ph.D., on "The amounts of nitrogen as ammonia and as nitric acid, and of chlorine in the rain water collected at Rothamsted," published in the *Journal of Agricultural Science*, Vol. I, October, 1905, pp. 280-303, Dr. Miller compared the nitrogen and chlorine contents of Rothamsted rain with the amounts found in rain water from various other parts of the world, as shown by analyses performed during the previous forty years. Contrasting, as far as that could be done, the composition of rain in tropical and in temperate countries, he came to the conclusion that tropical rain does not supply the soil with an essentially larger amount of nitrogen than the rain of temperate climates. Omitting some abnormal results at Caracas and in Mauritius, he found that the average total nitrogen brought down to the soil by rain amounted to 3.58 lb. per acre per annum in tropical countries, with the high average rainfall of 68.3 inches per annum.

Dr. Miller tabulated the monthly results of analyses of the rain which fell at Rothamsted during the period 1888 to 1901, and stated the average amount of nitrogen at 3.84 lb. per acre per annum, with an average rainfall of 27.25 inches per annum. In winter the total nitrogen was found to average 1.80 lb. per acre, and in summer 2.04 lb., the nitric nitrogen remaining constant, so that the increase was entirely due to a larger production of ammonia in summer. For every 1 part of nitric nitrogen he found in summer rain 2.55 parts and in winter rain 2.15 parts of ammonical nitrogen.

Professor C. G. Hopkins, in his "Soil fertility and permanent agriculture," 1910, pp. 309, 310, records the proportions of nitrogen brought to the earth annually by rain and snow in various places. From his statements the following table has been compiled:—

	Nitrogen Pounds per acre.
Rothamsted	3.97
Barbados	3.45
British Guiana	3.54
Kansas	3.69
Utah	5.42
Mississippi	3.64
Paris	8.93
Gembloux (Belgium)	9.20
Ottawa	4.32

Several of the above figures, together with others not quoted by Hopkins, are tabulated on page 286 of Dr. Miller's paper, appended to which there is also a bibliography of titles of 125 publications relating to rain water and its chemical composition.

It had been proposed to have a general discussion of the subject of Meteorological Chemistry at the International Congress of Applied Chemistry which was held in Washington, U.S.A., during 1912, and in this connection an attempt was made, a few years earlier, to organise a systematic examination of rain in various parts of the globe. There had been numerous previous analyses of rain water, but many of these results were of little practical value, because they had been made without any reference to the magnitude of the rainfall. Obviously, if the *average* composition of the rain during any particular month (or year) has to be determined, either the *whole* of the rain falling on some definite area *right through* that month (or year) has to be analysed, or a *fixed proportion* of that whole. Hence, in addition to noting the amount of rain that falls on such an area, it is most essential to include in each monthly sample the whole of each day's rain.

In connection with the scheme of world-wide examination an invitation from Dr. Miller to co-operate therein reached me a few weeks prior to the inauguration of the Union of South Africa, and, although greatly hampered by the unsettled condition of affairs just then, I undertook to aid in the investigation as far as circumstances would permit. Those circumstances, as subsequent events proved, could scarcely have been less propitious towards the organisation of a connected series of investigations.

As already stated, one of the ultimate objects of studying the chemical composition of rain, with reference to the proportions of ammonia, nitrates, chlorides and sulphates present therein, in different parts of the world, was that of comparing the rain of temperate with that of tropical countries. A subsidiary idea was to ascertain what differences, if any, were due to land and sea winds. The only series of analyses of rain previously made in Africa was that performed by Mr. Ingle, Chemist to the Transvaal Department of Agriculture, and published in the Annual Report of that Department for the year 1903-1904. In these the relations of ammonia to nitric nitrogen were exceptionally high, and so, probably, for some unexplained reason, not properly representative, as results subsequently obtained by Mr. Watt, Mr. Ingle's successor, were much lower. Mr. Watt shortly afterwards left the country, and so the investigation was dropped, and had not been resumed in 1910, when the general investigation above referred to was initiated.

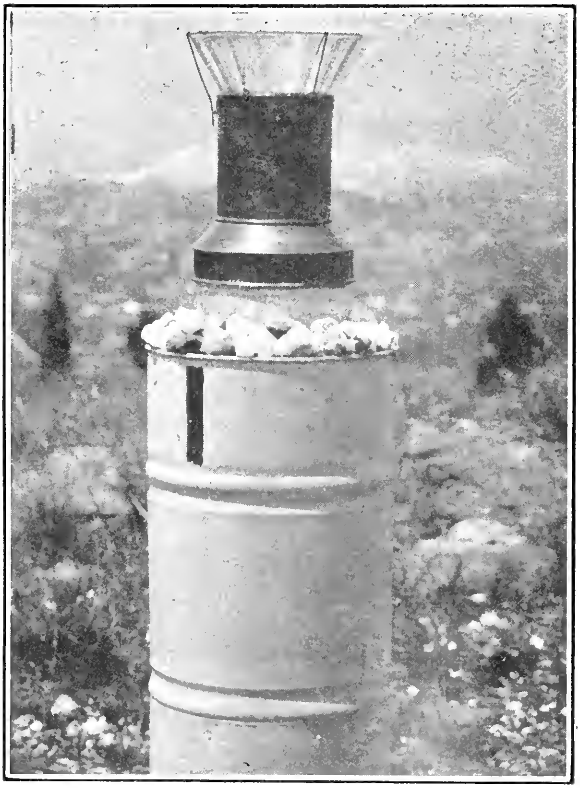
At the outset I sought and obtained the advice and practical help of Mr. R. T. A. Innes, Director of the Transvaal Observatory (now Union Astronomer), and of Mr. C. Stewart, Secretary of the Cape Meteorological Commission (now Chief Meteorologist of the Union); but there, too, difficulties confronted one, for meteorological work throughout the newly-formed Union was linewise in a state of fluidity.

My first idea was to collect and examine the rain only at Cape Town and Grahamstown, as typical of the two sections of the Cape Province which have their rainy seasons respectively in winter and in summer. Subsequent consideration, however, led to an endeavour to embrace the whole Union within the scope of the investigation. The collection of rain water typical of each of the four Provinces of the Union was therefore aimed at. In the Transvaal I decided, on Mr. Innes's suggestion, to have rain water collected (1) at the Johannesburg Observatory, (2) at the Potchefstroom Experimental Farm, and (3) at the Government Nurseries at Ermelo. On Mr. Stewart's advice, the following six collecting centres were resolved on for the Cape Province: Retreat, Mr. Stewart's residence (Cape Peninsula), Calvinia, Douglas, Kokstad (Mr. H. D. Coyte), Grahamstown (gaol), and Cradock (gaol). In the Province of Natal, Weenen (Experimental Farm) was selected as representing Upper Natal, Cedara (Government School of Agriculture), as typical of Central Natal, and Durban Observatory for the coast region. In the Orange Free State the centres were Bloemfontein, Modderpoort, and Lindley.

The method of collecting the rain water for analysis presented problems from the very start, not due only to the circumstances above alluded to, but owing as well to the climatological and other conditions of the country. In order to obtain a sufficient supply of rain water for monthly analysis by means of the eight-inch gauge, a monthly rainfall of about three inches would be needed. But if the whole Union was to be represented by the rain typical of each rainfall district, some of these arid areas would not afford much more than three inches of rain in an entire year. In any case, small rainfalls had to be considered, and so the course was adopted of mixing as one sample the rain collected during two or more months in succession.

On account of the long storage involved, it appeared undesirable to adopt this course more often than necessity compelled, but, on the other hand, it was impracticable to provide a sufficient number of gauges of the dimensions necessary to overcome the chemical difficulties occasioned by small rainfall. It was therefore decided in extreme cases to confine the determinations to nitrogen.

Another difficulty was involved in the dust storms frequent in certain parts of the Karroo, as well as in the more northerly Provinces of the Union, which would cause the accumulation of large quantities of dust in the gauges during the high winds that frequently precede rain. This would require the exercise of constant care to keep the gauge free from dust up to the very instant that a shower commenced. Such dust is frequently calcareous, and would therefore impart to the rain an alkaline reaction, while in the neigbourhood of great alkali tracts the dust might even contain much soluble salts. Of course, it will be sufficiently recognised that, quite apart from dust-bestrewn gauges, first rains would, in the districts mentioned, necessarily encounter considerable quantities of calcareous and alkali dust in their mere passage through the air.



C. F. JURITZ.—CHEMICAL COMPOSITION OF RAIN.

A further liability to error in the chemical results was foreseen in connection with the numerous hawks and other large birds which have their habitat on the expansive South African veld, and are apt to use any upward projection (such as a rain gauge) in the treeless Karroo, as a settling place, so fouling the gauge with their excreta. In fact, the Director of the Meteorological Observatory at Johannesburg at first considered it quite impossible to keep rain gauges free from dust and excreta, and believed that samples from even well-watched gauges would give most misleading results. As far as the dust was concerned, the decision arrived at was to eliminate it by simple filtration, and the bird problem having been experienced in Barbados, and there overcome by the use of large glass funnels, which the birds seemed to refrain from settling on, it was resolved to try the same plan in the South African districts wherever a similar trouble was likely to occur. The appended photograph illustrates the manner in which this difficulty was dealt with at the Johannesburg Observatory. The delivery spout of a five-inch gauge was removed, and the apex of its funnel opened out so as to allow the neck of a seven-inch glass funnel* to pass through. The glass funnel was then firmly held in position by three hooks of copper wire passing over the rim. A glass receiver was placed inside the gauge, so that, except for the three copper hooks, the rain came into contact with nothing but clean glass. The gauges were mounted in the usual way on firm stands, with their rims four feet above ground. Two of these gauges were placed a few feet apart, and the rain collected from them was stored in Winchester quarts until the end of each month. The glass funnels and receivers were kept clean by washing twice a day if no rain had fallen for a day or two, and every effort was made to prevent contamination of the water. Where there was possibility of the gauge being contaminated by birds perching on its rim, the additional safeguard was adopted of surrounding the funnel and gauge by a cylindrical screen of wire netting, the vertical wires of which projected above the highest horizontal strand, in order to prevent the birds from finding any foothold.

Unfortunately, the untoward circumstances already alluded to came in the way of the analysis of most of the rain water collected with so much precaution at Johannesburg; the Ermelo samples were likewise left untouched, and the Potchefstroom samples were only partially examined. But, for future guidance, it is nevertheless useful to record the truncated efforts made to obtain an idea of the composition of uncontaminated water from that centre.

Instructions were sent to all the collecting centres in the Cape, Transvaal and Natal Provinces on the above lines, and, as regards the period of storage, the following memorandum was

* Preferably one of Jena or resistance glass, so as to diminish the possibility of alkali being dissolved out.

furnished to each of these centres as well as to the five laboratories engaged in the chemical part of the work:—

As a rule each month's supply of rainfall should be analysed at the end of the month, a copy of all particulars in connection with such fall being supplied, mentioning any possible source of contamination that may have unavoidably occurred in the case of any sample either before, on, or after collection. If the amount of rain, in exceptional cases, should happen to be less than 200 c.c., the best course would be to keep it over and add it to the next month's rain.

After the method of collecting the rain, the method of analysing it claimed consideration. In deciding on this, I consulted the analytical chemists in charge of the various laboratories outside Cape Town, amongst whom the work was to be distributed, namely, at Bloemfontein, Durban, Grahamstown, and Pretoria. I had been furnished by Dr. Miller with a copy of the methods in use at Rothamsted, but some of these seemed wholly inapplicable under South African conditions, especially in certain parts of the Cape Province.

The following represents the lines of procedure eventually adopted. Determinations of nitrogen, both ammoniacal and nitric, were regarded as of most importance, and, when there was not sufficient water to enable other determinations to be carried out, these were given the preference. When it was impossible to devote 1,000 c.c. to these determinations, 500 c.c. was the quantity substituted, or, if even that were not available, whatever quantity was available was diluted with nitrogen-free water to 500 c.c. before distilling. After performing these determinations, chlorine was taken next in order. At Rothamsted the amount of water prescribed for this determination was one litre, but here, again, a smaller quantity had to suffice when necessity demanded it. For the determination of sulphates, preliminary evaporation in a large platinum dish was considered most satisfactory, but, in the absence of such an appliance, a Jena glass retort or a large Jena flask was decided on.

As far as the actual analyses are concerned, it is plain that uniformity of method was absolutely essential, seeing that the work was being done at five distinct laboratories, and so the following details of methods for chlorine, sulphur trioxide, ammoniacal and nitric nitrogen, employed at Rothamsted, were communicated to each of these laboratories, and adopted, except as above indicated.

Chlorine.—The method of estimation is that of titration with silver nitrate, potassium dichromate being used as indicator. The amounts of chlorine in rain show great variations, from one part per million to well over 200 parts per million, but as a rule the proportion is too small for accurate determination in the unconcentrated water. Prof. Warrington* found that some rain waters give an orange tint with the reagents employed, producing the idea that chlorine is absent. This orange tint is not discharged by the addition of a chloride. The procedure adopted for carrying out the determination is to add 5 c.c. of lime water, free from

* *Trans. Chem. Soc.*, 1889, vol. 55, p. 545.

chlorine, to 1,000 c.c. of rain water, and to concentrate the water, in an open basin, in a quiet room, to less than 250 c.c. After cooling, the water is filtered through a filter previously washed with chlorine-free water, into a marked 250 c.c. flask. The flask is then filled up to the mark, and the contents used for determination of chlorine in the usual way.

Sulphur trioxide.—For determining sulphates, it was proposed to collect the rain water for six months in succession, so as to make up one special sample of from four to seven litres of water. The rain used for this exclusive purpose is collected through a glass funnel having a small piece of asbestos cloth in the pipe no vulcanised caoutchouc being employed for connections. The combined quantity of 4 to 7 litres is concentrated in a retort to a small bulk, and filtered through Swedish filter paper previously washed with hydrochloric acid. In the filtrate, heated to boiling, sulphur trioxide is then gravimetrically determined by the addition of boiling barium chloride solution. The concentration in a *retort* is essential, because an open gas flame is a constant source of sulphuric acid. To avoid this the use of an alcohol flame was suggested, which would permit of a platinum dish being substituted for the glass retort, and thus avoid the possibility of contaminating the Barium sulphate precipitate by silica dissolved out from the glass.

Ammonia.—The retort and condenser are freed from ammonia by boiling some distilled water with a little magnesia in the former; after which one litre of rain water is introduced and boiled with a small quantity of magnesia until 250 c.c. have distilled over. In this distillate duplicate determinations of ammonia are made by Nesslerising.

Nitrogen as nitrites and nitrates.—The 750 c.c. of boiled rain water, remaining in the retort after determination of the ammonia, are transferred to a wide-mouthed stoppered bottle supplied with six strips of zinc foil converted into couple, and placed in an incubator at 21° to 24° for three days. The copper zinc couple used is prepared as follows: Six strips of zinc foil, four inches long by $1\frac{1}{4}$ inch wide, are bent at right angles along their middle in order to obtain stiffness. The couple is then further prepared in a series of five beakers, containing respectively (1) a dilute solution of sodium hydrate (2) very dilute sulphuric acid, (3) a three per cent. solution of copper sulphate (4) ordinary distilled water, and (5) distilled water free from ammonia. Through these five beakers the zinc foil is successively passed. It is rinsed both after the alkali and after the acid, but after the copper has been deposited the strips are simply drained, and carefully placed in the distilled water, as it is difficult to rinse without removing the copper. The couple should be entirely submerged when it is placed in the rain water.

It was not possible to arrange for commencing the collection of the rain water at all the designated localities simultaneously; in fact, nearly a year had passed after the scheme of investigation had first been mooted before any practical beginning could be made at all. When the first results began to come in—those from rain collected at Cedara, Natal—they seemed to show that the yearly amounts of nitrogen would be distinctly higher than in England, and Dr. Miller suggested the possibility that, owing to the higher temperature, the soil in Natal gives off more ammonia At the same time, the absence of ammonia from the Cedara water in November, 1910 (and from the Grahamstown rain of October, 1912), suggested nitrification, and this in turn led to the suggestion that such nitrification might be obviated by the addition of a small amount of a lead salt to samples liable to contain dust and nitrifying organisms. Another early modification of the collecting arrangements arose from the presence of leaves in the Durban sample. Though, to judge by comparison between the latter and the simultaneously collected Cedara sample, this had no appreciable effect, it was thought that an improvement in the collecting appliances might be effected by tying a piece of muslin (weighted down by a small stone in the middle) or wire gauze over the rain gauge, or else by placing over the gauge a perforated lead disc.

The collection of the samples in the fifteen selected centres was undertaken by the following:—

Cape Province:
- Retreat: The Secretary, Meteorological Commission.
- Calvinia: (No samples were received at the Cape Town Laboratory).*
- Douglas: Mr. A. C. Martin, Water Bailiff.
- Kokstad: Mr. H. D. Coyte, Attorney.
- Grahamstown: The Gaoler.
- Cradock: The Gaoler.

Transvaal:
- Johannesburg: The Director, Meteorological Observatory.
- Potchefstroom: Mr. T. Reinecke, Lecturer in Chemistry, Government School of Agriculture.
- Ermelo: Mr. A. C. Drummond, Forester.

Orange Free State:
- Bloemfontein: Mr. J. Lyle, Principal, Grey College School.
- Lindley†: Mr. John Oates.
- Modderpoort: The Provincial, St. Augustine's.

Natal:
- Cedara: The Chemist, Government Experiment Farm.
- Weenen: The Officer in charge, Government Experiment Farm.
- Durban: The Director of the Natal Observatory.

Of the Cape Province samples those from Retreat, Calvinia and Douglas were assigned to the Cape Town Laboratory, while the Kokstad, Cradock and Grahamstown samples were analysed at Grahamstown. The Transvaal samples were allotted to the Pretoria laboratory, and those of the Orange Free State were examined in the laboratory at Bloemfontein. The Durban laboratory dealt with the Natal samples. In all 127 samples of rain water were analysed in pursuance of the scheme of investigation outlined above, the results of the analyses being given in the following tables:—

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* Samples were collected, but the transport riders refused to convey them as their wagons were generally loaded with wool and skins in charge of natives.

† The Lindley samples were never received at the Bloemfontein laboratory.

I.—Cape Province.

Retreat.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911.											
July ...	7·38	·005	·200	10·47	—	·008	·334	·342	17·48	—	
August ...	3·17	·028	·543	9·30	—	·020	·389	·409	6·67	—	
September	4·34	·123	·170	7·60	—	·121	·167	·288	7·46	—	
October ...	2·60	·058	·110	13·00	—	·034	·065	·099	7·65	—	
November	·90	·255	6·580	—	—	·052	1·340	1 392	—	—	Little sediment.
December	1·14	—	—	—	—	—	—	—	—	—	
1912.											
January...	·24	·132	10·310	139·40	—	·007	·560	·567	7·57	—	Traces of sediment: three moths in the water.
February.	·36	1·927	1·980	—	—	·157	·161	·318	—	—	Traces of sediment: sample insufficient for Chlorine determination.
March ...	1·05	1·864	1·580	284·00	—	·443	·375	·818	67·46	—	Trace of sediment.
April ...	2·71	2·676	·160	11·70	—	1·641	·098	1·739	7·17	—	Fair amount of sediment.
May ...	5·08	·041	—	14·56	—	·047	—	—	16·73	—	
June ...	4·40	·016	—	16 69	—	·016	—	—	16·61	—	
July ...	1·70	·016	—	10·29	—	·006	—	—	3·96	—	
August ...	3·76	—	—	12·96	—	—	—	—	11·02	—	
September	5·63	—	—	17 75	—	—	—	—	22·61	—	

I.—Cape Province—(*continued*).

Douglas.

Month.	Rainfall in inches.	Parts per Million.				Pounds per Acre.					Remarks.
		Nitrogen.		Chlorine.	Sulphur Trioxide.	Nitrogen.			Chlorine.	Sulphur Trioxide.	
		As Ammonia.	As Nitrates.			As Ammonia.	As Nitrates.	Total.			
1911.											
October ...	·58	·990	·380	6·39	—	·130	·050	·180	84	—	Water yellowish, with a considerable amount of sediment.
November	1·66	—	—	—	—	—	—	—	—	—	
December	Nil	—	—	—	—	—	—	—	—	—	
1912.											
January...	1·11	·430	7·480	35·50	—	·108	1·878	1·986	8·91	—	Water brownish yellow, with little sediment.
February..	3·13	3·710	5·150	15·98	—	2·627	3·647	6·274	11 32	—	Fair amount of sediment.
March ...	3·05	1·540	8·030	14·20	—	1·063	5·541	6 604	9·80	—	Very little sediment.
April ...	1·31	·082	·330	3·91	—	·024	·098	·122	1·16	—	Fair amount of sediment.
May ...	·15	—	—	—	—	—	—	—	—	—	
June ...	·29	—	—	—	—	—	—	—	—	—	
July ...	·16	—	—	—	—	—	—	—	—	—	

I.—CAPE PROVINCE—(*continued*).

Grahamstown.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911.											
August ...	1·58	·109	·049	—	—	·039	·018	057	—	—	Turbid, with sediment of organic fragments. Sample too small for Chlorine determination.
September	2·85	·028	·138	5·65	—	·018	·089	·107	3·64	—	Dirty mineral sediment.
October ...	3·47	·016	·103	3·40	—	·013	·081	·094	2·67	—	Putrid odour: ants and cockchafer beetles.
November	2·63	·400	·133	4·65	—	·238	·079	·317	2·77	—	Putrid odour: ants and cockchafer beetles.
December	·41	·247	·642	—	—	·023	·060	·083	—	—	Excessive amount of organic matter. Sample insufficient for Chlorine determination.
1912.											
January...	4·14	·195	·106	4·30	—	·183	·099	·282	4·03	—	Clean sample.
February..	2·33	·222	·109	6·40	—	·117	·057	·174	3·37	—	Traces of sediment
March ...	1.93	·064	·279	5·87	—	.028	·122	·105	2·56	—	Excessive amount of organic sediment.
April ...	3·88	·217	·074	1·50	—	191	·065	·256	1·32	—	Traces of sediment.
May ...	·59	·421	·094	—	—	·056	·013	·069	—	—	Sample too small for further analysis. Water of a yellow colour, with excessive amount of organic sediment.

I.—CAPE PROVINCE—(*continued*).

Grahamstown—(*continued*).

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1912.											
June ...	1·94	·198 (June and July)	·068	4·80	—	·124	·043	·167	3·02	—	Excessive amount of organic sediment. (June and July)
July ...	·84										
August ...	1·01	·215	·094	—	—	·049	·021	·070	—	—	Sample insufficient for Chlorine determination: contained excessive amount of organic sediment.
September	2·12	·165	·143	6·20	—	·079	·069	·148	2·97	—	Considerable proportion of organic matter.
October...	2·23	Nil	·198	9·23	—	Nil	·100	·100	4·66	—	Large amount of dust and organic sediment.
November	·72	·049	·527	10·46	—	·008	·086	·094	1·70	—	Large amount of dust and organic sediment.

Cradock.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911.											
August ...	·62	·059 (August–October)	·077	4·80	—	·041	·052	·093	3·26	—	Traces of organic sediment.
September	·76										
October ..	1·62										

I.—Cape Province—(*continued*).

Cradock—continued.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911.											
November	1·21										
December	Nil	·042	·469	7·75	—	·019	·213	·232	3·52	—	Traces of sediment.
1912.											
January...	·80										
February..	1·22	—	—	—	—	—	—	—	—	—	Receiver damaged and contents lost.
March ...	1·11	·054	·405	4·86	—	·014	·102	·119	1·22	—	Trace of sediment
April ...	3·29	·815	·106	4·40	—	·606	·079	·685	3·27	—	Water of a yellow colour, with traces of sediment.
May ...	·40	·168	·403	7·30	—	·015	·037	·052	·66	—	Clear.
June ...	·50										
July ...	·57	·035	·059	5·75	—	·009	·015	·024	1·50	—	
August ...	·08										

Kokstad.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1912.											
January...	3·69	·163	·081	1·10	—	·136	·068	·204	·98	—	Clear, with traces of sediment.
February..	7·29	·163	·032	·90	—	·269	·053	·322	1·48	—	Clear, with traces of sediment.
March ...	1·64	·280	·094	3·10	—	·104	·035	·139	1·15	—	Clear.
April ...	1·77	·420	·163	2·00	—	·168	·065	·233	·80	—	Traces of sediment.

I.—CAPE PROVINCE—(*continued*).

Kokstad—(*continued*).

Month.	Rainfall in inches.	Parts per Million.				Pounds per Acre.					Remarks.
		Nitrogen.		Chlorine.	Sulphur Trioxide.	Nitrogen.			Chlorine.	Sulphur Trioxide.	
		As Ammonia.	As Nitrates.			As Ammonia.	As Nitrates.	Total.			
1912.											
May ...	·45	·445	·125	—	—	·045	·013	058	—	—	Trace of sediment: sample too small for further analysis.
June ...	·56	·171	·054	—	—	·022	007	·029	—	—	Clear.
July ...	1·00	·124	·057	1·40	—	·028	·013	·041	·32	—	Clear.
August ...	Nil	—	—	—	—	—	—	—	—	—	
September	·24	—	—	—	—	—	—	—	—	—	Sample too small for accurate analysis.
October ...	1·04	·052	·037	1·67	—	·012	·009	·021	·39	—	Sample contained a small quantity of wood wool.
November	1·71	·346	·370	—	—	·134	·143	·277	—	—	Clear: trace of sediment: sample insufficient for Chlorine determination.
December	7·15	·124	·163	1·00	—	·200	·264	·464	1·62	—	Clear.

II.—Transvaal Province.

Johannesburg.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1910.											
December	5·98	·250	·188	1·20	—	·339	·254	·593	1·62	—	
1911.											
January...	5·19	·150	·100	1·16	—	·176	·117	·293	·136	—	
February..	3·84	·210	·200	1·23	—	182	·174	·356	·107	—	

Potchefstroom.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911.											
November	4·38	·39	·25	—	—	·386	·248	·634	—	—	
December	2·58	·33	·30	—	—	·193	·175	·368	—	—	

III. Orange Free State.

Bloemfontein.

Month.	Rainfall in inches	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine	Parts per Million. Sulphur Trioxide	Pounds per Acre. Nitrogen As Ammonia.	Pounds per Acre. Nitrogen As Nitrates.	Pounds per Acre. Nitrogen Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Alkalinity, calculated as NaOH. Parts per Million.	Alkalinity, calculated as NaOH. Pounds per Acre.	Remarks.
1910													
Sept. ...	3·76	·329	·370	2·00	—	·280	·315	·595	1·70	—	6·0	5·11	
Oct. ...	2.97	·646	·293	2·00	—	·434	·197	·631	1·34	—	8·0	5·38	
Nov. ..	1 76	·340	·288	1·60	—	·135	·114	·249	·64	—	20·0	7·96	
Dec. ...	·80												
1911		257	185	1·00	—	·230	·165	·395	·89	—	4·0	3·57	
Jan. ...	3·15												
Feb ...	1·24	1·235	·412	·90	2·10	·346	·116	·462	·25	4·47	6·0	1 68	
March	8·16	·309	·164	·20		·570	·303	873	·37		neutral	nil	
April ...	3·36	·371	095	30	—	·282	·072	·354	·23	—	neutral	nil	Only about 2 inches collected.
May ...	1·27	2·573	·206	·80	—	·937	·075	1·012	·29	—	6·0	2·18	Bird excrement on funnel on 19th May.
June ...	·34												
July ..	·94	1·941	1·153	4·40		·444	·263	·707	1·01		4·0	·91	
Aug. ...	·07												
Sept. ...	·07	659	·823	1 60	6·19	·419	·524	·943	1·02	·91	neutral	nil	
Oct. ...	2·75												
Nov. ...	2·55	2·779	·525	1·10		1·679	·317	1·996	·66		10·0	6·04	
Dec. ...	·12												

III.—ORANGE FREE STATE—(*continued*).

Bloemfontein.—(*continued*).

Month.	Rainfall in inches.	Parts per Million: Nitrogen. As Ammonia.	Parts per Million: Nitrogen. As Nitrates.	Parts per Million: Chlorine.	Parts per Million: Sulphur Trioxide.	Pounds per Acre: Nitrogen. As Ammonia.	Pounds per Acre: Nitrogen. As Nitrates.	Pounds per Acre: Nitrogen. Total	Pounds per Acre: Chlorine.	Pounds per Acre: Sulphur Trioxide.	Alkalinity calculated as NaOH. Parts per Million.	Alkalinity calculated as NaOH. Pounds per Acre.	Remarks.
1912													
Jan. ...	·79	1·647	·453	·10	—	·294	·081	·375	·02	—	—	—	
Feb. ...	3·18	1·184	·216	·10	—	·852	·155	1·007	·07	—	—	—	
Mar. ...	1·39	·638	·309	—	—	·201	·097	·298	—	—	—	—	
April ...	3·27	·494	·124	·15	—	·365	·092	·457	·11	—	—	—	
May ...	·63	3·623	·296	·40	—	·516	·042	·558	·06	—	—	—	
June ...	·32	5·147	·329	2·20	—	·544	·055	·599	·37	—	—	—	
July ...	·42												
Aug. ...	nil	—	—	—	—	—	—	—	—	—	—	—	
Sept. ...	·02	3·912	·453	·18	—	1·080	·125	1·205	·050	—	—	—	
Oct. ...	1·20												
Nov. ...	·31	9·058	1·400	·26	—	·635	·098	·733	·018	—	—	—	
Dec. ...	2·34	2·573	·865	·13	—	1·362	·458	1·820	·069	—	—	—	

ORANGE FREE STATE.—(*continued*)

*Modderpoort.**

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911											
October ...	2·39	·194	·494	1·20	—	·105	·267	·372	·65	—	
November	4·64	—	—	—	—	—	—	—	—	—	Sample too small for analysis.
December	nil	—	—	—	—	—	—	—	—	—	
1912											
January ...	2·19	·206	·123	·40	—	·102	·061	·163	·20	—	
February	5·40	—	—	—	—	—	—	—	—	—	
March ...	2·40	2·059	·123	·20	—	1·118	·067	1·185	·11	—	Very yellow in colour.

IV.—NATAL PROVINCE.

Durban.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911											
January ...	2·47	·626	·150	13.20	—	·350	·084	·434	7·38	—	Large quantities of leaves, &c.: water filtered before analysis.
February	2·46	·533	·280	7·45	—	·297	·156	·453	4·15	—	
March ...	4·98	·296	·120	5·98	1·66	·333	·135	·468	6·74	1·87	
April ...	3·13	·296	·120	7·36	—	·210	·085	·295	5·21	—	

*Some, and possibly all, of the Modderpoort samples were not representative of the whole rainfall for the monthly periods, and the equivalents in pounds per acre are in consequence only approximations.

IV.—NATAL PROVINCE.—(*continued*).

Durban.—(*continued*).

Month.	Rainfall in inches.	Parts per Million.				Pounds per Acre.					Remarks
		Nitrogen.		Chlorine.	Sulphur Trioxide.	Nitrogen			Chlorine.	Sulphur Trioxide	
		As Ammonia.	As Nitrates.			As Ammonia.	As Nitrates	Total.			
1911											
May ...	1·67	·263	062	4·90	1·10	·099	·023	·122	1·85	·42	Large quantities of leaves, &c.: water filtered before analysis.
June ...	·20	—	—	—	—	—	—	—	—	—	
July ...	nil	—	—	—	—	—	—	—	—	—	
August ...	1·07	1·318	·330	22·00	—	·319	·080	·399	5·33	—	Large quantities of matter in suspension.
September	4·02	·132	·086	3·80	·50	·120	·078	·198	3·46	·45	Very clear and free from suspended matter.
October ...	15·33	·329	·130	5·60	2·23	1·141	·451	1·592	19·43	7·74	Nearly free from suspended matter.
November	3·47	·593	·140	13·40	3·90	·466	·110	·576	10·52	3·06	Quantities of leaves and suspended matter.
December	3·54	·395	·040	7·60	3·50	·316	032	·348	6·09	2·80	Small quantities of suspended matter.
1912											
January ...	2·95	·395	·100	8·52	3·41	·264	·067	·331	5·69	2·28	Sample very clear.
February	2·58	·741	·072	9·42	3·09	·432	·042	·474	5·50	1·80	Small quantities of suspended matter.
March ...	3·72	·593	nil	6·20	2·40	·499	nil	·499	5·21	2·02	Quantities of suspended matter.
April ...	1·43	1·320	·160	16·50	—	·427	·052	·479	2·10	—	
May ...	4·03	·920	·160	9·90	2·23	·839	·146	·985	9·03	2·03	
June ...	nil	—	—	—	—	—	—	—	—	—	

IV.—NATAL PROVINCE—*(continued.)*

Durban—(continued).

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Total	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide	Remarks.
1912											
July ...	·45	·171	·360	46 00	—	.017	.037	·054	4·68	—	Water filtered before analysis.
August ...	·37	·165	·720	51·17	—	·014	·060	·074	4·28	—	
September	·86	·263	·480	30·80	—	·051	·093	·144	5·99	—	
October ...	1·75	·873	·380	17·75	5·80	346	·150	·496	7 03	2·30	Small quantities of suspended matter.
November	2·77	659	·520	11·89	3·77	·413	·326	·739	7·45	2·36	
December	10·16	·263	·120	5·85	1·71	·604	·276	·880	13·44	3·93	

Weenen.

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates.	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Total	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide	Remarks.
1911											
February	5·04	·527	nil	1·42	—	·601	nil	·601	1·62	—	
March ...	5·71	—	—	—	—	—	—	—	—	—	
April ...	1·65	—	—	—	—	—	—	—	—	—	
May ...	1·52	·395	·096	1·70	—	·136	·033	·169	·58	—	Small quantities of suspended matter.
June ...	nil	—	—	—	—	—	—	—	—	—	
July ...	·08	—	—	—	—	—	—	—	—	—	
August ...	2·08	·395	4·800	1·90	—	1·86	2·259	2.445	·89	—	Quantities of suspended matter.
September	2·00	·099	·760	2·00	—	·045	·345	·390	·91	—	Fairly free from suspended matter.
October ...	2·19	·469	280	2·60	—	·232	·139	·371	1·29	—	Very clear.
November	2 45	·395	nil	2·80	—	219	nil	·219	1.55	—	Small quantities of suspended matter.
December	1·98	·790	1·100	2·30	—	·354	·493	·847	1·03	—	Quantities of suspended matter.

IV.—Natal Province—(*continued*)

Weenen—(*continued*).

Month	Rainfall in inches.	Parts per Million.				Pounds per Acre.					Remarks.
		Nitrogen.		Chlorine.	Sulphur Trioxide.	Nitrogen.			Chlorine.	Sulphur Trioxide.	
		As Ammonia.	As Nitrates.			As Ammonia.	As Nitrates.	Total.			
1912											
January	3·18	—	—	—	—	—	—	—	—	—	Bottle containing sample received broken.
February	4·72	2·110	·040	·88	—	2·253	·043	2·296	·94	—	Small quantities of suspended matter.
March ...	3·28	·720	·140	1·59	—	·531	·104	·638	1·18	—	Small quantities of suspended matter.
April ...	2·55	—	—	—	—	—	—	—	—	—	
May ...	·57	—	—	—	—	—	—	—	—	—	
June	05	—	—	—	—	—	—	—	—	—	
July ...	nil	—	—	—	—	—	—	—	—	—	Continued drought.
August ...	·30	—	—	—	—	—	—	—	—	—	
September	nil	—	—	—	—	—	—	—	—	—	
October ...	1·21	—	—	—	—	—	—	—	—	—	
November	2·85	—	—	—	—	—	—	—	—	—	
December	3·39	·263	620	1·77	—	·202	·475	·677	1·36	—	Small quantities of suspended matter.
						Cedara.					
1910							*Vlei*	*gauge.*			
October ...	4·55	·982	·048	2·62	—	1·001	·049	1·050	2 67	—	Small quantities of suspended matter.
November	2·63	nil	·330	2 81	—	nil	·196	·196	1·67	—	Dust in suspension.
December	5 88	·428	·140	2·01	—	·569	·186	·755	2·67	—	Small quantities of suspended matter.

IV.—NATAL PROVINCE—(*continued*)

Cedara (continued).

(Vlei gauge).—(continued).

Month.	Rainfall in inches.	Parts per Million. Nitrogen. As Ammonia.	Parts per Million. Nitrogen. As Nitrates	Parts per Million. Chlorine.	Parts per Million. Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1911											
January...	3·69	·461	·060	1·75	—	·452	·059	·511	1·72	—	Traces of suspended matter.
February	5·32	—	—	—	—	—	—	—	—	—	
March ...	4·08	1·120	·120	1·75	—	1·054	·111	1·165	1·66	—	
April ...	1·66	1·515	·150	1·42	—	·569	·056	·625	·53	—	Small quantities of suspended matter.
May ...	·57	—	—	—	—	—	—	—	—	—	
June ...	·17	—	—	—	—	—	—	—	—	—	
July ...	·09	—	—	—	—	—	—	—	—	—	
						Hill	*gauge.*				
August ...	1·65	2·306	1·900	3·20	—	·861	·709	1·570	1·19	—	Traces of suspended matter.
September	·81	·461	·430	·49	—	·084	·079	·163	·09	—	Quantities of suspended matter.
October...	7·96	·741	·210	1·40	—	1·334	·378	1·712	2·52	—	Very clear, with only traces of suspended matter.
November	5·71	1·054	·140	2·27	—	1·362	·181	1·543	2·90	—	Small quantities of suspended matter.
December	5·05	·066	·260	2·10	—	·075	·297	·372	2·40	—	Very clear.
1912											
January...	4·24	·066	·024	1·95	—	·063	·023	·086	1·87	—	Small quantities of suspended matter.
February	7.96	1·218	·070	1·22	—	2·193	·126	2·319	2·32	—	Quantities of suspended matter.

IV.—Natal Province—(*continued*).

Cedara—(*continued*).

(*Hill Gauge*)—(*continued*).

Month.	Rainfall in inches.	Parts per Million, Nitrogen. As Ammonia.	Parts per Million, Nitrogen. As Nitrates	Parts per Million, Chlorine.	Parts per Million, Sulphur Trioxide.	Pounds per Acre. Nitrogen. As Ammonia.	Pounds per Acre. Nitrogen. As Nitrates.	Pounds per Acre. Nitrogen. Total.	Pounds per Acre. Chlorine.	Pounds per Acre. Sulphur Trioxide.	Remarks.
1912											
March ...	3·15	·305	·040	3·37	—	·217	·028	245	2·39	—	Quantities of suspended matter.
April ...	1·28	} ·026 (April–May)	·100	2·84	—	·016	·060	·076	1 69	—	
May ...	1·36										
June ...	·11	—	—	—	—	—	—	—	—	—	
July ...	·17	} ·296 (July–October)	·430	7·25	—	·190	·275	·465	4·64	—	Small quantities of suspended matter
August ...	nil										
September	·40										
October ...	2·26										
November	2·37	1·252	·260	2·80	—	·671	·139	·810	1·50	—	Small quant.ties of suspended matter.
December	3·38	1·778	·280	2·30	—	1·360	·214	1·574	1·76	—	Small quantities of suspended matter.

The results in the foregoing tables are manifestly incomplete, and in other respects imperfect, so that, under ordinary circumstances, one would prefer postponing their collation until they could be made more complete; but the circumstances are not ordinary, and, as the inevstigation has now been discontinued, with but little prospect of its resumption for some years to come, I have thought it best to bring the results together in their present condition, notwithstanding the obvious blemishes, so that they may at least serve as a point of departure and as an indication of the needful precautions, should the work happen to be resumed on some future occasion. Meanwhile, the very incompleteness of the records precludes much discussion of the figures at the present stage.

Where possible, the rain water analyses have been summarised into annual aggregates, and the summaries thus obtained are as follows:—

Locality.	Twelve-month period covered.	Rainfall for period in inches	Pounds per Acre. Nitrogen. As Ammonia	As Nitrates.	Total.	Chlorine.
Grahamstown	August, 1911, to July, 1912	26·59	1·030	·726	1·756	23·38*
,, ..	Dec., 1911, to Nov., 1912 ..	22·14	·858	·735	1·593	23·63†
Kokstad ..	January, 1912, to Dec., 1912	26·54	1·118‡	670‡	1·788‡	—
Bloemfontein	Sept., 1910, to August, 1911	27·82	3·658	1·620	5·278	6·72
,, ..	Sept., 1911, to August, 1912	15·49	4.870	1·363	6·233	2·31¶
Durban ..	January, 1911, to Dec., 1911	42·34	3·651‖	1·234‖	4·885‖	61·16‖
,, ..	January, 1912, to Dec., 1912	31·07	3·906	1·249	5·155	70·40
Cedara ..	January, 1912, to Dec., 1912	26·68	4·710§	·865§	5·575§	16·17§

In four cases it has been found possible to make a comparison between summer and winter rains, in respect of their nitrogen content, and these are tabulated below:—

Localty and Period.	Nitrogen: In Pounds per Acre. Summer: Sept. to Feb. As Ammonia.	As Nitrates.	Total.	Winter: March to Aug. As Ammonia.	As Nitrates.	Total.
Grahamstown (Sept., 1911, to Aug., 1912)	·592	·465	1·057	·448	·264	·712
Bloemfontein (Sept., 1910, to Aug. 1911)	1·425	·907	2·332	2·233	713	2·946
Bloemfontein (Sept., 1911, to Aug., 1912)	3·244	1·077	4·321	1·626	·286	1·912
Durban (Sept., 1911, to Aug., 1912) ...	2·739	·780	3·519	1·796	·295	2·091

* Not including August and December, 1911, and May, 1912.
† Not including December, 1911, and May and August, 1912.
‡ Excluding one-fourth of an inch of rain during September, 1912.
¶ Not including March, 1912.
‖ Excluding one-fifth of an inch of rain during June, 1911.
§ Excluding one-tenth of an inch of rain during June, 1912.

In each of these four cases more nitric nitrogen was brought down by the summer than by the winter rains, and ammoniacal nitrogen was also larger in amount during the summer than during the succeeding winter months at Grahamstown and at Durban; at Bloemfontein considerably more nitrogen was brought down as ammonia in winter than in summer during 1910-1911, but during the succeeding year Bloemfontein also fell into line with the other two localities.

The salt spray from False Bay during south-east rains had a considerable effect in increasing the chlorides at Retreat during the summer months of 1912. At Douglas the rain showed large proportions of chlorides for a locality so far inland; possibly this may be in some way connected with the saltpans in the district.

My thanks are due in the first place to Mr. R. T. A. Innes, Union Astronomer, and Mr. C. M. Stewart, Chief Meteorologist, for their valued advice and aid; next to all those who undertook the trouble of collecting rain water from month to month and forwarding the samples to the Government laboratories; and, lastly, to the officers of the various laboratories, for their assistance in carrying out the analyses here recorded, and particularly to Mr. A. Stead, B.Sc., F.C.S., of the Bloemfontein Laboratory, and Mr. J. S. Jamieson, F.I.C., of the Durban Laboratory, for the work done by them in this connection.

MAIZE PRODUCTION. —In a brochure, entitled "Maize Cultivation and Export," issued towards the close of 1909, under authority of the Governments of the Cape, Natal, Orange River and Transvaal Colonies, it was stated that "maize is the staple crop of a large part of Natal, the Transvaal, Rhodesia, and Eastern Province of Cape Colony, and the Eastern Districts of the Orange River Colony." On the same page it was frankly confessed that "the whole of civilised South Africa produces, at present, less than one per cent. of the world's crop"; and yet "maize is a crop eminently suited to vast areas of South Africa, and vast quantities could be produced if the veld were brought under cultivation." Mr. J. Burtt-Davy, who interested himself very greatly in maize breeding during his incumbency of the post of Government Botanist and Agrostologist, resigned that office some months ago in order that, in the ampler atmosphere of a private position, he might with greater freedom and effectiveness devote his energies to fostering the maize industry in South Africa. Under those circumstances all—and they are numerous—who appreciated Mr. Burtt-Davy's efforts on behalf of that industry in the past, will give a warm welcome to the bulky volume that has just issued from the press as a result of his labours.* The book is written with the object of meeting

* "Maize: its history, cultivation, handling, and uses." 8vo., pp. xl., 831. London: Longmans, Green & Co. 1914. 60 oz., 25s.

the diverse needs of the farmer, the student, the teacher, and others concerned with the maize industry and its various branches, such as commerce, manufactures, and the supply of agricultural implements, machinery, and fertilisers. It is inscribed to General Botha, whose photograph constitutes the frontispiece, and there are 245 other illustrations. The author is not sparing of statistical and other tabular information, no less than 132 tables being embodied in the work. In his opening chapter, on the importance of the maize crop, Mr. Burtt-Davy takes care to point out that this importance, great as it is, is not *wholly* derived from the grain, for there are other parts of the plant deserving of a more extended use for winter-feeding than they are put to at present. Even the refuse of maize may be put to a variety of industrial uses, and probably when South Africa awakes to an adequate realisation of the commercial possibilities of many products that are now regarded as so much waste, the cobs, stalks, and straw of maize will take their place with other articles like seaweed and prickly pear, that are now looked upon as mere cumberers. In his closing chapter the author returns to this phase of the subject, and it is to be hoped that some, amongst the many who are sure to study this book, will turn from the reading of that final chapter with strong desires to give practical effect to the hints contained therein. Emphatic endorsement is given to the opinion that South Africa will be in days to come the maize granary of Europe, and although the professor of Economics at Harvard, Professor T. N. Carver, considers maize to be the leading product of the United States and maize-growing the leading industry, Mr. Burtt-Davy, echoing the views expressed in the brochure of 1909, is convinced that for maize production South Africa has enormous advantages over America. The dryness of the winter allows the South African farmer to harvest and shell in the field up to the very day when he starts planting his new crop; in South Africa the percentage of grain damaged by the weather is exceedingly small; and the moisture content of the grain is some 5 per cent. lower in South African maize than in the American article. To these advantages may be added the considerations that South Africa has an excellent local market for a large part of her maize crop, and, because she owns her own railways, she can carry the surplus to the coast at cost. Three chapters are assigned to the climatic requirements, the geographical distribution, and the botanical characters of maize, three to maize-breeding, four to what may be termed maize agrostology, including maize pests, and in the later chapters the chemistry and feeding value of maize are dealt with, as well as its preservation by silage. Finally, there is a bibliography of over 400 titles. Altogether the South African maize grower will find in this monograph a compendium of information and advice excellently adapted to his peculiar needs.

Sir DAVID GILL.

SIR DAVID GILL,

K.C.B., LL.D., D.Sc., F.R.S., F.R.S.E.

(*Born 12th June, 1843. Died 24th January, 1914.*)

For the second time, within a few weeks, the South African Association mourns the loss of one of its past presidents. By the death of Sir David Gill, which took place on January 24th last, science has lost an astronomer of exceptional capacity and skill and a powerful advocate of its claims, in all its branches, on the community at large.

David Gill was born at Aberdeen on the 12th June, 1843. He received his early education at the Bellevue and Dollar Academies of that city, and afterwards proceeded to the Marischal College and University, Aberdeen. Though destined to succeed his father in business, his interests from early days lay rather in scientific pursuits. The direction these interests took in later life was, as he himself was fond of relating, largely inspired by Clerk Maxwell, under whose influence he was brought during his course at the Marischal College.

On the completion of his University course he at first settled down to a business career, but devoted all his leisure to the construction and use of astronomical instruments, with a view to furthering the work which he had at heart. The success he achieved in this manner attracted the attention of Lord Lindsay, who at the time was contemplating the creation of a private observatory at his father's seat (Dun Echt) and led to the offer from the Earl of Crawford that Gill would take charge of this observatory. Recognising the opportunity that this would afford him of fulfilling his desire to devote himself exclusively to science, Gill resolved, at considerable pecuniary loss, to abandon his business and accept Lord Crawford's offer.

The next few years were spent in planning and fitting out the equipment of the observatory and in making preparations on an elaborate scale for an expedition, proposed by Lord Lindsay, to Mauritius to observe the transit of Venus in the year 1874.

Such an event had not occurred for more than a century. Its occurrence at this time served to focus the attention of astronomers on the problem of the determination of the sun's distance from the earth, and numerous costly expeditions were fitted out to places whence the phenomenon might be favourably observed with a view to the determination of this important astronomical constant with all precision attainable.

The comparative ill success of the results secured, so far as they related to their immediate purpose, led Gill to the consideration of alternative methods by which the same end might be more effectively attained. Hitherto determinations of the Sun's distance, or what is equivalent, the scale of the Solar system had been based on the comparisons of observations made simultaneously, or almost simultaneously, from different stations widely separated on the Earth's surface. This of course necessitated the employment of different observers and different instruments at each station.

The quantities under investigation were so minute that there always remained uncertainty as to whether the results derived might not in considerable measure be attributed to some personal or instrumental peculiarities, rather than to the primary phenomenon sought. To obviate such uncertainty, Gill proposed to make use of the so-called "diurnal method," which enabled a single observer, with the same instrument throughout, to make all the necessary observations. The parallax was to be derived by the difference in the apparent displacement of a planet in relation to the surrounding stars as derived from observations soon after rising, and that derived from similar observations just before setting The heliometer had already proved in Gill's hands a highly efficient instrument for measuring these minute displacements, and a preliminary attempt by means of the planet Juno at Mauritius had convinced him of the ultimate efficiency of the method when a more extended series of observations under more favourable geometrical conditions both as regards the position of the observer and that of the planet could be got.

A favourable opportunity for a further application of the method occurred on the occasion of the opposition of Mars in 1877. To secure the most advantageous conditions it was necessary to occupy a station as near as possible to the equator, and the Island of Ascension was selected as being convenient of access and, as far as could be ascertained, likely to yield favourable weather conditions. The interest of the Royal Astronomical Society was readily secured, and through their means the necessary funds were obtained to provide for an expedition.

This expedition, of which a charming account has been written by Lady Gill, proved a complete success, though almost doomed to failure from the outset by a serious accident to the instrument, which would have deterred a less determined observer from proceeding.

Shortly after his return to England, the post of H.M. Astronomer at the Cape became vacant through the retirement of Mr. Stone, and Gill was selected as his successor. He occupied the position for a space of 28 years, and it was here that the principal contributions to his life's work were made. On his arrival he found the establishment but poorly equipped and inadequately staffed, but by his own energy and persistent pressing of its claims to official support he left it with an equipment that would bear favourable comparison with that of any existing astronomical observatory.

Under Stone's directorship the establishment had been almost exclusively devoted to meridian astronomy. To enable him to follow up the researches which had been brought to so successful a conclusion in Ascension, Gill desired that the extra meridian appliances should be supplemented, and to this end obtained by purchase from Lord Lindsay the heliometer that he had used in Mauritius and Ascension. He devoted his personal attention to the working of this instrument, primarily with the object of determining with all available precision the annual parallaxes of a series of stars, selected either on account of their brightness or on account of their large proper motions, as likely to yield measurable results.

The researches were afterwards continued with a new and more powerful heliometer furnished by the Lords Commissioners of the Admiralty, in response to Gill's urgent representations. In all the distances of some 22 stars were determined with one or other or both of these instruments, the observations with the old heliometer being shared by Gill with Elkin, who had voluntarily offered to accompany Gill to the Cape for the purpose, and those with the new instrument with Finlay and De Sitter.

Gill has himself pointed out that in preparing the programme of his second parallax-campaign he was guided not so much by the desire to select such stars as would yield considerable parallaxes, but rather by the wish to make a contribution to cosmical astronomy, which would throw light on the general distribution of stars in space. A volume in which he summarises the results of his researches* contains an excellent discussion of the material available at the time of its publication as bearing on this important question.

To elucidate the problems of cosmogony it was, however, essentially desirable that more rapid, even if less accurate methods, should be used. Gill was perhaps one of the first to recognise the advantages of celestial photography as a means of securing data on a wholesale scale rather than by the slow and laborious methods of visual observations.

The year 1882 was a memorable one in the annals of astronomy. The appearance of the great comet of that year was the occasion for numerous attempts to secure photographs of this remarkable object. For the most part these attempts were of little scientific value, as the cameras employed were not provided with the means of following the comet through its diurnal movement. However they showed effectively that the comet could be photographed.

There was at the time no photographic equipment at the Cape Observatory, but Gill secured the assistance of a local photographer, and with the aid of his camera strapped to the counterpoise of an equatorial telescope, so as to allow of motion to compensate for the earth's rotation during exposure, excellent pictures of the comet were secured. But what struck Gill more forcibly

* *Cape Annals*, vol. viii, part ii.

than the comet itself was the number and perfection of the star images found to be impressed on the plate. The images were such that their positions could be easily measured with high precision. Here then was a means by which the stars throughout the sky could be rapidly charted. Moreover by regulating the time of exposure the pictures could be made to indicate any desired limit of stellar magnitude. Correspondence with Admiral Mouchez, the Director of the Paris Observatory, was at once opened, the outcome of which was the formation of an International Committee of Astronomers, which first met in Paris in 1887, to discuss the project of obtaining photographs on a uniform plan of the whole sky.

But without waiting for the deliberations of this Committee, Gill set to work to make a preliminary survey of the Southern skies. With the aid of grants from the Government Grant Fund of the Royal Society, and partly at his own expense, a series of photographs covering the whole region of the sky from 18° S. declination to the South Pole was secured during the years 1885-1889.

At first it seemed probable that the measurement and discussion of these plates would have to be relegated to a remote future, but thanks to a timely offer of co-operation from Kapteyn, of Gröningen, arrangements were made by which all the plates were sent to Holland and measured there. The results of this happy collaboration are contained in three volumes of the Cape annals under the title of the *Cape Photographic Durchmusterung*, whereby the visual "Durchmusterungs" of Argelander and Schönfeld are extended to the South Pole.

The work has proved invaluable as a contribution to statistical enquiries regarding the distribution of stars of different magnitudes in the sky, and as affording preliminary rough data to form the basis of a more accurate survey.

Meanwhile, in April, 1887, the Paris Conference had met and plans had been agreed on whereby the larger scheme of photographing the whole sky on a scale of 1 millimetre to a minute of arc was divided up among eighteen co-operating observatories, the largest share being apportioned to the Cape. Regular work on this programme was begun at the Observatory in 1892, and has continued to the present time. The publication of results, which will be contained in eleven volumes, giving the accurate positions in duplicate of about half a million stars, is however now in progress, and Gill had the satisfaction of seeing the issue of the first of these volumes shortly before his death.

The general organisation of this scheme was controlled by the Paris Committee, which met again on various occasions between 1889 and 1909. At each of these meetings Gill was present, and his voice was prominent in guiding the course of procedure. His vigorous presence and directing influence at such meetings will be sorely missed in the future.

Before the full significance of this vast undertaking, as bearing on the cosmical problems which Gill had in view, can be attained, a generation or more must elapse, when a repetition of the work in whole or in part may be expected to throw light on the changes that are taking place. For the investigation of such changes the earlier records cannot fail to prove of the highest value.

No reference has hitherto been made to Gill's further researches on the Solar Parallax. The great success of the Mars expedition led him to look forward with hope to a still more ambitious project from the favourable oppositions of Iris, Victoria and Sappho in 1888-9, and it was largely with a view to this scheme that the new 8-in. heliometer was installed. As, however, the Observatory was not favourably situated for the employment of the diurnal method and Gill's other official duties prevented an extended absence from the Observatory, it was necessary to invoke the assistance of other suitably equipped observers. On Gill's initiation arrangements were made which secured the co-operation of the heliometers at the Cape, Yale, Leipzig, Göttingen, Bamberg and Oxford while no less than 22 observatories offered assistance in meridian observations of the planet and comparison stars used for the heliometer observations.

The comprehensive programme was brought to a satisfactory conclusion and an exhaustive discussion of the material made by Gill, with the assistance of Elkin and Auwers. The results obtained gave not only by far the most reliable determination of the solar parallax, but incidentally also a strong determination of the mass of the moon, the constant of nutation and the mechanical ellipticity of the Earth.

Among other valuable researches with the heliometer must be mentioned an extensive series of observations of Jupiter's satellites by Gill and Finlay in 1891-2, subsequently continued by Mr. Bryan Cookson in 1901-2.

While Gill's personal share in the observational activities of the establishment was largely confined to the use of the heliometer, a steady programme of meridian observations was continued under his directorate, and the reductions of arrears of observations accumulated by his predecessors in office were brought to completion. There resulted the Cape General Catalogue of stars for the epoch 1865, based on observations made under Sir Thomas Maclear during the years 1860-1870, and catalogues for the epochs 1885, 1890, 1900. The catalogues for the last epoch were no less than three in number, including the determination of accurate star positions of some 8,560 stars for the standardisation of the astrographic plates from observations between the years 1896-1899, some 2,798 zodiacal stars as reference points for determinations of planetary motion observed between 1900-1904, and 1,100 southern stars, of which accurate modern places were required by Prof. Boss for the completion of his fundamental catalogue, observed during 1905-6.

Meanwhile, with the sanction of the Admiralty, a new meridian circle had been constructed and erected in a specially designed house, in accordance with plans prepared by Gill. Much time was spent on preliminary investigations of the instrument before it was brought into regular use in 1905. Though no definitive results with this instrument were obtained during Gill's directorate, subsequent discussion of the observations have served to prove that it has in a large measure realised the high expectations that he had formed.

The munificent gift to the Observatory of a large refractor of 24-in aperture, fully equipped for the most refined spectroscopic researches, by Mr. Frank McClean in the year 1897, served to open up new fields of research, into which he threw himself with characteristic energy.

One of the earliest objects to which it was devoted was to the confirmation of Mr. McClean's own discovery of the presence of oxygen in certain of the fixed stars, but Gill's greater interest lay in the application of the spectroscopic method to the refined measurement of velocities in the line of sight. Such determinations, if carried out on a sufficiently extensive scale, might be expected to throw light on the great cosmical question of the stellar distributions. Moreover, even in the early days of the use of the method he had foreseen the possibility of utilising it for a determination of the dimensions of the solar system with an accuracy at least comparable to that with which it had been derived from even the best previous methods. A large number of photographs of spectra with this object in view were obtained during his tenure of office. These have been subsequently discussed and a value of the solar parallax derived in almost perfect accord with that obtained by Gill in previous methods.

Early in his career at the Cape, Gill succeeded in impressing on the Colonial authorities the urgent desirability of an accurate survey of the country. Thanks to his persistent advocacy and tact in securing the co-operation of the various authorities concerned, South Africa has now been covered with a network of primary triangulation extending from Cape Agulhas to within a few miles of Lake Tanganyika, of an accuracy which bears favourable comparison with any similar system in the world. Most of this has been accomplished under Gill's directorship. It was his ambition to see the chain carried throughout the continent so as to connect up with the surveys in Egypt and thence ultimately with the great European surveys.

Vast as was the work accomplished either personally by Gill or under his immediate directorship during his career at the Observatory, he always had time to spare to help on projects for the advancement of science. He was early elected to the presidency of the South African Philosophical Society, which was founded shortly before his arrival in the Colony, and always took a deep interest in its work. When the foundation of the South

African Association for the Advancement of Science was contemplated, Gill was called into consultation, and the present constitution of the Association owes much to his advice. He was chosen as its first president, and it was largely due to his influence that the Association commenced its existence on a basis which has secured its continued and permanent usefulness. He continued, up to the end, his interest in the Institution which he had thus helped to found, and only a very few weeks before his death he presented the Association with the photograph of himself which accompanies this memoir.

Gill left South Africa in October, 1906, and formally retired from official life on February 20, 1907.

He made his home in London, where he continued to devote his time to the furtherance of scientific projects. His advice was much sought in relation to the design and construction of large telescopes and geodetic apparatus, and it was seldom that he could be visited without meeting some British or Foreign astronomer who was seeking his assistance. He gave his services freely in connection with the various scientific societies, and was rarely absent from the regular meetings of such bodies as the Royal Society of London or the Royal Astronomical Society. He served as President of the British Association in 1907, an honour which he was invited to accept partly in recognition of his extensive services to the Society in connection with its visit to South Africa in 1905. He served on the Council of the Royal Society and the Royal Astronomical Society, and was president of the latter Society in 1909 and 1910. He was nominated as British representative on the International Geodetic Association and on the International Bureau of Weights and Measures. He recently succeeded Lord Cromer as President of the Research Defence Society.

In spite of these numerous preoccupations he found leisure to complete a project which he had in view when he left the Cape, and the material for which he had been collecting for some years previously, namely the preparation of a "History and Description of the Cape Observatory."

This work contains a fascinating description of the early struggles of his predecessors, but no reader can fail to appreciate how much the establishment is indebted to Gill for the high status it has attained to-day among the observatories of the world.

This monumental work forms a fitting climax to a lifetime devoted to the furtherance of natural knowledge, and he was happy in living to see its completion.

In the middle of December last, though previously in the best of health, he was suddenly stricken down with an attack of pneumonia. A strong constitution enabled him to rally on two or three occasions, but pleurisy and heart trouble intervened, and he quietly breathed his last on January 24th. His wife, though in a weak state of health, nursed him devotedly till the end.

The funeral took place at the Old Machar Churchyard, Aberdeen, on January 28th, and simultaneously memorial services were held at St. Mary Abbott's Church, Kensington, and at the Church of St. Michael and All Angels, Observatory Road, the church at which he regularly worshipped while in South Africa.

The large number of floral tributes, together with the full attendance at these services testify to the world-wide respect in which he was held. Several foreign Governments and scientific societies all over the world sent representatives to pay their last tribute to one who was universally beloved.

His keen delight in handling a new instrument, or in discussing a new problem, or new methods of dealing with an old one, could not fail to communicate to all who came in contact with him somewhat of his own enthusiasm and zeal.

To these inspiring qualities, combined with a geniality of manner which gave him ready access to officials of all classes, must be attributed his great administrative success. When Gill wanted anything done, he always knew exactly what he wanted, and there were few in a position to meet his requirements who could say him nay. He would permit of no shoddy work. Every detail must be of the best.

For instance, though the immediate requirements of boundary survey might be met at a small cost, he would eagerly press that it might be conducted with geodetic accuracy, such as to ensure that at no future time would there be likely to be a call for repetition. In astronomical measurements of all classes there existed in his own mind no standard of accuracy short of "perfection," and with this ideal in front of him no detail could be too insignificant to be worthy of his attention.

Outside his work he was an enthusiastic sportsman and a keen golfer. He was excellent as a raconteur and will be well remembered by many who were not brought into more intimate contact with him as a racy after-dinner speaker.

His domestic life, though clouded from time to time by the shadow of his wife's ill-health, was of the happiest. To those who were admitted to this inner circle his loss will be irreparable while many others will share the feeling that they have lost a true and warm-hearted friend. All will join in heart-felt sympathy with the much-beloved and sorrowing widow who has survived him

S. S. H.

A FEW NOTES ON WATER DIVINING.

By W. Ingham, M.I.C.E., M.I.Mech.E.

It is not within the scope of this short paper to deal with the class of individuals carrying out this work, but rather with the power they are supposed to possess of finding water. The subject of water divining has been investigated by Professor Barrett, F.R.S., of Dublin University, and by Professor J. Wertheimer, B.Sc., F.C.S., of the Merchant Venturers' Technical College, Bristol, and their conclusions are submitted for consideration.

In his book, "Psychical Research," published in 1911, Professor Barrett, F.R.S., says that

A dowser requires to be tested before he can be relied upon, and it is always better, before sinking a well, to have the independent evidence of more than one water-finder, *for the dowser is by no means infallible, though he generally thinks he is.*

The conclusions arrived at by the Professor are as follows:—

(*a*) That those who really possess the faculty of divining are rare, and many pretenders exist.
(*b*) The involuntary motion of the forked twig, which occurs with certain persons is due to a muscular spasm that may be excited in different ways.
(*c*) The explanation of the success of good dowsers, after prolonged and crucial tests is a matter for further physiological and psychological research, though provisionally we may entertain the working hypothesis suggested, *viz.*, unconscious clairvoyance.

Professor Wertheimer states in his report that he requested all the well-known diviners in Great Britain to take part in the test. He points out, however, that the best known diviners, such as Chesterman, Gataker, Mullins and Tomkins, declined to take part in the tests. Another diviner, named Kerslake, who originally consented to undergo various tests, declined when asked to fix a date.

Professor Wertheimer says in paragraph 4 of his report:—

The main object of the tests described below was to ascertain whether or not the movements of the dowser's rod, or the sensations he experiences, are due to any cause exterior to himself; an experimental investigation in regard to this seemed necessary before any attempt to ascertain the nature of the alleged external influence.

My attitude of mind in regard to the matter was quite neutral; for, while I should have been glad if the results of the experiments had shewn that there was a new unknown external force I was, on the other hand, fully aware of the possibility of persons misleading themselves in such matters, and mistaking subjective for objective effects.

Professor Wertheimer goes on to say:—

I should like to add at the outset that I do not in any way doubt the absolute honesty of every dowser, amateur and professional, with *whom I have up to now had the pleasure of experimenting.* They showed their belief in their own powers by consenting to submit them to *a test.*

Before proceeding to give an account of the experiments, it may be added that in all cases special precautions were taken to avoid the possibility of the dowser ascertaining anything about the place where the experiments were to be performed. Those who lent their properties were not told anything about the dowsers until they arrived to perform their experiments and the dowsers were not told what places they were to visit until they met me on the day appointed for the experiments.

Although very interesting, it is unnecessary for me, in a short paper of this kind, to analyse the various tests to which the diviners were subjected, but the conclusions arrived at by Professor Wertheimer are given below:—

In so far as these experiments have gone, I am inclined to believe that the motion of the dowser's rod and the sensations which he experiences are not due to any cause outside himself. The experiments do not answer definitely the question whether or not dowsers have the power to find water; but I think they show (*a*) *that experienced dowsers did not give the same indications in the same places*; and (*b*) that the movements of their rods were in most of the experiments described due purely to subjective causes.

It would be futile to infer that the power of divining is not possessed by certain individuals, but how far it is desirable to spend large sums of money on their recommendations is quite another matter.

There is no doubt that many successes have been obtained by diviners, and it is within my personal knowledge that small quantities of water were found on two occasions in England, where, as an engineer, I should not have had the temerity to recommend the sinking of wells. The quantities obtained in the two cases referred to were about 20,000 and 45,000 gallons per day respectively. It is a well-known fact, however, that it is very difficult to sink a well or bore in earth, shales, the sandstones, chalk, limestone, the oolites, and certain other formations, without intersecting some underground water, and to this fact alone many of the dowsers' successes are to be considered due.

A diviner is supposed to rely absolutely on the occult power he possesses when selecting a site for obtaining water, but it is generally found that he has some elementary knowledge of geology and hydrology as well, and that he is not guided altogether by the divining power.

It is also difficult to understand how a diviner discriminates between water and metals, for the divining rod is supposed to be affected in both cases.

A hydraulic engineer with large experience, who is thoroughly conversant with geology and hydrology, is, without doubt, in a much better position to deal with schemes requiring *large supplies of water* than one who simply relies on the divining power only. In fact, I am not aware of a single instance where a diviner has been called in to obtain large supplies of water. On the contrary, I know of a large number of cases in the neighbourhood of Johannesburg where water has been found by diviners, but has failed altogether in a dry season. The reason, of course, is not far to seek, for the diviners on the Rand have generally been successful in connection with small supplies from quartzite fissures in impermeable rocks, and this is also the reason for their successes being principally with small supplies of under 100,000 gallons per day.

In 1887, at the annual audit of the accounts of the Urban District Council of Ampthill, Bedfordshire, England, the Local Government Auditor, Mr. W. A. Casson, refused to pass an account which had been paid to a well-known diviner. The objection was raised by several ratepayers, who produced geological plans and sections showing that, if the diviner's recommendation was acted upon, the Council would be boring into a stratum of Oxford clay, the thickness of which had been proved by boring to a depth of 700 feet.

An automatic water finder has been invented for indicating water up to 1,000 feet in depth.

In the pamphlet issued by the makers they say:—

> The principle on which the instrument works is the measuring of the strength of the currents which flow between the earth and the atmosphere, and which are always strongest in the vicinity of subterranean water courses the flowing waters of which are charged with electricity to a certain degree. Should a subterranean spring be present under the instrument the needle commences to move and the observer must carefully note the number of degrees the needle moves on the scale, and the position of the instrument should be changed from time to time; the spot where the greatest movement of the needle has been obtained is that where the boring should be carried out.
>
> If the needle remains stationary, it may be taken for granted that a subterranean spring does not exist under the spot where the instrument is fixed.

The cost of the instrument in England is £50, for depths up to 500 feet.

The makers also say:—

> In all cases where our staff use the Patent Automatic Water-Finder we are prepared to bore on the principle of *no water no pay*.

A few experiments have been made at Zuurbekom, with an instrument belonging to Mr. Ford, of Johannesburg, but they were most unsatisfactory. It is, however, possible that the instrument was not in good working order, and it will be advisable to carry out a further set of experiments before giving a definite opinion about it.

The philosopher "Albinus," as far back as the year 1700, wrote:—

> I ween that no confoundeder thing is to be found in the world than the divining rod business, for whatsoever is right and fit according to one, the same is wrong and unfit according to others, until there is no good to be presumed out of so much confusion.

This, I think, clearly sums up the position to-day.

In conclusion, I may add that the divining rod has been used by myself, and this has led me to take an unbiassed view in discussing the matter. There is no doubt that diviners have been successful in many cases, but I do not think that any Engineer would be justified in expending large sums of money on the recommendation of a diviner.

PRODUCTION OF SUGAR IN THE PROVINCE OF MOZAMBIQUE.

By James Munro.

Blessed with a combination of favouring conditions—including a warm climate, abundant rainfall, a magnificent river system, a fine level surface contour, soil naturally highly fertile, and an abundant and industrious Native population—the Province of Mozambique has, in the opinion of every authority who has visited it, agricultural possibilities far surpassing those of any other part of South Africa. All are agreed that the soil is most favourably adapted for the easy and profitable raising of a great variety of crops, but, though differing as to details, in other respects, all combine in the statement that the production of sugar on an enormous scale is what its rich rivers, valleys and fertile plains are particularly adapted for, declaring that for this purpose this favoured land is unsurpassed by any other on the face of the globe.

Speaking on this point, Mr. T. R. Sim, formerly Conservator of Forests in Natal, and an expert in both agriculture and arboriculture, referring more particularly to the Limpopo Valley, said, in a report to the Governor-General, Col. Andrade:—

> It forms probably the most fertile tract of large area in South Africa. . . . . No other such valley exists in South Africa for the cultivation of sugar on an extensive scale, and where the facilities for preparation, cultivation, and collection, and manipulation are so abundant.

And, again:

> The conditions are more suitable than exist extensively anywhere in Natal or Zululand, and remind me, on an enormously enlarged scale, of the few best spots in the lower Umhlatuze Valley.

Indeed, Mr. Sim spoke of this Valley as capable of being made into one vast sugar field, which would more than supply the sugar consumption of the whole of South Africa.

Mr. F. T. Nicholson, Secretary of the Transvaal Agricultural Union, an agriculturist of wide South African experience, speaking also of the lower Limpopo Valley, in a separate report, said that it consisted of the most fertile lands which it had ever been his lot to see. In his opinion the most profitable crop would be sugar-cane,

> Which grows most luxuriantly and whose sugar contents is remarkably high, considerably above that of the Natal plantations, and coming to maturity much earlier.

This authority spoke most favourably of the Inhambane district for sugar production, and, also, of course, of those of the Quelimane district, where he found sugar-cane growing most luxuriantly, being unusually tall and thick, and yielding a large percentage of sugar.

Then, again, Mr. O. W. Barrett, then Director of Agriculture for the Province, an American agricultural authority of standing, speaking of the extraordinary fertility of parts of the Inhambane district, said:

> Indeed so fertile is the soil in parts that at Mutamba (the starting point of the railway to Inharrime) there is a sugar plantation so rich naturally that it is never fertilised or even ploughed.

his comment on this phenomena being:

> What would a Cuban or a Hawaiian sugar planter think of having no ploughs, nor mules, nor oxen, on his estate, and yet having a good growth of cane year after year?

Mr. Barrett also spoke highly favourably regarding the Zambesi area for sugar production, whilst, with reference to the district of Quelimane, he declared that it alone should yield an export of more than half-a-million tons of sugar, leaving plenty of ground for rice, beans, maize, fibre plants, etc. Concluding, he gave the opinion that, along with sisal fibre, sugar-cane would constitute the best paying crop throughout the Province as a whole, whose natural fertility he described as simply amazing, and in certain places unparalleled elsewhere.

Mr. Barrett's successor as Director of Agriculture, Mr. R. N. Lyne, F.L.S., now Director of Agriculture in Ceylon, another prominent authority on tropical and sub-tropical agriculture, after speaking of the Province as the most favourably conditioned, from an agricultural point of view, of any country in South or East Africa—probably, indeed, in the whole continent—declared that sugar would certainly become one of the leading crops, as the cost of producing it compares favourably with what obtains in Natal and Zululand. Indeed, he predicted an enormous expansion in the sugar producing industry of the Province, particularly in the Zambesi and Chiré areas, in the Limpopo Valley, and such like, declaring that its only limiting factor would be the want of sufficient labour; and, hence, he added, the adoption of labour-saving methods should be the first care of capitalists.

Yet despite this almost unique suitability of the Province of Mozambique for sugar production on a large and profitable scale, the sugar industry is of but recent establishment. Indeed, up to the year 1890 the only sugar-cane produced was that grown by Natives for their own primitive purposes, mainly for chewing directly. Even to-day, with an output in the neighbourhood of 30,000 tons annually, the production is far below what might have been expected with such favouring factors in operation, though in the near future that amount will be very largely exceeded. Moreover, until quite recently, practically the whole of the output was limited to a region in the Zambesi area measuring not more than one degree in Latitude and not much more than two degrees in Longitude, all comprised within a belt measuring not more than about 150 miles in length by 80 miles in breadth. Indeed, as late as 1911, over 21,000 tons out of a total of 27,500 tons for the entire Province, were produced within this small area, abutting on the lower Zambesi River, mainly on its right bank, in the territory of the Mozambique Company.

It was in the year 1890 that the first sugar-growing and manufacturing company in the Province was founded, *i.e.*, the Companhia do Assucar de Moçambique, whose estate has lately been leased by Messrs. Hornung & Co. The first crop was in 1893, when 605 tons of sugar were produced. The estate is in the Prazo Maganja Aquem Chiré, on the left bank of the Zambesi River. The factory is on the right bank of the Qua-Qua River, near the old township of Mopeia. Other particulars respecting this important concern are given later on in this paper. The next of the leading sugar companies to start operations was the Sena Sugar Factory, Limited (Villa Fontes), which was formed in 1905, and commenced working in 1906 in preparing the land, its output now being the largest of all the sugar companies. Its concession is in the Prazo Caia, on the right bank of the Zambesi River, near the township of Villa Fontes, in the territory of the Mozambique Company. In October, 1910, this company took over the property of the Companhia de Exploraçao de Fabrica de Assucar de Morromeu, a French syndicate, becoming known as the Sena Sugar Factory, Limited (Morromeu). The estate is in the Prazo Luabo, on the right bank of the Zambesi River, near the township Morromeu, in the territory of the Mozambique Company.

Altogether there are seven sugar factories at work in the Province of Mozambique—One at Mutamba, Inhambane, two on the Buzi River, in the territory of the Mozambique Company (namely, Inhanguvo and Lusitania), one at Inhamcurra, Quelimane, and the three just referred to on the Zambesi River at Mopea, Villa Fontes, and Morromeu. There is another very small one at Inhambane, but, in a review of this scope, it is too small for serious consideration.

The approximate outputs of these factories for 1911 were as follows:—

		Tons.
1.	Mutamba, Inhambane	1,500
2.	Inhanguvo, Buzi River	3,100
3.	Lusitania, Buzi River	1,700
4.	Morromeu, Zambesi River	3,500
5.	Mopea, Zambesi River	6,500
6.	Villa Fontes	11,000
7.	Inhamcurra, Quelimane	300
	Total output for Province	27,600

At that date the total number of Natives employed in growing and manufacturing the sugar was approximately 11,000 during crop time, and a little more than half that number during off-crop time. The output of sugar per man employed was as follows:—

Inhambane	.. ..	3 tons per man.
Inhanguvo	.. ..	3 " "
Lusitania	.. ..	2.8 " "
Zambesi	.. ..	2.4 " "

which are low figures, contrasting with about 4 tons per man in Natal.

The total area under cane, including new cultivation on estates then working, was about 30,000 acres, but only a portion of this was cropped in 1911.

Between thirty and forty varieties of cane are grown on the estates, the ubiquitous Yuba being found on all of them.

The estate with the highest yield of any in the Province is that at Inhambane, where the Inhambane green variety of cane is principally grown. This yielded 40½ tons per acre, 10 tons 7 kilos of cane producing 1 ton of sugar. This is equivalent to 4 tons of sugar per acre. The cost of growing and manufacturing a ton was from £5 10s. to £6.

It is undoubted that the sugar industry is as yet only in its infancy in the Province. As we have seen, the output in 1911 was 27,600 tons, and it is calculated that the output for the year 1914 will be more than double that amount. At the present, six more sugar estates are being opened up, whilst the present concerns are rapidly extending their operations and putting up new plant. Of these new estates, one is on the Chiré, and the other at Bompona, where large areas have already been put under cultivation, it being expected that in two years' time there will be enough to justify the erection of a factory. Again, further south, the Rhodesian Cotton Company, at Ville Machado, has been making experiments in growing sugar on the Pungue flats, with very satisfactory results. So much so, that there is every possibility of central mills being established and land allotted to small farmers of about 100 hectares each, the enterprise being under the auspices of strong financial groups. The success of such an undertaking seems assured, as there is an open market in Southern Rhodesia for the bulk of their product. The scheme is somewhat similar to that proposed by the Municipality of Chai-Chai, for sugar production in Gaza.

Then, in Inhambane district, the Mutamba Sugar Estates, Limited, which is a reconstruction of the Inhambane Sugar Estates, Limited, is going in for extensive planting and large development generally.

Still further south, in the Lourenço Marques district, we have the Inkomati Sugar Estates, Limited, through whose property a railway, 90 kilometres in length, is now being constructed, from Moamba to Xinavane. This new company has already a large area under Yuba cane, which will be ready for cutting next season. Plant for the erection and fitting up of a factory will arrive in a few months.

Again, in the Lourenço Marques district, the African Agricultural Estates, Limited (originally the Movene Estates, Limited), have already planted considerable areas with Yuba cane, on their concession of 300 square miles, extending from Moamba to the Umbeluzi. Later on, the output from this estate should be a very large one, as all the operations are on a very extensive scale.

Lastly, the survey has just been completed of a large area amounting to something like 30,000 hectares, extending from the Maputo at Salamanga to the Portuguese border. It will be developed into a large sugar estate by a Natal company.

In estimating the possibilities of the industry in the Province, it should always be borne in mind that there the growth of cane per acre, and the sugar content, are both considerably greater than in Natal, where the average yield of cane is about 30 tons per acre every two years.

At Inhambane, on the other hand, where Inhambane green is principally grown, the average, in 1910, was 40½ tons per acre, 10 tons 7 kilos of cane producing 1 ton of sugar, which is equivalent to 4 tons of sugar per acre, the cost of growing and manufacturing a ton being from £5 10s. to £6.

At Inhanguvo, on the Buzi, 698.22 acres yielded 38.6 tons of Yuba cane and 2.83 tons of sugar per acre, being at the rate of 1 ton of sugar from 10.3 tons of cane. Two fields which were cultivated between the rows yielded: (1) 60.9 tons of cane and 4.46 tons of sugar per acre; and (2) 70.8 tons of cane and 5.1 tons of sugar per acre, showing strikingly what can be effected by adopting a higher standard of cultivation.

On the Zambesi, one variety, 109 D, gave, from 400 acres, an average of 75 tons per acre. But the average throughout the Zambesi area is probably not more than 35 tons of cane and 2.8 tons of sugar per acre, the cost per ton being between £8 and £9 at the factory.

At present the licences for the distillation of spirit from molasses are practically prohibitive. On only one estate, at Inhamcurra, is it done, the lessees distilling for the Companhia do Borror, who have a monopoly of its sale in the district. At all other estates, except Villa Fontes, where the molasses are mixed with the megass for fusel, it is wasted.

Besides the above, there is a strong movement among the agriculturists of Chai-Chai, who are growing sugar-cane in much abundance. These agriculturists have found that it is impossible, with their limited capital to erect the necessary expensive plant for sugar mills. The municipality have taken the matter up, and advised a scheme on similar lines to what has been done in Zululand, whereby the farmers can bring their sugar-cane to a central mill, receiving at once a fixed sum per ton, and if the crop has been gathered, the sugar disposed of to receive *pro rata* according to agreement the balance of profit. The municipality has applied to the Provincial Government for power to raise a loan on the rates of Chai-Chai, for the purpose of erecting a central sugar mill, to treat the sugar-cane from these agriculturists. Should such a scheme come to full fruition, it will mean that thousands of hectares of rich alluvial soil in the Limpopo Valley, at present lying barren, will be productive in producing thousands of tons of sugar annually. If this co-operative scheme between the municipality and the agriculturists of Chai-Chai becomes a success, there is little doubt that it will be extended, and other municipalities, no doubt, will follow on similar lines, to assist the agriculturists in the production of sugar.

It would seem as if the Province has just entered into competition with other parts of the world in sugar producing, and numerous applications have been constantly received by the local Government for information regarding sugar land. Needless to say, there are vast tracts of land, in all parts of the Province, from its most northern to southern extremities, suitable and available for such cultivation.

To give an idea of what has been done by some of the companies in developing the sugar industry, hereto is appended a history and details of information regarding three of the sugar factories and sugar plantations on the Zambesi, which the writer recently visited:—

Companhia do Assucar de Moçambique.

This Company was formed in 1890, and is actually the first one which started sugar growing in the Province of Mozambique.

Its first crop was in 1893, when 605 tons of sugar were made.

The original factory was a very small one, being only able to make 60 tons of sugar per week. Since then the capacity of the factory has been increased gradually by improvements and additional machinery.

Its weekly output reached, in 1902, 220 tons, and this year from 350 to 400 tons of dry sugar.

Since the beginning of 1911, the Company's estate has been leased to Hornung & Co.

The concession of this Company, which measures 50,000 acres, is situated in the Prazo Maganja Aquem Chiré, on the left bank of the Zambesi River.

The factory is on the right bank of the Quáquá River, about two miles from the old township Mopea and three miles from the Zambesi. Its geographical position is Long. 35° 43′ 45″ E. Lat. 17° 58′ 10″ S.

The landing and loading station is on the Zambesi, near the Native village Murriua, where all the cargo received by river steamers is discharged, and all the sugar for export is shipped to the coast port, Chinde.

The landing stage is connected with the factory by a 20″ gauge railway, which runs through the middle of the plantation.

The discharging of heavy cargo on the landing place is done with a 10-ton derrick crane.

Plantation.

Area Under Cultivation Since 1905:—

1905	3,500 acres.
1906	3,625 ,,
1907	3,900 ,,
1908	4,000 ,,
1909	4,000 ,,
1910	4,100 ,,
1911	5,300 ,,
1912	5,425 ,,
1913	5,900 ,,

Steam Ploughs in Use:—

From 1895 .. 1 Set of Class B B Compound Engines complete with Ploughs.
,, 1906 .. 1 Set of Class B B Compound Engines complete with Ploughs.
1 Set of Class Z 5 Compound Engines complete with Ploughs.
,, 1912 .. 1 Set of Class B B Compound Englines complete with Ploughs.
2 Sets of Class Z 5 Compound Engines complete with Ploughs.

Supplied by Messrs. John Fowler & Co., Ltd., Leeds.

Irrigation Machinery:—

18 Portable Compound Engines:—
7 with 12″ Centrifugal Pumps
9 ,, 10″ ,, ,,
2 ,, 7″ ,, ,,

total capacity 2,500,000 gallons per hour.
1,000 feet Piping.
4,000 ,, Fluming.
35 miles of Irrigation Canals (earth work).

Railway Line and Rolling Stock (20 in. gauge):—

16 Miles—24 lb. Track.
8 ,, —14 lb. ,,
$5\frac{3}{4}$,, —12 lb. ,,
$5\frac{1}{2}$,, —10 lb. Track (Portable).
5 — 4 Wheel-Coupled bogie tank Locomotives.
300 Cane Trucks, each of 3 tons capacity.
2 — 10 ton bogie trucks for transport of heavy material.

Draught Oxen:—For transport from fields to Permanent Railway, and Watercarts for Ploughs:
76 — Native Bred.

Field Labour:—

Supervision:—6 White men (not including 2 ploughmen), 6 Coloured Demerara men, 1 Goanese, 50/75 Native Capitaos.

Manual Labour:—During Crop time—*i.e.*, from about May until December—an average of:—70 Skilled labourers per day, 2,000 Labourers per day (Natives).

During Off-crop, an average of:—25 Skilled labourers per day, 1,200 Labourers per day (Natives).

FACTORY.

The Factory was originally built and started as a pioneer concern in 1892. It was the first sugar Factory in tropical Africa.

The whole of the buildings were constructed of native timber cut in the forest and sawn into 8″ square logs: the main building had a span of about 30 feet and was 30 feet high to the apex of the roof; it was pulled down only this year and replaced by a fine steel building.

The capacity of the original Factory in 1892 was 60 tons of sugar per week. Ten years later, in 1902, the output for one week had increased to 220 tons, and this year the Factory is capable of making 350 to 400 tons of dry sugar in one week.

The cane is unloaded from small trucks on to an endless *Carrier*, composed of narrow boards attached to two chains, which pass round a revolving drum at either end. This *Carrier*, travelling at the rate of about 24 feet per minute, delivers the cane into a pair of crushing rollers, which prepare it for the Mills.

These *mills* are a set of nine rollers in sets of three rollers, between which the cane is successively passed; between each set of Mills is a short carrier, of the same type as the cane carrier, but made of steel entirely, which carries the mat of partly crushed cane from one mill to the other; from the third Mill the megasse is carried by similar means to the Boilers for fuel.

The *Boilers* consist of one Water Tube Babcock & Wilcox Boiler—in which the water is inside the tubes and the heat outside—and six multi-tubular Boilers—in which the water is outside the tubes. These supply steam to the whole Factory at 100 lbs. per square inch.

There are two steel chimneys 120 feet high for natural draught.

The *Juice* from the Mills is pumped through vessels in which it is heated by the waste steam to boiling point; from these it passes to a large number of settling tanks after being treated with the usual reagents; the cleared juice, now of the appearance of Sherry, is passed through a Triple Effect Evaporator, and two-thirds of the water is evaporated under Vacuum, the syrup resulting from this evaporation is pumped to receiving tanks, from which it is periodically drawn into the Vacuum Pans as required.

These Pans are of various sizes, and consist of large cast iron cylindrical vessels with conical bottoms and tops; inside are series of copper coils through which steam is circulated; the tops of the pans are connected by large tubes to Toricellian Barometric condensors and a Vacuum pump, the interior of the pans always being more or less in vacuo throughout the boiling process.

In these pans the syrup is boiled slowly and concentrated until a fine grain like sand appears; this is the commencement of the formation of Sugar, and as the process is continued the grains increase in size.

When the size of grain required is reached, the boiling is stopped, air admitted, and a valve at the bottom opened, and the massecuite—that is, the sugar surrounded by a "masse" of treacle or molasses—flows out into the tanks, where it is cooled previous to being separated in the Centrifugal machines.

These are baskets of fine wire gauze, suitably supported and revolved at a high speed of 9,000 circumferential feet per minute; the fluid molasses is impelled through the holes leaving the granular Sugar behind in the baskets, from which it is discharged every few minutes.

The Sugar is now ready for bagging and shipment. Any class of sugar is made at this Factory for Refineries or for direct consumption without charcoal filtration.

Additional Machinery.

Two Stone Flour Mills:—To make flour for the Native labourers, who are all fed on the Estate.

Vertical Saw:—To cut up logs.

Circular Saw:—To cut up firewood.

Cold Storage Plant:—For the benefit of the staff.

All the above machinery is steam driven.

Crops.

The following are the figures for the year 1893 until last year.

Year	Raw Sugar		White Sugar
1893	605	tons	—
1894	807	,,	—
1895	·77	,,	—
1896	966	,,	—
1897	261	,,	—
1898	1,094	,,	—
1899	1,674	,,	—
1900	2,600	,,	—
1901	1,271	,,	—
1902	1,796	,,	—
1903	2,056	,,	—
1904	3,719	,,	—
1905	4,157	,,	—
1906	3,165	,,	—
1907	1,770	,,	—
1908	6,016	,,	—

Year	Raw Sugar		White Sugar
1909	6,277 ,,	of which	836 tons
1910	6,210 ,,	,, ,,	2,000 ,,
1911	7.777 ,,	,, ,,	3.696 ,,
1912	5.905 ,,	,, ,,	4.472 ,,

This year's crop, now in course of production, is estimated at from 7 to 8,000 tons.

The sugar produced since 1908 was disposed of as follows:

Year	U. K.	Portugal	Transvaal	Province of Mozambique	Other Ports
1908	1,683·640	4,318·000	—	15·040	—
1909	920·000	4,500·440	—	20·080	—
1910	1,000·000	3,209·000	—	1·650	·034
1911	1,568·500	1,459·500	—	3·250	50·000
1912	1,364·600	—	50·000	18·650	—

WHITE SUGAR.

Year.	Transvaal.	Province of Moçambique.	Other African Coast Ports.
1908	—	—	—
1909	791·520	14·000	30·040
1910	1,920·794	79·685	·202
1911	3,141·212	554·635	—
1912	3,109·728	840·957	521·122

THE SENA SUGAR FACTORY, LIMITED, MARROMEU.

This Estate belonged formerly to the Companhia de Exphoracao da Fabrica de Assucar de Morromeu, a French Syndicate from whom it was taken over in October, 1910, by the Sena Sugar Factory, Limited, already established at Villa Fontes.

It is situated in the Prazo Luabo, in the territory of the Companhia de Moçambique, on the right bank of the Zambesi River, near the township Morremeu, the geographical position of which is: —

Long.	35°	57′	19″	E.
Lat.	18°	17′	17″	S.

The Estate measures about 7,500 Acres, and runs about 7½ miles from the Zambesi and 2¾ miles inland.

The Factory where the sugar is manufactured, with dwelling houses for staff, offices, etc., is situated near the Zambesi River, where is also the landing and loading place for cargo received and Sugar to be shipped.

A 10-ton Derrick Crane for discharging heavy machinery and other cargo assists in the unloading of the River Steamers.

From the Factory a railway line of a 24 inch gauge runs in different directions through the Estate.

Plantations.

No figures are at hand for the time the Estate was under the control of the French Company. When the Sena Sugar Factory, Ltd., took it over there were about 2,500 acres under cultivation, which number was increased to

3,460	Acres in the same year	
5,580	,, ,,	1911
6,940	,, ,,	1912
7,220	,, ,,	1913

Steam Ploughs in Use:—

From 1910	1 set
,, 1912	3 sets

All supplied by Messrs. John Fowler & Co., Ltd., Leeds

Irrigation Machinery:—

1 Portable Compound Engine with 12″ Centrifugal pump, capacity 180,000 gallons per hour.

Railway Line and Rolling Stock:—(24″ gauge).

12½	miles	21 lb. Track.
4	,, ...	24 lb. ,,
1	,, ...	28 lb. ,,
2½	,, ...	Portable Railway Track.
2	..	6 Wheeled Coupled Tank Locomotives.
3	..	4 ,, ,, ,, ,,
260	..	Cane Trucks.
25	..	Sundry Trucks.

Draught Oxen:—For Transport from fields to Perm nent Line. 68 Native Bred.

Field Labour:—

Supervision:—7 White men, 4 Coloured Demerara men. 30/50 Native Capitaos.

Manual Labour:—During Crop time—*i.e.*, from about May until December—an average of 62 Skilled Native Labourers per day, 2,000 Labourers per day (Natives).

During Off-Crop, an average of 1,200 Labourers per day.

Factory.

This Factory was built by the Fives Lille Engineering Company of France.

Since the business was taken over in 1910 by the Sena Sugar Factory, Limited, a large amount of money has been spent to bring the Factory up to its present capacity.

The *buildings* are throughout of Steel, of spacious construction and wide spans, the walls being filled up with concrete, giving a substantial appearance.

The original *Mills*—taken out at the end of 1910—were two single three roller Mills with rollers 1.600m. long by 0.800m. diameter, each driven by its own engine. These Mills were abandoned, and for the 1911 Crop an eleven roller set was installed in a new building, with a complete new system of Railway lines and sidings leading to and from the cane carrier, which also was rebuilt to enter the Factory in an entirely different direction. To these Mills a fourth set of rollers have been added, making now 14 rollers.

The *Bagasse* from the last Mill is conveyed to the Boilers to be burnt.

The *Boilers* are five Brouilleur type as originally installed, and a Vertical Water Tube Westgarth "Nesdrum" boiler erected for the 1912 crop.

The *Mill Juice* is passed through tubular heaters until it is above boiling pont, and from there goes to settling tanks, the clear juice then passing through a Quadruple Effect Evaporator to be concentrated to one-third of its original volume. From the Evaporator the new syrup goes to storage Tanks for the Vacuum Pans, in which it is boiled to Sugar, then discharged into Tanks to cool, after which it is centrifuged, and is then ready for sale.

This Factory has a capacity of 300 to 350 tons of Sugar per week according to the richness of the canes manipulated and quality of Sugar required.

Additional Machinery.

Two Stone Flour Mills:—To make flour for the Native labourers, who are all fed on the Estate.

A Circular Saw:—To cut up timber and firewood.

A Cold Storage Plant.

All the above machinery is driven by steam.

Crops.

The followng are the figures as from the year 1911, when the first Crop was reaped by this Company:—

1911	... ...	4,201.100 Ks. Raw Sugar.
1912	... ...	7,060.150 Ks. Raw Sugar.

The last Crop of the Companhia de Exploraçao da Fabrica de Assucar de Marromeu (1910) was 2,686.080 Ks.

The present Crop now in course of production is estimated at 7,000.000 Ks.

The Sugar produced was disposed of as follows:—

Year.	U. K.	Portugal.	Madeira	Province of Mozambique.
1911	3,027.200	960.000	211.650	2,250.000
1912	3,876.625	3,168.825	8.500	6.200

While under the control of the French Company, the Crops were, as far as records exist, as follows:—

	Tons.
1902	2,950
1903	1,190
1904	3,500
1905	1,900
1906	700
1907	1,200
1908	2,000
1909	2,011
1910	2,680

The Sena Sugar Factory, Limited, Villa Fontes.

This Company was formed in 1905, and commenced operations at the beginning of 1906 by marking out the plantation, growing seed cane, and by preparing the land for the planting in the following Rainy Season.

At the end of 1906 a start was made with the foundations of the Factory, Stores and Dwelling Houses, building of which was commenced in 1907 and concluded in 1908.

The Concesson of this Compnay is situated in the Prazo Caia on the right bank of the Zambesi River, in the territory of the Companhia Moçambique, and near the township of the Villa Fontes, the geographical position of which is:—

Long.	33° 28′ 21″ E.
Lat..	17° 48′ 33″ S.

It measures 5,500 hectares—or about 13,600 acres—and runs for about 10 miles along the Zambesi, and extends inland for about seven miles along the unnavigable River Zangue.

The Factory where the Sugar is manufactured is situated at about 2½ miles from Villa Fontes, at a place called Changadeia, which is connected with the township of Villa Fontes by a railway.

From the Factory there runs also a railway line, 7½ miles long, to Marra, a small native village on the banks of the Zambesi, about 6 miles below Villa Fontes, where the Company have their landing and loading staton, where all the cargo received by the River Steamers is discharged, and all the Sugar for export is shipped to the coast port Chinde.

Plantation.

Area Under Cultivation:—

	Acres.
1905	49
1906	661
1907	1,329
1908	2,138
1909	2,400
1910	2,822
1911	2,857
1912	3,666
1913	5,666

Steam Ploughs in Use:—

From 1906 .. 1 Set of Class Z 5 Compound Engines complete with ploughs.
„ 1907 .. 2 Sets of Class Z 5 Compound Engines complete with ploughs.
„ 1912 .. — Sets of Class Z 5 Compound Engines complete with ploughs.

Supplied by Messrs. John Fowler & Co., Ltd., Leeds.

Irrigation Machinery:—

18 Portable Compound Engines, with 12 in. Centrifugal Pumps, total capacity 3,780,000 gallons per hour.
4,850 Feet Piping.
4,300 Feet Fluming.
45 Miles of Irrigation Canals (earth-work).

Railway Line and Rolling Stock (36 in. gauge):—

20 Miles 28 lb. Track.
5½ Miles 35 lb. Track.
16 Miles 14 lb. and 16 lb. Portable Track.
3 6-Wheeled Coupled Tank Locomotives.
300 Cane Trucks, each of 4½ tons capacity.
25 Sundry Trucks.

Draught Oxen:—For Transport from Fields to Permanent Railway:—

150 Native Bred.

Field Labour:—

Supervision:—7 White men, 11 Coloured Demarara men, 60/120 Native Capitaos.

Manual Labour:—During Crop time—*i.e.* from about May until December—an average of 120 Skilled Native Labourers per day, 3,300 Native Labourers per day.

During Off-Crop time an average of 80 Skilled Native Labourers per day, 2,200 Native Labourers per day.

FACTORY.

The following is a description of the Factory where the Sugar is manufactured:—

The Factory building is of Steel throughout, and consists of four spans of 30 feet, two spans of 45 feet, and one of 18 feet. The height varies from 30 feet to 50 feet, and length of each span is about 75 feet.

The *Lighting* throughout is by some 300 incandescent electric lamps at 220 volts.

The Engineers' *Workshops and Stores* are in a separate steel building, about 200 feet by 30 feet span, with the necessary lathes, drilling machines and planing machines.

The *Cane is unloaded* from the Trucks on to an endless travelling conveyor, by which it is delivered down a chute to the Mills.

The *Mills* consist of a crusher for preparing the cane, and three Mills, each having three rollers weighing some nine tons each, and all driven by one 400-horse-power Engine, followed by a powerful fourth Mill of three 12-ton rollers, driven by one 250-horse-power Engine. The Cane passes in a continual blanket or mat through the successive Mills, and refuse crushed cane—known as bagasse—issuing from the fourth Mill is conveyed to the Boilers and burnt for raising steam.

The *Boilers* consist of four Babcock and Wilcox Water-tube boilers and one Westgarth "Nesdrum" Vertical Tube Boiler. There is one chimney of steel plates 150 feet high.

The Juice extracted by the Mills is passed through strainers, heated and clarified in a large battery of settling tanks, from which the clear Juice passes to a triple effect evaporator, where two-thirds of the water is evaporated off. The resulting liquor, now known as syrup, is then pumped to storage tanks, from which it is drawn into the Vacuum Pans, in which it is boiled to Massecuite, that is until the grains of Sugar are formed to the required size, surrounded by molasses as the "Mother Liquor."

The Vacuum Pans are discharged periodically, when and as the process is completed, the issuing Massecuite is allowed to cool slowly, and then conveyed to the Centrifugal machines, which consist of perforated baskets about 36 in. diameter, lined with fine wire gauze. These baskets revolve at a high velocity; the centrifugal force expels the molasses through the gauze and the dry marketable Sugar is left behind in the basket. The Sugar is discharged on to a Conveyor, by which it is carried to a "Jacob's Ladder" elevator and deposited on an overhead floor. From there it is thrown down chutes into bags, weighed and sewn up ready for shipment.

Originally built to crush 500 tons of cane in 24 hours, this Factory has been added to year by year until now it is capable of crushing 900 tons in 24 hours, equivalent to a weekly output of some 450 tons of dry Sugar.

Any quality of Sugar can be made here, from Brown Sugar for the Refineries to White Granulated Sugar for direct consumption, without passing over Charcoal Filters.

Additional Machinery.

Two Stone Flour Mills:—To make flour for the Native labourers, who are all fed on the Estate.

A Vertical Saw:—To cut logs for building purposes.

A Circular Saw:—To cut up firewood.

A Cold Storage Plant:—For the benefit of the staff.

This machinery is driven by steam.

A Pug Mill:—For Brickmaking, worked by oxen.

One 10-ton Derrick Crane:—At the landing stage at Marra, for discharging heavy cargo.

CROPS OBTAINED SINCE THE FORMATION OF THE COMPANY.

The following are the figures from the year 1908, when the first Crop was reaped, until last year:—

Year.	Raw Sugar. Tons.	White Sugar. Tons.
1908	5,199	—
1909	8,911	136
1910	4,838	1,994
1911	8,949	1,261
1912	7,562	482

The Crops in 1910 and 1912 were relatively small on account of a severe drought.

This year's Crop, now in course of production, is estimated at 10,000 tons.

The Sugar produced during the years mentioned was disposed of as follows:—

	Raw.			White.	
Year.	U. K.	Portugal.	Province of Mozambique.	Transvaal	Province of Mozambique
1908	2,774	2,395	17	—	—
1909	5,297	3,511	22	103	—
1910	1,597	3,027	10	1,515	—
1911	2,834	2,873	4	1,728	31
1912	3,710	7,364	24	421	72

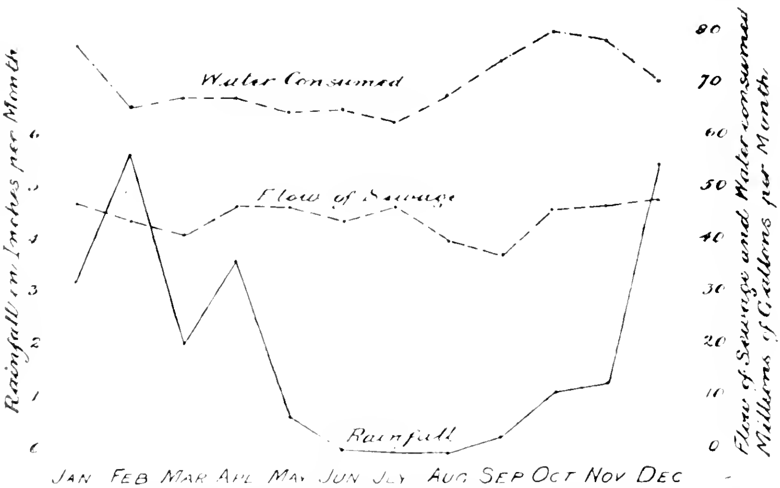
INTERNATIONAL ELECTRICAL CONGRESS.—In conjunction with the International Electrical Congress, which is to be held at San Francisco during September, 1915, the following South African Engineers have been appointed honorary members of the International Committee on Congress organisation: Prof. John Orr, South African School of Mines and Technology, Johannesburg; Mr. J. H. Rider, P.O. Box 4563, Johannesburg; Mr. J. Hubert Davies, P.O. Box 1386, Johannesburg; and Mr. Frank Pickering, South African Railways, Capetown.

AFRICAN INSECTS.—The *Journal of the African Society* announces that one of the most capable entomologists in the United States Bureau of Entomology, Mr. W. F. Fiske, has been engaged to make a thorough investigation of the bionomics of the tsetse fly, *Glossina morsitans*. He will work under the direction of the Royal Society, and the expense will be borne by the Government of Nyasaland. As a preliminary, he has gone to Uganda, to investigate *Glossina palpalis*. Thence he will go to Nyasaland for the purpose of his special study. It is interesting to note, in this connection, the considerable increase that has taken place recently in the work of the Entomological Research Committee. The Committee's activities last year had, as its outstanding feature, the establishment of the Imperial Bureau of Entomology. 80,000 specimens of insects were received during the year, of which 75 per cent. came from Tropical Africa.

THE RELATION OF SEWAGE FLOW TO WATER SUPPLY.

By William John Davenport.

It will be noticed in the accompanying diagram* that the sewage flow is approximately 60% of the water consumed. This is to be accounted for by the fact that the town is not completely reticulated with sewers. The balance of the water consumed is at present disposed of by French drains or thrown on the soil, etc. By examining the diagram it will be noticed that the water consumption is at its lowest whilst the sewage flow is within 1½ million gallons of its absolute maximum per month—during the month of July—or an absolute maximum percentage of water consumed reaching the sewers of 74.6. During August, although the water supplied has increased by five million gallons, the quantity reaching the sewers is less by six millions of gallons. As gardens are now being put in order, etc., it indicates that five



million gallons of water have been used for irrigation purposes, in addition to six millions that have been first used for household purposes.

September is a dry month, and it will be seen that a further seven million gallons of water was consumed, coupled with a drop of three millions in the sewage outflow. This gives twelve million gallons of water used for garden purposes, plus nine million gallons that have first been used for household purposes.

October sees another six million gallons consumed, or a total above July of thirty-five million gallons. It will be observed that the sewage discharge has increased to nearly the July quantity, from which it can be inferred that, as rain has fallen, the inhabitants are less thrifty, and are content to allow practically

* A comparison of the water consumed in Johannesburg during 1912, with the flow of sewage as affected by the rainfall.

the whole of the water used for household purposes to reach the sewers.

November has a slightly greater rainfall than October, and there is a small decrease in the water consumption, and a return of the sewer discharge to the July figure. This does not alter the fact that approximately sixteen million gallons were used during the month that did not have any visible effect on the sewage flow compared with that during the month of minimum consumption. The total above the July consumption is fifty-one million gallons.

December has a rainfall of 5.50 inches. It is promptly shown by a drop in the water consumed of eight million gallons. The discharge of sewage is only increased by one million gallons. This still leaves seven million gallons that can only be accounted for by the watering of gardens. This brings the total above the July consumption rate to fifty-eight million gallons.

January has rather a deficient rainfall, it being only 3.30 inches. The water consumption is seventy-eight million gallons, compared with seventy-one million gallons for December. The sewage flow is still only about half a million gallons above that of July.

The difference between the water consumed in January and the water consumption for July compared on the basis of flow of sewage, is fourteen and a half million gallons. This would bring the total water used since July that did not show any effect on the quantity of sewage up to seventy-two and a half million gallons.

February has a good rainfall, it being 5.70 inches. On this account the drop in the water consumption amounts to twelve million gallons for the month. The water consumed is three million gallons above, and the discharge of sewage three million gallons below, that of July. There is probably no diminution of the household consumption, the difference in the flow of sewage being due to the usual garden irrigation, by utilising the water that has been used in the house.

The quantity of water over and above that actually necessary for domestic and trade consumption, as shown by the July figures, now reaches the total of seventy-five million gallons. There is no doubt that more water is actually used during the summer months for baths, etc., but there are no means of estimating the quantity.

In the four months ending December, 1912, fifty-eight million gallons were supplied in excess of that shown by the sewer discharge, on the basis of the July figures, and in one month—October—the excess was seventeen million gallons. From this it can be seen that a pumping plant is required for supplying this excess, which would be idle during six months of the year.

A study of the diagram shows that, if the whole town was reticulated by sewers, and all the water consumed in July reached the sewer, the maximum flow of sewage would be only one and a half million gallons, or 3.19% greater than the flow during the month of minimum consumption. The deduction, therefore, is that it is quite reasonable in designing the sewage system for a town climatically similar to Johannesburg, to base its capacity upon the minimum water consumption plus, say, a 15% increase, to allow for a factor of safety.

The South African Diamond Fields. — Dr. Wagner's recently published book* is a most valuable account of the geological and economic aspects of the diamond fields of the Union, Rhodesia, German South-West Africa, and the Belgian Congo. The author has had a large experience in the mines and diggings, and has a thorough knowledge of the results obtained by other geologists who have investigated various parts of the subject. The long table of contents, the numerous references in the text, and the excellent list of previous publications will enable readers to follow up almost every detail in the geological side of the subject, but the lack of an index is a great source of inconvenience.

The discussions of the many geological problems raised by the diamond-bearing rocks are marked by their fairness to all previously expressed views and by their sound common sense. The greatest difficulty in the petrology of the original deposits is due to the fact that the rocks are unknown in an unaltered state, and there are no signs that new discoveries will remove this difficulty.

The first chapter deals with the habit and general characters of the rocks known as kimberlite; in the second there is a very useful and complete account of the minerals which occur in kimberlite; in the third chapter the petrography of all the known varieties of kimberlite is described, as well as of other rocks which there is reason to think were genetically connected with them, the concluding section being devoted to speculations on the possible connection of the eruption of these deep-seated rocks with the event which resulted in the elevation of the sub-continent in late Cretaceous or Tertiary times.

The fourth chapter deals with the extraordinarily interesting xenoliths which are evidently related in origin to the kimberlite containing them; in the fifth chapter the diamond is described, the characteristics of the stones got from different mines, and there is a careful discussion of the various views as to the origin of the diamond, which the author shows has probably crystallised in the magma that gave rise to kimberlite while it was deep down in the earth's crust.

The next three chapters are devoted to the methods of mining under the various conditions in the chief mines, the separation of the diamonds from the kimberlite, of which they form from

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* P. A. Wagner, "The Diamond Fields of South Africa." pp. xxv, 347, maps and illus. Johannesburg: *The Transvaal Leader*, 1914.

two to twelve millionths per cent., and a short discussion of the factors which control the working of a mine at a profit.

The ninth and tenth chapters contain an account of the secondary deposits, and the various questions raised by the diamonds in these beds are fully discussed.

In the last chapter there is a list of the existing diamond-mining companies in the sub-continent, and tables of statistics relating to diamond production.

The numerous photographic illustrations of exposures, rock-sections, plant, etc., are well chosen and printed, as is also the case with the maps and diagrams.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, February 14th: Mr. W. Calder, President, in the chair.—"Notes on Structures": A. S. **Ostreicher.** The author described the method adopted by him in the construction of a wooden roof of 100 ft. span, and 45 ft. from abutment hinge to apex hinge, which had to be erected at comparatively short notice in order to replace another roof that had collapsed six weeks after completion. The roof designed by the author depended for its construction entirely upon the carrying capacity of bolts, the roof being designed like a steel structure with gussets, the bolts taking the place of rivets.

Wednesday, March 18th: Mr. W. Calder, President, in the chair.—"The recovery of bye-products: the plant required, and its location": K **Austin.** The author referred primarily to the bye products obtainable in the combustion of coal, and particularly in connection with the manufacture of coke, the working of gas-producing plants, and the smelting of iron in blast furnaces. The possibilities of recovering ammonium sulphate, tar, and benzol on a profitable scale were pointed out.

(Kimberley Branch).—Thursday, March 19th: Mr. J. Harbottle in the chair.—"Concentration of diamondiferous ground, as applied to the works of the De Beers Consolidated Mines, Limited": J. **Stewart.** A short account of the earlier methods of concentration was given, and the present arrangements for working the pulsators and grease tables described in detail.

Geological Society of South Africa.—Monday, February 16th: A. L. Hall, B.A., F.G.S., President, in the chair.—"The Bushveld complex as a metamorphic Province" (Presidential address): A. L. **Hall.** A review of the more important results produced by the intrusion of the Bushveld Plutonic complex into the surrounding sedimentary rocks. The schistose rocks over the disturbed portion of the metamorphic province are essentially due to thermal metamorphism, but possesses special structural features arising from the additional influence of intense pressure.

Monday, February 23rd: D. P. McDonald, M.A., B.Sc., President, in the chair.—"Notes on some prehistoric stone implements found in Katanga": F. E. **Studt.** The implements were: an arrow-head of white quartz; a "celt" fashioned from the greyish white granular quartzite of the Kafubu Beds; an axe-head made from massive hæmatite; two spheroidal stone hammers, one of quartzite and the other of ferruginous laterite; two similarly but roughly shaped quartzite hammers; and a "hole-stone" of greyish brown sandstone.—"The granite dykes of the 3,520 ft. level, Kimberley Mine": Prof E. H. L. **Schwarz.** The paper opened with a general historical account of granite dykes in South Africa, to which was appended a *résumé* of the recorded occurrences of the hornblende schists in the north-west of the Cape Province, and a discussion of the irregular dykes, mostly of pegmatite type, which, together with the schists, pass into the foliated rocks surrounding the masses of granite in the area. The author proceeded to describe in detail the rocks of the section on the 3,520 ft. level.

South African Institute of Electrical Engineers.—Thursday, February 19th: Mr. W. E. Dew, President, in the chair.—Presidential address: W. E. **Dew.** The address dealt with the Institute and its work, and suggested the compilation of a record of all the important information respecting details, alterations and reports on the general workings of concerns dependent upon electric power.

Thursday, March 19th: Mr. W. E. Dew, President, in the chair.—"Impressions of my American tour" J. W. **Kirkland.** A summary of observations made by the author in regard to the generation of electric power, and various developments of its application in the United States.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, February 21st: A. Richardson, M.I.M.M., President, in the chair.—"A method of assaying concentrates and battery chips for gold and platinum metals": A. F. **Crosse.** A method for determining gold, platinum and osmiridium in ores, concentrates, etc., was detailed.

Saturday, March 21st: Prof. G. H. Stanley, A.R.S.M., M.I.M.E., F.I.C., Vice-President, in the chair.—"Relation of falls of roof in collieries on the Middelburg Coalfield to weather changes": C. J. **Gray.** It was found, on comparing the annual accident rates with the year's rainfall, and the number of accidents in particular months during a period of seven years, that a decrease in the annual rainfall corresponded with an increase in liability to accident from falls of roof in the collieries, and *vice versa*, and that this liability was almost certainly much greater in the dry winter months than in the summer months. While both annually and seasonally the accident rates change in a reverse direction to the rainfall, they also change seasonally in a reverse direction to the temperature and annually in a reverse direction to the atmospheric humidity.

South African Society of Civil Engineers.—Wednesday, March 11th: F. O. Stephens, M.I.C.E., President, in the chair.—Presidential address: F. O. **Stephens.** The address dealt with railway surveys and surveying engineers, particularly referring to their duties and bearing on the cost of the undertaking. The temporary character of the employment of engineers on railway survey work was criticised as tending neither to the well-being of the profession nor to the best service of the country. There are mainly two railway systems in South Africa—the South African Railways, with a capital of 81¼ million pounds sterling, and the Rhodesian and Beira Railways, with a capital of 16 millions. These, it was considered, should be able to afford a small permanent department of experienced engineers for running preliminary surveys. It was also argued that in the past there had not been sufficient surveys made, nor had the tract of country to be crossed been sufficiently studied before the construction of a line was started.

Cape Chemical Society.—Friday, March 27th: Prof. R. Marloth, M.A., Ph.D., President, in the chair.—"Notes on some indigenous and other fodder plants": Dr. C. F. **Juritz.** A table of 70 analyses was given, including both fresh and dried plants of various kinds. These were commented on and compared with analyses of similar plants in other countries. It was suggested that in view of the wealth of fodder plants indigenous to the country, labour spent in the introduction of such plants from abroad was to a great extent needless. Particular attention was given to the feeding value of certain species of *Euphorbia*, *Opuntia* (Prickly Pear), and Kaffir melons (Tsamma and Monketaan), experimental cultivation of the latter having yielded from 180 to 300 tons of melons per acre, the potential yield of oil from the pips amounting to from 700 to 1,200 lbs. per acre.

NEW BOOKS.

Letcher, O.—*The bonds of Africa: impressions of travel and sport from Cape Town to Cairo*, 1902-1912. 9 × 5½ in. pp. 267. Maps and illus. London: John Long, Ltd. 1913. 12s. 6d. net.

Gill, Sir David.—*A history and description of the Royal Observatory, Cape of Good Hope.* 15 × 11 in. pp. cxc, 136. Maps, plan, illus. London: Published by the Admiralty. 1913.

COSMOGONIC HYPOTHESES.

By Robert T. A. Innes.

The best known and still the most widely accepted cosmogonic theory is Laplace's nebular hypothesis. This hypothesis was only put forward in a tentative manner by its author, although on several occasions he recurred to the subject. It is proper to note that although it is doubtful if anyone had ever a greater facility for clothing his ideas in mathematical formulae, Laplace used none in explaining the nebular hypothesis. Many cosmogonies have been based on ideas not essentially different from Laplace's, that is the condensation of a primitive nebula into rings, which later disrupt into planets, whilst the central and final condensation forms the central body or sun of the system. The fission theory of the formation of satellites and double stars from condensing bodies is closely connected with the nebular hypothesis.

Other sets of cosmogonies are indicated under the meteoric or planetesimal hypothesis, and capture theory. Kant's cosmogony was more general in that he postulated neither nebulous matter nor meteors—merely matter. The nebular hypothesis of Laplace, and its modifications by Faye, Darwin, See, and others, seized on the popular mind, because it was not in too marked discord with the theological teachings of the age, "the earth was without form, and void." Genesis i, 2.

By the very mode of its existence, the human race can view but a small part of the drama of nature. On the surface of the earth, thanks mainly to the geological record, the mode of the evolution of flora and fauna, and the making of rocks is fairly clear. But when we view not the surface of the earth, but bodies outside the earth—the planets, stars and nebulae, our interpretation is not so easy. We cannot even say if the sun, and with it the earth, is growing hotter or colder. We imagine the rhythm of the universe is periodic, but until one period is completed—and this the human race cannot live to see—how can we tell, nay, even guess, the nature of its periodicity? The periodicity may be complicated, is almost certainly more complicated than that of a butterfly which goes through the stages of egg, caterpillar, chrysalis, butterfly, etc., and what person could by the closest inspection of, say, a millionth of any one of the sub-periods, egg, caterpillar, chrysalis or butterfly, foretell the other sub-periods? It is probably thus when we attempt to explain the evolution of the stars. When Laplace wrote his nebular hypothesis, facts were few, the laws of thermodynamics had not even been formulated, and modern chemistry was in its infancy. Hypotheses without facts are not uncommon; the Greek genius loved hypotheses, but seemed to disdain facts, and the effects of their examples are buried deep in the fibres of our mentality. The fundamental assumption of the nebular hypothesis is that a nebula can condense, *i.e.*, not only get more dense, but even form ultimately liquids and solids of various atomic weights. This assumption has no foundation in nature, and is so improbable that it cannot be accepted without proof. Lockyer's meteoritic hypothesis started with a swarm of solid bodies, meteorites, which by their collisions gave rise to a nebula, which then followed more or less closely the developments suggested by the Laplacian theory, but the spectroscopic evidence on which it rested has since been proved to be devoid of foundation.

Although many cosmogonic hypotheses have been imagined, I wish to show that another can be added to them; its chief merit being that it takes into account the few facts of observation which are available to-day. The hypothesis is compounded of the planetesimal hypothesis of Chamberlin and Moulton, and the radiation theory of Arrhenius with the addition of an explosive element suggested by the mutations of uranium-radium-helium.

The primordial stuff out of which the universe is made is in the form of meteors. Aggregations of meteors are caused by collisions and gravitation. These aggregations increase in size, forming, firstly, cometary bodies; secondly, planetary bodies; thirdly, sun-type bodies. Growth is continuous in one direction in all these bodies, so that a cometary body by the addition of more meteorites can pass into a planetary body, and a planetary body similarly into a sun-type body, but a sun-type body cannot increase in size indefinitely, as a time comes when it will disrupt with explosive force. A cometary body is a loose aggregation of meteors. A planetary body is a solid body in which the forces of solidification and cohesion are at a maximum. A sun-type body is a liquid body, of which the sun is a prototype. The reverse process cannot take place; thus a sun-type body cannot shed meteorites and so lose matter until it becomes a planetary body, etc. Under certain circumstances such as the near presence of a large mass, a cometary aggregation can, however, be dissipated, but this is an indirect effect which does not concern us here. All three classes of bodies can radiate substances in the form of electrons, although at vastly different rates, so that they can pass from the solid or liquid to the gaseous state, which is and will be called here the stellar state, and from the gaseous or stellar state to the final form—the nebulous state. The stellar state is the first step in the degradation of atomic matter.

It has to be considered how this hypothesis fits the facts. Clausius has taught us that the end of the universe as an abode of life or available energy will be reached when entropy* becomes a maximum, and that it does tend to such a maximum. This conclusion is not contradicted, it is only enlarged so as to include in the available energy the enormous stores of power contained

* In Thermodynamics "entropy" means a property of a body expressed as a mathematical quantity which remains constant when a gas changes its volume or does work without any heat entering or leaving it, but which, if a small amount of heat enters or leaves the body, is increased or diminished proportionately to this amount divided by the absolute temperature.

in every atom. The end of the universe, or at least one sub-period of it, is reached when every atom has disintegrated into its component parts, be they electrons or the elusive nebulium of which nebulae are mainly composed. The older cosmogonists started with nebulium, which in some way could condense into atoms and end with vast cold stars consisting of heterogenous collections of atoms containing enormous stores of unavailable energy. The present hypothesis reverses the process. We know there are meteorites—numbers flash through our atmosphere and are seen on every clear, dark night; a few reach the surface of the earth. Examination and analysis of the meteors which have been found, show that in the main these bodies contain all the elements found upon the earth, and that they are compact bodies formed under considerable pressure. How they came into being is quite unknown; to us they must represent an earlier stage or sub-period of the universe akin to the egg or chrysalis stage in the butterfly's period of existence. The earth is increasing its mass by these falls of meteorites, but the increase, although constantly in action, is very slow. But it is improbable that the planets of the solar system were formed by this process; it is possible that the planets grow by accretion, but their formation was due to explosions of the central mass. As long as matter was considered to be inert, there was no limit to the quantity of it which could be assembled in one mass and held together by the power of the mutual gravitation of its parts. But it is obvious on further thought that a time will come when the gravitational pressure of a mass will break into the atomic structure of its matter and cause explosions. It is by such explosions that planets are thrown off. We can imagine, that in the solar system one great explosion threw off all the planets and their satellites, and that some of the satellites are due to sub-explosions at the same epoch, and some due to capture of remnants. In this, the solar-type of explosion, but one 730th part of the solar mass was thrown off, but we may expect all types of explosions—thus the original mass might explode into two nearly equal parts, examples of which we see in many double-star systems, or the explosion might be so shattering that the original mass is almost uniformly broken into thousands of fragments forming a star-cluster like ω Centaurus or ξ Toucan. Or the mass of a system may so nearly balance the explosive force that explosions are muffled and intermittent; these would give rise to stellar-variability or in the case of a body like the Sun, act as one of the causes of sunspots. It has been shown that some of the transformations of radium are rhythmic, a fact which suggests that the sunspot period may be due to atomic disintegration.

Here we may remark, that it is not impossible that explosive action on the Earth, as shown in volcanic action, is due to the liberation of atomic energy. Formerly it was ascribed to the percolation of water into hot strata, but the recent researches of A. Brun have proved that the ejecta of volcanoes are free from either steam or water. A time comes when the central mass of a system becomes fairly quiescent, such as the Sun now is. In this quiescent stage, the Sun is a globe of liquid with an enormous radiation of heat and light waves, and emitting electrons; its heat being mainly due to atomic disintegration, which will continue as long as any of it remains, or, in other words, as long as it contains atoms of more than gaseous atomic weight. Its end will be approached by its passing into the gaseous or stellar state, which will later devolve into a nebula. There are no dark suns or stars. Continuity requires that the Earth and other planets should be going through a like process, but on a much slower scale, owing to their smaller masses, and perhaps also to the different proportions of the elements of which their chemical constitutions are built up. One can imagine that whilst, say Jupiter, is still growing by planetesimal accretion, the Sun's attractive mass may become so small through the emission of electrons that the centre of our system will be transferred, in the course of ages, to the planet Jupiter.

The explosion hypothesis suggests an explanation for the phenomena exhibited by the so-called Novas or new stars. These are small stars which almost instantly increase enormously in luminosity and slowly and somewhat irregularly fade away, often to small nebulae. These may be assumed to be gaseous stars, in which the ratio of the specific heats exceeds one and one-third; they are then essentially unstable, and a time comes when a radical change of state occurs—a sudden blaze up, followed in most cases by a rapid disintegration into the final state of nebulosity, in which entropy has become a maximum and atomic energy a minimum.

The implication of this hypothesis in the glacial epochs of the Earth is simple. A glacial period will come on slowly as the heat of the Sun falls through the rhythmic close of a period of chemical disintegration; the hot period will follow suddenly with a prodigious melting of the polar-ice caps and vaporization of a great part of the oceans—a time of cloudy skies and the enormous rainfall of a carboniferous era, a time of maximum temperature following the epoch of greatest cold comparatively closely. If temperature and time were plotted the curve would resemble that of the light of a variable star, as it should, because the cause at work is the same.

If we seem to live in an age of uniformity in temperature conditions, it is perhaps because the race can only flourish under such circumstances, the theory gives no promise of continued uniformity. An explosive disintegration of atomic energy on the Sun may occur at any time. We can only surmise from past conditions on the Earth that at present the Sun is getting colder in preparation, or as an antecedent to a further outburst. Here, again, the behaviour of variable stars is an indication; although some of these stars are remarkably regular in their changes, others are not; and generally, the fainter the minimum, the more rapid and brighter the following maximum.

In building up the above hypothesis, the following facts of observation have been borne in mind:—

1. The mutation of heavy elements, such as Uranium (atomic weight 238.5) into Helium (atomic weight 4) with an enormous liberation of energy spread over thousands of millions of years.
2. The changing of stars into nebulae of which some four or five cases are known, whereas the reverse process is unknown.
3. Gaseous stars (spectra showing helium and hydrogen, with or without bright lines) are very light, their density not exceeding 1-9th that of the Sun, whilst their gravitative power seems to be "nil." Thus the brilliant close pair of *a* Crux shows no orbital motion, whilst the essentially wider solar-type star *a* Centaurus is a rapid binary pair.*
4. Nebulous matter is found near most stars of the gaseous types—thus the nebulous regions of Orion are in the midst of helium-type stars, nebulous matter is unknown near solar-type stars.

As under the explosion hypothesis the Sun is liquid, it cannot maintain its temperature by contraction, because liquids are virtually incompressible, hence Helmholz's theory of the maintenance of solar heat is not applicable. It is further improbable that gaseous or stellar-type masses always contract as they radiate heat; on the contrary, Kelvin's investigations indicate very strongly that such masses of gas may expand. The argument that spiral nebulae are systems in formation overlooks the palpable fact that these objects are exceedingly faint. Long exposure photographs give very misleading pictures of spiral nebulae. In nearly every case the total brightness is less than any one of its neighbouring small stars. It would be of the same order of reasoning to assert that islands are formed out of wisps of cirrus cloud.

The commonly received view that gaseous stars are hotter than liquid or sun-type stars has perhaps been engendered by the classification really based on the nebular hypothesis, *viz.*, that white stars are the hottest, and that sun-type stars already show signs of cooling, but Huggins clearly shows that solar-type stars are the hotter—thus in his "Atlas of Spectra," 1899, p. 85, he says:—

> In strong contrast with this falling off in Vega at about λ 3,700, the continuous spectrum of the solar stars, Procyon and notably Capella—that is to say, the narrow bright intervals between the numerous strong dark lines . . . is obviously far more intense.

And it may fairly be asked, if the gaseous or stellar type of star is the hotter, why it should not show metallic lines in

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* "Wider" is used in a general sense and includes the effect of surface luminosity, because as far as distance alone goes, *a* Centaurus is not so wide as *a* Crux. See Newcomb's remark on a star in Orion, which is quoted in the references given later.

its spectrum. The answer, under the new hypothesis, is that such stars no longer contain substances of high atomic weight, as these substances have disintegrated into the simpler gaseous elements.

One cannot imagine the process (in a universe tending to uniformity and to a maximum of entropy) by which a simple gas, such as nebulium is, can be transformed into complex atoms containing enormous stores of energy. The reverse process seems to be a more fitting one; it starts with heterogeneity and finishes with homogeneity.

In short, Laplace's nebular hypothesis as a representation of nature is quite untenable, as it is contrary to observation and to known chemical and thermodynamical laws; in spite of this, literally volumes of mathematical deductions (but not by its author) have been drawn from it.

I have added a list of references to various modern authorities whose views have influenced my own; some numerical results have been quoted.

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BRUN, A.—*Recherches sur l' Exhalaison volcanique.* Geneva, 1911. A brief notice of Brun's researches will be found in the *Britannica Year Book*, 1913, p. 106.

BARNARD.—*The Temporary Stars. On the present appearance of some of these bodies. Astronomische Nachrichten* No. 4655, 1913, May 20.

Nova Cygnus, 1876: Its appearance is distinctly hazy.

Nova Auriga, 1891: Its image is ill-defined.

Nova Sagittarius, 1898: It is always hazy and ill-defined.

Nova Lacerta, 1910: It presented the appearance of a very small nebula, less than 2 inches in diameter, of a bluish-white colour.

CHAMBERLIN, T. C.—*Journal of Geology*, 1911, Vol. xix. In a paper in this volume, the author points out how his planetesimal hypothesis has been strengthened by the discovery of radio-activity.

CHAMBERLIN, MOULTON and others.—*Contributions to Cosmogony and the Fundamental Problems of Geodesy—The Tidal and Other Problems*, 1909.

This is a remarkable work, which is published under cost price by the Carnegie Institution of Washington, but it is so poorly advertised that its circulation is far below its real merits. For this reason, I venture to quote some of the conclusions reached in it.

Chamberlin:—"The application of the most radical and the most rigorous method of estimating the frictional value of the present water-tides . . . seems to show that they have only a negligible influence on the Earth's rotation. . . . The tides of the lithosphere are chiefly elastic strains, and have little retardative value. . . . The accelerative forces seem to be also negligible. . . . There has been no such change in the rate

of the Earth's rotation . . . as to require to be seriously considered in the study of the Earth's deformations." (p. 59.)

Chamberlin writes (p. 23):—"There can be no theoretical doubt that there are tides of the lithosphere."

Since then Professor A. Young's discovery of lunar-tide effects on the Karoo has been published.*

Moulton:—"In a word, the quantitative results obtained in this paper are on the whole strongly adverse to the theory that the Earth and Moon have developed by fission from an original mass, and that tidal friction has been an important factor in their evolution. Indeed, they are so uniformly contradictory to its implications, as to bring it into serious question, if not to compel us to cease to consider it as even a possibility." (p. 133.)

". . . The hypothesis of Laplace has the support of no observational evidence. On the contrary, there are well-known considerations . . . which compel us to reject it. . . ." (p. 137.) As to the possibility of the fission-theory of the formation of satellites, planets and double-stars, Moulton's conclusions are:—

"(1) We find that the Sun cannot arrive at this critical stage (fission) until its mean density shall have exceeded 307×10^{11} on the water standard. This corresponds to an equatorial diameter of the Sun of about 22 miles. (2) We find that the Sun cannot become so oblate as Saturn is now until its mean density shall have exceeded 148×10^{10} on the water standard. . . . Since even the latter density is impossibly great, we conclude that the Sun will never become so oblate as Saturn is now, and that it will always be more stable than Saturn is now.

"(3) We find that Saturn cannot arrive at the critical state at which Jacobian ellipsoids branch, until its mean density shall have become 21 times that of water. . . . We conclude because of the great density demanded that Saturn will never suffer fission." (p. 159.) "Perhaps the hypothesis that stars are simply condensed nebulae, which has been stimulated by a century of belief in the Laplacian theory, should now be accepted with greater reserve than formerly. Up to the present we have made it the basis not only for work in dynamical cosmogony, but also in classifying the stars. It may be the time is ripe for a serious attempt to see if the opposite hypothesis of the disintegration of matter—because of the enormous sub-atomic energies, which perhaps are released in the extremes of temperature and pressure existing in the interior of suns, and of its disperson in space along coronal streamers or otherwise—cannot be made to satisfy equally well-known phenomena. The existence of such a definitely formulated hypothesis would have a very salutary effect in the interpretation of the results of astronomical observations. We should then more readily reach what is probably a more nearly correct conclusion, *viz.*, that both aggregation and dispersion of matter under certain conditions are important modes of

* "Tidal Phenomena at Inland Boreholes near Cradock," *Trans. Roy. Soc. of South Africa*, 1913, Vol. III, pt. I.

evolution, and that possibly together they lead in some way to approximate cycles of an extent in time and space so far not contemplated." (p. 160.)

LUNN.—"Geophysical Theory Under the Planetesimal Hypothesis."

In this paper, if I grasp aright the meaning, the author shows, by adopting plausible laws of compression and density, that it is only small bodies that can be very dense, which is borne out so far as they go by astronomical observations; thus we have

Type.	Body.	Mass.	Density.
Planetary	Meteorite	Infinitesimal	3 to 8
,,	Mercury	1/5,000,000	1.21
,,	Earth	1/330,000	1.00
Sun or Solar	Sun	1	0.26
Stellar or			
Gaseous	Algol*	3	0.14
,,	β Lyra	9/6	0.00016

COX.—"Beyond the Atom." 1913.

"One pound of the emanation would, at its maximum intensity, radiate energy at the rate of about 10,000 horse-power. This large emission of energy from the radio-active bodies throws an interesting light on two questions which have long been the subject of controversy, the age of the Earth and the source of the heat of the Sun." (p. 109.)

Period of fall of Uranium to half-value 6,000,000,000 years. (Table, p. 91.)

KELVIN (and GREEN).—"The Problem of a Spherical Gaseous Nebula. *Trans. R. S. of Edin.*, 1907-1908.

" It is scarcely possible to conceive that any fluid composed of the chemical elements known to us, could be gaseous in the Sun's atmosphere at depths exceeding 100 kilometres." (p. 268.)

Kelvin called a gas in which γ, the ratio of the specific heats, is greater than $1\frac{1}{3}$ a gas of species P; and it is almost certain that all monatomic gases have $\gamma = 1\frac{2}{3}$.

"We see that the central temperature of a globe of gas P in equilibrium increases through gradual loss of heat by radiation into space. We then see also that the internal energy of a globe of gas P, continuing in a condition of approximate equilibrium, while heat is being radiated away across its boundary, would go on increasing, and the work done by mutual gravitation of its parts would go on increasing till the gas in the central regions becomes too dense to obey Boyle's Law." (p. 281.)

In the above statement no account is taken of any possible liberation of atomic energy, but, even without this, it is evident that the underlying idea of contraction is at fault, and that a decrease of internal temperature and increase of size could go on together.

So far as observation goes, the evidence is in favour of the latter view. Although hardly supplying an exact parallel, it is

* Uncertain; Stebbins gives Mass 0.55, Density 0·02

well known that the gaseous envelopes of comets contract as they approach the Sun.

NEWCOMB.—"The Stars: A Study of the Universe." 1902.

"A very remarkable case is that of ζ Orionis. It has a minute companion at a distance of 2.5″. Were it a model of the Sun, a companion at this apparent distance should perform its revolution in 14 years. But, as a matter of fact, the motion is so slow that even now, after 50 years of observation, it cannot be determined with any precision. It is probably less than 0.1″ in a year. The number expressing the comparison of the density and surface brilliancy of this star with those of the Sun is probably less than 0.0001. The general conclusion to be drawn is obvious. The stars in general are not models of our Sun." (p. 200.)

NEWCOMB.—"Popular Astronomy." 1882.

"Then a mathematical computation of the attractive power exerted by such a system of masses (500,000,000 sun-masses) shows that a body falling from an infinite distance to the centre of the system would acquire a velocity of 25 miles a second." (p. 501.)

This calculation does not seem to be correct, but it serves to show how impossible it is for the potential energy of a nebula composed of nebulium, helium and hydrogen to be changed by gravitation into the radio-active and other atomic energies of heavy atoms. The velocity with which a small mass falling from rest at an infinite distance would strike the Sun is 380 miles a second. This means that a gram falling into the Sun would generate 44,844 calories; this is but 1/50,000th of that evolved by radium.

PERRY.—"The Life of a Star." "*Nature.*" 1899, July 13.

"Assumptions like those of Homar Lane and Ritter may lead to results which are altogether wrong. . . . Homar Lane, Lord Kelvin, Ritter and all people who have tried to make exact calculations, have assumed that the stuff of which a star is composed behaves as a perfect gas in a state of convective equilibrium. . . . But if we apply our results to the Sun we find that at its centre there is a density 33, that is, 50 per cent. greater than the ordinary density of platinum. It seems to me that speculation on this basis of perfectly gaseous stuff ought to cease when the density of gas at the centre of the star approaches 0.1 or one-tenth of the density of ordinary water in the laboratory. . . . It seems to me that if a mass of this kind of gas (in which γ, the ratio of its specific heats $= 1\frac{1}{3}$) gravitates by itself from an infinite distance, it retains all its energy. But such gas must surely be imagined to be radiating heat, as it is not at zero temperature. Where can it get such heat? I come to the conclusion that there must be atomic energy available somehow in it. . . . I say that no substance for which $\gamma = 1\frac{1}{3}$ can behave as a perfect gas."

Kelvin's remarks on and his endorsement of Professor Perry's conclusions will be found in *Nature*, 1907, February 14.

RAMSAY.—" Elements and Electrons," 1912.

" Cordite, the explosive powder used for our artillery, evolves 1,253 calories per gram. . . Radium, 2,800,000,000 calories."

SCHWARZ, E. H. L.—*Causal Geology*, 1910.

The ideas awakened by this original and suggestive book gave rise to the present paper.

ADDENDUM.

Since the above was written, a paper on the " Structure of the Universe," by Professor J. C. Kapteyn, has appeared in *Scientia*, Vol. XIV. He writes (page 352):

> Must we conclude that the nebulæ are *not* the birthplace of stars? It may seem so. Let us not conclude too hastily, however. There are nebulæ and nebulæ. . . . . Herschel saw in them (the planetary nebulæ) a likeness to what, according to Laplace's cosmogony, must have been the primitive aspect of our solar system, and he thus imagined that they must be worlds in *statu nascenti*. . . . . Such a view now seems untenable. The planetary nebulæ cannot be the birthplace of the stars. . . As I have just now said, there is one nebula for which the radial velocity has been determined, which is *not* planetary. It is the well-known Orion nebula belonging to the class of the irregular nebulæ. May not these irregular nebulæ give birth to the stars?"

On page 353 he writes:

> How have to explain the fact that the internal velocity of stars increases steadily as they grow older? The astronomer who, in his study of the motion of the heavenly bodies has found hardly a trace of any other force than gravitation, will naturally turn to gravitation for such an explanation. . . . . If it be true that mutual attraction of the stars has generated such an enormous amount of internal motion in the time needed by the stars for their evolution from helium to second- or third-type stars, how have we to explain the fact that we find the same matter nearly at rest at the first stage of stellar life? . . . . What may be the explanation? Is there really no gravitation in primordial matter? I have no solution to offer?"

Although the whole of Professor Kapteyn's article should be read, the above extracts are those which chiefly concern my argument. The first extract shows that in Professor Kapteyn's opinion a great part of the Nebular Hypothesis must be thrown overboard, in that it is only the large irregular nebulae such as that of Orion that we must now look to as forming the matter out of which stars are formed. This, however, supplies no answer to the pressing question, Whence comes the energy which transmits light elements into heavy elements? In the second extract given, Professor Kapteyn is very sure that the order of evolution is (1) irregular nebulae, (2) helium stars, (3) hydrogen stars, (4) metallic line stars, (5) absorption band stars, and mainly because the velocities of stars increase in this order. The remarkable discovery that stellar velocity depends on spectral type was made independently and by different methods of attack almost simultaneously by two American astronomers, Dr. Campbell, of the Lick Observatory, and the late Lewis Boss. The following little table is taken from Lick Observatory *Bulletin* No. 196, 1911, April 20:—

Spectral Class.			Velocities in kilometres a second. Campbell.	L. Boss.
B-B5	Helium Stars	... ...	(6·2)	(6·2) [classes Oe5-B5]
B8-B9	Helium Stars	... ...	6·7	(9·6) [B8-A4]
A	Hydrogen Stars	... ...	10·3	(13·5) [A5-F8]
F	Hydrogen-metallic Stars	...	14·4	
G	Metallic stars, solar type	...	15·9	15·9
K	Intense metallic stars...	...	16·8	16·8
M	Absorption band stars	...	17·1	17·1

The rough interpretation of the spectral classes enclosed in square brackets is my own; Oe5 is the class of bright line spectra which were not considered by Campbell. The assumption that increasing velocities indicate later evolutionary stages seems to be unnecessary for Kapteyn's argument which it appears would be just as strong, if not stronger, if the other view had been adopted. No analogy will suit the case, but one or two rough analogies may help to fix one's ideas. A piece of coal in a locomotive may be looked upon as a small mass of energy in rapid motion; when thrown into the furnace, it parts with much of its energy, it is partially vaporised and emitted as smoke which soon comes to rest in its medium, in this case the atmosphere. Or, consider a comet with an enormous velocity near the Sun; it throws off a tail of vapour which vapour loses velocity, and probably enough comes finally to rest in the Ether. The life of a planetesimal is roughly the same—the origin of such a body is unknown to us, but its existence is a fact which should not be ignored. These bodies are travelling through space with velocities comparable with those of the G, K and M type stars. Ultimately, under mutual coalescence, their higher atomic elements resolve into the lighter elements. At first as a planetesimal the mass flies through space without any diminution of velocity, but as the life history outlined in my address progresses, light-wave or radiation pressure commences and some of the energy is communicated to the Ether; in this way velocity is lost, and finally matter in the last stage of exhaustion and approximating to the Ether itself, merges its velocity in that of the Ether which is nil. When the velocity of particles emitted from atoms are comparable with the velocity of light, the etheric resistance becomes very large. It is, perhaps, axiomatic to assert that no particle can travel quicker than light, but this being assumed, the resistance in such a case would be infinite. The case of the brilliant double-star *α* Crux has already been adverted to. It is composed of stars of magnitudes 1.58 and 2.09, spectral class B1, but it shows no motion due to gravitation since the first measures made some 86 years ago. Had it been a sun-type star, the two bodies would be revolving around their mutual centre of gravity in some 25 to 30 years. It is certain that there is no such motion, so that we are faced with two alternatives: (1) that these stars, in spite of their brilliancy, are of very small mass compared with the Sun; (2) that the material they are composed of has little or no gravitative power, or that the gravitative power is neutralised by radiation pressure.

NOTES ON THE DISTRIBUTION AND CHARACTERS OF REPTILES AND AMPHIBIANS IN SOUTH AFRICA, CONSIDERED IN RELATION TO THE PROBLEM OF DISCONTINUITY BETWEEN CLOSELY ALLIED SPECIES.

By JOHN HEWITT, B.A.

(*With Four Maps.*)

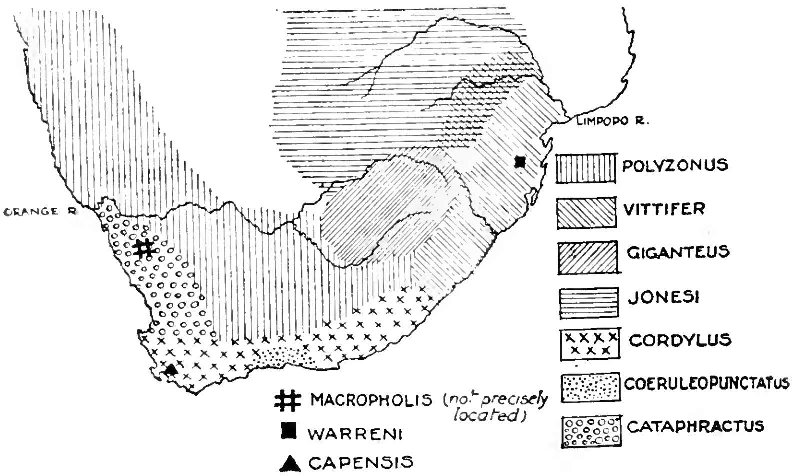
The data for the study of geographical distribution of animals in South Africa are rapidly becoming obscured as a result of the operations of civilised man. Amongst the terrestrial vertebrates, probably the reptiles and batrachians are now most suitable for zoogeographical studies, as their natural distribution has not been so radically modified through human agency as is the case with the higher vertebrates

Through the work of the late Dr. Bolus and others, botanists are well acquainted with the broad facts of plant distribution in South Africa, and as animal and plant life are so closely associated and mutually dependent, it may be inferred that some correspondence must obtain in their manner of distribution. The facts are as follows: the *orders* and *genera* of flowering plants separate themselves into a number of well-defined botanical regions, but the families and many of the genera of reptiles range throughout the sub-continent, and only in a very loose way may we distinguish two areas, an Eastern and a Western, partly separated by the Drakensberg Range: nevertheless, the *species* of polytypic genera of reptiles do in some cases arrange themselves into areas which roughly coincide with the various floral regions, but in other cases the species of a genus occupy areas which seem to have no relation with botanical regions. The exact distribution of all these species and the nature of the characters which separate them from their nearest allies, may be expected to afford important data bearing on the great question of the origin of species. Some of the contested problems we may hope to investigate are: (1) What is the importance of Isolation, geographical or topographical, as a factor in the formation of species? May several species arise from the same stock within a uniform environment provided that several portions of that environment are separated from each other by barriers? (2) What is the evidence for and against mutations as opposed to the older view of a gradual evolution through more or less minute and fluctuating variations? (3) Are specific characters adaptative?

Isolation as a factor of primary importance in the evolution of species. This view has been vigorously championed by Wagner, Romanes and Gulick, and by many systematists.

The term Isolation may be used in reference to all the various factors which prevent the interbreeding of two groups of animals, but for the present I use it only in a geographical or topographical sense.

H. Seebohm has stated, "So far as is known, no species of birds has ever been differentiated without the aid of geographical isolation." Dr. Jordan, dealing with birds and fishes in North America, attached the greatest importance to barriers which effect isolation: in regions broken by barriers which isolate groups of individuals, we find a great number of related species. The Rev. Mr. Gulick makes a good case for isolation from a study of the land shells which live under apparently uniform conditions in the forests of the Hawaiian islands, where an original variable stock seems to have separated into a number of distinct species unaided by any process of selection, and simply as a result of the geographical separation of the colonies which gave rise to the various species. For a similar investigation in South Africa the land shells of the genus *Achatina* would probably prove eminently suitable as the genus abounds in local forms: in this genus no case of divergence which is clearly a result of unassisted isolation has yet been brought to my notice, but a more thorough investigation than I have been able to make is much to be desired. In the case of most reptiles in South Africa we are not likely to find anything strictly parallel to the phenomena recorded by Gulick, seeing that their active life makes geographical isolation almost impossible within uniform environments, which are unbroken by large natural barriers. On the other hand, this subcontinent presents such a number of different climates and environments even in limited areas that in attempting to account for the differences between two forms, which are geographically separated, we can hardly ever be certain that the factor of environment has been eliminated. Amongst the lizards, perhaps the most sluggish or most homeloving are the species of *Zonurus*. There are ten species which are distributed in distinct areas, those areas in most cases coinciding with regions of very distinct climatic or physical conditions. These specific areas are contiguous, but for the most part do not overlap except to a slight extent in the case of the group of related species, including *Zonurus cordylus*. The species of the *cordylus* group are distributed as follows: *cordylus* occupies the coastal belt of Cape Colony: a very close allied form, *vittifer* lives in Natal and parts of the Transvaal, whilst another near ally occupies the central plateau from the Transvaal to Angola, its distribution somewhat overlapping that of *vittifer* in the Transvaal: two other species, which are not so closely related to *cordylus* as *vittifer* or *jonesii* seem to occupy small areas within the larger area of *cordylus*, *Z. capensis* being known only from the Hottentot Holland mountain, and *Z. coeruleopunctatus* occurring on a hill between Knysna and Avontuur. If we assume that these forms all originated from the same stock we cannot satisfactorily explain the occurrence of the two species last mentioned as due to peculiar environmental conditions when the wide range of *cordylus* is considered, and as their scutellation characters are in some respects primitive they are, perhaps, best regarded as isolated sections of the original variable stock. However, if this case may be thus explained, it is the only example known to me of differentiation of species solely as a result of geographical isolation within a uniform environment. Excepting the case of *Z. cordylus* and its two nearest allies, *vittifer* and *jonesii*, the genus *Zonurus* is remarkable amongst lizards in South Africa in that species whose areas are geographically adjacent are apparently not closely related: for instance, *cordylus*, the coastal species of the Cape, gives place to *cataphractus* in Little Namaqualand, to *polyzonus* in the central and northern regions of the Cape, and this, again, is succeeded by *giganteus* in the Free State, but these four species



Distribution of the species of *Zonurus* in South Africa.

are very sharply separated from each other in a number of their specific characters. It is probable that these large differences between the species are in part a result of their sluggish and retiring habits, which facilitate geographical isolation.

Sluggishness of habit certainly favours the differentiation of a genus into species. The *pumilus* group of chamaeleons, which are proverbially slow of movement, comprises half a dozen or more species, each of which is the local form of some area along the southern coast: but how far the differences are due to isolation, and how far to environmental differences, it is hard to say, as it cannot be said that the environmental conditions are identical in any two cases. No other genus of lizards is split up into so many species within the same region.

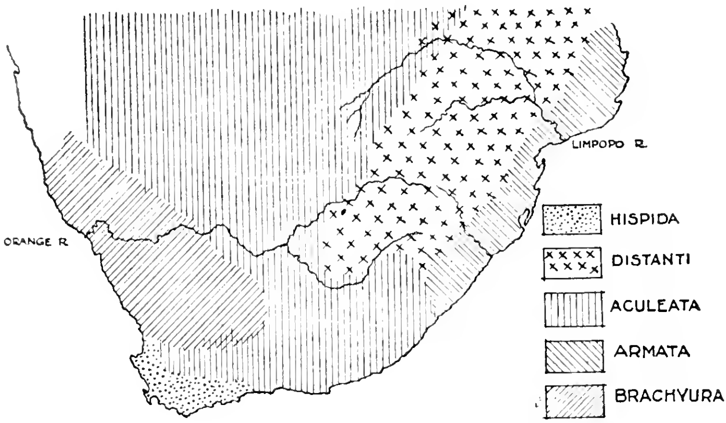
It is interesting to note the change of fauna in passing from the Eastern to the Western districts of South Africa, distinguished as they are by profound differences of climate. A number of widely distributed tropical species reach as far south as Natal or Eastern Cape Colony, but are quite unrepresented in the Western parts of the Cape, probably because the climate is unsuitable, *cf.*, the lizards *Homopholis wahlbergi*, *Lygodactylus capensis*, *Mabuia quinquetaeniata*, and the snake *Dendraspis angusticeps*: in many other cases a widely distributed tropical species reaches as far south as Natal or Eastern Cape Colony, but in Western Cape Colony is represented by a closely allied species. The water frog, *Rana angolensis*, occurs from Angola to German East Africa, and passes southwards along the Southern coast as far as George, but in the Karroo and Western districts of the Cape it is replaced by *R. fuscigula*, a closely related form: the cobras *Naia haie* and *N. nigricollis* extend from the Nile to Natal, but in the Cape are replaced by *N. flava*: the toad *Breviceps mossambicus* ranges from German East Africa to Natal, but our Cape form is *gibbosus*: the common toad, *Bufo regularis* occurs practically throughout Africa except Barbary, but is unknown in the carroid regions of the Cape, where, however, *B. gariepensis* (*granti*) is common. Now, as there is no strongly defined geographical barrier separating the Eastern and Western parts, there is great probability that the differentiation of species in these cases has been determined by climate and related environmental influences.

Amongst all genera of Lizards in South Africa, it is the general rule that closely related species of the same genus are geographically separated, and not only so, but usually in such a way that the *specific areas coincide with regions of very different climatic or vegetational condidions*: on the other hand, the American systematists in various groups of animals report that their *closely allied species occupy distinct portions of the same environmental area*, this being broken up by natural barriers which prevent free communication.

The *hispida* section of the genus *Agama* is distributed somewhat on the same plan as the species of *Zonurus*. *A. hispida* proper, seems to be confined to the South-West parts of the Cape. *A. brachyura* occurs in Little Namaqualand, and other Western parts of the Cape, *A. distanti* occurs on the high veld of the Free State and Transvaal, *A. aculeata* occurs in the Kalahari, Namaqualand and the Karroo, whilst *A. armata* ranges from Natal to East Africa. Unlike *Zonurus*, hoewver, these species are neither greatly nor sharply separated from each other in their structural characters. We may add that *A. atra*, which structurally belongs to a different section of the genus, occurs in the same localities as any of the above-mentioned species, though it is actually quite isolated topographically from any *Agama* that may live in its neighbourhood, owing to its rock-frequenting habits.

The distribution of the geometric tortoises has much in common with the scheme of *Zonurus* and of the hispid *Agamas*.* The snakes of the genus *Psammophis* are also distributed in a similar manner.† In view of these facts, it may be stated that in South Africa the environment directly or indirectly produces the species as described later on, probably the simplest explanation would be in terms of the natural selection theory with or without Lamarckian factors, and yet it seems to me just possible that these different environments have merely operated in providing a means of isolation for the several portions of the original varying stock.

The isolation afforded by the different environments probably is a real factor in the formation of species, and the fact that allied species almost invariably occur in different environments may mean that only in this way can isolation be effected: still it is hardly likely that this is the only way in which environment affects the species. There are, moreover, several classes of facts



Distribution of *Agama hispida* and allies.

which are not easily explained in accordance with the view of geographical isolation as a prime or sole factor. Firstly, there are some cases known where the most closely related species live in the same localities: as instances may be mentioned the frogs *Rana oxyrhynchus* and *R. mascareniensis* or the grass frogs *Rana grayi* and *R. fasciata*, and amongst snakes *Boodon lineatus*, *B. infernalis* and *B. guttatus* or *Chlorophis natalensis* and *C. hoplogaster*. In these cases, though their whole distribution areas may not completely coincide, the related species often occur together in the same place, and there can be no reason for suspecting that they ever were geographically separated into distinct areas. It may be argued indeed that even here each species may be topographically isolated from its nearest ally through some peculiar mode of life, such, for example, as obtains

* See Duerden in Report S.A.A. Advancement of Science, Kimberley (1906), **3**, 204.

† See Records Albany Museum **2** [4] 268.

within the genus *Agama* or *Mabuia*: *Agama atra* and *A. aculeata* both occur at Kimberley, but they do not meet, as the former lives entirely amongst rocks on kopjes, whilst the latter inhabits the open veld or climbs up trees (*fide* J. H. Power): exactly similar differences of habit separate the skink *Mabuia sulcata* from its near ally, *M. striata*, and they also occur near Kimberley. However, whilst admitting the scantiness of our knowledge with regard to the habits of some of our commonest reptiles and batrachians, I think it very improbable in the cases above mentioned, that the species are separated by habits which effect rigid isolation in a topographical sense. Indeed, the most likely explanation of the occurrence together of closely related species in a series of widely separated localities, is that they share a preference for the particular kind of environment which obtains in those localities.

Secondly, how can we explain adaptations in terms of the isolation theory? As stated later on, the structural specific characters are not as a rule obviously adaptative, but sometimes they are almost certainly so. How is it possible to suppose that isolation alone, unaided by natural selection or Lamarckian factors can direct the chance variations to which a rounded snout is susceptible into a sharp cutting snout, such as is found in various burrowing species of reptiles found in the Kalahari? And yet it is such differences that separate the Kalahari species from their allies elsewhere. Again, the lizard genus *Eremias* comprises many species which inhabit the drier parts of Africa and Asia. Some of them have transparent scales in the lower eyelid; others have the lower eyelid entirely granular and opaque, which no doubt represents the primitive condition, whilst between the two extremes are other species which collectively show a complete range of intermediate conditions. The character of the lower eyelid is very constant in any one species, and in some cases would alone serve for the identification of the species. Now this transparency of the lower eyelid seems to be an adaptation against the blinding sandstorms of an arid country, the lizard which is thus provided being enabled to see with his eyelids closed. Similar adaptations are found in other genera. If we accept that explanation, it will be impossible to explain this typical case of Orthogenesis, the evolution along definite lines of the transparent "window-eyelid" from the scaly opaque eyelid, as merely the result of isolation. As a matter of fact, *lineocellata* which possesses a "window eyelid" occurs in the same district as *namaquensis*, in which the lower eyelid is scaly and only semi-transparent, and indeed the South African species of this genus apparently do not as a whole distribute themselves into quite distinct areas. Nevertheless, though in such cases topographical or geographical isolation seems to have in no way contributed to the splitting of this genus, yet *Eremias* has one pair of closely related species, *viz.*, *E. lineocellata* and *E. pulchella*, in the formation of which geographical isolation may have played an important part: the former occurs in the Transvaal, Free State, and Bechuanaland, the latter in the carroid areas of Cape Colony: it should be added that the differences between them are very slight, being based mainly on the degree of keeling of the dorsal scales.

The fact that many genera can be structurally divided into groups of closely related species, the members of each group being geographically separated whilst members of different groups may live together in the same locality, may imply that species formation of a larger kind occurs without the help of geographical isolation: for instance the species of the geometric group of *Testudo* have a geographical significance, but besides these the genus includes some very distinct species, such as the giant tortoise (*T. pardalis*) which commonly occurs in the same localities as any of the geometric tortoises, and there is no reason for supposing that the giant and geometric tortoises ever were geographically separated.

Mutations.—By many biologists the mutation theory has been thought to afford an explanation of the discontinuity between species, and saltatory evolution has been welcomed as affording a much better handle for the tool of natural selection than was available in terms of the older Darwinian hypothesis. The term mutation, as used by De Vries, implies a genetic variation which is constantly transmitted to the offspring, and which introduces a new character to the organism: as such it is distinguished from fluctuational variations, which are not transmissible as definite single characters. Whether these two classes of variation are rigidly distinct may well be doubted, and it is obvious that if we distinguish between them only on the basis of their transmissibility, the term mutation might be used to include variations so small as to be scarcely perceptible, in which case the theory loses much of its value as an explanation of discontinuity or of the origin of new characters. Broadly speaking, therefore, a mutation is understood to mean a variation which is relatively large as well as definite and transmissible, and in this sense I employ the term here. There can be no doubt about the reality of mutations in certain cases, but that such mutations have contributed to any considerable extent in the formation of species is not so certain. The phenomena of Mendelian inheritance include the production of what may rightly be called mutations in the recessives, and instances of Mendelian inheritance are common enough, both in animals and plants An interesting case is that of our common rat *Mus rattus*, of which two colour varieties occur in Grahamstown and elsewhere, a pale-bellied form and a dark-bellied form: these forms have been shown by Mr. Bonhote to follow the law of simple Mendelian inheritance. On the other hand, it has been suggested that the various mimetic forms of the same species of butterfly are of Mendelian origin, but Prof. Poulton has recently shown that in some cases at least such is not the case, the various forms being connected together by various grades of intermediates.

De Vries found that his new "elementary species" (which correspond in degree to what we should call constant varieties) appeared within the very home of the parent form from which they arose, and he says, "Many distinct species (his elementary species) can and do exist side by side in the same range, and are in fact found to be heaped up in the centre of their area of distribution, but more scattered at the periphery." Now it is obvious that such a mode of evolution is not likely to have effected the origin of the great majority of our species, for they are geographically separated, but it is possible that mutational evolution may explain the various cases of closely allied species living together in the same environment. However, if we seek for characters which are essentially mutational, it is most difficult to find a clear case. The two green water snakes *Chlorophis natalensis* and *C. hoplogaster* are often found in the same localities : the former has along each ventral scale of the body a distinct keel on each side, whilst the latter is described as having perfectly smooth ventral scales. Formerly I suspected that the keel of *natalensis* represents a mutation quite unconnected with the smooth scale of *hoplogaster*, but careful examination of the latter species led to the discovery of a very slight, but nevertheless distinct rudiment of a keel in the ventral scales of *hoplogaster*, which at once suggests that the *natalensis* condition has been arrived at through a series of minute stages and that the *hoplogaster* and *natalensis* conditions will be found to grade. Similarly though the ringhals has all its body scales sharply keeled, whilst its generic allies the cobras have smooth scales, we cannot assume that this is a mutation character, seeing that in other snakes such as *Causus* or *Leptodira* all grades from strongly keeled scales to smooth scales may be met with in the same genus, whilst the same species may exhibit a wide range of variation in its keeling. The genus *Acontias*, including our commonest blindworm, will probably afford an interesting study in evolution, as it has differentiated into species which in certain localities are very distinct, but in other places seem to merge. *Acontias meleagris* and *A. lineatus* occur together in Little Namaqualand, where they seem to be quite distinct species, the latter being easily recognised by its much depressed and strongly projecting snout. At Port Elizabeth typical *meleagris* occurs, and along with it a form which is recorded by systematists under the name of *lineatus*, but whilst agreeing in all other respects with that species, it differs in the form of the snout, therein resembling *meleagris* rather than *lineatus*, and indeed it may be an aberrant juvenile form of *meleagris* Whatever name we apply to it, this form may be fairly regarded as intermediate between *lineatus* proper and *meleagris* (juvenile) but such intermediates are not found apparently in Namaqualand The large black blind worm *Acontias* *plumbeus*, found in the Transvaal low country, will probably be found to merge gradually into *A. meleagris*.

In many genera of reptiles, systematists make use of the wide differences in the number of repeated parts for the separation of species: for instance, we might separate the lizard genus *Zonurus* into its species, merely by counting the transverse rows of body scales. Now such "meristic" variations, though they do not introduce new characters, yet inasmuch as they are definite and constant, might be styled mutations; but as a matter of fact, they are usually very indefinite, though there may be discontinuity between the speecies. In some species of snakes, *e.g.*, the mamba, the number of longitudinal rows of scales on the body is highly variable. But in the genus *Psammophis* the various species show much less variability in this respect and amongst the chief characters used by systematists for separating *P. crucifer* from *P. Sibilans* is the occurrence of 15 longitudinal rows of body scales in the former and 17 rows in the latter, yet specimens of *crucifer* with 17 rows of body scales are known. The same two species may be distinguished by the number of subcaudal scales, but, as the observed range is from 62 to 81 in *crucifer*, and from 86 to 104 in *sibilans*, we cannot describe this form of variation as other than fluctuational, and no doubt with more material the two series will be found to overlap. *Chlorophis natalensis* again has 114 to 140 subcaudal scales, whereas *C. hoplogaster* has 85 to 107, and the Rhodesian species *C. neglectus* has 77 to 114.

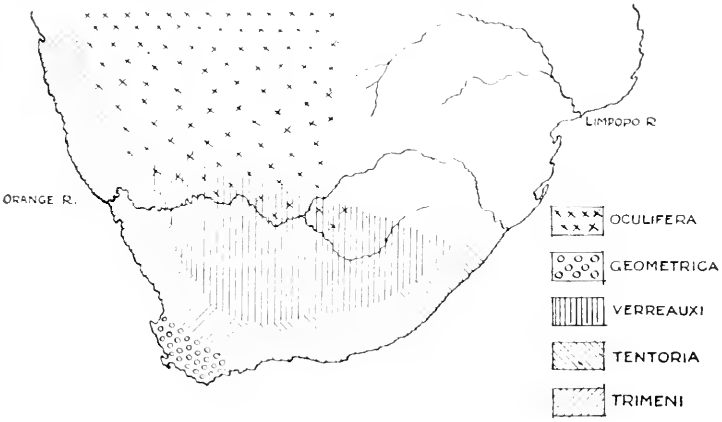
An apparently good instance of a mutation character is found in the specific characters which separate the smallest South African gecko, *Lygodactylus capensis*, from its ally *L. ocellatus*. The former has the margin of its mental scute deeply cut on both sides, but in the latter the margin of the mental scute is entire: these conditions appear to be quite constant, and I have found no intermediates. It is of interest to note that two Madagascar species of *Lygodactylus*, which are distinct from ours, show precisely similar differences, probably indicating a great antiquity for this "mutation."

Again, though there is abundant evidence of much intergrading of characters within the species of a genus, yet, as Gadow has pointed out, such intergrading is not necessarily the same thing as continuity. Our 17-scaled specimen of *Psammophis crucifer* is in every other respect typical of the species, and is not to be regarded as an intermediate between *sibilans* and *crucifer*. Dr. Duerden, in his admirable work on the geometric tortoises, found very much intergrading in respect of nearly all the characters he employed for the discrimination of the species, and expressed the opinion that they furnished no evidence in favour of the mutation hypothesis: but though he found three distinct types of combinations which were sufficiently separated from any transitional forms to be given specific rank, yet he was so impressed by the amount of intergrading within the group as to make this statement :

I am convinced that if all the tortoises belonging to the *geometrica* group at present living in South Africa could be gathered together . . . there would be an almost imperceptible passage from one so-called species to another: there would be numerous specimens of which it would be impossible to say to which of two species they should belong.

However this statement can only be considered as a possibility, for as yet nothing truly intermediate between *oculifera* and *verreauxii* has been brought to light, though Miss Wilman, of the Kimberley Museum, has secured numerous tortoises from a district where both these forms occur. In my opinion there is real discontinuity in this case at the present day.

No doubt, those of us who deny the occurrence of mutations in specific characters and yet admit that species are real entities,



Distribution of *Testudo geometrica* and allies.

will find some difficulty in explaining the structural discontinuity between species. Probably the simplest explanation is to suppose that a complete range of intermediates has existed, but such intermediates have either been directly cut out or have merged into one of the divergent stocks. This is indeed the view actually held by De Vries. That an actual cutting out has occurred in some cases is obvious enough from the distribution data: for instance, the genus *Tetradactylus* in Western Cape Colony extends from Capetown to Knysna, and is quite unknown in Eastern Cape Colony, though it is not uncommon in parts of Natal, Zululand, and the Transvaal. The snake *Amphorhinus multimaculatus* is common on the high veld of the Transvaal and in the neighbourhood of the Cape Division, but is quite unknown in intervening districts. But such cases are rather rare, and generally speaking the areas of nearly related species either closely adjoin or actually overlap. It may be presumed that the extent of isolation in habit that obtains between two divergent stocks will largely determine the chances of survival of intermediates: if strong differences of habit should accompany structural divergences, intermediates are less likely to persist.

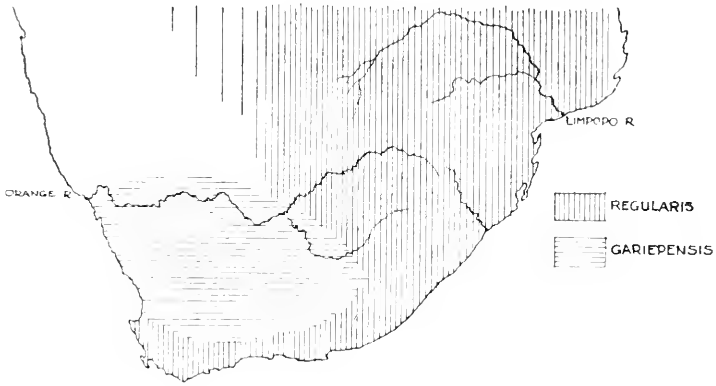
Are specific characters adaptative?—A great many instances of utility in trivial characters have been brought together by Darwin, Wallace, and their followers, but the structural characters which separate species are not usually regarded by systematists as of particular value to their possessors. For example, two allied species of antelope, Lichtenstein's Hartebeest and the Red Hartebeest, are distinguished by the form of their horns. Now whilst admitting the general utility of horns in antelopes, it is hard to believe that the particular form of horn in either species is specially adapted to the peculiar needs of that species. But one may argue, as the Darwinists do, that our ignorance of the minutiæ of the life history of species is so profound that we can form no proper conception of the function of such characters: moreover, it is possible that structures which at one time were of great importance have now ceased to be of use. This latter argument can only be applied with great caution, but it should not be overlooked. The extraordinary protective devices which are such a feature of the Karroo insect fauna and the remarkable facts of mimicry amongst our butterflies must in terms of the simplest theory which can explain those facts imply a high degree of usefulness in the characters concerned, either to-day or in past times; yet in the case of the butterfly mimics at any rate, the necessary facts required to prove the utility of the deception—*viz.*, the decimation of unprotected butterflies in enormous quantities by discriminating foes, and the immunity of mimics and mimicked species—seem to be almost entirely lacking, and we have to assume that the mimicry was evolved at a time when the struggle for existence amongst butterflies was much keener that it is to-day. Again, as is well known, orchid flowers are constructed with some elaborate mechanisms for bringing about cross-fertilisation through the agency of insects, and the majority of species cannot be self fertilised; but quite a number of species are known in which the same beautiful contrivances are still found, and yet the species are no longer dependent on insects, being always self-fertilising.

Amongst reptiles the structural characters which separate species only rarely appear to be undoubtedly useful. Examples are found in *Typhlosaurus lineatus* or *Typhlops schiuri*, which are both separated from their allies by the possession of a sharp cutting snout, enabling them to burrow in the sun-baked soil of the Kalahari. The window-eyelids of several species of the genus *Eremias* may also be counted in this category.

In the frogs, adaptative differences often separate the main groups of species in a genus: for instance the aquatic species of *Rana* have broadly-webbed feet, whilst grass frogs have only slightly webbed feet. But when we consider the differences between the most closely allied species, rather than between the groups of species, we cannot be so certain. *Rana fuscigula* of Western Cape Colony has entirely webbed feet and shorter legs, whereas *Rana angolensis* of Eastern Cape Colony has rather longer legs, and the feet are described as three-fourths webbed, but that these characters are peculiarly useful to each species in its particular environment seems a little doubtful, especially as their distribution areas slightly overlap and in intervening districts both species may occur in the same locality. Yet, of the geometric tortoises, Dr. Duerden wrote:

> If one were able to study the peculiarities of the environment closely, there is little question that the variations would be found to be largely adaptative.

On the other hand, it is impossible to see utility in the structural characters which separate the cobras, the species being distinguished mainly through a slightly different arrangement of the scales on the head, and such distinctions constitute the specific differences in many other closely allied species of snakes. Lizards also present many cases of species differentiation based on varied arrangements in the scutellation of the head or body. *Chamæleon ventralis* of Grahamstown is separated from *C. pumilus* of Capetown by several characters, amongst the chief of which is the shape of the lobes which form a fringe under the throat. *Agama hispida* of the Cape division is distinguished from *distanti* of the Free State and Transvaal, chiefly in that the belly scales of the former are keeled and spinose, whilst those of the latter are almost or entirely smooth. Similar differences separate *armata* of Natal from *aculeata* of the Kalahari and Karroo. *Bufo regularis*, the common toad, has a granular belly, whilst *B. gariepensis*, the Karroo species has a smooth belly. It seems very probable indeed that the structural characters which separate species are not necessarily of importance to the species, or at any rate are not of life and death importance. Nevertheless it is highly probable that in many cases there do exist between allied species certain physiological differences which are adaptative. There seems to me no other explanation of such facts as the following: The common toad, *Bufo regularis*, is widely distributed throughout Africa (except Barbary), and is common in all suitable localities from Egypt to the Cape, but does not occur in the carroid parts of the Cape, where, however a closely-allied species, *B. gariepensis* (*granti*) is fairly abundant. The Egyptian cobra ranges from Palestine to Zululand, and the black-necked cobra from Egypt and Senegambia to Natal, but neither of them enters the Cape, where the yellow cobra is common. Now seeing that the common toad enjoys such a wide distribution, but does not penetrate into the Karroo, though it occurs on the north, east and south sides thereof, we may fairly assume that it cannot live there, and most probably also the Egyptian cobra avoids Cape Colony because the climate does not suit its particular constitution. It seems to me, indeed, that the differences between the toads *Bufo regularis* and *B. gariepensis* are far more profound than those which are shown in their skins, and that the external differences are only to be regarded as incidental accompaniments of a different constitution. In the case of toads it is obvious that natural selection must operate, especially during their tadpole stages, and in the drier parts of South Africa, where rains fall at rare intervals, and natural pools soon disappear, there can be no doubt but that differences in the duration of the tadpole life may be of life and death importance. Now I have elsewhere endeavoured to show that in all probability the genus *Bufo* came to South Africa from the North, in which case it may well be that *B. regularis* represents the ancestral form in South Africa. This being the case it will be of great interest to know to what extent *regularis* and its presumed derivative *gariepensis* differ in the duration of their tadpole life, a question which unfortunately I cannot answer. Nevertheless some careful



Distribution of *Bufo gariepensis (granti)* and of *Bufo regularis*.

observations made by J. H. Power, of Kimberley, show that *Bufo vertebralis*, another probable derivative of *regularis*, an inhabitant of the drier parts of the Cape, has an unusually short tadpole life, the period from deposition of eggs to the appearance of the young toads covering only 16 days, which is the shortest batrachian metamorphosis known to me. This species moreover can make use of muddy pools for its tadpole life, whereas *regularis* seems to require running water. Such an adaptation can be easily explained in terms of the natural selection theory, though the possibility of a Lamarckian explanation must also be considered, seeing that the development of tadpoles is so easily accelerated or retarded by varying the temperatures.

However, the differences between *regularis* and *vertebralis* probably are not merely the result of differences in the periods of development of the tadpoles, for according to observations made by J. H. Power, the same species of frog (*Rana fuscigula*) may vary extremely in this respect without showing any perceptible differences in the adults. When we consider the profound differences of environment which characterise the different regions in which our closely allied species are isolated, it cannot be doubted but that their physiological processes are not quite the same, which of course implies adaptation in the specific physiological characters. Such species physiologically, as well as morphologically, are distinct entities. On the other hand, if several species may arise as a result of isolation within a uniform environment, there can be no adaptational differences whatever between them. Differences in habit between allied species which inhabit the same locality probably imply constitutional differences, and so far as we can judge, may have no direct relation to the structural characters separating the species.

Closely allied species which on the whole occupy distinct regions are sometimes found to overlap considerably in their distribution, but even then the specific peculiarities of habit may often be seen. Dr. R. Broom gives a very suggestive case when dealing with the golden moles.* *Chrysochloris asiatica* occurs commonly in the Cape Peninsula, and passes eastwards as far as Bredasdorp and Swellendam. *C. hottentota* occurs from Stellenbosch to Zululand. He says:

> At Stellenbosch, both *C. hottentota* and *C. asiatica* are found in the same gardens, but they apparently keep certain regions to themselves. Thus in my garden *C hottentota* is the species commonly met with, while across the road in the college quadrangle *C. asiatica* most commonly occurs. It appears probable that *C. asiatica* prefers the drier and sandier soil and *C. hottentota* the richer garden soil. The breeding season of *C. hottentota* appears to be later than that of the smaller mole.

Later on he points out that though Stellenbosch is separated from the Cape Peninsula by only about twenty miles of rather sandy soil, *C. hottentota* has not been found at Capetown, where *C. asiatica* is common. It would appear that these two species are adapted to minor differences of the environment.

The hypothesis of the close physiological adaptation of species to a particular environment must imply that a particular species will not be able to persist permanently as such if removed from its own environment and placed within that of its ally. Tested in this way, the hypothesis might not be of very wide application, and Mr. Bateson has emphasised the fact that at the present day the fit of an organism to its environment is not after all very close. Bateson's statement is no doubt correct in numerous cases, but it must be clearly emphasised that the hypothesis only relates to the case of closely allied species geographically separated in different physical environments. It seems to me worthy of serious consideration as a factor in evolution, as it helps to afford an explanation of the beginnings of discontinuity between species when structural adaptations are not included in the specific characters: for firstly, through physiological adaptation to different environments the same stock tends to become

* *Trans. S.A. Phil. Soc.* (1907), **18**, 296.

divided into isolated sections and as Gulick states, "No two portions of a species possess exactly the same average character," so that such isolated sections must from the first be slightly different in average character. How that adaptation is brought about I cannot pretend to discuss. If it be merely the result of spontaneous internal impulses, the process of natural selection will have to be invoked, in which case the cutting out of the less adapted forms must accentuate the structural discontinuity: on the other hand, it may be that compensatory impulses arise in direct response to the environment. Secondly, structural differences would probably tend to arise as a result of a different physiology.

The fact that some species can live without structural differentiation in various different environments is not inconsistent with the assumption that the groups belonging to the different environments differ physiologically, though the differences may be insufficient to effect actual isolation. That physiological differentiation should precede the morphological differences, is not improbable when we consider that this is a well known phenomenon amongst Bacteria and other lowly organisms.

Conclusions.—The study of the distinctive characters and distribution of closely allied species of reptiles in South Africa furnishes the following data relating to the origin of specific discontinuity:—

1. That it is difficult to find evidence in favour of the mutation theory at any rate in the numerous cases of closely related species which are geographically separated.
2. That the structural characters which separate species are sometimes adaptative, but often, perhaps usually, not so.
3. That closely allied species are often rigidly confined to adjacent but distinct areas, which differ in climatic and vegetational conditions.

From this last-mentioned fact we are probably entitled to assume—

(*a*) That such species must be physiologically adapted to the particular environment.

(*b*) That they are therefore in a dual sense isolated from each other. Now any form of isolation will alone imply some degree of discontinuity in structural characters, since no two portions of the same stock have exactly the same average character.

(*c*) Such adaptation might conceivably be brought about by the cutting out of the less adapted (natural selection) in which process some structural discontinuity would be caused.

These suggestions will explain only the commencement of the discontinuity. By what process the structural specific characters are further built up I do not know, but, if all species have a physiological as well as a morphological significance, it may be broadly expressed that the structural differences are an expression of different physiological processes.

THE WINBURG METEORITE.—At a recent meeting of the Royal Society a paper on "A meteoric iron from Winburg, Orange Free State," by W. A. D. Rudge, formerly professor of physics at Grey University College, Bloemfontein, was read. An account was given of the structure, and of the mechanical and magnetic properties of the meteorite, which is said to have fallen in 1881. It consists of large crystals of ferrite, with veins and crystals of an iron-nickel alloy, the nickel not amounting to more than 3 per cent. Flakes of the alloy, being insoluable in dilute acid, are easily separable from the ferrite, in the crystals of which very fine crystals of the alloy are found enclosed. The material stands a stress of nearly 10 tons per square inch before yielding, and in the elastic limit, Young's modulus is nearly the same as for pure iron. When the metal was submitted to a pressure of 7,000 lb. dead load, "slip" bands were developed, showing evidence that twinning had been set up. The magnetic properties resemble those of Swedish iron, but for moderate field strengths the susceptibility is greater, but less for very strong fields.

RADIOTELEGRAPHIC INVESTIGATION.—Under the auspices of the British Association a Committee has been formed to organise a special investigation of the effect on the propagation of electric waves of the total eclipse of the sun, which will take place on the 21st August next. The eclipse will afford an exceptional and important opportunity of adding to existing knowledge of the propagation of electric waves through air in sunlight and in darkness, and across the boundaries of illuminated and unilluminated regions. It will be total along a strip extending from Greenland across Norway, Sweden, Russia and Persia to the mouths of the Indus. In Russia the duration of totality will be a little more than two minutes. There are two main points calling for investigation during the eclipse. In the first place the propagation of signal bearing waves through air in the umbra and penumbra will probably obey laws different as regards absorption and refraction from those obeyed in illuminated air. In the second place, the strength, frequency and character of natural electric waves, and of atmospheric discharges, may vary. The variations may occur either because the propagation of natural waves from distant sources is facilitated or impeded by the eclipse, or, possibly, because the production of natural electric waves or atmospheric discharges is, for some unknown reason, affected by the eclipse.

These points have previously been investigated to only a slight extent. The observers of signals during the solar eclipse of the 17th April, 1912, nearly all agreed that the strength of the signals was greater during the eclipse than an hour before or after. There was only one special observation of strays during the same eclipse, when very pronounced and remarkable variations were recorded during the passage of the shadow-cone across Europe. To investigate the propagation of signals across the umbra it will be necessary to arrange for wireless telegraph stations on either side of the central line of the eclipse to transmit signals at intervals while the umbra passes between them. This transit of the umbra occupies about two minutes. It is thus very desirable that the Scandinavian and Russian stations should transmit frequently throughout several minutes before, during, and after totality. But stations other than those favoured by their proximity to the central line should endeavour to keep a complete record of the variations of signals during the eclipse. Stations in Europe west of the central line and stations in the Mediterranean and in Asia Minor may find noticeable changes in the strength of signals, particularly long distance signals, between the hours of 10 a.m. and 3 p.m., Greenwich time; and it is probable that the stations of India and East Africa, and ships in the Indian Ocean, may feel the effect of the penumbra in the afternoon. On the other hand, ships in the Atlantic, and fixed stations in Eastern Canada and the United States, will probably be affected by the penumbra in the early morning. At Montreal the eclipse (partial) is at its greatest phase at 5.52 a.m. Standard Time. It is possible that the eclipse may have some influence even when it is invisible. The investigation of strays is of as great interest as that of signals. So far as is yet known, the natural electric waves reaching wireless telegraph stations in latitudes higher than 50° appear to travel mostly from the south. Thus the greatest changes produced in strays by the eclipse will probably be experienced at stations in Scandinavia and Russia, to reach which the waves must cross the path of the umbra. At the same time changes of some kind are to be expected in other districts than these, and it is therefore desirable that statistical observations of natural electric waves be made all over the world, and especially at places within an earth quadrant of Southern Russia. It is also desirable that meteorological observations, including those of atmospheric ionisation and potential gradient, should be at the disposal of the Committee when considering the records of strays and signals. The Committee proposes to prepare and circulate special forms for the collection of statistics of signals and strays, especially within the hemisphere likely to be affected by the eclipse; it will endeavour to make provision for the transmission of special signals at times to be indicated on the forms; and it will offer for the consideration of the authorities controlling stations near the central line a simple programme of work. The discussion of the observations, and the comparison with the meteorological data, will be carried out by the Committee; and digests of the statistics, together with the conclusions drawn from the analysis, will be published in due course. The Committee would be greatly aided in the organisation of this investigation if those possessing the necessary facilities and willing to make observations during the eclipse would communicate with the Hon. Secretary, Dr. W. Eccles, University College, London, W.C., at the earliest possible date.

ANTHROPOLOGICAL RESEARCH.—The Council of the South African Association for the Advancement of Science, in its last Annual Report, announced* that the sum of £20, previously specially allocated in the Association funds for Anthropological research, had been awarded to Miss Agnes W. Tucker, B.A., for the purpose of aiding her in the prosecution of her anthropological studies in South Africa. Miss Tucker had been further assisted by a grant for research from the funds administered by the Royal Society of South Africa, as well as by a grant from the Witwatersrand Council of Education, and by a Croll Scholarship awarded her by the South African College. Miss Tucker hopes, during the course of the present year, to publish such results as she has been able to obtain, and although very much still remains obscure, she will endeavour to give a fairly complete report of some aspects of the culture of the tribes specially studied by her. Meanwhile she has furnished the following details of her recent journey—

"On May 3rd, 1913, I set out for Capetown, where I made all my purchases for camping in Walfish Bay and German South-West. Thence I proceeded overland to Springbok, in Little Namaqualand, to interview the ex-captain of the Bondelzwarts, and their leader in the late war against the Germans, Abram Morris. The information was the more interesting in that the Bondelzwarts tribe is one of the oldest in Great Namaqualand, though since the German-Hottentot war it has practically ceased to exist as a separate tribe. Later on, in Keetmanshoop, I had an opportunity of interviewing some other of their chief men, but found they could add but little to my knowledge; indeed, Abram Christian's words proved to be quite true, that all who knew anything of the tribal customs had perished in, or soon after, the war.

From Springbok I went to Walfish Bay, where I spent three months among the Topnaars—in many respects the most interesting of all the surviving tribes of Hottentots. The Topnaars dwell among the sand dunes of Walfish Bay and subsist upon the fruit of the 'Naras, a cucurbitaceous plant which grows only in this region. The fruit, which is a species of melon, is extremely nutritious and luscious, so that as long as it is in season the natives

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* *Vide* this volume, p. xv.

do not trouble about any other food. The territory inhabited by this tribe is dreary in the extreme, and for a people devoid of proper home and with insufficient clothing, it is very unhealthy, owing to the rapid changes of temperature, the violent winds which bring clouds of dust, and the heavy damp fogs at night. It is little wonder, then, that the people are saturated with disease, and are in every sense degenerate.

Their pastoral habits have been almost entirely abandoned since the German occupation of Great Namaqualand, as the boundary between British and German territory cuts right through their original tribal grounds, and they can no longer wander where they will. Thus the whole tribe has been reduced to the condition of the Strandloopers of early Dutch days.

In spite of such unpromising material and such dismal surroundings, my best results were obtained in Walfish Bay.

It is very probable that the Topnaars broke away from the main stream of Hottentot migration many centuries ago. As they wandered southwards with their flocks they came upon these 'Naras fields, where food was to be had six months in the year for the simple picking of it. Yielding to the temptation they remained in the neighbourhood of Walfish Bay in the desert coastal zone. For years they must have been isolated, and when other people broke in upon them it was American and English sailors who were hunting whales along the West Coast.

The coming of the white man was the beginning of their ruin, but their degeneration has been unaccompanied by much contamination of tribal custom. It has become gradually laxer and less complicated and tribal lore less rich, but what there is is pure. Hence I was able to make fairly complete studies of their social and tribal organisation, their sociology, and partly, too, of new aspects of their religious and magical beliefs.

Law and government could not be studied here, as the tribe has been too long under English influence and jurisdiction. I therefore went inland to Berseba, in German South-West, where the Gai Khauas, a tribe which originally inhabited the Tulbagh district in the Cape Colony, and migrated across the Orange River after 1809, when chieftainship was abolished by the British, still nominally retain their old tribal organisation, and are governed by their own laws under their own captain. The tribe is unfortunately not pure, as many of the families were bastardised before ever they crossed the river. Their customs are, therefore, much modified by Dutch influence, and great caution has to be used in coming to any conclusions regarding their original culture. However I gained many new lights upon their culture here.

All the other tribes which originally inhabited German South-West are now disintegrated, and the whole people is fast degenerating and becoming bastardised. Unlike the Bushmen, who died out pure, the Hottentot is disappearing only to leave a rapidly increasing tainted population of Bastards behind him. Indeed, among children under ten I had the greatest difficulty in obtaining any pure specimens of their race. White blood is traceable somewhere in the parentage always.

Old people of any intelligence are few, and they alone know anything of tribal lore. The Hottentot himself says he has been absorbed into a new condition of things, and it takes him all his time to keep abreast of the tide. An onlooker sees that he is not keeping abreast, and never will for all his struggle.

The material for further investigation is thus no longer to be had, and I had perforce to be content with the remnants I had been able to gather. On some lonely farm, perhaps, some old man or some old woman may still be able to add to the collected facts, but the time for further systematic scientific work is past.

TRANSACTIONS OF SOCIETIES.

GEOLOGICAL SOCIETY OF SOUTH AFRICA.—Monday, March 23rd: D. P. McDonald, M.A., B.Sc., President, in the chair.—"Outlines of the geology of German South-west Africa": Dr. E. **Rimann.**—"On the occurrence of the Brazilian trilobite *Pennaia* in the Bokkeveld beds": Prof. S. J. **Shand.** Clarke, in his monograph on the Devonian fossils of Parana, erects three new genera for the Brazilian representatives of the *Metacryphaeus* group of the *Phacopidæ*. One of these new genera, *Pennaia*, is known to Clarke only as a Brazilian genus. The author described a new species, the first of the genus to be recognised in South Africa, having been found by Mr. R. A. Page on the farm Osplaats in the Hex River Valley. For this the name *Pennaia africana* is proposed.—"Note on graphite coated diamonds from the Premier Mine": Dr. P. A. **Wagner.** The author described four well-formed diamond crystals, coated with a thin film of graphite, by which they were rendered black and opaque.

SOUTH AFRICAN SOCIETY OF CIVIL ENGINEERS.—Wednesday, April 8th: F. O. Stephens, M.I.C.E., President, in the chair.—"Ferro-concrete works at Mossel Bay and Knysna": F. W. **Waldron.** A description was given of a ferro-concrete jetty at Mossel Bay for the landing and shipping of goods into lighters, and of a similarly constructed wharf at Knysna; also of an elevated circular tank capable of containing 10,000 gallons, and of the casting and laying of a number of reinforced concrete pipes for surface water drainage at Mossel Bay.

ROYAL SOCIETY OF SOUTH AFRICA.—Wednesday, April 15th: S. S. Hough, M.A., F.R.S., Vice-President, in the chair.—"Note on a theorem of Ph. Gilbert, regarding the differentiation of a Special Jacobian": Dr. T. **Muir.**—"Note on Rosanes' Functions, resembling Jacobians": Dr. T. **Muir.**—"The Triple Stellar System ζ Virginis and Σ 1757": R. T. A. **Innes.** These stars, although a considerable distance apart, constitute a system, as they are moving through space with almost identical velocities and directions.—"A Curious Mosquito": G. A. H. **Bedford.**—"On the porosity of the rocks of the Karroo System": Dr. A. L. **du Toit.** Determinations were given of the porosity of 90 rocks, the majority being from borehole cores. It was found with respect to the three-fold division of the Beaufort beds that the mean porosity of the sandstone was 2.9 % for the lower, 5.2 % for the middle, and 5.5 % for the upper division. The figures for the Transvaal phase of the Karroo were much higher. The effects of weathering in increasing the porosity were discussed and analysed.—"A Note on the Temperatures of the air observed at Mochudi."

Dr. J. R. **Sutton.** A brief account was given of some points of interest in the results of temperature observations by Harbor at Mochudi in the Bechuanaland Protectorate. The extremes of temperature are considerable, the greatest range so far observed being from 108° F. to 28° F. The mean maximum temperatures depend upon the sun's meridian altitude in much the same way as as they do at Kimberley. The annual cold wave of the middle of July is felt at Mochudi as it is elsewhere further South.

South African Institute of Engineers.—Thursday, April 16th: Mr. W. Calder, President, in the chair.—"Irrigation, with special reference to the future of Engineering work in South Africa": F. K. **Stevens.** The author broadly sketched the irrigation methods adopted in the United States, Canada, Australia, India and Egypt, and then compared the various systems of applying the water to the lands. He indicated the sources of water supply in South Africa (1) from perennial streams; (2) from rivers subject to large fluctuations; and (3) from rivers subject to occasional flow, and, with special reference to South Africa, discussed the subjects of rainfall and run-off, pumping, and pumping appliances, some of the financial aspects of irrigation, the opportunities for engineering work in connection with irrigation, and finally gave some details with regard to a number of South African irrigation schemes, in existence and projected.

NEW BOOKS.

Maugham, R. C. F.—*Wild game in Zambesia.* 8vo. (9 × 6 in.) pp. xii, 376. Map and illus. London: John Murray. 1914. 12s. 26 oz.

Lucas, Sir Charles and **A. Berriedale Keith.**—*A historical geography of the British Colonies. Vol. 4: South Africa.* New ed. $7\frac{1}{2} \times 5$ in. Pt. I, pp. viii, 331. Pt. II, pp. iv, 332. Maps. Oxford: Clarendon Press, 1913. Each part 6s. 6d.

Cory, G. E.—*The rise of South Africa: a history of the origin of South African colonisation and of its development towards the East from the earliest times to* 1857. Vol. 2; 1820-1834. $9\frac{1}{2} \times 6$ in. pp. xvi, 489. Maps and illus. London: Longmans, Green & Co., 1913. 18s.

Range, Dr. P.—*Geologie des Deutschen Namalandes: Beiträge zur geologischen Erforschung der Deutschen Schutzgebiete.* Heft 2. pp. 104. Map, illus. Berlin: Kgl. Preuss. Geol. Landesanstalt. 1912. 10×7 in. M.12.

Darter, A.—*The Pioneers of Mashonaland.* pp. 213. London: Simpkin, Marshall, 1914. 5s.

Voigt, B.—*Deutsch-Südwestafrika: Land und Leute.* pp. xii, 111. Port. illus. Stuttgart: Luzac & Co., 1913. 2s 6d.

Sargent, A. J.—*South Africa: Seven lectures prepared for the Visual Instruction Committee of the Colonial Office.* $7\frac{1}{2} \times 5$ in. pp. viii, 120. Map and illus. London: G. Philip and Son, 1914. 8d. nett.

Stigand, Capt. C. H.—*Hunting the Elephant in Africa and other recollections of thirteen years' wanderings.* 9×6 in., pp. xv, 379, illus. The Macmillian Co. New York, 1913. $2.50.

THE HUMOUR OF ESTRANGED INDO-GERMAN COGNATES.

By Rev. W. A. Norton, S.S.M.

A pedagogue friend of mine asked me to make him a list of Aryan cognates for the sake of his pupils, and this is the result of work on Prof. Herman Hirt's *Indogermanischer Ablaut*, of which my paper is largely a digest, although I must also make my acknowledgments to the late lamented Dr. Skeat.

My method has been to produce under each Aryan root a sentence to illustrate various forms which it takes. The sentence is often nonsensical enough, if not alarming (for crude physical ideas are naturally the oldest, and best illustrate the common life of our primitive forefathers) so I beg my readers will forget the sentiments and fix their minds only on the words which express them. These consist, as far as possible, of various forms of the same Aryan roots, and the faint suggestion of Alice in Wonderland, due to the frequent strangeness of the conjunction is only an index to the amazing distance which the word's meaning will travel by association, etc. I have preserved English throughout, using only words that somehow or other appear in that language, because a foreign word means so little to an Englishman, but, if adapted to his own language, helps at once to an enlargement of his vocabulary, and a linking-up with the original language.

In some cases the cognate words are not far apart either in force or meaning: take *slack* and *lax* (L)*; *name, naam, nama* (Sk), *nomen* (L), *ὄνομα* (Gk); *us, ons, uns* (G), *nos* (L) *asman, nas* (Sk), *ἡμᾶς* (Gk).

For a wide difference in names and things, which yet are cognate, take *honey* and *kancanam* (Sk for *gold*); again, *teach* and (G) *zeigen*, the change of former and latter consonants both illustrating Grimm's Law.

The case is similar with several obsolete or nearly obsolete English words: *e.g.*, *thrum* is the end of a thread in weaving, *i.e.*, its term or terminus (L). *Eme* means *uncle* in old English (old G = Oheim), but is connected with Gk. *τῑμή* (honour) *τηρέω* (to guard). *Neem* (D for *to take*) is the L *emo* (to buy). In primitive barter you *took* the other man's or woman's goods for your own.

A famous case commented on by Max Müller for the light it throws on the primitive history of European Botany is *Birch* (Sk *Bhurjas*) cognate with L *fraxinus* (ash) the tree which took its place in other lands.

A last example is *pejor* (L comparative of bad) and *fey* (doomed), which reminds us that our forefathers also thought that if we give a dog a bad name we might as well hang him.

* The following abbreviations are employed throughout this paper:—L = Latin, Gk = Greek, G = German, D = Dutch, Sk = Sanskrit.

Some words *seem* close, through *false* association. How tempting to the harassed housewife, for example, is the idea that the houseboy sent on an *errand* is *erring* and straying like an *arrant knave, i.e., errant boy*. Whereas *errand* is pure English, and has nothing probably to do with *errare*, which is so *universaliter* human!

Some words are really close in form and meaning, but not obviously so, because of the omission of a letter. Thus, a *nit* is very like a grain of *dust*, in Gk. κονις (stem κονιδ); but it has dropped its *h*.

Sometimes the meaning is even identical, with the form apparently very different: thus a *hurdle*, a *crate*, and a *grating*, are similar in form, or rather in make, and their names etymologically allied.

Having illustrated various types of relation between Aryan words in their variant forms, I shall now give further examples in connection with their Aryan bases in Hirt's order. It will be seen how extraordinarily different has been the development, though the base will reveal the unity of origin.

Aryan Bases of One Syllable.

Base.	*Illustrations.*	*Remarks.*
DHE (place, do)	The *deed* is not a hypothesis but a *fact*.	The Gk θ (L *f*) corresponds (by Grimm's Law) to our *d*
SPE (extend)	The psalmist did not despair (L), though but a *span's space* (L) of life seemed left him.	de-*sperare* is to lose patience, and *long* suffering. Double consonants are very stable in Aryan languages.
LED	He was full of *lassitude* (L) and always *late*.	Aryan liquids are very stable.
STHA	The Canon had a *stool standing stationary* (L) in his *stall*.	Double consonants again.
BHA	Many a *fable* (L) passes on the '*phone* (Gk) and many a pro*phet's* (Gk) *fame* (L) is blighted.	
MAGH	The *mechanics* (Gk) of a *mighty machine* (L from Gk).	
BHOG	To *bake* their fellow-men was a *func*tion of the anthropo*phagi* (Gk).	φ in Gk (*f* in L) = our *b* by Grimm. In Herodotus' story of Pharaoh's experiment with isolated infants to

Base.	*Illustrations.*	*Remarks.*
		find the original language of man, they first utter the *Phrygian* word *bekos* (bread) from this base, and so showed Phrygian to be (not the original language but) an Aryan language.

BASES OF ONE SYLLABLE WITH A DIPHTHONG.

DHEI (suck)	The young have a *filial* relation to the *female*	These Latin words are connected with *felare* and the Gk θῆλυς.
POU (foal)	*Pullets* (L) are the young of animals : the *puerile* (L) human is cared for by a *pedagogue* (Gk really πάϝις).	
MOI	Of old the *Mime* (G) was considered *mean* and false* : his character must necessarily become *mutable* (L)	
OUS (mouth)	The doctor *aus*cultated (L) with his right *ear* and delivered his verdict *or*ally (L).	For the ear, from its shape, is also an orifice or mouth (L *os*).
GHOUM	Tennyson's "Jaws of vacant darkness" were the *faucal* orifices of *Chaos* : but has Chaos *gums* ?	This is a case of χ = *g* by Grimm. Note that (L) *f* ha to represent all the aspirates, as the Gk θ and χ are wanting in Latin.
PAU	*Pyro*technics are artistic *fire*-works.	*cf.* the base Pou above. The *p* is aspirated in the English form (by Grimm's Law).
SOUT	The boy was *sad*dened by his *sat*isfying (L) dinner.	But the *s* is dropped in the Greek. The boy was doubtless a *hed*onist—too fond of sweet things. [L *sua(d)via* ; Gk (σϝ)ηδϝεα (*swe-dwea*).]

* Such is the meaning of old High G *mein*.

Two-syllabled Bases.

Bases.	*Illustrations.*	*Remarks.*
ERA bases		
Aramos	The King's *arms ramify* from his trunk, and at his coronation he wears an *armill* on his shoulders.	*Arm(us)* and *ramus* illustrate Hirt's Point of the Voll stufe I & II: the former from *áramos*, the latter from *arámos*.
Ero (love)	David when at *rest* from war became *ero*tic.	
K̂era	The rhino*ceros* is an aristo*cratic* looking beast, but has but a small *cere*bral development.	The horn, κρατος strength, καρα the head, and the brain are all fairly obviously connected.
K̂era (mix)	This *crock* is a specimen of the *ceramic* art, in form like the *crater* of a volcano.	The crater is, of course, a *mixing* bowl for wine and water, itself originally of clay *mingled* with water.
Ĝera	The hail beat out the *grain* from the standing *corn*.	Again *cf.* Grimm's Law.
Gwera	The specific *Gravity* of the *bari*tone was equal to that of a *quern* or handmill.	Baritones will excuse the implication as to their weight. The Βαρυς-τονος is one of the Greek ecclesiastical modes. Note the labialisation in the Greek: sometimes it occurs also in Latin *cf. bos* against *Sk gaus* and our *cow*.
Gwero	A *crane* belongs to the sub-family *Gruin*ae.	
Ghere	What think you of the *char*acter (Gk) of a man who *grub*bed up a *grave* with a *fork* (L)	The garden fork for digging was doubtless anterior to the table fork which we have only used about three centuries.
Tereb	The houses of the *thorp* were *trab*eated black and white.	Our ancient Aryan dorps were built of wood (at least in the north). Lat.

Bases.	*Illustrations.*	*Remarks.*
		trabs a beam, then a stripe, *e.g.*, on a senator's toga.
Dera	The taxi*derm*atist *tore* his skin.	From Gk δείρω to flay.
Dhera	I *dread* this *fraud*ulent person	But fraud is *not* connected with *fear*.
Pera	The Christians of Jerusalem *fared* into *Peraea*.	Peraea was *beyond* Jordan (περαν τοῦ Ἰορδανου) hence the name; and to reach it they had to cross or *fare* over (περᾶν) that river
Pero	You take *pre*cedence be*fore* me.	
Werod	*Radicals* (L) pull up things by the *roots*. Mangel *Wurzel* (G) is roots!	Note that the High G sibilizes the low G *t* instead of aspirating it, as it should by Grimm's law. *cf. zu*, *zahn* for *to*, *tandje*.
Stero	They were *STrewn* upon the *STrand* in con*STer*nation at the *STrategics* of the enemy.	Constant double consonants again. Strategy is the management of a στρατος, which is a "leaguer" or army *laid* out in order.
ELA bases		
Kole	In spite of the in*clement* weather, they *colonised* a *hill* by Stock*holm*, which is so called from being built on *columns* of wood.	A *holm* is a river-island (*cf.* the Flat Holm and Steep Holm in the Severn Sea). The connection between this and *hill*, and that and *column* is obvious. Early Greek *colonies* had to be settled where there was a *hill* to flee to from pirates.
Kela (call)	I heard the *clear* (L) *low* of a first-*class* (L) cow.	A clear view is one that calls aloud A *classis* or fleet was *called* together by a signal. A *lowing* from KELÁ has lost the weak first

Bases.	*Illustrations.*	*Remarks.*
		syllable. Teutonic words from KÉLA would begin with *h*— by Grimm. *cf.* Schiller: Du Bächlein silber*hell* und *klar*.
Gela	In this *glac*ial weather he gave us *cold jelly*.	The connection between *glaces* and *gelées* will be clear to all. But English *cold* will have its beginning sharp.
Gelag	What a *galaxy* of *milk*-maids.	The change from $\gamma\alpha\lambda\alpha\kappa\tau$ to *milk* is an interesting case of labialisation of gutturals.
Ghele	Was the *yellow* gas *Chlorine* known to the *Flavian* Emperors?	
Tele	I have not the *talent* of patience to *tolerate* a broken *thole* to my oar.	This base supplies pf. and supine to *ferre* (= bear). The thole *bears* the strain of the oar. A talent is a lump of gold or silver which *bore* very heavily, *e.g.*, on the shoulders of Naaman's servants.
Pele	*Folk* are *full* to re*pletion* (L) of this *plebeian* (L) *plethora* (Gk).	The *plebs* was the *full* meeting of the citizens in their *folk* mote.
Pela	The *pelagic floor* was as plain in its mani*fold* movement as the *flat* of a *palm*.	P is the Southern equivalent of low G. f by Grimm (*cf.* above).
Phele	What a *flaring blast*! what a *blasting flare*!	B, on the other hand, is our equivalent of of the Southern f
Melo	What a *florid bloom*! what a *blooming Flora*!	
Mele	His *blood* was a *melan*-choly *blue-black*.	For the denasalising of *m* before *l* when the intermediate vowel drops out, *cf.* $\beta\lambda\acute{\omega}\sigma\kappa\omega$, $\mu o\lambda o\hat{\upsilon}\mu\alpha\iota$ etc.
Seleb	How *labor*iously he *sleeps*.	*cf. labes*, a slipping away.

Bases.	*Illustrations.*	*Remarks.*
Skela	Do not *lace*rate the *slain* !	*cf.* the preceding for ellipse of *s* before *l*. The guttural of *lacero* and λακίζω re-appears in our *slaughter*.
EJA, EMA, ENA bases, &c.		
Gene	I *know* the *Gnostics* (Gk) were a (*g*)*not*able (L) sect.	*cf.* the preceding for the dropping of the guttural before *n*.
Wena	*One*simus *venom*ously *wish*ed ill to Philemon.	The primitive method of poisoning was magical rather than physical. It was ill-*wishing*. Yet a poison drug was useful (ὀνήσιμον).
(S)tona	The *thunder* of the de*tona*tion was heard on *Thurs*day.	Thor or Thunor was God of "*thunner*" (dialectical: *cf.* G *Donner*).
Dema	*Dame* Alice and the *Nuns* have the *material* to *tim*ber their dome, and that is the chief *matter*.	The first two are corruptions of *dom*(*i*)*na*. Matter, &c. (stuff for *house* building) have lost the initial *d* of *domus*, which like the G *Zimmer* and *Dorf*, was *timber*-built.
Doma	*Adm*etus means un*tamed*, but she whom he called "*Damar*" (wife), had the in*dom*itable courage.	We do not, like the Greeks, now consider women-folk domestic animals: but some in England just now might well be tamed !
Deja	He had a great *zeal* for *Jaeger's* clothing.	ζῆλος and διώκω are connected with *jägen* (to hunt).
EWA bases		
Krewo (bloody flesh)	*Raw* pan*creas* (Gk) is *crude* (L) diet.	The English word originally began with a *h*
Tewo (be strong)	A *thousand* was the *total* of those buried in one *tumid tomb*.	*Thus*-hund may be a 'strong hundred.' *cf.* Bantu, where 100 is the

Bases.	*Illustrations.*	*Remarks*
		great number (Suto le-kho'o &c)
Bhewa	What will the *fu*ture of *phy*sicians *be* ?	
Sewa	Planets of the *sol*ar (L) system are near the *sun* at their peri*helion*.	Gk (*sawel*-ηλιος.
Skewa (hide)	He *hid*es himself under an ob*scu*re es*cu*tcheon.	Shields were originally (like the Zulu) made of *hide*, which once *covered* a beast.
Mega	The *mega*therium was *much more mag*nificent than a *maha*raja's elephant.	The nasals are thus very constant in Aryan, ranging from Welsh *mawr* to Sk. The mumbling toothless babe at the breast begins by calling on "*m*other" with an *m* all over the world, so primitive is that sound.

DISYLLABLES WITH DIPHTHONGS.

EXEI bases		
Tersei	The *tor*rid zone is a *thir*sty place!	
Weidei	Admire the *witty ideas* of the *vis*ionary.	From *vid-sio* : ἰδέα from Ϝιδεῖν.
EXAU bases		
Gwejew	He illustrated from *bio*logy and *zoo*logy with a *vi*vid *quick*ness.	*Vivus* has lost the initial guttural, labialised in βιος (*cf.* βαινω, *venio*) and swallowed in ζωη, but preserved n English, according to Grimm, as *q*.
Wer(au)	Be*ware* to *rever*ence the *hor*izon, in painting the pan*orama*.	Last two Greek, from ϝοράω see.
Welau (to veil round)	A *veil*ed couple of great *vol*ume were *waltz*ing.	The idea is con*volu*tion, wrapping something together.

Bases.	*Illustrations.*	*Remarks.*
EXEU bases	Has *kar*ma *cre*ated all this *gear*?	Sk. kr. *Yare* in nautical English (*cf.* the wreck-scene in the "Tempest") is cognate.
Akous	*Acous*tics is the science of *hearing*.	—*not* connected with *ear*, *aures* (see above)
Ereudh	He has *rub*ricated in his map the *Eryth*raean or *Red* Sea.	Gk has preserved the initial vowel which L and Teutonic have lost.
Kokoubh (top)	What a *capital heading* for his first *chapter*.	For the medial consonant *cf.* *hoofd*, *Haupt*.
Genewo	He *genu*flected on both *knees* to the pentagon.	
Dejewo	*Tuesday* is so named from *divine Zeus* or *Ju*piter.	(= sky-father) gen. Διος. Sk. *Dyaus*. Lithuanian *Devas*.
Bhereu	He *brewed* a *fer*vent bowl of *broth*.	
EXE bases		
Perei	There is a great *peril* in em*piri*cists' ex*peri*ments.	Perhaps connected with fare (*v. supr.*) *Gefahr* (G) is danger one goes through. *cf.* *periclum* (from *per-eo*) and *perish*.
Meleit	*Mild Melissa* speaks *mel-li*fluously.	
EXEN bases		
Elengh	*Lungs* are "*lights*" because full of air.	
Dekemto	A *dean* was originally a ruler over *ten*: a *deca*gon has ten sides: a *cent*urion was the captain of a *hund*red: a *hecatom*b, a sacrifice of 100 beeves.	*Doyen* has lost the guttural of *decanus*, as *ten* that of *tegen*. Hund-*red* = hund-*rate*. Hecatom*b* ἑκατόν β(όες).
	Quinqua*ge*sima is the fif*tieth* (fif-*ty* = 5 × *10*) before Easter and	Quinqua-*gin*ta, πεντή-κοντα; *cent* and *hund*-red: The

N.B.—Contrast θεος (below), which may be the Southern or Mediterranean idea of divinity as opposed to Zeus, the Northern or Aryan idea.

Bases.	*Illustrations.*	*Remarks.*
	Pente*cost* the fiftieth after.	first syllable of *dec*em(to) has been dropped in all these.
Stoment	The *stom*ach is so called from its having a little *mouth*.	This case is similar to the last in that (L) *mentum* (chin), (G) *Mund*, have dropped the first syllable of the base; (Gk) στομα(τ) half of the second syllable.
EREK bases		
Kere	He was *cre*mated at his own *hear*th.	
Kered	In spite of the weakness of his peri*cardi*um (Gk) he was *heart*ily *cord*ial (L).	*cf.* Slavonic *Srdce* where the initial guttural becomes a sibilant.
Torek	He *threw* his *tore* at him.	
Meret (dead)	The *murd*erer struck a *mort*al blow. *Mars* is the god of *Mors!*	*Mortal* (Gk) βροτος, the *m* being denasalised as above before the liquid.
Marog	The *Marq*uis *marks* his *march*es at the *marg*in (L) of a stream.	
Wereg	The *Org*anisation (Gk) was an en*erg*etic (Gk) piece of *work*.	
	He *urg*ed him to *wreak* (vengeance).	The last word is but a cognate accusative, unnecessary in old English.
Werem	The *verm*icelli is *worm*-eaten!	
ELEK bases		
Kolos	He *col*lared (L) the ring*hals* and the ring*hals* *col*lared him.	
Pele	The pe*plos* was a kind of *pel*isse like a *fil*my sur*plice*.	A *film* is a thin skin or *fell*, (L) *pellis*: hence *pellic*eus or fur coat, and *sur*pelisse, or white tunic worn over it, because of the coldness of the church.
Peleth (Spread)	The *plat*ypus was licking a *plate* in the *field*.	The *veld* is thus a broad and open *place*.

Bases.	*Illustrations.*	*Remarks*
Bheleg	The banks of the *Phlegon* are a *bleak* yet *flagrant* spot.	Bleak: *cf. bleach, blanc.*
ENEK bases		
Onokt	The *Nycti*corax, a *noct*urnal bird, seeks its prey by *night.*	Night: (D. and G. *Nacht*). Note the Teutonic aspirate, by Grimm.
Onogh	The *onyx* stone is the colour of a *nail*, but not *ung*ular in form.	The Greek νύσσω (stab) from ENOGH, (ἔγκος, a spear) has, like *Nagel*, lost the initial vowel.
Onebh	A*phro*dite was surrounded by a *nebul*ous mist.	(G) *Nebel*, (L) *Imber* ὄμβρος and νέφος are all allied herewith.
Onobh	The *umb*ilical cord is so called because it is attached to the *navel.*	*cf. umbo*, boss of a shield, and ὀμφαλος γῆς (the earth's centre).
Bhenedh	*Bind* the two *nod*ules together.	*Nodus* has lost its first syllable, like mentum, etc., above
Senot	The *Notus* is a *south*erly wind.	This case is similar.
EWEK bases, &c.		
Awekwe	He declaimed the *epic vocally.*	(L) voc-s Sk palatalises *vach-*, as (Gk labialises Fεπ.ος
Awege	*Augustus* did not *vegetate*, but *waxed* stronger by the *vig*our of his *hy*giene	Note that *wach*sen in H. Germ. aspirates acc. to Grimm.
Ewegh	The Greek was de*vo*ted to his *Euch*o-logion	Note how (e)vov-eo softens the original aspirate.
Ewet	A *wether* does not in these days produce *veal.*	*Veau* for *vit*ulum (calf). There is an interesting bit of pastoral history in this change of the word from *bovine* to *ovine* species.
Ewod	The science of *und*ulating *water* is called *hydro*dynamics.	Note Grimm in *unda*, ὕδατ-, *water.* (G) *wasser*, as usual,

Bases.	*Illustrations.*	*Remarks.*
		sibilising instead of aspirating the *t*
Owe(s)	What *ve*sture did he *wear*?	
Ewes (lighten)	Mount *Ves*uvius and *Ves*ta matches are both com*bus*tible.	
Awese	The *eastern Aurora* of the *Easter* sun shines forth about the *ver*nal equinox, but this is not true in *Aus*tralia	Auster is the south, where the sun most lightens. The ancients did not dream of a great south land facing antarctic cold on *its* south
Dhewes (breathe)	What *furious theologians*!	θεος is connected with Slavonic *duch* (a spirit) and probably with Dutch *dwaas*. So in Swahili: *ana wazimu* he has ancestor spirits = gods = he is mad (δαιμονιζομενος). See DEJEWO above.
Sewep	*Hyp*notism is *somn*iferous	(σ)υπ νος = sop nus
Bheweg	The *fug*itive Anglo*phobe* *bowed* to me	Thus (G) beugen = φευγειν (Gk) φοβος shews labialisation of the g.
Lewep	The *leper* trembled like a *leaf*.	(G) *Laub*, *cf.* Grimm. λεπας scale, λεπος shell
Bhejod	It *bit* him in the *fosse*	fod sa from fodjo.
EXEK bases		
Odakru	The *lachr*ymose whaler dropped a *tear* into the *train* oil.	(*i.e.* oil of blubber, distilling like tears (G) Thrane).
Okosth	*Os*teology may explain the *ossi*fication of his *costal* muscles	from ὀ(κ)οστεον (L) *os* a bone!
EXE bases		
Deike	The *teacher* was within the juris*dic*tion of the *judge*	(ju dex = jur dic s. (G) *zeigen* (Gk) δεικ νυ ναι to point, shew, *cf.* δακ τυλος digitus.
Leikwe	*Leave* his *relic*s alone.	*cf.* (G) b(e)leiben, (D) blijven, labialised like Gk λιπεῖν.

Bases.	*Illustrations.*	*Remarks.*
Jeuge (bind)	A syzygy is a conj*unc*tion or *yok*ing together.	
Ede	"*Odol* for the *teeth*," said the *dent*ist.	Odont- (ea)tooth (G) Zahn (e)dent "The eater" (all connected with base EDE).
Nogwe	The *nud*ity (L) of Greek *gymn*astic (Gk) was not always exactly *naked*ness.	
Pede	The chiro*pod*ist (Gk) hit his *foot* against the *ped*estal (L).	
Rege	The *Rani reigned* (L) in her own *regal* (L) *right*.	Note the palatal in Sk. Raja regis (L) and the aspirate in Teutonic *Recht*, &c
Veghe	The *uxorious* (L) man carried a great *weight* in his *vehicle* (L).	The old Latin wife, like the modern native's, seems to have carried the burden. She was the *vector*.
Bhere	The stars *conferred fortune* at his *birth*.	
Gweme	The *bases* of the President's statue *came* by great ad*ventures*.	*bases* from the labialised *βαινω* (L) *venio*.
AXE bases		
Age (drive)	The *active* (L) *agronomist* (Gk) of the *embassy examined* the *acre* according to the *agrarian* laws.	Amb*ag*es (cf. ex-*ag*men) a going round there with a messager.
Nase	There are two *nasal* orifices in the *nose*.	
OXE bases		
Okwe	The *eye* doctor gave an *ocular* demonstration at the aut*ops*y.	*Oogen*, *Augen*, have the media, by Grimm: ὀπ σί, is labialised.

TRISYLLABIC BASES.

Bases.	*Illustrations.*	*Remarks.*
DEREWO	*Dry*ads, if not *dru*ids, are connected with *trees*.	It is doubtful if *Druid* is connected with δρῦς (oak) *cf.* δορυ (spear).
KWEKWELO	The bi*cycle* is a free-*wheel*,	
AJEWO	and goes on for *ever* and *aye*, *e*ternally through the *aeons*.	Gothic, *aiws*. Sk. *ayus* (L) *aivom* (*aevi*-ternus) = *αἰών*.

I trust that these nonsense-sentences have not wearied my readers—I have been thinking largely of young students whose philological labours need lightening. They at least have shown the extraordinary powers of dialectical change and association, as the mingled causes which have set our languages so far apart in the Aryan family, that we can seldom recognise by the light of nature the cousinship between the derivatives from the same original base.

I recently heard of two brothers who had been working for years in South Africa, but had not succeeded in meeting, until they were one day introduced to one another. A similar estrangement of members of the same family long parted in distant lands has suggested the title of my paper—"The humour of estranged Indo-German cognates."

I commend to our educationists the following method of teaching European languages, and so much of ancient languages as are required for the understanding of these by the ordinary "modern side" boy. Surrender Latin and Greek composition, and even Syntax, appropriating part of the time saved to elementary Aryan philology, and use Greek, Latin (French, Italian Spanish, etc.), and German vocabularies, to illustrate Grimm and other philological laws given by the philology elements. In this way we preserve the practical utility of the classics for English derivatives and scientific nomenclature; but we teach the words in connection with the original Aryan bases, and the modern forms of Aryan, somewhat as in the following key. The examples of the preceding pages might help to lighten the subject and to amuse the youthful philologists.

Key to Illustrations.*

MONOSYLLABIC BASES.

I. MONOPHTHONGAL.

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
do	thun	dhe	facere	τιθεναι	
meet	Mass (measure)	me	Mensura	μέτρον	
Seed	Saat	se	Semen		
†slack	schlaff	sleg	laxus		
†take		teg	tango		
†Span		spe (extend)	Spes Spatium		
†let (late)	lassen	led	lassus		
stand	stehen	stha	stare		
†stall stool	—		—		
	—	†bha	fari Fama Fabula	φωνή, προφήτης	
†Might (may)	Macht	magh		μηχανή	
†bake	backen	bhog		φώγειν, φαγεῖν	

II. DIPHTHONGAL

1. Bases containing I.

own	(eignen)	Aik	—		
†Errand		Air (one sent)			
(uncle)	Oheim !	kwei	—	τηρέω, τιμή	
nip	kneifen	gnaib	—		
		†dhei (suck)	felare: filius femina	θῆλυς	
Needle	Nadel (nähen)	nei	—		
†fey (doomed)	—	pe (bad)	pejor		
		poi	bibere potus poculum		
		poi	Pastor	ποιμήν	
feed foster		poit	—		Connects with above. But **S** gives this as PA.

S = Skeat. Sk = Sanskrit.

† The rows of cognates thus prefixed are illustrated in the foregoing examples.

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
†Foal ...	—	Pou ...	Pullus Puer	παϝις	
†mean ...	O. mein (false)	Moi ...	mutare		
sith(since)	seit(dem)	sei (late)...	serus		
?small ...	smahi ...	smeik ...	mica ...	(σ)μικρός	

2. Bases containing U.

Udder ...	Euter ...	Oudh ...	uber	οὖθαρ	
†? Ear ...	Ohr ...	Ous (mouth)	Os Ausculum!		
†Gum ...	Gaumen...	Ghoum ...	Fauces ...	χάος	
Rook ...	—	Krouk ...	—	κραυγή	*vide* infra.
†Fire ...	Feuer ...	Pau ...	—	πῦρ	
†sad ...	satt ...	sout ...	sat-is		

DISSYLLABIC BASES.

A. WITH SECOND SYLLABLE LONG.

I MONOPHTHONGAL.

ERA BASES.

†Arm ...	do ...	Aramos ...	Armus Ramus		
Rudder ...	Ruder ..	ere ...	Remus ... ratis ?	ἐρετμός	
(ab***ra***_sion_)	—	ara ...	arare ... radere rastrum	ἀρόω	
†Rest ...	Rast ...	ero (love)	—	ἐράω	
—	—	Kera ...	Cerebrum	κέρας, κρατός κάρηνον	
Hornet ...	Horniss ...	Kera ...	Crabro		
Rook (v sup)	—	Kero ...	Corvus Cornix	κόραξ	
†Hurdle ...	—	Kerat ...	Crates	κορώνη, κράζω	
† ? (Crock) (stir)	rühren ...	Kera (mix)	—	κεράννυμι, κεράμος, κρητήρ	
(grateful)	—	gwere (sing)	gratus		
†Corn ...	Korn ...	Gera ...	Granum		
†Quern ...	(millstone)	Gwera ...	gravis ...	βαρύς	
†Crane ..	Kranich ...	Gwero ...	Gr(o)us ...	γέρανος	
†Grave ...	Grab ...	ghere ...	Furca ! ...	χαράσσω	

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
†Thorp ...	Dorf ...	Tereb ...	Trabs! ...	τέραμνον	(house) for τέραβνον
Thread ...	Draht (wire)	terei ...	tero ...	τρίβω	
through...	—	tera ...	(in)trare trames		
†tear ...	—	dera ...	—	δείρω	
†dread ...	trueben ...	dhera ...	Fraus ...	ταραχή	
fare ...	fahren ...	pera ...	—	περάω	
(roast)?	braten ...	pere ...	—	πίμπρημι	
fore D. vroeg	frueh ...	pero ...	prae ...	πρωί	
Birch ...	Birke ...	Bherag ...	Fraxinus (ash!)		
†Root ...	Wurzel ...	Werod ...	Radix		
wreck ...	—	wereg ...	—	(F)ρήγνυμι	
shear ...	scheren ...	skere ...	—	καρῆναι	
†strew ... Strand...	streuen ... —	stero ... —	sterno ... stravi ...	στορέννυμι στρατός	
spurn ...	spornen	sphere (spring)	sperno		

ELA Bases.

	(drive)	ela ...	alacer ...	ἠλάθη	
†Hill ... Holm ...	Huegel ...	Kole ...	Columna Columen clemens!	κολώνη	
lew (-warm)	lau ...	kele ...	calere		
†low (of a cow)	hallen (sound) hell ...	kela (call)	calare ... clarus clamo Classis!	καλέω	
†(Cleric) ...	Holz (wood)	kola ...	—	κλάδος, κλῆρος	
Haulm ...	Halm ...	Kelam (stalk)	Culmus	κάλαμος	
(gush)?	quellen ...	gwele ...	—	βάλλω	
†cold ...	kalt ...	gela ...	gelidus Glacie		
†Milk ...	Milch ...	Gelag ...	Lac ...	γάλα	
—	melken ...	melag ...	—		
yellow ...	gelb ...	ghele ...	flavus ...	χλωρός	

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
glide ...	gleiten glatt	ghelo ...	glaber ...		
Hail ...	Hagel ...	ghela (rush ferment)	—	χάλαζα	
thole (endure)	—	tele ...	(t)latus ...	τάλαντον	
†full ...	voll ...	pele (vb)...	plenus ...	πίμπλημι	
	Volk ...	—	?plebes ..	πλῆθος	
†Floor ...	Flur ...	pela (spread out & approach)	—	πλησίον, πέλαγος	
Fold (hand?)	falten ...	,,	planus palma!		
flat ...	flach ...	..	—	πλατύς	
†Blast (blow)	blasen ...	bhele ...	flare		
Mould Meal	mahlen ...	mela ...	—	μαλακός, (ἀ)βληχρός	oft)
†Bloom ...	Blümen ...	melo ...	Flos ...	βλώσκω	
†blue Blood Black ...	blau Blut	mele ...	— —	μέλας	
Wool ...	Wolle ...	Werena ...	Lana		
†Sleep ...	schlafen ...	seleb ...	Labor, labo Labes		
slay ...	schlagen ...	skela ...	lacero ? ...	λακίζω	

ENA Bases.

—	Atem ? ...	ana ...	Animus ...	ἄνεμος	
Name ...	Name ...	Onomen ...	Nomen ...	ὄνομα	
Honey ...	Honig ...	kanak ...	—	κνήσος	
†(Kin(d) ...	Kind ...	gene ...	Genitor ...	γένεσις	
(Knave ...	Knabe ...		Natus ...	γνητός	(brother)
†(know (ken)	kennen können ...	gene ...	nosco ...	γιγνώσκω	
D. donker	dunkel ...	dhwena (be extinguished)	—	θνητός, θάνατος	
†wish ...	wünschen	wena ...	Venenum	ὀνήσιμος	
(win ...	gewinnen	weneu)			
Snare ...	Schnur ...	sene ...	nere ...	νῆσις	
spin ...	spinnen ...	spene ...	—	πενέσθαι	(work)
—	stöhnen ...	stena ...	—	στενάχω	
†thunder ...	donnern ...	(s) tona ...	tonare		
—	—	sena (bathe)	na(ta)re ...	Νηρεύς	

EMA Bases.

English.	*High German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
grim(etan, AS)	—	ghreme ...	—	χρεμετίζω	(neigh)
†Sk Timber	Zimmer ...	dema (build)	Do(min)us Materies!	δέμας	
†tame ..	zähmen ...	doma ...	domare ...	("Α)δμητος Δάμαρ	(wife)
Sand ...	do ...	same (rub)		Ἄμαθος	

EJA Bases.

yawn ...	gähnen ...	gheja ...	hiare. hisco	χαίρω	
gleam ...	glühen ...	ghleja ...	—	χλιαρός	(warm)
†(Zeal) ...	Jagen ...	deja (hasten)	—	διώκω, ζῆλος	
Withy ...	Weide ...	weje (twist)	viere Vimen		
sift ...	sieben ...	seja	—		
Shine ...	scheinen...	skeja ...	—	σκιά	
Stone ...	Stein ...	steja (be hard)	stipare (stuff?)	στέαρ?	

EWA Bases.

Wind	Wind ...	awe ...	Ventus ...	ἄημι, ἀάζω for ἀϝάδjω	
hew ...	hauen ...	kowa ...	cudere		
†raw ...	roh	Krewo bloody flesh	cruor crudus	κρέας	
†Thousand	Tausand	tewo (be strong)	totus tumeo	τύμβος, σάος	
foul ...	faulen ...	pewa ...	Pus		
be ...	—	bhewa ...	fui ...	φύσις	
Burn ...	Brunnen	Bhrewa ..	—	φρέαρ	
Bride ...	Braut ...	mrewa (say)			
Son ...	Sohn ...	sewa (beget)			
†S. Sun ...	Sonne ...	sewa ...	Sol ...	(Saw)ἥλιος	
sweet ...	suss ..	sewad (taste)	suavis ...	ἡδύς	
†S. Hide ..	Haut? ...	skewa (hide)	ob-scurus	σκῦλον, σκῦτος	
Slumber lower	Schlummer	slewe (be silent)			

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
Feather ...	Feder ...	PETA ...	—	πέταμαι	
good ...	gut ...	aghodh ...	—	ἀγαθός	
?Berry ...	Beere ...	bhese (rub off)	—	ψάω, ψωμός ψάμαθός,	
!much (mickle)	—	mega ...	magnus	μέγας	
say ...	sagen ...	sokwe ...	in-(s)quam	ἔπος	

II. DIPHTHONGAL.

1. Bases with I.

greedy ...	—	gherei (desire)	horior ...	χάρις, χαίρω	
!thirsty ...	durstig ...	tersei (be dry)	torreo		
love ...	lieben ...	leubhei ...	lubet		
will ...	wollen ...	welei ...	velle		
!wit ...	wissen .	weidei ...	video ...	ἰδεῖν, οἶδα	

2 Bases with U.

quick ...	—	gwejew ...	vivus ...	βιός, ζῆν	
	Riemen ...	werau (beware for)		ῥῦσθαι	
!(S. wary	gewahr ...	wer ...	vereri	ὁραω)	
	!walzen ...	welau (veil round)	volumen	εἴλυμα	

B. WITH SECOND SYLLABLE SHORT.

(1. **EXEU**; *where X = varying middle consonant.*)

yare gear		Sk. Kr.	**S** Creo		
strew ...	streuen ...	Sk. str ...	struo ...	στόρνυμι	
hear ...	hören ...	akous ...	—	ἀκούω	
—	ohne ...	eneu ...	—	ἄνευ	
nine ...	neun ...	enewen ...	novem		
!red ...	rot ...	ereudh ...	ruber ...	ἐρυθρός	
run ...	rennen ...	oreu ...	orior ? ruo	ὄρνυμι	

English.	*High-German.*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
†Head ...	Haupt ...	Kokoubh (top)	Caput		
leap ...	laufen ...	keleu ...	Callis (calv—)	κέλευθος	
†Knee ...	Knie ...	Genewo ...	Genu ...	γόνυ, γωνία	
Fleece ...	Fliess ...	toleu ...	—		
—	—	†dejewo ...	divus Dies	Ζεύς	
true ...	treu ...	dhereu ...	—		
D. veel ...	viel ...	peleu ...	pollere ...	πολύς, πλοῦτος	
{†brew ...	brauen ...	bhereu ...	ferveo ...		
{ broth ...	—		de-frutum (of wine)		
"*Nous*"	Sinn ...	Senewo ...	—	(σ νόϝος	

(2. EXEI.)

Roe ...	Reh ...	Eroi (goat)	—	Ἔριφος	
†(K)Nit ...	Niss ...	Koneid ...	—	κόνις	
†"Ex-peri-ment"	—	perei (tempt)	periculum	πεῖρα	
—	Mehlthau!	Meleit ...	Mel ...	μέλι(σσα)	
blithe, mild					
?Fr. Saule	Saal-(weide)	Seloik ...	Salix ...	ἕλικη	

(3. EXER. EXEN.)

{†light ...	leicht ...	elengh ...	—	ἐλαχύς	
{ Lung!					
Lamb	—	Elen-bho (Hart)	—	ἔλαφος	
Want ...	—	ewen (be-reaved)	—	εὖνις	
—	—	ewen (Bed)	Venus	εὐνή	
{†te(ge)n	Zehn ...	dekemto...	decem ...	δέκα, -(δ)κόντα	
{ hund-(red)	hund(erd	,,	centum ...	ἑκατόν	
†Mouth ...	Mund ...	Stoment...	Mentum...	στόμα	

(4 Bases ending in—**EK**
where K = final consonant.)

(*a.* **EREK.**)

English.	*High-German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
Hearth	Herd	kere	cremo		
Heart	Herz	Kered	Cor	κήρ	
crack	krachen	garog			
throw	drehen	torek	torqueo		
D. draaien	—	—			
Thrum (end of thread)	—	Terem (end)	Terminus	τέρμα	
(pray)	fragen	perek	preco posco		
Freckle	—	perek	—	προκάς	(Doe !
sprinkle?	sprenkeln				
Murder	morden	meret (dead)	Mors	βροτός	
March	Mark	Marog	Margo		
Work	Werk	wereg	—	ἔργον, ὄργανον, ῥέζω	
wreak	raechen	wereg	urgeo		
Worm	Wurm	Werem	Vermis		

b **ELEK.**

D. Hals	Hals	Kolos	Collum	
Fell	do.	pele	Pellis.	πεπλος
fold	falten	pelet	—	διπλάσιος, διπλῶμα
Field	Feld	peleth (spread)	–	πλατύς
bleak(ch)	bleich(en)	Bheleg	flagro	φλέγω
melt	schmelzen	meled		

(*c.* **ENEK, EMEK.**)

Night	Nacht	Onokt	Nox	νύξ, ἀκτίς
Nail	Nagel	Onogh	Unguis	ὄνυξ
—	—	enogh (stick)	—	νύσσω, ἔγκος
(Nebula)	Nebel	Onebh	Nebula	ὄμβρος, νέφος
—	—	—	Imber	ἀφρός
Navel	Nabel	Onobh	Umbilicus	ὀμφαλός
D. neem	nehme	enemo	emo	
us (ons)	uns	enos	nos	ἡμᾶς
bind	binden	bhenedh	Nodus!	πεῖσμα
South	Sueden	Senot	—	νότος

(*d.* EJEK, EWEK.)

English.	*High German*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
(speak)		—	Praeco (Prai jeqo)	εἶπον	
? Bug Bogey	—	Bojes (fear)			
—		awekwe	Vox	ἔπος	
wax	wachsen	awege	augeo augustus vigeo	ἀϜέξω	
bid	beten	ewegh (pray)	voveo	εὔχομαι	
†Wether	Widder	ewet	Vitulus		
†Water	Wasser	Ewod	Unda	ὕδωρ ?	Weave !
†wear	—	owe(s) (clothe)	Vestis	ἕννυμι	
	—	?ewes	(Vesta Vesuvius)	εὕω	
†Easter	Ostern	awese (lighten)	Aurora Ve(s)r	ἠώς, αὔσος αὔριον	Ear
—	? wahr	(wes-ro)	verus		
†? D. dwaas	—	dhewes (breathe)	Furius	θεός	(dhwesos) Slav. Duch. mhd. getwas (go).
reek	riechen	sewek	—		
		?sewep	sopire Somnus	ὕπνος	
†bow	beugen	bheweg	fugo	φεύγω, φοβέω	
Leaf	Laub	lewep	—	λέπος	(shell)
†Bite	beissen	bhejod	fodio		
Deal	Teil	Dojol	—		

(*e.* EXEK.)

†Tear	Thräne	Odakru	Lacruma	δάκρυ
Hammer	do.	Akamon (Stone)	—	ἄκμων. κάμινος
—	—	†Okosth	Os Costa (rib)	ὀστέον (oksth-)

(5. Bases ending in E)

(*a.* EXE.)

†teach	zeigen	deike	dixit Ju-dex	ἔδειξα
†leave	(b)leiben	leikwe	linquo	λιπεῖν
†wit	wissen	weide	video	ἰδεῖν

English.	*High-German.*	*Indo-German.*	*Latin.*	*Greek.*	*Remarks.*
Dug (teat)	—	dheughe (give profit)	—	τυχεῖν	
† Yoke ...	Joch ...	jeuge (bind)	Jugum ...	ζυγον	
Tongs ...	Zange ...	deike ...	—	δακεῖν	
† (eat ...	essen ...	ede ...	edo ...	ἔδω	
(Tooth ...	Zahn ...	—	(E)dens ..	ὀδούς	
† naked ...	nackt ...	nogwe ...	nudus ...	γυμνός	
Foot ...	Fuss ...	Pede ...	Pedem ...	πούς	
† Right ...	Recht ...	rede ...	rego Rex	—	Raj (Skt) -rix (Keltic)
† weigh ...	wiegen ...	weghe (ride)	veho Uxor !		
—	—	seghe ...	—	ἔχειν	
go ...	gehen ...	eje .	e(j)o ...	εἶμι	
Flood ...	Flut ...	plewe (swim)	pluit .	πλώω	
Birth ...	Geburt ...	bhere ...	fert Fors	φαρέτρον	
come ...	kommen	gweme ...	venio	βαίνω	

(*b.* **AXE.**)

† Acre ...	Akker ...	age (drive)	ago, Ager Amb-ag-es Ex-amen	ἄγω, ἀγρός	
—	—	jage (offer)	—	ἁγνός, ἅζομαι	
Nose ...	Nase ...	do. ...	Nares Nasus		

(*c.* **OXE.**)

† Eye ...	Auge ..	Okwe ...	Oculus ...	ὄμμα, ὄψομαι, ὄψ	

TRISYLLABIC BASES.

† Tiw (god of War)	Ziu ...	Dejewo ...	divus Jupiter	Ζεύς, δῖος	Sk. & Lit. devas
† Tree ..	—	Derewo ...	—	δρῦς, δόρυ	
† Aye (Goth Aiws)	—	ajewo ...	Aevum ...	αἴϝων	
Wheel ...	—	Kwekwelo	—	κύκλος	
spew ...	speien ...	spejewa ...	sputum ...	πυτίζω	

South African Economic Plants. The *Bulletin of the Imperial Institute* (1914) **12** [1], records the results of some investigations recently performed in the Institute's laboratories into the economic values of some South African plants. Amongst these was some aloe fibre from Bechuanaland, thought to have been derived from *Aloe Lugardiana*. This fibre was lustrous, fairly fine, and soft, of pale straw colour, and well cleaned and prepared. It was found to be of fairly good strength, and varied in length from 20½ to 37½ inches, averaging about 30 inches. Its percentage of cellulose was found to be low, and this fact, coupled with a rather high loss on hydrolysis, indicated that it was somewhat inferior to Sisal hemp in respect of chemical composition and behaviour, and that it would probably prove to be less durable. The fibre was valued at £27 to £28 per ton in London, and would probably be saleable in the United Kingdom as a cordage material, although rather short for that purpose. Another economic plant examined was *Scilla rigidifolia* from Swaziland. The leaves were dry and rather brittle, containing a fair proportion of fibre, which, however, was very weak, and could not be profitably extracted for textile purposes. It is possible, nevertheless, that the leaves might find a market for paper making, and with this object in view they were examined. Compared with Algerian esparto grass the leaves yielded a larger proportion of pulp, although the ultimate fibres of the pulp were rather shorter. It seemed likely, therefore, that the dried leaves would be saleable for paper making at a price approximating to that of Algerian esparto grass. At such a price, however, it appeared obvious that the collection and export of the leaves of *S. rigidifolia* would not be profitable, and so the employment of the plant for paper making in South Africa was suggested, or the local conversion of the leaves into "half stuff," which could then be shipped to Europe, and so effect a considerable saving in the cost of transport. A third economic product to which allusion is made in the *Bulletin* is the timber of *Khaya nyasica* from the Mozambique Province. The wood was well seasoned and uniformly sound, and weighed 38 lb. per cubic foot. When freshly cut it was pinkish-red with a brown tinge, but on exposure the colour improved to a deeper red-brown. It was uniform in texture, firm, moderately hard, and worked freely, and would be classed as a good average African mahogany; so closely, indeed, did it resemble mahogany that it was imagined there would be no difficulty in selling it as such; in fact, it is said that many woods inferior to it are already being sold as mahogany.

ALGUNS ELEMENTOS PARA O ESTUDO DO CLIMA DE LOURENÇO MARQUES.

Por Augusto de Almeida Teixeira.

Este trabalho é principalmente baseado nas observações do Observatorio "Campos Rodrigues" e nas dos antigos postos da Capitania do Porto e Missão Suissa.

Frequentemente se fazem referencias aos elementos meteorologicos da Africa do Sul, para o que foram consultadas as esplendidas memorias sobre o assunto dos Ex.mos Srs. Robert T. A. Innes, Director do Observatorio Astronomico da União, J. R. Sutton, Director do Observatorio de Kimberley, Charles Stewart, Director dos Serviços Meteorologicos da União, Coronel H. E. Rawson, membro da Commissão de Meteorologia, e capitão de fragata Hugo de Lacerda, ex-chefe dos Serviços de Marinha de Moçambique, algumas das quaes veem publicadas nos relatorios annuaes dos Congressos Scientificos da "South African Association for the Advancement of Science."

Temperatura.

A temperatura é sem duvida o principal elemento a considerar, qualquer que seja o aspecto sob que se pretenda encarar o clima de uma região. A média annual da temperatura em Lourenço Marques tem o valor de 22°.2 C. (72° F.) obtida por observações de 14 annos. A temperatura média mensal tem os seguintes valores: (Quadro No. 1).

Como se vê, a differença entre o mês mais quente, janeiro, e o mais fresco, julho, não attinge o valor de 8° C. (14° F.), justificando o poder considerar-se regular este clima, o que é natural consequencia da posição de Lourenço Marques cercada de NNE a SW pelas aguas do Rio Incomati, da bahia e do estuario do Rio Espirito Santo. Esta circumstancia, o predominio dos ventos maritimos, principalmente nas horas de mais calor, e, por ultimo, a escassez de calma concorrem para amenizar a temperatura, tornando o clima mais agradavel do que era de esperar da sua posição geographica.

É conhecido o aquecimento que para a costa oriental da Africa resulta da corrente maritima de Moçambique, contrariamente ao que succede na costa occidental resfriada pela corrente de Benguella, facto confirmado pela inspecção de uma carta isothermica onde pode verificar-se que para igual latitude correspondem temperaturas mais elevadas na primeira costa e que nella a temperatura augmenta de S para o N.

Igualmente o Sr. C. Stewart, pela analyse das temperaturas da Africa do Sul, concluindar-se um aumento de temperatura de O para E ao longo do parallelo de latitude e de S para o N ao longo da costa E.

No estudo do caso particular de Lourenço Marques, a comparação das temperaturas do logar com as das regiões para W não pode fazer-se á primeira vista, por causa da grande differença de altitude e posição de Lourenço Marques ao litoral, mas é facil fazer-se com a dos outros pontos da costa.

D'esta comparação conclue-se ser o augmento de temperatura de Durban para Lourenço Marques inferior ao que seria de esperar, dada a differença de latitude de 234 milhas existente entre os dois pontos.

Assim, a média annual de Lourenço Marques é superior á de Durban apenas em 0°.6 C. (1°.1 F.), a do mês mais quente 1°.1 C. (2°F.); a temperatura do mês mais frio é sensivelmente a mesma nas duas cidades.

Os valores extremos—maxima e minima absolutas—são superiores em Lourenço Marques, respectivamente, cêrca de 1°.3 C. (2°.3 F.) e 2°.1 C. (3°.8 F.). (Quadro No. II.)

Se compararmos Durban e East-London, distando 190 milhas em latitude, encontramos differenças muito maiores: o mesmo se dá entre Lourenço Marques e Inhambane com uma differença de latitude de 124 milhas, sendo para notar que Inhambane se afasta bastante quanto ás maxima e minima absolutas, por divergir muito do regime meteorologico do litoral da Africa do Sul.

Estas comparações são favoraveis a Lourenço Marques quanto ao augmento de temperatura de S para N e demonstram a semelhança do clima pelo que respeita á temperatura das cidades de Lourenço Marques e Durban, havendo maior differença no valor da temperatura minima absoluta inferior na ultima cidade.

Talvês concorra para esta circumstancia a configuração da costa para o S da Ponta Zavora e a extensão da bahia, que dêem origem á corrente de Moçambique se affastar de Lourenço Marques, não elevando tanto a sua temperatura, o que só um estudo mais detalhado das correntes pode confirmar.

Pela analyse das temperaturas dos differentes meses verifica-se ser bastante agradavel a temperatura de maio a outubro, para os quaes é tambem menor a percentagem de humidade relativa. Nos meses de dezembro a março, com as temperaturas mais elevadas, o clima toma um aspecto mais tropical, sobretudo nos dois ultimos, os mais humidos. Nos restantes meses, de transição, com frequencia as temperaturas são agradaveis.

As quatro estações não são bem caracterizadas, pois os meses de transição estão longe de poderem chamar-se—primavera e outono—sendo mais adequado dividir o anno em duas estações—quente e chuvosa de outubro a março, fresca e quasi sêcca de abril a setembro.

No quadro No. III registam-se as variações da temperatura—média mensal e a chuva média de cada mês:

As differenças durante o augmento da temperatura para o mesmo periodo são menores e affectam maior regularidade do que durante o decrescimento, talvez devido á influencia da chuva que retarda a marcha ascendente da temperatura, diminuindo-lhe o valor, e pelo contrario, nos meses em que menos chove, o decrescimento é muito mais rapido, devendo notar-se que a estes meses corresponde menor nebulosidade, o que, juntamente com a maior irradiação nocturna occasionada pela superior duração da noite, deve concorrer para essa descida mais rapida. A marcha do sol influe na variação annual da temperatura, havendo o retardamento usual.

A variação de temperatura durante o dia pouco offerece de irregular. A minima dá-se, como é normal, antes de nascer o sol, e a maxima cêrca das XIII horas, sendo o augmento mais rapido e accentuado das VII para as IX; depois, talvez por effeito da persistencia dos ventos maritimos, o crescimento torna-se mais lento.

A diminuição da temperatura com o pôr do sol não é tão accentuada; depois da meia noite até á hora da minima, o decrescimento é em cêrca de 1° C. A irradiação nocturna durante o anno não parece ter influencia tão grande como era de esperar, o que talvez se explique attendendo a que nas noites de menor nebulosidade é mais frequente o *cacimbo*, o qual, como se sabe, compensa a irradiação devido á grande quantidade de calor liberto pela condensação de vapor de agua existente na atmosphera. O cacimbo é muito mais frequente na estação sêca. A média das oscillações diarias, cujo valor annual regula por 10° C (18° F), tem o seu maior valor 11° para 12° C (20° para 21°,5 F), de abril a agosto e nos outros meses este valor desce progressivamente a 7°,0 C (12°,6 F). Esta differença provém de que, oscillando a variação maxima média cêrca de 7° C. (12°,6 F.), a variação minima oscilla de 10° C. (18° F.), isto é, a oscillação de temperatura minima é muito maior do que a da maxima, o contrario do que succede em Lisboa, o que nos parece poder explicar-se pela coincidencia aqui existente das chuvas e da maior nebulosidade na epoca quente. Alem d'isto, os *ventos quentes* de N e NNW, originados pela passagem das perturbações atmosphericas, tambem se fazem sentir na epoca fresca, causando elevações de temperatura relativamente mais importantes do que na outra.

Analoga differença existe entre os valores de maxima e minima absolutas, devida ás mesmas causas.

Estes valores extremos de temperatura offerecem bastante interesse no estudo de um clima, posto que o desenvolvimento das doenças endemicas, segundo lemos, dependa essencialmente das medias de temperatura. O europeu residente nestes climas torna-se muito mais sensivel ás variações de temperatura, ainda mesmo aos pequenos decrescimentos que na Europa nada impressionam, e tanto mais quanto mais longa é a sua permanencia, o que talvez se possa justificar pelo seu depauperamento physico e pelo estado hygrometrico da atmosphera. A necessidade que parece haver de evitar mais cuidadosamente, nestes climas, os resfriamentos pelas suas más consequencias, dá tambem importancia ao conhecimento dos valores extremos da temperatura.

O exame das maximas e minimas absolutas, contidas no Quadro No. IV, pode impressionar desfavoravelmente, mas estas variações extremas são devidas ao *vento quente* de NNW que antecede a passagem das depressões atmosphericas, seguido immediatamente de vento S fresco, originando grande abaixamento de temperaturas, por vezes de 16° C. (28°.8 F.) em uma e meia hora.

Esta circumstancia, sem duvida importante, é commum a toda a costa da Africa do Sul, de Walfisch Bay a Durban.

Dos tres annos completos de observação no Observatorio extrahimos os seguintes elementos:

Temperatura maxima superior a 35° C (95° F) registou-se...	21	vezes
Temperatura maxima superior a 40° C (104° F) registou-se	5	„
Temperatura minima entre 9° e 10° C (48°.2 e 50° F) registou-se	21	„
Temperatura minima entre 8° e 9° C (46°.4 e 48°.2 F) registou-se	6	„
Temperatura minima entre 7° e 8° C (44°.6 e 46°.4 F) registou-se	1	„
Temperatura minima igual a 25° C (77° F) registou-se	1	„
Temperatura minima entre 24° e 25° C (75°.2 e 77° F) registou-se	8	„
Temperatura minima entre 23° e 24° C (73°.4 e 75°.2 F) registou-se	26	„
Variação de temperatura no mesmo dia de 25°.8 C (46°.4 F)	1	„
Variação de temperatura no mesmo dia entre 20° e 25° C (36° e 45°.5 F)	17	„
Variação de temperatura no mesmo dia entre 15° e 20° C (27° e 36°.4 F)	67	„

Como se vê, as temperaturas superiores a 40° C (104° F) e inferiores a 9° C (48°.2 F) podem considerar-se excepcionaes e bem assim as variações diarias superiores a 20° C (36° F).

Igualmente se conclue que raras vezes a temperatura minima diaria é superior a 24° C (75°.2 F), e poucas a 23° C (73°.4 F), pelo que durante a noite, em geral, o calor incommoda pouco.

Parece-nos, pois, que estas temperaturas extremas e variações diarias elevadas não devem impressionar muito desfavoravelmente, dada a sua pequena frequencia, devendo notar-se que temperaturas superiores a 40° C. (104° F.) registam-se em climas temperados, como Lisboa, e ainda na França, onde os valores minimos são muito inferiores aos d'aqui.

Sobre a explicação d'este *vento quente* NNW, que se registou sempre que a temperatura excedeu 32° C. (89°.6 F.), voltaremos a falar. Não ha duvida que é bastante incommodo devido a ser extremamente sêco, causando uma impressão não menos desagradavel que a provocada pelos ventos quentes e humidos.

Pressão Barometrica.

A pressão barometrica que occupa um logar principal na Meteorologia passa para o segundo plano no estudo de um clima e consequente influencia na vida humana, se não considerarmos os seus effeitos nos outros elementos, pois as suas oscillações parecem não ter influencia perceptivel sobre o homem e só nas grandes altitudes é um elemento climatologico de importancia.

No quadro No. V mencionam-se os valores das medias mensaes e annual, para um periodo de sete annos, da pressão barometrica reduzida a 0° C e ao nivel do mar.

Alem da dupla variação diaria, impropriamente chamada maré, explicavel por varias theorias que mais ou menos satisfazem, existe bem definida a variação annual com os valores, minimo em dezembro e maximo em julho, correspondendo e média annual á média de abril, para o mesmo periodo de sete annos.

Esta variação annual dá-se em sentido contrario á variação de temperatura, como é regra nos continentes de climas temperados.

Analysando as variações em vinte e quatro horas, nota-se que a minima da noite tem geralmente logar das III para as IV horas, e a do dia das XV para as XVI, sendo a regra geral: a maxima da manhã regista-se das VIII para as IX horas, havendo tendencia para se dar mais cedo de outubro a dezembro, e a maxima da noite é retardada, dando-se geralmente das XXIII para as XXIV horas, e mesmo depois da meia noite. A minima do dia é inferior em cêrca de $1^{mm}.5$ (0″.059) á da noite, o que é mais pronunciado de outubro a janeiro, a maxima do dia excede a outra em cêrca de $0^{mm}.5$ (0″.0197), sendo a differença mais elevada de junho a outubro; consequentemente, a differença entre a maxima e a minima do dia é mais accentuada que a da noite. Estes factos, na sua maioria, parecem-nos explicar-se pela marcha diaria da temperatura já mencionada, e ligados á hora do nascer e occaso do sol.

As pressões extremas registadas no Observatorio são: maxima $779^{mm}.4$ (30″.686), minima $746^{mm}.2$ (29″.378), isto é, uma variação absoluta de $33^{mm}.2$, comprehendida entre os limites registados para Durban e East-London. As minimas absolutas, como é natural, correspondem á passagem das depressões, seguindo-se as maximas que se accentuam quando o regime anti-cyclonico se fixa no planalto de uma forma mais estavel.

Alem d'estas duas variações regulares—diaria e annual—falta considerar as variações irregulares provenientes da passagem de areas de altas ou baixas pressões.

Como exemplo de uma d'estas pertubações e dos seus effeitos nos outros elementos meteorologicos, apresentaremos os respectivos valores horarios de uma depressão em 28 de setembro de 1912, que pouco interesse offerece a quem tenha estudado phenomeno semelhante em qualquer outro local na Africa do Sul, e simplesmente servirá para evidenciar a analogia do regime meteorologica de Lourenço Marques com o d'esses pontos. (Quadro No. VI).

A simples observação dos valores d'este quadro torna evidente todos os effeitos na temperatura, direcção e força do vento, tensão de vapor e humidade relativa. As depressões, occasionando quasi sempre *ventos quentes* de NNW e do N, influem na evaporação, tornando-a excessiva, o que obriga a cuidados especiaes para não faltar agua no evaporometro e no psychrometro.

Nesta depressão, a duração do *vento quente* foi a usual, mas a descida rapida da temperatura, quando o vento depois de uma pequena calma se fez ao S, não foi das mais accentuadas: geralmente esta calma dura um maximo de 20 minutos, rompendo depois o vento S com bastante violencia, por vezes com rajadas correspondentes a velocidades 70, 80 e ainda 100 kilometros á hora, provocando as chamadas *tempestade de pó*, aqui menos frequentes do que vêmos mencionada para outros locaes da Africa do Sul.

As depressões nem sempre são precedidas de cirrus, e, quando o são, notam-se principalmente com dois ou tres dias de antecedencia.

Poucas horas antes do vento rondar para o S é frequente formar-se uma barra no horizonte e o ceu ir-se nublando successivamente com uma camada de cirrus-stratus e depois de cumulos e cumulos-nimbos. O S por vezes vem acompanhado de chuvas, mais frequentes nos segundo e terceiro dias, sobretudo na epoca da chuva, mas nunca chove quando o vento está do quadrante do N. Outras vezes vem acompanhado de trovoadas. O vento ESE, que nesta depressão se registou ás XII horas de 29, persistiu depois durante bastantes horas, como é frequente, com intensidade variavel, por vezes fresco, fazendo-se depois E e ENE.

Tivemos occasião de verificar em 1912 que as depressões se fazem sentir em Durban com uma antecedencia de oito a vinte horas em relação a Lourenço Marques.

Geralmente são mais frequentes em maio e de agosto a dezembro; teem menor duração na epoca sêca do que durante as chuvas.

Este exemplo comprova geralmente as seguintes conclusões a que entre outras chegou o Sr. Sutton na sua memoria "*On the variation of the hourly meteorological normals at Kimberley during the passage of a barometric depression*": Causarem as depressões um grande exaggero nas variações normaes da pressão e da temperatura, influenciarem a nebulosidade, sobretudo para as nuvens baixas, originarem chuvas, mais abundantes no segundo dia, e por ultimo parece-nos tambem dever concluir-se entrarem no continente de preferencia de S ou SW e não do N, e ainda não atravessarem o sul de Africa de W para E, etc., etc.

Faltam nos no entanto elementos para um estudo detalhado d'estas depressões o que tambem alongaria muito este trabalho o que não é o nosso intento.

Vento

Em Lourenço Marques são raras as horas de calma o que, juntamente com os ventos predominantes do lado do mar, muito concorre para amenizar o clima. Nos annos 1909 a 1912 registaram se, respectivamente, vinte e quatro, duas, vinte e nove e sessenta e uma horas de calma, numero insignificantissimo, não attingindo em média annualmente trinta horas.

Os anemometros do Observatorio estão collocados sobre o edificio assente em terreno pouco accidentado, não, havendo nada mais elevado muitos kilometros em roda.

No quadro No. VII média de quatro annos, verifica-se ser pequeno o numero de dias em que o vento é fraco, menor ainda os de vento forte, e somente são muito frequentes os dias de vento moderado.

Quanto á variação diaria da direcção, era facil prever, dada a posição de Lourenço Marques no litoral, a influencia bem manifesta da viração e do terral. O terral faz-se sentir mais nos meses de abril a agosto, e menos em novembro e dezembro; principia pelas XXIII horas e termina geralmente depois das IX, o mais tardar ás XI, sendo rarissimo haver vento dos quadrantes W depois do meio dia, a não ser quando sopra o *vento quente* NNW.

Nos meses em que este regime está bem estabelecido, só quando o vento de N ou S sopra com violencia, é que não ronda para os quadrantes de W, durante a noite.

Conforme a regra nas circunstancias de Lourenço Marques, durante o dia a força do vento excede a da noite, soprando geralmente mais fraco das O ás III horas, aumentando successivamente até ás XVI horas, persistindo fresco até ás XIX; como se vê, a velocidade do vento está ligada com a variação de temperatura, mas, quando esta decresce, a velocidade do vento não diminue logo como é mais usual.

Dois factos ha a mencionar: ás XI horas dá-se geralmente uma diminuição do força do vento, o que talvês se justifique pela influencia do regime, viração e terral, pois esta diminuição é mais accentuada nos meses de abril a agosto, sendo a esta hora que geralmente o vento ronda; talvês pela mesma causa, o decrescimento da força do vento é mais accentuado das XXI para as XXIII horas. (Quadros Nos. VIII e IX).

A regra da *viração* e do *terral* serem mais intensos nos meses de maior variação de temperatura e de menor velocidade nos outros ventos predominantes, explica o estabelecer-se mais accentuadamente este regime nos meses de abril a agosto. Em Lourenço Marques, a velocidade média do vento é mais elevada nos meses de setembro a janeiro.

Os graphicos com as percentagens da frequencia e kilometros percorridos nos differentes rumos facilitam bastante a analyse do regime nos varios meses.

Na quadra mais quente, de outubro a maio, predominam os ventos ENE a SSW, com pequena percentagem de ventos do quadrante NW e dos rumos SW a W. O vento predominante do quadrante SE successivamente vae rondando para SW de outubro a maio, e igualmente se nota um augmento de percentagem de NE para ENE até fevereiro, em que predomina este ultimo rumo, a qual por sua vez diminue bastante em março. Assim, durante os meses mais quentes predominam os ventos maritimos e ainda o SSW que é bastante frio. Nos restantes meses de viração e terral mais pronunciados naturalmente são mais frequentes os ventos de W, augmentando de abril a julho a frequencia de NNW e diminuindo nos tres seguintes meses. Até junho o vento augmenta em frequencia de SE para SW, voltando então a soprar com mais frequencia de S, SSE e do quadrante NE.

Em resumo: nos meses de maio, junho e julho predominam os ventos dos quadrantes W, principalmente NNW e depois SSW; nos meses de novembro, dezembro e janeiro predominam os ventos dos quadrantes NE e SE, principalmente ENE, E, ESE e ainda o S. Os outros meses podem considerar-se de transição para estes regimes mais definidos.

A percentagem do numero de kilometros percorridos nos differentes rumos acompanha a percentagem na frequencia, notando-se naquella um augmento nos rumos em que, como vimos, o vento sopra com maior força.

As monsões que se sentem para o N no canal de Moçambique não se fazem aqui notar, ainda que talvez tambem tenham influencia na força e direcção do vento.

A analyse do quadro No. X mostra a influencia do *Geral* de SE, que como se sabe, predomina no Oceano Indico nesta latitude, pois a resultante annual é sempre proximamente SE e, na maioria dos meses, principalmente dos meses quentes, a resultante é tambem d'este quadrante. Isto é, estes valores põem em evidencia um grande deslocamento de ar para NW, sem duvida devido ao grande aspirador da Africa equatorial, o que o Sr. commandante Hugo de Lacerda já tinha concluido pelas analyses do anno de 1909, justificando a maior frequencia das depressões na quadra quente por esta aspiração ser mais accentuada. O Sr. commandante Hugo de Lacerda emittiu a hypothese de que os regimes de altas pressões dos dois oceanos que banham a costa de Africa servissem de compensadores ao desiquilibrio que tende constantemente a dar-se na Africa Central, reforçando a sua opinião com a circumstancia de não haver resultante em Kimberley.

Quando falámos das perturbações barometricas, mencionámos a existencia dos *ventos quentes*, communs ao litoral da Africa do Sul. A maioria dos illustres meteorologistas que se teem occupado d'estes ventos attribuem-lhes completa semelhança com o *Foehn dos Alpes*, que foi cabalmente explicado pelo Dr. Hann, e sopra no lado N dos Alpes, muito quente e sêco, quando um cyclone se manifesta na Europa Occidental com as pressões mais baixas na Inglaterra e as mais altas no Mediterraneo Oriental, e no lado S, na Italia, em circumstancias oppostas.

Se considerarmos só Lourenço Marques, a explicação de uma forma identica pode, á primeira vista, parecer pouco apropriada, dada a distancia a que ficam elevadas montanhas para N e NNW, alem de que a subida do litoral para o planalto da Rhodesia não se faz abruptamente, mas sim por ressaltos fracos.

No entanto, provindo da Africa equatorial, é natural que seja de temperatura elevada, e a descida para o litoral ainda o torna mais quente e sêco, pois não atravessa na sua passagem para o S qualquer região que lhe possa diminuir a temperatura ou elevar a humidade. A absoluta analogia com os ventos da costa da Africa do Sul mais justifica esta explicação, ainda reforçada porque em Inhambane não se faz sentir tão caracteristicamente quente e sêco, pois ali o vento NNW já não provém dos elevados planaltos do interior.

A contrapor a este vento quente, temos o vento S cuja temperatura pouco elevada tem muito maior influencia no clima, por ser muito mais frequente, ao contrario do NNW que, como dissemos, dura poucas horas e poucas vezes se faz sentir; não se deve porém confundir nos graphicos da percentagem com o NNW devido ao terral.

Novamente chamaremos a attenção para as rajadas violentas correspondentes a 60, 70, 80 e 100 kilometros á hora, que se sentem, por vezes, ao principiar o vento S, quando da passagem das perturbações atmosphericas.

As maiores velocidades horarias registadas em quatro annos de observatorio foram: 88 kilometros com vento SSE e 77 kilometros com S em outubro e março de 1911, attingindo varias vezes velocidades entre 60 e 70 kilometros.

Não se nota em Lourenço Marques qualquer rotação diaria do vento num ou noutro sentido (*backing ou veering*).

Humidade relativa e tensão de vapor.

Segundo a classificação mais geral considera-se—moderadamente humido—o clima cuja humidade relativa está comprehendida entre 60 e 80 por cento, assim deve ser classificado Lourenço Marques porque, como se vê no quadro No. XI, não só a média annual, mas as medias mensaes, ficam entre estes limites.

O conhecimeto do estado hygrometrico da atmosphera é um elemento de valor pela sua influencia deprimente e desagradavel, sobretudo para temperaturas elevadas. Em Lourenço Marques, como já vimos, o vento quente excessivamente sêco é bastante incommodo, ainda que indubitavelmente menos prejudicial á saude que o vento quente e humido. Aos cinco primeiros meses do anno corresponde a maior percentagem de humidade relativa, e a menor aos de julho a outubro, isto é, aquelles de menor temperatura e de chuva mais escassa.

O excesso de humidade nos meses de março a maio, contribue para os tornar peores do que seria de esperar, se attendessemos só á sua temperatura relativamente baixa.

Se compararmos o graphico das temperaturas mensaes com o da humidade relativa, vê se que, variando em sentido differente, não existe uma relação perfeita, pois ha um certo atrazo na marcha da curva da humidade. Assim, em abril, em que o decrescimento da temperatura já se tornou sensivel, a humidade attinge o seu maximo valor, principiando só então a decrescer até setembro, em que attinge o minimo valor, ao passo que a temperatura sobe desde julho.

Em relação á epoca das chuvas, a humidade relativa attinge o seu maximo quando ella está a findar, e o seu minimo em setembro, pouco depois de começar a augmentar a quantidade de chuva mensal.

O facto de predominarem os ventos maritimos na epoca quente deve tambem influir nos valores da humidade relativa, pois, segundo a observação, os ventos mais humidos são os de NE a SSW por E.

Em theoria, a humidade relativa, sendo a relação $\frac{f}{F}$ entre a tensão de vapor f (humidade absoluta) num dado momento e a tensão de vapor F no estado de saturação, deve diminuir com a temperatura, pois o numerador d'esta fracção pouco augmenta com ella ao passo que a denominador cresce bastante.

Já vimos que na variação annual existe um atrazo em relação á marcha da temperatura; vejamos agora a influencia d'esta na variação diurna.

O maximo valor da humidade relativa antecede o nascer do sol, coincidindo com a minima thermometrica; o valor minimo tem geralmente logar pelo meio dia, antes da maxima da temperatura; o decrescimento acompanha regularmente o subir da temperatura. O augmento da percentagem de humidade é mais rapido da hora da minima até ás XXI horas, depois augmenta vagarosamente, registando-se por vezes o estado de saturação ou valores aproximados.

O valor minimo absoluto da humidade relativa corresponde aos dias de *vento quente*, chegando a ter o pequeno valor de 8 por cento.

A variação média tem um valor annual de 33 e, analogamente á variação de temperatura, é maior nos meses mais frescos, o que tambem succede com as differenças entre as maxima e minima absolutas. Ás vezes, pelas XXI horas, nota-se um accrescimo rapido na humidade relativa e na tensão de vapor, sem duvida ligada á marcha da variação da temperatura já mencionada.

A marcha da tensão de vapor, tanto annual como diaria, acompanha regularmente a temperatura. A tensão de vapor média annual tem o valor de 14^{mm}.71; a variação média oscilla entre 3^{mm}.11 e 5^{mm}.15, de uma forma analoga mas mais regular do que a temperatura, e nas suas differenças existe o mesmo acordo. O valor minimo diurno tem logar á hora da temperatura minima, o valor maximo varia das XII para ás XVII horas, sendo posterior á maxima temperatura e occorrendo mais tarde nos meses mais frescos.

Os valores extremos registados em 4 annos, são: maximo 26^{mm}.7, minimo 4^{mm}.3.

Pelo que fica dito, sobresae bastante o elevado estado de humidade relativa durante a noite.

O cacimbo torna-se muito frequente nos meses de junho a setembro, por vezes consegue-se medir no udometro, de 2 decimetros de diametro na boca, 0^{mm}.1, 0^{mm}.2 e, mais raras vezes, 0^{mm}.3.

A agua proveniente de cacimbo e nevoeiro recolhida no udometro durante o anno de 1912, foi 12^{mm}.1, devendo notar-se que neste anno a percentagem de nebulosidade foi menor que a usual.

É geralmente reconhecido ter grande influencia no cacimbo a percentagem de nebulosidade, correspondendo em Lourenço Marques a menor nebulosidade média ás XXI horas, relativamente ás horas de observação. No entanto, devo mencionar que o Sr. Sutton, como resultado da sua observação directa em Kimberley, concluiu não ser condição essencial para haver cacimbo não haver nuvens e que isto só concorre para lhe apressar o começo e que são elementos determinantes para a formação do cacimbo, a humidade do ar perto da saturação e o comprimento da noite.

Por vezes notamos cacimbo abundante em noites nubladas, o que confirma a opinião do Sr. Sutton.

Com o vento N e NNW não ha cacimbo, que se regista em maior quantidade nas noites em que o terral se estabelece fraco.

Chuva

Os elementos meteorologicos das regiões que, como Lourenço Marques, estão situadas nos limites de zonas, são mais ou menos affectados pelos caracteristicos das duas zonas com que confinam.

A epoca das chuvas em Lourenço Marques, de outubro a março, isto é, quando o sol está mais proximo do zenith, corresponde ao regime tropical (*sol vertical*). Nos seis meses de abril a setembro, a quantidade de agua medida no udometro é cêrca da quarta parte da que cae na estação das chuvas, notando-se um pequeno augmento correspondente ao mês de julho, que apezar de insignificante, talvês seja originado no regime *chuva de inverno* mais vulgar nos climas sub-tropicaes.

A média annual da chuva é 677^{mm} (26".660) numero ainda comprehendido na designação de *chuva moderada*, mas já bastante perto do regime denominado *chuva escassa*.

Estando Lourenço Marques situado na zona sêca (20° para 30° de latitude) assim classificada segundo as leis da circulação da atmosphera, deduzidas na supposição da superficie da terra ser homogenea, e ainda porque nestas latitudes a chuva é pouco abundante quando uma componente do vento é dirigida do polo para o equador, justifica-se que a totalidade da chuva seja inferior ao valor medio da agua caida na zona tropical.

O exame de uma carta de distribuição de chuvas mostra ser a zona sêca mais accentuada no hemispherio sul, nas costas occidentaes dos continentes, devido a varias causas como: direcção predominante do vento, disposição das cordilheiras, regime cyclonico, etc. Com isto coincide o regime de Lourenço Marques, onde não são frequentes as chuvas torrenciaes de pequena duração nem as moderadas de duração prolongada sem interrupção, como é frequente nas zonas temperadas e em algumas partes da zona tropical.

No quadro No. XII vão indicados os valores medios mensaes e annual da quantidade de agua recolhida e o numero medio de dias de chuva, conforme os resultados de quatorze annos.

No Observatorio são considerados dias de chuva, aquelles em que se regista quantidade superior a $0^{mm}.1$.

Os meses mais chuvosos são dezembro e janeiro, e os mais sêcos junho, julho e agosto.

O graphico da percentagem de chuva correspondente ás differentes direcções do vento torna evidente a sua abundancia quando este sopra de SSE a SW, principalmente do S e depois de SSW. Em relação aos outros rumos a percentagem é muito menor, sobretudo a N e NNW, onde é insignificante. Ao rumo W corresponde uma maior percentagem de chuvas devido a serem mais frequentes as trovoadas d'esse lado, embora para as mais violentas se registem aguaceiros de varias direcções.

Em quasi todos os trabalhos já mencionados, contesta-se não só a theoria dos ventos predominantes de SE, mas tambem estes causarem a chuva na Africa do Sul. O Sr. C. Stewart accrescenta que se deve esperar chuva em Port Elizabeth e East London, quando, á passagem das depressões para o N, o vento ronda de N para o S na peninsula do Cabo, e regista o facto de em Port Elizabeth, num mês de excepcional frequencia de SE, a chuva ter sido 86 por cento abaixo do normal.

Em Lourenço Marques as chuvas mais copiosas correspondem igualmente á passagem das depressões, por vezes, tambem ao rondar o vento de N para S, mas mais geralmente no dia seguinte ou no immediato a este. É para notar igualmente que aos meses de maior percentagem de vento SE, não corresponde um aumento definido na quantidade de chuva. Em resumo: o regime de chuvas em Lourenço Marques, obedecendo ao typo de *chuvas tropicaes* em relação á epoca, está ligado com a passagem das depressões, aproximando-se do regime denominado *chuvas cyclonicas*.

Quando no traçado das isobaras o centro de altas pressões se estabelece em Lourenço Marques, registam-se ás vezes pequenos aguaceiros com ventos variaveis, o que está em desacordo com a theoria das chuvas de *convecção*, pois, como é sabido, aos centros de alta pressão correspondem correntes de ar descendentes, as menos proprias para provocarem as chuvas.

Em Lourenço Marques as chuvas são mais frequentes das IV ás IX horas e das XVIII á meia noite; nas restantes horas chove mais de noite do que de dia, e menos das XV ás XVII horas, isto é, quando a velocidade do vento é maior.

Em quatro annos, 1909 a 1912, registaram-se vinte vezes chuvas superiores a 30 millimetros durante vinte e quatro horas. D'estas, as maiores quantidades medidas no udometro são:

Em 1909. Janeiro, 70mm (2".757) em uma hora e quinze minutos.
Novembro, 30mm (1".181) em quinze minutos.
Dezembro, 50mm (1".969) em quinze minutos.
Dezembro, 96mm (3".781) em quatro horas.
Em 1910. Fevereiro, 181mm (7".128) em doze horas.
Outubro, 43mm (1".693) em quarenta minutos.
Em 1911.—Outubro, 50mm (1".969) em uma hora.

Conjuntamente com a percentagem de horas de sol encoberto e com a nebulosidade, apresentamos um graphico da chuva que nos parece interessante pela impressão geral da ligação d'estes tres elementos, e do estado geral da atmosphera.

Tambem apresentamos um graphico do numero médio mensal de dias de chuva e de trovoadas.

Evaporação

Para medir a evaparação, emprega-se no Observatorio um evaporometro "Piche," effectuando-se a sua leitura ás IX horas. Como se sabe, o estudo da evaporação não está bem definido, não se podendo comparar observações feitas com o mesmo instrumento em dois locaes differentes, facto devido principalmente á influencia da temperatura da agua. Admitte-se que a evaporação augmenta com a temperatura da agua e velocidade do vento, e diminue com a humidade e com a pressão atmospherica. É o que se verifica em Lourenço Marques onde a influencia da temperatura e da velocidade do vento são bem manifestas, tanto na variação de dia para dia, como de mês para mês. No entanto, este ultimo factor é o predominante, pois a evaporação é maior durante a estação quente, nos meses de maior velocidade de vento. Em março, caracterizado por um accrescimo de velocidade do vento, a evaporação augmenta igualmente. A influencia da pressão e humidade, factores menos importantes, tambem não é contraditada na inspecção dos respectivos valores diarios.

Para o estudo da evaporação nas differentes horas faltam elementos. O que se tem tornado bem evidente, é o seu augmento extraordinario durante as horas de *vento quente*.

O quadro No. XIII com os valores medios da evaporação mensal pode confirmar o que fica exposto sobre o assunto.

Nebulosidade e horas de sol a descoberto.

O estado de nebulosidade é de grande importancia na Meteorologia, pois, alem da sua intima ligação com a chuva, tem grande influencia na distribuição da radiação solar e da irradiação terrestre e fornece elementos para o estudo das correntes superiores da atmosphera e para a previsão do tempo.

Investigações recentes do Professor Albot, tendentes a demonstrar a influencia das nuvens sobre a percentagem da radiação solar que chega á superficie terrestre, levaram-no a concluir soffrer esta radiação uma perda de 50 por cento do seu valor ao atravessar a atmosphera sem nuvens, e que esta percentagem augmenta notavelmente com a nebulosidade, por absorpção e reflexão.

Admittindo que em média 52 por cento da superficie da terra está obscurecida pelas nuvens, conclue que a radiação solar que attinge a superficie da terra fica reduzida a 24 por cento do valor que tem no limite superior da atmosphera, o que põe em evidencia a influencia da nebulosidade na Meteorologia.

As observações de nebulosidade são feitas no Observatorio tres vezes ao dia: IX, XV e XXI horas. (Quadro No. XIV.)

A média mensal da quantidade de nuvens está de acordo com a distribuição de chuva. Pelas horas de observação regista-se um decrescimento no sentido da manhã para a noite, a não ser em junho e julho em que a maior quantidade de nuvens se regista ás XV horas.

O numero de observações de ceu limpo e de algumas nuvens é superior ao do ceu encoberto com ou sem *claros*. A nebulosidade média de Lourenço Marques (4.6) aproxima-se bastante do valor attribuido para esta latitude nas cartas *isonéfas*, e está proxima do limite superior da nebulosidade da Africa do Sul.

Os cumulus predominam todo o anno, e na epoca das chuvas os cumulus e cumulus nimbus. Os cirrus observam-se sobretudo á tarde, de janeiro a março, e em maio, frequentemente orientados de SW a NE, parecendo algumas vezes irradiar de um ponto do quadrante SW; movem-se mais usualmente de W para E. Os stratus são mais frequentes nas manhãs da epoca fresca.

Como é natural, o numero de horas de sol a descoberto está intimamente ligado com a nebulosidade. No Observatorio emprega-se o " Sunshine " Jordan que tem o inconveniente de registar as observações com um erro de 1 a 2 por cento por não serem as folhas impressionadas quando o sol está baixo.

A percentagem de horas de sol a descoberto está na razão inversa da chuva e nebulosidade, como se vê pela inspecção do graphico, onde se registou a percentagem de horas de *sol encoberto*, a nebulosidade e a chuva.

Esta relação não é perfeita, succedendo que os meses de menor percentagem de sol descoberto, outubro e novembro, não são os de maior chuva e nebulosidade.

Se sommarmos as percentagens de horas de sol e nebulosidade, vêmos que esta somma varia de 118 a 97, respectivamente nos meses mais chuvosos e nos mais sêcos, porque a percentagem de nebulosidade oscilla entre maiores limites—62 e 24—do que a percentagem de sol—73.5 a 52.3. Varia formulas se tem apresentado para ligar estes dois elementos, o que é difficil, attendendo a que pode registar-se grande quantidade de nuvens, sem encobrir o sol.

O maior numero de minutos de sol descoberto regista-se (Quadro No. XV) das XIII para ás XVI horas, isto é, durante as horas mais quentes e de maior velocidade do vento, decrescendo progressivamente ao aproximarem-se as horas do nascer e pôr do sol; quando augmenta nota-se um retardamento das XI para ás XIII horas e, durante o decrescimento, este accentua-se mais das XVI para ás XVII horas. (Em Lourenço Marques o sol está todo o anno acima do horizonte até ás XVII horas e 8 minutos). Estas alterações estão sem duvida ligadas ás dos outros elementos já mencionados. Estes factos são communs em todos os meses, com pequena differença. Nos meses de maior percentagem de horas de sol a augmento dá-se de preferencia das X para ás XVI horas.

Em tres annos de observação houve quarenta e cinco dias sem sol, isto é, em que o papel não foi impressionado, quinze dias em que foi impressionado menos de 10 minutos, e 46 entre 10 minutos e 1 hora.

Actinometro e irradiação solar e nocturna.

É conhecida a importancia do estudo da radiação solar pela sua influencia em todos os elementos meteorologicos.

No Observatorio emprega-se um actinometro de Marie-Davy, usando-se a formula de Bouguer. As suas indicações não são, como se sabe, de confiança, por varias causas, principalmente a absorpção dos raios caloriferos obscuros pelo vidro.

As experiencias, especialmente do professor Crova, mostram que a calor recebido do sol tem um maximo numa epoca intermedia entre o inverno e o verão, em maio no hemispherio N; durante o verão a intensidade diminue até alcançar um minimo, crescendo depois até um segundo maximo no outomno. Apenas possuimos observações completas durante o anno de 1912. Nestas observações notamos dois maximos um em fevereiro e outro em setembro, respectivamente 45.6 e 44.7 graus actinometricos e correspondentes aos dois maximos do outro hemispherio; os valores minimos são 36.3 e 41.2 graus actinometricos em maio e dezembro.

As observações fazem-se ás IX, XII e XV horas, o que não é bastante para se poder estudar a dupla variação diaria, e nellas se regista um maior valor nas observações do meio dia e depois nas das IX horas.

Tal como são feitas estas observações podem interessar mais particularmente á agricultura.

No estudo da radiação solar empregam-se no Observatorio, alem do actinometro, um thermometro de maxima irradiação solar, cujo reservatorio está coberto de negro de fumo numa camara de vidro onde se fez o vacuo, e um thermometro de minima irradiação nocturna, de alcool, que se colloca de forma que o seu reservatorio fique no foco de um espelho parabolico, metallico, dirigido para o Zenith.

Nos valores que apresentamos (Quadro No. XVI), medias de tres annos, não se nota senão a variação annual acompanhando a da temperatura á sombra.

Os respectivos graphicos dizem respeito á maxima média da radiação solar e aos valores—minima absoluta—de irradiação nocturna em cada mês.

Os valores—maxima e minima absolutas—de tres annos, nestes dois thermometros, são 75°.6 C. (168°.1 F.) e 7°.8 C. (46°.0 F.).

Thermometros na relva.

Observam-se as temperaturas na relva com dois thermometros, um de maxima de reservatorio negro e outro de minima, pretendendo dar uma ideia da maior quantidade de calor recebido e irradiado pelas plantas. Os seus valores, média de tres annos (Quadro No. XVII), interessam especialmente á agricultura, e acompanham sensivelmente a marcha annual da temperatura. Os valores extremos, registados durante o mesmo periodo, são 52°.2 C. (129°.6 F.) e 5°.7 C. (42°.3 F.).

Temperatura do Terreno.

A temperatura do solo offerece bastante interesse pelos seus effeitos na temperatura do ar, sobretudo pelo que respeita ás suas variações.

O solo aquece e arrefece tanto mais facilmente quanto maior é a sua conductibilidade, poder emissor, poder absorvente e capacidade calorifica.

Na areia concorrem em maior grau todas estas circumstancias favoraveis, ao contrario do que succede com a agua.

A temperatura do solo, ainda que menos importante na vida vegetativa do que a temperatura do ar, é no entanto um elemento a considerar. Por sua vez, a vegetação, bem como a evaporação, alteram a temperatura do terreno.

É tambem para notar que alguma relação parece existir entre a temperatura do terreno e a existencia e desenvolvimento de certas doenças, como a diarrheia e a febre typhoide.

A leitura dos thermometros collocados a 0.5, 1, 2 e 3 metros de profundidade effectua-se ás IX horas, e das medias dos seus valores, para um periodo de tres annos, publicamos um quadro No. XVIII.

Como é natural, existe acordo com as tres leis da temperatura do solo, a saber: a da amplitude, a do retardamento na epoca dos valores extremos e, por ultimo, a da reducção da amplitude com o periodo considerado e com a profundidade.

Trovoadas.

As trovoadas são muito mais frequentes em dezembro e depois em outubro, novembro e maio, e menos em junho, julho e agosto, coincidindo esta frequencia com a das perturbações atmosphericas; já mencionámos o facto de, quando o vento ronda para o S na passagem das depressões, vir ás veses acompanhado de trovoadas.

Quando as mais baixas pressões se estabelecem para W ou SW e o barographo principia a traçar uma linha sinuosa, são vulgares as trovoadas com aguaceiros de W. As grandes trovoadas, que ás vezes duram horas, são acompanhadas de vento fresco variavel em direcção. São mais vulgares ao anoitecer e menos do nascer do sol ás XIII horas. Como se vê, as trovoadas em Lourenço Marques podem, na sua maioria, classificar-se em *trovoadas de depressões* de preferencia a *trovoadas de calor*.

Os relampagos sem trovões registam-se muitas vezes um ou dois dias antes da passagem das depressões e a sua frequencia segue a mesma marcha da trovoada.

Outros phenomenos.

Apresentaremos ainda um mappa com varios elementos meteorologicos, alguns dos quaes já foras considerados: (Quadro No. XIX).

O nevoeiro é mais frequente na estação fresca, sobretudo de manhã. O granizo regista-se poucas vezes, sendo digno de nota pela sua abundancia o que em 1912 caiu na cidade baixa.

As corôas lunares observam-se muitas vezes e os halos, que são pouco frequentes, assignalam em geral uma proximidade de chuva.

Consideracoes geraes.

Procurámos, sem alongar demasiado este trabalho, apresentar os elementos mais importantes para o estudo de um clima, guiando-nos na sua enumeração pelas indicações dos professores J. Hann e Cleveland Abbe, em harmonia com as observações de que dispunhamos.

Se pretendermos abranger numa unica designação os caracteristicos do clima para uma determinada região, poderemos adoptar variadas classificações, agrupando dois ou mais dos seus principaes elementos meteorologicos; e como estes já ficaram definidos em relação a Lourenço Marques, passaremos em revista quaes as classificações que se lhe podem adaptar, considerando as bases geralmente admittidas.

A primeira e mais antiga classificação é a *solar* ou *astronomica* em tres zonas: tropical, temperada e arctica.

Lourenço Marques está fóra da zona tropical, na sua verdadeira accepção, e no emtanto Supan, cuja classificação está muito aceeite, limita estas zonas, não pelos parallelos de latitude, mas pelas linhas isothermicas, confinando a zona tropical pela isothermica de 20° C. (68° F.) com a qual coincide aproximadamente o limite dos *ventos geraes* e das palmeiras. Segundo esta classificação, Lourenço Marques está na zona tropical, mas, se passarmos em revista os seus principaes elementos meteorologicos, comparando-os com os caracteristicos das zonas tropical e temperada (temperatura, pressão, respectivas variações, humidade, estação das chuvas, quantidade de agua recolhida, etc., etc.), vê-se facilmente que estes elementos estão influenciados mais ou menos regularmente pelas duas zonas principaes. Por isso nos agrada mais a classificação de Koppen que, attendendo ás relações com a vida organica, considera especialmente o numero de meses do anno em que a temperatura se conserva dentro de certos limites.

Nesta classificação, a termo *sub-tropical* applica-se ás regiões onde quatro a onze meses são quentes, acima de 20° C. (68° F.), um a oito meses temperados entre 10° a 20° C. (50° a 68° F.) e onde o regime das chuvas é geralmente caracterizado pela sua pouca abundancia.

Lourenço Marques está bem comprehendida nesta zona com a sua temperatura média mensal durante nove meses acima de 20° C. (68° F.), os restantes tres meses com valores inferiores a este mas acima de 10° C. (50° F.), e com a totalidade de chuva de 677^{mm} (26".660)—*chuva moderada*.

Outra base geral para classificação de climas é a *geographica* que comprehende tres divisões—continental, oceanica, insular ou litoral; esta ultima que corresponde a Lourenço Marques participa mais ou menos dos caracteristicos definidos das outras zonas.

Sob o ponto de vista *aero-physico*, o clima tem sido classificado: quanto á *temperatura*: quente, intermediario e frio, ou regular, medio e extremo; e quanto á *humidade*: humido, intermedio e sêco. Pelo que respeita á temperatura de Lourenço Marques, alem do que já ficou mencionado, podemos classificar o seu clima como *regular*, pois assim se considera quando a variação da temperatura annual é inferior a 10° C. (18° F.) e aqui a differença entre os meses mais quentes e mais frios não chega a 8° C. (14°.4 F.). Se attendermos á humidade, já vimos que lhe competia a designação de *moderadamente humido*, com a sua humidade relitiva annual e mensal entre os limites 68 e 80 por cento. Como dissemos, outras classificações mais restrictas teem sido apresentadas pela combinação de dois ou mais elementos meteorologicos. Por simples menção diremos apenas que na classificação em trinta e cinco provincias climatologicas de Supan, pertence a esta região o nome de *Provincia Tropical de Africa*, e na classificação de Koppen, debaixo do ponto de vista botanico, a designação de *Mesotherma*.

Resta-nos ainda falar de uma base de classificação *Physeologica*, que comprehende dois grupos:

(*a*) Segundo as sensações que produz:—clima suave, agradavel, humido, desagradavel, etc.:

(*b*) Segundo os effeitos geraes de cada clima:—reconstituinte, deprimente, rigoroso, etc.

É-nos mais difficil abordar este assunto por falta de competencia, pelo que sobre elle faremos apenas ligeiras considerações.

Em nossa opinião, Lourenço Marques não pode comprehender-se numa unica d'estas divisões, dada a diversidade de regimes apontados, quer nas duas estações, quer de mês para mês. Não é de mais repetirmos aqui a affirmação já feita quanto á variabilidade de sensações produzidas por pequenas alterações de temperatura nos diversos europeus que habitam as regiões tropicaes e que tal facto é principalmente dependente do seu depauperamento physico e do estado hygrometrico da atmosphera; citarei ainda, por exemplo, o facto de na impressão pessoal ter influencia, o seguir-se a um dia bastante quente outro de menor temperatura mais humido ou menos ventoso, o que exaggera a sensação do calor.

Consideremos agora, muito superficialmente, os effeitos do clima. Como vimos, o anno pode dividir-se em duas epocas, *quente e chuvosa* de outubro a março, *fresca e quasi sêca* de abril a setembro, pois as quatro estações não são aqui bem caracterizadas.

Durante os meses mais quentes e humidos o clima tem aproximadamente caracteristicos de tropical, mas os ventos predominantes do lado do mar, soprando, mais fortemente ás horas de maior calor, concorrem para o amenizar.

O ceu apresenta-se por vezes com o aspecto dos climas tropicaes, e a passagem das perturbações atmosphericas com os *ventos quentes* do N, seguidos de ventos frios do S, tornam estes meses desagradaveis e depauperantes. Estas depressões tambem se sentem na estação fresca, menos frequentemente comtudo, nos meses melhores.

Os meses de fevereiro e março são talvez os mais accentuadamente tropicaes, pela maior frequencia de calor humido, que ás vezes se sente ainda em abril e maio.

Apezar do clima nesta epoca não ser absolutamente bom, os seus effeitos deprimentes sobre o organismo podem em grande parte ser corrigidos por medidas de hygiene apropriadas. Assim o affirma Sir Patrick Manson quando, escrevendo sobre doenças tropicaes, diz: "acclimatisation is less an unconscious adaptation of the physiology of the individual than an intelligent adaptation of his habits."

Sobre a adaptação da raça branca nesta cidade o Sr. commandante Hugo de Lacerda friza a semelhança d'este clima com o de Durban, onde a raça branca se tem adaptado. Esta semelhança é bem conhecida e pode confirmar-se com a analyse das circumstancias meteorologicas das duas cidades, onde, como vimos, a temperatura é sensivelmente identica, bem como a humidade relativa, sendo aqui inferior a quantidade de chuva.

Na estação fresca o clima pode considerar-se bom, especialmente os meses de junho a outubro, cuja temperatura e menor humidade os torna muito agradaveis e reconstituintes.

Uma rapida consulta aos relatorios dos Ex.^{mos} Srs. chefes do Serviço de Saude, no que diz respeito ao districto sanitario de Lourenço Marques, põe igualmente em destaque as boas condições sanitarias durante os meses mais frescos, e que o estado sanitario é considerado muito bom, especialmente de junho a outubro.

Finalmente, em reforço da nossa opinião sobre o optimo clima da estação fresca, citaremos as seguintes phrases do Sr. commandante Hugo de Lacerda:

"No inverno, durante o regime de bom tempo, ainda com os ventos S. o clima pode-se pôr a par dos melhores do mundo; ha dias nessa epoca tão amenos e luminosos que bem podem merecer a vulgar designação de dias criadores, produzindo um bem estar muito apreciavel.

"A temperatura média em Lourenço Marques nos meses mais sêcos do anno é proximamente igual á temperatura média annual do Transvaal, e a temperatura média dos meses de junho a outubro corresponde á temperatura média dos meses de novembro a abril, de Middelburg; os habitantes d'essas regiões teem, portanto, para onde fugir facilmente aos rigores da temperatura baixa d'essa altitude, vindo para a que então se pode chamar—a 'costa azul' da Africa do Sul."

(TRANSLATION.)

DATA FOR THE STUDY OF THE CLIMATE OF LOURENÇO MARQUES.

By AUGUSTO DE ALMEIDA TEIXEIRA.

This work is mainly based upon observations made at the Campos Rodrigues Observatory and those obtained at the old Port Captain's and the Swiss Mission's stations.

In the course of this work reference is frequently made to the meteorological elements of South Africa. These have been culled from the most excellent papers written on the subject by Messrs. Robert T. A. Innes (Director of the Union Astronomical Observatory), J. R. Sutton, Director of the Kimberley Observatory), Charles Stewart (Chief Meteorologist for the Union), Colonel H. R. Rawson (Member of the Meteorological Commission), and Commander Hugo de Lacerda (late Chief of Marine Services for Mozambique), some of which have been published in the Reports of the Annual Sessions of the South African Association for the Advancement of Science.

TEMPERATURE.

Temperature is unquestionably the principal element to take into account, whatever may be the aspect under which one wishes to study the climate of a certain district. The mean annual temperature at Lourenço Marques, according to observations made in 14 years, is 22.2° Centigrade (72° Fahr). The mean monthly temperature is expressed in Table No. I.

The difference between the hottest month, January, and the coolest, July, therefore, is not as much as 8° C. (14° F.) thus permitting of the climate being called *regular*, a natural consequence of the position of Lourenço Marques, which is surrounded from NNE to SW by the waters of the Incomati River, the Bay and the estuary of the Espirito Santo River. This circumstance, the predominance of sea breezes, especially in the hottest hours of the day, and, lastly, the scarcity of calms, contribute to improve the temperature and make the climate far more pleasant than could be expected from its geographical position.

It is well known that the Mozambique current has the effect of warming the East Coast of Africa, while the Benguella current produces the cooling of the West Coast, as confirmed by an inspection of the isotherms, from which it can be seen that to equal latitudes higher temperaures correspond in the former coast, and that temperature increases from South to North.

Similarly Mr. C. Stewart, by analysing the temperatures in South Africa, concluded that an increase of temperature took place from West to East along the parallels of latitude, and from South to North along the East Coast.

In studying the particular case of Lourenço Marques, the comparison of the local temperatures cannot be made at first sight with those of the Western Districts, owing to the large difference in altitude and to the position of Lourenço Marques on the littoral; it is an easy matter, however, to make such a comparison with other places on the coast.

From such a comparison (see Table No. II) one concludes that the increase in temperature between Durban and Lourenço Marques is smaller than one might expect from the difference of latitude (234 miles) existing between the two places.

Thus the annual means at Lourenço Marques exceed Durban only by 0.6° C. (1.1° F.), the means for the hottest month being 1.1° C. (2° F.), while the temperature in the coldest month is practically the same in both towns.

The extreme temperatures—absolute maxima and minima—are higher at Lourenço Marques respectively by about 1.3° C. (2.3° F.) and 2.1° C. (3.8° F.).

If we compare Durban with East London, at a distance of 190 miles in latitude, we find much greater differences, and the same occurs between Lourenço Marques and Inhambane, where the latitudinal difference is 124 miles, while it should be noted that Inhambane differs considerably as to the absolute maxima and minima, owing to its diverging to a great extent from the meteorological conditions of the South African littoral.

These comparisons are favourable to Lourenço Marques as to the increase in temperature from south to north, and show the similarity of the climate as to temperature in the towns of Lourenço Marques and Durban, a larger difference being noted in the absolute minima, which are lower in the latter place.

This circumstance may be partly due to the configuration of the coast to the South of Zavora Point, and the extent of the Bay, which compel the Mozambique current to keep away from Lourenço Marques, thus preventing the increase of temperature there, but this can only be definitely ascertained by means of a more detailed study of the currents.

From the analysis of temperatures in the various months, one finds that the temperature in the months from May to October is rather agreeable, the percentage of relative humidity also being smaller in these months. The temperatures being higher, the climate from December to March becomes more tropical, especially in the last two months, which are the dampest. In the remaining month, which may be called transitory, the temperature is more pleasant.

The four seasons are not well marked by special characteristics. The transition months cannot be called "Spring" and "Autumn," and it is more correct to divide the year into two seasons, that is, the warm and rainy season from October to March, and the cool and practically dry season from April to September.

In Table No. III the variations of temperature are registered, with the monthly means of temperature and rainfall.

Differences in the same period during the rise of temperature are smaller and more regular than during its decrease. This is, perhaps, due to the influence of the rainfall, which retards the rise of temperature, thus decreasing it, while, on the contrary, in the month of least rain the decrease takes place more rapidly. It should be noted that these months are less cloudy, and this fact, combined with the great nocturnal radiation caused by the higher duration of the night, must contribute to a quicker decrease.

The march of the sun bears upon the annual variation of temperature, and the usual retardation takes place.

Variations of temperaure in day time show very little irregularity. The minimum occurs normally before sunrise and the maximum at about XIII, the increase being more rapid and pronounced between VII and IX; after this hour, owing probably to the influence of sea breezes, the increase becomes more slow.

The decrease of temperature at sunset is not so pronounced: from midnight to the hour when the minimum temperature occurs the decrease is generally 1° C. Annual nocturnal radiation seems not to have so great an influence as one might expect, which may be explained by the fact that dew is more frequent in less cloudy nights, and this compensates for radiation, owing to the great amount of heat liberated by the condensation of water vapour existing in the atmosphere. Dew occurs far less frequently in the dry season. The mean daily oscillation, the annual range of which is about 10° C. (18° F.), attains its maximum—11° to 12° (20° to 21.5° F.)—from April to August, while in the other months it decreases steadily to 7° C. (12.6° F.). This difference arises from the fact that, the mean maximum variation oscillating about 7° C. (12.6° F.), the minimum variation oscillates 10° C. (18° F.), that is to say, the oscillation of the minimum temperature is much greater than is the case with the maximum temperature, this being the opposite of what happens in Lisbon. I think that this can be accounted for by the coincidence here of rainfall and the greater cloudiness in the hot season. Besides the *hot winds* from N and NNW, caused by the occurrence of atmospheric disturbances, are also felt in the cool season, and cause increases of temperature which are relatively more important than in the other season.

An analogous difference exists between the absolute maximum and minimum, which is due to the same causes.

These temperature extremes are rather interesting for the study of a certain climate, although the development of endemic diseases depends, according to some writers, on the mean temperatures. Europeans residing in this climate become much more sensible to the variations of temperature even in respect of such small decreases as cause no impression in Europe, and the longer their term of residence the more they feel such variations, this being possibly due to physical exhaustion and the hydrometric state of the atmosphere. The apparent need for avoiding chills in these climates, owing to their bad consequences, also lends importance to the knowledge of temperature extremes.

An examination of the absolute maxima and minima shown in Table No. IV gives one an unfavourable impression, but these extreme variations are due to the *hot winds* from NNW that precede atmospheric depressions, and are immediately followed by fresh South Wind which causes great decreases of temperature, these being at times as much as 16° C. (28.8° F.) within one and a half hour.

This undoubtedly important circumstance is common to the whole South African Coast, from Walfisch Bay to Durban.

From the observations of three complete years I have obtained the following data:—

Maximum temperature higher than 35° C. (95° F.) was registered	21 times.
Maximum temperature higher than 40° C. (104° F.)	5 ..
Minimum temperature between 9° and 10° C. (48.2° and 50° F.)	21 ..
Minimum temperature between 8° and 9° C. (46.4° and 48.2° F.)	6 ..
Minimum temperature between 7° and 8° C. (44.6° and 46.4° F.)	once.
Minimum temperature equal to 25° C. (77° F.) . .	once.
Minmum temperature between 24° and 25° C. (75.2° and 77° F.)	8 times.
Minimum temperature between 23° and 24° C. (73.4° and 75.2° F.)	26 ..
Variation of temperature on the same day, 25.8° C. (46.4° F.)	once.
Variation of temperature on the same day between 20° and 25° C. (36° and 45.5° F.)	17 times.
Variation of temperature on the same day between 15° and 20° C. (27° and 36.4° F.)	67 ..

Thus temperature higher than 40° C. (104° F.) and lower than 9° C. (48.2° F.) may be considered exceptional, and the same can be said of variations in one day higher than 20° C. (36° F.).

Similarly, one concludes that the minimum daily temperature is rarely higher than 24° C. (75.2° F.), very seldom above 23° C. (73.4° F.), and for this reason the heat at night is not, as a rule, very troublesome.

I am therefore of opinion that these extreme temperatures and high variations in one day should not have a very unfavourable result, owing to their rare occurrence. It should also be noted that temperatures above 40° C. (104° F.) are registered in temperate climates, such as Lisbon and in France, where the minima are far below those obtaining here.

I shall refer again to this NNW *hot wind* that has always been registered whenever the temperature exceeded 32° C. (89.6° F.).

This wind is unquestionably unpleasant. It is extremely dry, and causes an impression not less disagreeable than the hot damp winds.

Barometric Pressure.

Barometric Pressure, which plays an important part in meteorology, is of secondary importance in the study of a climate and its consequent influence upon human life, especially if we do not consider its effects upon the other elements, as its oscillations seem to have a perceptible influence upon the human body, and only in very high altitudes does it become a climatic factor of importance.

In Table No. V the monthly and annual means of the pressure are shown for a period of seven years, reduced to 0° C. at sea-level.

Besides the double diurnal variation, improperly called "tides," which are more or less satisfactorily accounted for by various theories, the annual variation taking place is well defined. The minimum in December and the maximum in July, and the annual means, correspond to the April means, for the same period of seven years.

These annual variations occur in the opposite direction to the variations of temperature, as is usual in temperate continents.

If we analyse the variations in 24 hours we notice that the nocturnal minimum generally occurs from III to IV, while the diurnal minimum takes place, as a rule, between XV and XVI, while the morning maximum is registered between VIII and IX, with a tendency to occur earlier from October to December; the nocturnal maximum is late, usually occurring between XXIII and XXIV, and even after midnight. The diurnal minimum is about 1.5^{mm} (0.059″) lower than the nocturnal minimum, this being more pronounced from October to January; the diurnal maximum exceeds the nocturnal by about 0.5^{mm} (0.0197″), the higher difference taking place from June to October; consequently, the difference between the diurnal maxima and minima is more pronounced than is the case at night. Most of these facts seem to be explained by the daily march of temperature, as mentioned before, and to be connected with the hours of sunrise and sunset.

The extreme pressures as registered at the Observatory are: Maximum, 779.4^{mm} (30.686″); minimum, 746.2^{mm} (29.378″); *i.e.*, an absolute variation of 33.2^{mm} (1.308″), which is within the limits registered at Durban and East London. The absolute minima naturally correspond to the occurrence of depressions, and are followed by the maxima, which become more pronounced when the anticyclonic system becomes more stably fixed upon the plateau.

Besides these two regular variations, daily and annual, one has also to consider the irregular variations arising from the *passage of areas* of high or low pressure.

As an instance of one of these disturbances and its effects on the other meteorological elements, I shall mention the respective hourly ranges of a depression on the 28th September, 1912, which may be of very little interest to those who have studied similar phenomena in any other locality in South Africa, but which will serve to give evidence as to the analogy of the meteorological conditions of Lourenço Marques with those of such places.

The mere observation of Table No. VI shows all the effects on temperature, the direction and velocity of the wind, vapour pressure, and relative humidity. Depressions, by causing NNW and N *hot winds*, practically in every case have some influence on evaporation, and render it excessive, thus requiring special attention to avoid the shortage of water in the evaporimeter and psychrometer.

In this depression the duration of the *hot wind* was as usual; but the rapid decrease of temperature, when the wind, after a short calm, veered to the south, was not very pronounced. This calm generally lasts a maximum of 20 minutes, when the south wind breaks out with violence, sometimes with a velocity of 70, 80, and even 100 kilometres per hour, and brings about the so-called "dust storms," which are less frequent here than in other localities of South Africa.

Depressions are not always preceded by cirrus clouds, and when this occurs it is chiefly noticed two or three days before.

A few hours before the wind veers to the south the horizon frequently becomes cloudy, and the sky gradually obscured by cirro-stratus, followed by cumulus and cumulo-nimbus. The south wind is at times accompanied by rain, which is more frequent on the second and third days, especially in the rainy season, but it never rains when the wind comes from the north.

On other occasions it is accompanied by thunderstorms. The ESE wind, which on this occasion was registered at XII on the 29th, prevailed for a good many hours, as is frequent, with variable velocity, being sometimes quite fresh, and it finally veered to E and ENE.

I had the opportunity of ascertaining, in 1912, that depressions are felt in Durban from eight to 20 hours before they occur at Lourenço Marques. They are generally more frequent in May and from August to December, and last a shorter period in the dry season than in the rainy season. This example seems to prove in a general way the following conclusions which Dr. Sutton arrived at in his paper "On the variation of the hourly meteorological normals at Kimberley during the passage of a barometric depression":—That depressions greatly increase the normal variation of pressure and temperature; that they influence cloudiness, especially in the case of low level clouds; that they originate rains, which are more abundant on the second day; and, finally, it seems to me that it can also be concluded that they come inland, by preference from the S or SW, and not from the N, also that they do not travel across South Africa from west to east, etc., etc.

I lack, however, sufficient data for a detailed study of these depressions, and such would not come within the scope of this paper, which I do not intend making too long.

Wind.

In Lourenço Marques the hours of calm are very rare, and this fact, combined with the prevailing sea-breezes, contributes to a great extent to make the climate more pleasant.

From 1909 to 1912, 24, 2, 29, 61 hours of calm respectively were registered, this being very insignificant, and not reaching an average of 30 hours per annum.

The Anemometers at the Observatory are placed over the building, which is situated on very even ground; for many kilometres around there is nothing higher than the Observatory itself.

In Table No. VII, giving the means for four years, one sees that only in a limited number of days is the wind light, that strong winds are even less frequent, and that only moderate winds are really very frequent.

As to the variation of the direction of the wind, it would be an easy matter to foresee, on account of the position of Lourenço Marques on the littoral, the very pronounced influence of the land and sea-breezes. Land breezes make themselves felt particularly from April to August, and not so much in November and December; they begin at about XXIII, and generally go down after IX, and not later than XI. It is most rare to get wind from the W quadrant after noon, except when there is the NNW *hot wind*.

During the months when this system is well established, it is only when the N or S wind blows violently that it does not veer to the W quadrant during the night.

According to the rule applying to circumstances such as are peculiar to Lourenço Marques, the velocity of the wind is higher in the day time than at night; it is weaker between the hours O and III, and increases steadily until XVI, and a fresh wind prevails until XIX. As will be seen, the velocity of the wind is connected with the variation of temperature, but when the latter decreases, the velocity of the wind does not usually immediately diminish.

Two facts should be mentioned: at XI the velocity of the wind generally decreases, and this may be explained by the influence of the land and sea-breezes, as the decrease is more pronounced from April to August, and it is at this time that the wind generally changes. The more pronounced decrease in wind velocity from XXI to XXIII is perhaps due to the same cause.

The rule as to land and sea-breezes being more intense in the months of greater variation of temperature and the smaller velocity of the other prevailing winds, accounts for such a condition being more pronounced in the months from April to August. At Lourenço Marques the average velocity of the wind is highest from September to January.

Tables VII, VIII and IX, showing the frequency and the number of kilometres traversed in the different courses, facilitate considerably the analysis of the conditions in the various months.

In the hottest season, from October to May, ENE and SSW winds prevail, with a small percentage of winds from the NW quadrant and from SW to W directions. The prevailing wind from the SW quadrant successively veers to SW from October to May, and an increase in the percentage from NE to ENE is similarly noticed up to February, when the latter direction prevails, decreasing, however, considerably in March. Thus, the prevailing winds during the hottest months are the sea winds and also the SSW wind, which is rather cold. In the remaining months, when the land and sea breezes are more pronounced, the W winds are naturally more frequent. The frequency of the NNW wind increases from April to June, and decreases in the three following months. Up to June the wind increases in frequency from SE to SW, and it again blows with more frequency from S, SSE and from the NE quadrant.

In short, the winds from the W quadrant, principally NNW and next SSW, prevail in May, June, and July; in November, December, and January the winds from NE and SE quadrants prevail, especially ENE, E, ESE, and also S.

The other months may be regarded as a transition between these more clearly defined conditions.

The percentage of the number of kilometres traversed in the different directions accompanies the percentage of frequency, the former showing an increase in the directions in which, as we have seen, the wind blows more violently.

The Monsoons at the N of the Mozambique Channel are not felt here, although they may also have some influence on the velocity and direction of the wind.

A study of Table No. X shows the influence of the SE trade wind which, as is known, prevails in the Indian Ocean in this latitude, as the annual resultant is always approximately SE, and in most months, especially in the hot months, the resultant also falls to the same quadrant. These figures show a great displacement of air toward NW, which is no doubt due to the great aspirator of Equatorial Africa, as Commander Hugo de Lacerda had already concluded in 1909, thus justifying the greater frequency of depressions in the hot season through this aspiration being more pronounced. Commander Hugo de Lacerda put forward the hypothesis that the high pressure systems of the two Oceans that wash the coast of Africa might compensate for the loss of balance which shows a tendency to occur in Central Africa, and strengthened his opinion by the circumstance of there being no resultant at Kimberley.

When I referred to the barometric disturbances I mentioned the existence of the *hot winds* which are common to the South African littoral. Most of the distinguished Meteorologists who have studied these winds consider them absolutely similar to the *Foehn of the Alps*, which was ably accounted for by Dr. Hann, and is a very warm, dry wind, which blows in the North of the Alps when a cyclone occurs in Western Europe, with the lowest pressure in England and the lightest in the Eastern Mediterranean, and in the south of the Alps in Italy, when the reverse is the case.

If we take Lourenço Marques only into account, a similar explanation might at first sight appear as not being very apposite in view of the distance from the high mountains towards N and NNW, and the fact, besides, that the elevation of the littoral to the Rhodesia plateau is not abrupt.

Originating, however, in Equatorial Africa, it is natural that its temperature should be high, and the descent towards the littoral makes it even warmer and drier, as in its passage towards the south it does not travel through any region that could decrease its temperature or increase its humidity.

Absolute analogy with the winds of the South African coast serves to justify this explanation, and this is also backed by the fact that in Inhambane it is not so characteristically hot and dry. The wind there does not come, however, from high plateaus in the interior.

In opposition to this hot wind we have the south wind, the low temperature of which has a greater influence on the climate owing to its greater frequency than the NNW, which, as I said before, lasts only a few hours and is seldom felt; it should not, however, be mistaken in the percentage diagrams for the NNW caused by the land-breeze.

I shall again call attention to the violent winds, with a velocity corresponding to 60, 70, 80, and 100 kilometres per hour, which are felt at times when the south wind commences to rise during an atmospheric perturbation.

The highest hourly velocities registered during the observations of 4 years were: 88 kilometres with SSE wind and 77 kilometres with south wind in October and March, 1911, velocities varying from 60 to 70 kilometres being often recorded.

At Lourenço Marques no daily backing or veering of the wind is noted.

Relative Humidity and Vapour Tension.

According to the widest classification a climate, the relative humidity of which falls between 66 % and 80 %, is considered as *moderately moist*, and this classification should apply to Lourenço Marques, where, according to Table No. XI, not only the annual but the monthly means are comprised within these limits.

Knowledge of the hydrometric condition of atmosphere is a valuable element owing to its depressing and disagreeable influence, especially in high temperatures. In Lourenço Marques, as we have seen, the excessively dry *hot wind* is very unpleasant, although it is unquestionably less prejudicial to health than a warm damp wind. The greatest percentage of relative humidity corresponds to the first 5 months of the year, and the smallest is recorded from July to October, which are the months of lowest temperature and very scarce rains.

The excess of humidity from March to May contributes to make these months worse than what might be expected if we only took into consideration their comparatively low temperature.

If we compare the diagrams of monthly temperatures with those of relative humidity we shall see that they follow different directions, but there exists no perfect relation between them, as there is a certain retardation in the march of the humidity curve. Thus in April, when the decrease of temperature is already noticeable, humidity attains its maximum, and then it begins to decrease until September, when it reaches its minimum, while the temperature rises from July on.

In relation to the rainy season relative humidity attains its maximum at the close of the season, and the minimum is reached in September just after the amount of monthly rainfall begins to increase.

The fact that sea winds prevail in the hot season should also have its influence on the ranges of relative humidity, as according to observation the dampest winds are those of NE to SSW through the E.

In theory, relative humidity, $\frac{f}{F}$ being the ratio between vapour tension f (absolute humidity) at a certain moment, and vapour tension F at saturation, should decrease according to temperature, as the numerator does not increase much, while the denominator becomes greater.

We have already seen how a retardation occurs in the annual variation in relation to the march of temperature; let us now see the latter's influence on the diurnal variation.

The maximum relative humidity precedes sunrise, and coincides with the thermometrical minimum; the minimum generally occurs at about noon, before the maximum temperature, and the decrease follows regularly the rise of temperature. The increase in the percentage of humidity is more rapid from the hour of the minimum until the XXI; afterwards it slowly increases and saturation, or near approaches thereto, are recorded.

The absolute minimum of relative humidity corresponds to *hot wind* days, and it goes down as far as 8 per cent.

The mean annual variation is 33, and similarly to the variation of temperature it is greater in the coolest months, the same occurring with the difference between the absolute maximum and minimum. Sometimes a rapid increase in relative humidity and vapour tension is recorded at XXI, this being no doubt connected with the aforesaid march of the variation of temperature.

The march of vapour tension, both annual and daily, regularly follows temperature. Mean annual vapour tension is 14.71^{mm}, and the mean variation oscillates between 3.11^{mm} and 5.15^{mm} in a similar but more regular manner than is the case with temperature, and the same agreement exists in its differences. The diurnal minimum takes place at the hour of the minimum temperature; the maximum varies between XIII and XVII, and is later than the maximum temperature, especially in the coolest months.

The extreme ranges in 4 years are: Maximum 26.7^{mm}, minimum 4.3^{mm}.

The foregoing emphasises to a considerable extent the high condition of relative humidity during the night.

Dew is very frequent from June to September. The rain gauge (2 decimetres in diameter) sometimes records 0.1^{mm}, 0.2^{mm}, and very seldom 0.3^{mm}.

The dew and fog water collected in the rain gauge in 1912 amounted to 12.1^{mm}. It should be noted that the percentage of cloudiness last year was less than usual.

It is generally acknowledged that the percentage of cloudiness has a considerable influence upon dew. The smallest amount of average cloudiness in Lourenço Marques is at XXI in relation to the hours of observation. I should, nevertheless, mention that Dr. Sutton, as a result of his direct observations at Kimberley, concluded that a clear sky was not essential to the formation of dew, that this merely contributes to hasten its commencement, and that the dampness of the air and the length of the night are the determining factors in the formation of dew.

I often noticed that there was abundant dew in cloudy nights, and this fact confirms Dr. Sutton's opinion.

There is no dew with N and NNW winds, the former showing a higher record during such nights when a gentle landbreeze is blowing.

RAINFALL.

The meteorological data of regions which, like Lourenço Marques, are situated within the zone limits, is more or less affected by the characteristics of the two zones with which they connect.

The rainy season in Lourenço Marques from October to March, namely, when the sun is nearer the zenith, corresponds to the tropical condition (*vertical sun*). During the six months from April to September, the quantity of water recorded by the rain gauge is about one quarter of that falling during the rainy season, a small increase being noticed in the month of July, which, though insignificant, may perhaps have its origin in the *winter rainfalls*, which are more common in sub-tropical climates.

The annual rainfall mean is 677^{mm} (26.660″), which figure is still comprised in the designation of "moderate rainfall," but approaching very closely to that called "light rainfall."

Lourenço Marques being situated within the dry zone (20° to 30° latitude), so classified according to the laws of circulation of the atmosphere, which are deduced on the assumption of the earth's surface being homogeneous, and furthermore owing to the fact that in these latitudes the rain is scarce when a component of the wind is diverted from the pole to the equator, will account for the total rainfall being inferior to the average amount of water falling in the tropical zone.

The examination of a chart of distribution of rainfall will show that the dry zone is mostly accentuated in the southern hemisphere, on the west coasts of continents, this being due to various causes, such as: prevailing direction of the wind, existence of mountain ranges, cyclonic conditions, etc. The conditions of Lourenço Marques coincide with this, when neither the heaviest short downfalls, nor moderate rainfalls lasting continually for many hours, are frequent, as often happens in temperate zones and in some parts of the tropical zone.

In the Table No. XII the average monthly and annual amounts of rainfall collected are shown, also the average number of rainy days according to the records of 14 years. At the Observatory, all days on which an amount of over 0.1^{mm} is recorded, are considered as rainy days.

The months of most rainfall are December and January, and the driest are June, July, and August.

The chart showing the percentage of rain corresponding to the different directions of the wind gives evidence of its abundance when the latter blows from SSE to SW, but chiefly from the S and then from the SSW. In relation to the other wind directions the percentage is much lower, especially the directions N and NNW, where it is insignificant.

A higher percentage of rainfall corresponds to the direction W, which is due to thunderstorms being more frequent from that side, although showers from various directions are recorded in the most violent thunderstorms.

Nearly all the above-mentioned authorities reject not only the theory of the prevailing SE winds, but further that those winds cause the rain in South Africa.[8] Mr. C. Stewart adds that rain may be expected at Port Elizabeth and East London whenever the winter northwesterly winds veer from north to south in the Cape Peninsula, indicating the passage of a disturbance to the north-east, and records the fact that in Port Elizabeth in the only month when the SE was at all prevalent the rainfall was 80 % below normal.

In Lourenço Marques the most abundant rainfalls correspond likewise to the passing of depressions, also sometimes to the veering of the wind from N to S, but more generally on the next day or the following one. It is also worth noting that the months showing greater percentage of wind from SE do not correspond to a defined increase in the amount of rain. In short, rainfall in Lourenço Marques, following the type of *tropical rainfalls* to the season, is closely connected with the passing of depressions, and approaches the rainfall known as *cyclonic rainfall*.

When in the isobars the centre of high pressure is established at Lourenço Marques, small showers are sometimes recorded with changing winds, which is in disagreement with the theory of "convectional" rainfalls, because, as is known, descending air currents correspond to the centres of high pressure, and such currents are the least likely to promote rain.

In Lourenco Marques rainfalls are very frequent from IV to IX and after XVIII; during the remaining hours it rains more at night than during the day, and it rains the least from XV to XVII, that is to say, when the velocity of the wind is greater.

During four years—1909 to 1912—on 20 different occasions, rainfalls have been recorded which registered over 30 millimetres in 24 hours. Of these the highest figures recorded by the rain gauge are as follows:

In 1909—January 70^{mm} (2.757″) in 1 hour 15 minutes.
November 30^{mm} (1.181″) in 15 minutes.
December 50^{mm} (1.969″) in 15 minutes.
December 96^{mm} (3.781″) in 4 hours.
In 1910—February 181^{mm} (7.128″) in 12 hours.
October 43^{mm} (1.693″) in 40 minutes.
In 1911—October 50^{mm} (1.969″) in 1 hour.

Together with the percentage of sunless hours and cloudiness, I give a diagram of rainfall which I consider interesting on account of the general impression it affords as to the connection of these three elements, and of the general condition of the atmosphere.

I also introduce a diagram showing the average monthly number of rainy days and thunderstorms.

Evaporation.

A "Piche" evaporimeter is employed at the Observatory to measure the evaporation, the instrument being read at IX. As is known, the study of evaporation is not well defined, it being impossible to compare the observations made with the same instrument in two different localities, this being principally due to the influence of the temperature on the water. It is admitted that evaporation increases with the temperature of the water and the velocity of the wind, and decreases with humidity and atmospheric pressure. This is what actually takes place in Lourenço Marques, where the influence of the temperature and the velocity of the wind are quite manifest, both on variations from day to day and from month to month. This latter factor is, however, the prevailing one, as evaporation is greater during the hot season, in the month of greater wind velocity. In the month of March, which is characterised by an increase in the velocity of the wind, the evaporation likewise increases. The influence of pressure and humidity, which are factors of less importance, is not contradicted by an examination of the respective daily ranges.

Data are lacking for the study of evaporation during the different hours. Its extraordinary increase during the hours of occurrence of the *hot wind* has, however, become quite evident.

Table No. XIII, showing the means of monthly evaporation, will confirm the above remarks on the subject.

Cloudiness and Hours of Sunshine.

The state of cloudiness is of great importance in meteorology, because, apart from its close connection with rainfall, it has a great influence in the distribution of solar radiation and terrestrial radiation, and affords data for the study of the upper currents of the atmosphere and for the forecasting of the weather.

Recent researches by Professor Abbot, tending to demonstrate the influence of the clouds on the percentage of solar radiation which reaches the terrestrial surface, lead him to conclude that the solar rays suffer a loss of 50 % in value when passing through a cloudless atmosphere, and this percentage of loss noticeably increases with cloudiness, through absorption and reflection.

Taking it that an average of 52 % of the terrestrial surface is obscured by clouds, he concludes that the solar radiation which reaches the terrestrial surface is reduced to 24 % of its total amount, and this fact enhances the influence of cloudiness in Meteorology.

Observations of cloudiness are made at the Observatory three times a day, at IX, XV and XXI.

The monthly average of the amount of cloud is in agreement with the distribution of rainfall. From the hours of observation a decrease is recorded from morning towards night, except in June and July, when the greatest amount of cloud is registered at XV.

The number of observations of clear sky and sky with a smalll quantity of cloud exceeds those of overcast sky with or without breaks.

The average cloudiness of Lourenço Marques (4.6) closely approaches the figure attributed to this latitude in the cloudiness charts, and nears the maximum cloudiness of South Africa.

"Cumulus" clouds prevail all the year round, and during the rainy season "cumulus" and "cumulo-nimbus." "Cirrus" are observed more especially in the afternoon, from January to March, and in May, frequently grouped from SW to NE, and sometimes seeming to irradiate from a point in the SW quadrant: they move more usually from W to E. "Stratus" are more frequent in the morning of the cool season.

As is natural, the number of hours of sunshine is very closely connected with cloudiness.

The Jordan Sunshine recorder is employed at the Observatory, but has the inconvenience of recording the observations with an error of from 1 to 2 %, owing to the sheets not printing when the sun is low.

The percentage of hours of sunshine is in the universe ratio to rain and cloudiness. This can be seen from Table XIV and the diagram recording the percentage of sunless hours, cloudiness and rain.

This relation is not perfect, and it so happens that the months of lower percentage of sunshine, October and November, are not those of greater rain and cloudiness.

If we add the percentage of the hours of sunshine and cloudiness, we shall see that this addition varies between 118 and 97, respectively, in the months of greatest rainfall and in the driest ones, because the percentage of cloudiness oscillates between wider limits—62 and 24—than the percentage of sunshine—73.5 to 52.3.

Various formulæ have been introduced to connect these two elements, but this is rather a difficult matter, seeing that it is possible to register a great quantity of clouds without hiding the sun.

The highest figure in minutes of sunshine is registered, as seen from Table No. XV ,from XIII to XVI, that is during the hours of greater heat and wind velocity, and decreasing steadily toward sunrise and sunset. When it increases, a retardation is noticeable from XI to XIII, and during the decrease the latter is more pronounced from XVI to XVII. (In Lourenço Marques the sun is above the horizon all the year round up to $5^h\ 8'$ p.m.) These alterations are undoubtedly connected with those of the other elements already mentioned.

These facts are common to all the months, with a slight difference. In the months of higher percentage of hours of sunshine the increase takes place more often from X to XVI.

During three years of observation there were 45 days of no sunshine, days when no printing of the "sunshine" paper took place, 15 days when it printed during less than 10 minutes, and 46 days from 10 minutes to 1 hour.

ACTINOMETER AND SOLAR AND NOCTURNAL RADIATION.

The importance of the study of solar radiation is well known owing to its influence in all Meteorological elements.

At the Observatory a Marie-Davy actinometer is employed, and the Bouger formula is used. This actinometer's records are not, as everyone knows, reliable, for different reasons, principally on account of the absorption of some calorific rays by the glass.

Experiments made, especially those of Professor Crova, show that the heat received from the sun attains its maximum at an intermediate period between winter and summer, in May in the northern hemisphere; during summer the intensity diminishes until it reaches the minimum, and rises again to a second maximum in Autumn. I possess complete observations only for the year 1912. In these observations (see Table No. XVI) I notice two maxima, one in February and the other in September, respectively 45.6 and 44.7 actinometric degrees, corresponding to the two maxima of the other hemisphere; the minima are 36.3 and 41.2 actinometric degrees in May and December respectively.

The observations are made at IX, XII, and XV, which does not suffice to permit of the study of the double daily variation: in these observations a higher value is recorded, first at noon and then in those taken at IX.

These observations, such as they are, may be of interest to agriculturists.

For the study of solar radiation, besides the actinometer, the Observatory employs a thermometer of maximum solar radiation, with a blackened bulb enclosed in a vacuum glass sheath, and a thermometer of minimum nocturnal radiation containing alcohol, which is placed in such a way that the bulb remains on the focus of a parabolic metallic mirror, turned towards the zenith.

The figures presented in Table No. XVI, being the average for three years, show only the annual variation accompanying that of the temperature in the shade.

The respective diagrams refer to the maximum means of solar radiation and to the absolute minimum of nocturnal radiation in each month.

The absolute maxima and minima of three years in these two thermometers are 75.6° C (168.1° F) and 7.8° C (46° F).

Grass Thermometers.

Temperatures over the grass are observed with two kinds of thermometers, one of maximum with blackened bulb and another of minimum, for the purpose of getting an approximate idea of the greatest quantity of heat received and radiated by the plants. Their records, averaged for three years, shewn in Table No. XVII, are of special interest to agriculturists, and noticeably follow the annual march of the temperature: The extremes recorded during the same period are 52.2° C (129.6° F) and 5.7° C (42.3° F).

Temperature of the Earth.

The temperature of the earth affords considerable interest on account of its effects on the temperature of the air, principally in respect of the latter's variations.

The soil warms up and cools down the greater its conductibility, radiating power, absorbing power, and calorific capacity. In sandy soil all these favourable circumstances occur to the greatest extent, while the opposite is the case with water.

The temperature of the soil, though less important to vegetable life than the temperature of the air, is nevertheless an element worth considering. On the other hand vegetation, as well as evaporation, alters the temperature of the soil.

It is also worth observing that there seems to exist some relation between the temperature of the soil and the existence and development of certain diseases, such as diarrhœa and typhoid fever.

The reading of the thermometers placed at 0.5, 1, 2, 3 metres depth is taken at IX. I attach hereto a table (No. XVIII) of the averages during three years. Naturally there exists some agreement with the three laws of the temperature of the earth, *i.e.*, the law of amplitude, that of retardation during the period of the extremes, and finally that of reduction of amplitude, which varies with the period under consideration and with the depth.

Thunderstorms.

Thunderstorms are most frequent in December, then in October, November, and May, and least frequent in June, July, and August, this frequency coinciding with atmospheric disturbances. We have already mentioned the fact that the wind veering to the South when depressions occur, it is often accompanied by thunderstorms.

When the lowest pressures become established towards W and SW, and the barograph begins to trace a sinuous line, thunderstorms are common, with showers from W. Violent thunderstorms, which sometimes last for hours, are accompanied by fresh winds of variable directions. They are more common at nightfall and the last from sunrise to XIII. As one sees, most thunderstorms in Lourenço Marques may be classified as *depression thunderstorms* rather than *heat thunderstorms*.

Lightning without thunder is often recorded one or two days previous to the occurrence of depressions, and their frequency follows the same march as the thunderstorms.

Other Phenomena.

I give in Table No. XIX various meteorological data, some of which have already been considered.

Fog is more frequent during the cool season, especially in the morning. Hail is seldom recorded, and that which fell in 1912 in the lower part of the town is worthy of notice on account of its abundance.

Lunar coronæ are often observed; halos, which are not frequent, generally mark the approach of rainfall.

General Remarks.

I have endeavoured without excessively enlarging on this paper, to introduce the most important data for the study of a climate, and have followed the indications of Professors J. Hann and Cleveland Abbe, in harmony with the observations in my possession.

When trying to comprise the characteristics of the climate for a given region, in one designation only, we may adopt various classifications, grouping two or more of its principal meteorological elements; and as these have already been defined in regard to Lourenço Marques, I shall review the classification that can be adopted, taking into consideration the basis in general use.

The first and oldest classification is the "Solar" or "Astronomical" in three zones—tropical, temperate, and arctic.

Lourenço Marques is outside the tropical zone proper. Supan, however, whose classification is generally accepted, limits these zones, not by the parallels of latitude, but by the isotherms, and confines the tropical zone by the isotherm of 20° C (68° F) which the limit of the *trade winds* and of the palms approximately coincides with.

According to this classification, Lourenço Marques is in the tropical zone, but if we consider its principal Meteorological elements, comparing them with those characteristic of the tropical and temperate zones (temperature, pressure, respective variation, humidity, rainy season, quantity of rainfall, etc., etc.) one can easily see that these elements are more or less influenced by the two principal zones. That is why I prefer the classification of Koppen, who, paying attention to the relations of temperature with organic life, especially takes into account the number of months of the year in which the temperature is kept within certain limits.

In this classification the term *sub-tropical* is applied to such regions where from 4 to 11 months are hot (over 20° C or 68° F), 1 to 8 months are temperate (10° to 20° C or 50° to 68° F, and where the rainfall is generally deficient.

Lourenço Marques is correctly included in this zone, its average monthly temperature during nine months being over 20° C (68° F), the remaining three months being lower but over 10° C (50° F), and its total rainfall being 677^{mm} (26.660") (*moderate rain*).

Another general basis for the classification of climates is the *geographical* one, which comprises three divisions, namely, *continental*, *oceanic*, and *insular*, or *littoral*; the latter, which corresponds to Lourenço Marques, more or less, partakes of the defined characteristics of the other zones.

From the *Aero-physical* point of view climate has been classified as follows:—As regards *temperature*—hot, intermediate, and cold, or regular, medium, and extreme; and as regards *humidity*—damp, intermediate, and dry. As regards the temperature of Lourenço Marques in addition to what has already been mentioned, we may classify its climate as *regular*, as this is the classification applying to those climates where the variation in the annual temperature is under 10° C (18° F), and here the difference between the hottest and coldest months does not reach 8° C (14.4° F).

Taking humidity into consideration, we have already seen that it is entitled to the designation of *moderately damp*, as its relative annual and monthly humidity falls within the limits 68 and 80 per cent.

As mentioned, other more distinct classifications have been introduced by the combination of two or more meteorological elements. I shall just mention that, taking the classification of Supan (35 climatic provinces), this region belongs to the *Tropical African Province*, and in Koppen's classification, under the botanical standpoint, to the *Mesotherms* group.

I will also mention another basis of classification, *Physiological*, which comprises two groups:—(*a*) according to the general sensation produced, mild, pleasant, humid, disagreeable, etc.; (*b*) according to the general effects of the particular climate, invigorating, relaxing, rigorous, etc.

It is difficult for me to deal with this subject, and I shall therefore merely make a few remarks.

In my opinion Lourenço Marques cannot be included in any one of these divisions owing to the variety of conditions referred to, whether in both seasons, or whether from month to month. It is not out of place to repeat here the assertion already made with regard to the variation of sensations produced by small alterations of temperature on those Europeans who inhabit tropical areas, and that this fact is principally due to their physical exhaustion and the hygrometric state of the atmosphere. I may furthermore mention, for instance, the influence on individuals of a hot day being followed by one of lower temperature, damper and less windy, thus causing an apparent exaggeration on the personal sensation of heat.

Let us now consider, very superficially, the effects of the climate.

As stated, the year may be divided into two seasons, namely, *hot and rainy* from October to March, *cool and almost dry* from April to September, the four seasons not being well characterised here.

During the hottest and dampest months the climate has characteristics approaching to tropical, but the prevailing sea winds blowing harder during the hours of greater heat contribute to make it more pleasant.

The sky sometimes takes an aspect akin to tropical climates, and the occurrence of atmospheric disturbances, together with *hot winds* from the north followed by cold winds from the south makes these months unpleasant and relaxing.

These depressions are also felt during the cool season—not so frequently, but they nevertheless occur during the most pleasant months.

February and March are perhaps the most pronounced tropical months, on account of the greater frequency of damp heat, which is sometimes still felt in April and May.

Though the climate during this season is not absolutely good, its depressing effects on the constitution may to a great extent be corrected by proper hygienical measures. This is stated by Sir Patrick Manson, who, writing on tropical diseases, says:—"Acclimatization is less an unconscious adaptation of the physiology of the individual than an intelligent adaptation of his habits."

Concerning the adaptation of the white race in this town, Commander Hugo de Lacerda emphasises the similarity of the climate to that of Durban, where the white race has adapted itself to its climatic environment. The similarity is well known, and may be confirmed by the analysis of the meteorological elements in both towns, where, as we have seen, the temperature and relative humidity are closely identical, the amount of rainfall here being considerably lower.

During the cool season the climate may be considered good, especially from June to October, when the temperature and lower humidity render these months more agreeable and invigorating.

A brief consultation of the reports of the Chief Medical Officers in the past, referring to the Health District of Lourenço Marques, also enhances the conviction as to the satisfactory health conditions in the cooler months. During these months the health "status" is considered very good, especially from June to October.

Finally, I shall quote Commander Hugo de Lacerda, whose words support my own views regarding our splendid climate during the cool season:—

"In winter during the period of fine weather, and with the south winds prevailing, the climate may be placed on a level with the best in the world. There are days during this season that are so pleasant and bright that they may well be designated as glorious days, producing a wonderful feeling of satisfaction, much to be appreciated.

"The average temperature of Lourenço Marques during the driest month of the year is approximately equal to the average annual temperature of the Transvaal, and the average temperature during the months of June to October corresponds to the average temperature of the months from November to April in Middelburg. By coming down to what may be called the *côte d'azur* of South Africa, the inhabitants of those districts have, therefore, a place where they can easily go to in order to avoid the rigours of the low temperature of their altitudes."

QUADRO NO. I.

TABLE NO. I.

Temperatura média (média de 14 annos).
Mean temperatures (average for 14 years).

J.		F.		M.		A.		M.		J.		J.		A.		S.		O.		N.		D.		Anno Year	
C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
25·90	78·6	25·41	77·7	24·37	75·8	23·00	73·4	20·50	68·9	18·23	64·8	18·01	64·4	19·47	67·0	20·88	69·6	22·27	72·1	23·45	74·2	25·03	77·1	22·21	72·0

QUADRO NO. II.
TABLE NO. II.

Temperatura em varios logares.
Temperature at various places.

Local *Place*	Altitude aproximada *Approximate Altitude*		Latitude—Sul *Latitude—South*	Longitude—Este *Longitude East*	Temperatura média annual *Mean annual temperature*		Temperatura média mês mais quente *Average temperature hottest month*		Temperatura média mês mais frio *Average temperature coldest month*		Maxima absoluta *Absolute maximum*		Minima absoluta *Absolute minimum*	
	Metros *Metres*	Pés *Feet*			C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
East-London	6	20	33°2′	27°23	18·2	64·8	21·1	70·0	15·6	60·1	38 3	100·9	2·8	37·0
Durban	79	260	29°51′	31°00	21·6	70·9	24·8	76·6	18·1	64·6	43·1	109·6	5·7	42·3
Lourenço Marques	59	193	25°58′	33°36	22·2	72·0	25·9	78·6	18·1	64·6	44·4	111·9	7·8	46·0
Inhambane	3	20	23°52	35°24	24·3	75·7	28·1	82 6	20·5	68·9	34·0	93·2	13·6	56·5

QUADRO NO. III.

TABLE NO. III.

Variações mensaes na temperatura e quantidade de chuva.
Monthly variations in Temperature and amount of Rainfall.

Meses *Months*	Differença de temperatura *Difference in temperature*		Chuva total *Total rainfall*	
	C.	F.	Millimetros *Millimetres*	Pollegadas *Inches*
J	+0·87	+1·5	126·3	4·974
F	−0·49	−0·9	89·1	3·509
M	−1·04	−1·9	63·4	2·497
A	−1·37	−2·5	39·2	1·545
M	−2·50	−4·5	30·8	1·213
J	−2·27	−4·1	12·8	0·505
J	−0·22	−0·4	13·9	0·547
A	+1·46	+2·6	12·3	0·446
S	+1·41	+2·5	29·4	1·158
O	+1·39	+2·5	64·8	2·552
N	+1·18	+2·2	88·6	3·490
D	+1·58	+2·9	107·3	4·226

QUADRO NO. IV.
TABLE NO. IV.

Temperaturas extremas.
Extreme temperatures.

	J.		F.		M.		A.		M.		J.		J.		A.		S.		O.		N.		D.		Anno *Year*	
	C.	F.	C	F.	C.	F.	C.	F.	C.	F.	C	F.	C.	F.	C.	F.	C.	F.	C.	F.	C	F.	C.	F	C.	F.
Maxima absoluta *Absolute maximum*	37.2	99.0	37.0	98.6	35.4	95.7	33.7	92.7	34.9	94.8	30.6	87.1	31.9	89.4	37.2	99.0	40.7	105.3	41.4	106.5	44.4	111.9	42.5	108.5	44.4	111.9
Minima absoluta *Absolute minimum*	18.4	65.1	17.2	63.3	15.7	60.3	12.5	54.5	12.1	54.5	8.4	47.1	7.8	46.0	8.1	46.6	9.9	49.8	11.9	53.4	11.2	52.2	11.9	53.4	7.8	46.0

QUADRO No. V.
TABLE No. V.

Medias mensaes e annual da pressão atmospherica (a 0o C. e ao nivel do mar)

Monthly and annual means of atmospheric pressure (at 0° C. and at sea level)

J.		F.		M.		A.		M.		J.	
Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*
760·48	29·941	760·85	29·955	762·39	30·012	764·05	30·081	765·71	30·146	768·38	30·252

J.		A.		S.		O.		N.		D.		Anno *Year*	
Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*	Millimetros *Millimetres*	Pollegadas *Inches*
768·58	30·259	766·34	30·172	765·32	30·131	763·39	30·055	762·75	30·030	760·43	29·938	764·05	30·081

QUADRO No VI.

TABLE No. VI.

Alguns elementos meteorologicos durante a passagem de uma depressão

Meteorological Data observed during the passage of a depression.

1912 Setembro *September*		Pressão *Pressure*		Temperatura *Temperature*		Humidade *Humidity* 100 - Saturação 100 - *Saturation*	Tensão de vapor *Vapour tension* Millimetros *Millimetres*	Vento *Wind*	
Dia *Days*	Horas *Hours*	Millimetros *Millimetres*	Pollegadas *Inches*	Centigrados *Centigrade*	Fahrenheit.			Direcção *Direction*	Força *Velocity* Kilometros *Kilometres*
27	XIII	765·9	30·15	23·7	74·7	56	12·2	E	25
	XIV	764·9	30·12	23·4	74·1	59	12·7	E	27
	XV	764·0	30·08	22·5	72·5	59	11·8	E	29
	XVI	763·4	30·06	21·7	71·1	60	11·5	ENE	23
	XVII	763·3	30·05	21·0	69·8	63	11·5	ENE	33
	XVIII	763·2	30·05	20·1	68·2	68	11·9	ENE	32
	XIX	763·4	30·06	19·8	67·6	86	13·0	ENE	32
	XX	763·5	30·06	19·7	67·5	70	12·0	ENE	29
	XXI	763·6	30.06	19·8	67·6	75	12·9	ENE	27
	XXII	763·5	30·06	19·7	67·5	75	12·8	ENE	32
	XXIII	763·0	30·04	19·6	67·3	70	11·8	ENE	30
	XXIV	762·6	30·02	19·1	66·4	68	11·2	ENE	25
28	I	761·9	30·00	18·0	64·4	63	9·8	NNE	23
	II	761·3	29·97	17·2	63·0	61	8·9	NNE	23
	III	760.7	29·95	16·7	62·1	54	7·6	NNE	20
	IV	760·2	29·93	15·8	60·4	56	7·5	NNE	24
	V	760·0	29·92	15·5	59·9	54	7·1	NNE	25
	VI	760·0	29·92	15·8	60·4	49	6·5	N	25
	VII	759·8	29·91	18·4	65·1	41	6·4	NNW	27
	VIII	759·2	29·89	23·6	74·5	31	6·8	NNW	34
	IX	758·9	29·88	27·0	80·6	27	7·1	NNW	36
	X	758·1	29·85	29·1	84·9	24	7·3	NNW	42
	XI	756·9	29·80	31·9	89·4	18	6·5	NNW	39
	XII	755·7	29·75	33·4	92·1	15	6·1	N	34
	XIII	754·3	29·70	34·7	94·5	14	5·8	N	34
	XIV	753·1	29·65	35·5	95·9	11	5·3	N	36
	XV	752·0	29·61	35·9	96·6	10	5·0	N	34
	XVI	751·6	29·59	35·4	95·7	11	5·2	N	32
	XVII	751·4	29·58	34·4	93·9	12	5·3	N	30
	XVIII	751·5	29·55	33·0	91·4	13	5·0	N	29
	XIX	752·0	29·61	30·8	87·4	18	6·1	N	26
	XX	752·6	29·63	29·5	85·1	20	6·3	N	25
	XXI	754·9	29·72	27·5	81·5	20	8·0	N	27
	XXII	756·3	29·78	20·4	68·7	60	10·7	S	40
	XXIII	757·2	29·81	19·8	67·6	58	10·1	S	35
	XXIV	757·6	29·83	19·2	66·6	59	9·9	S	27
29	I	758·2	29·85	18·7	65·7	62	10·0	S	26
	II	758·8	29·88	18·2	64·8	63	9·9	S	24
	III	759·1	29·89	17·7	63·9	66	9·9	S	23
	IV	759·8	29·91	17·2	63·0	67	9·8	S	19
	V	760·4	29·94	16·7	62·1	68	9·6	S	19
	VI	761·4	29·98	16·8	62·2	67	9·5	S	20
	VII	762·3	30·01	18·4	65·1	68	10·8	S	23
	VIII	762·9	30·04	20·0	68·0	56	9·8	S	24
	IX	763·4	30·06	21·4	70·5	59	11·0	S	25
	X	763·5	30·06	21·6	70·9	59	11·2	SSE	24
	XI	763·4	30·06	23·7	74·7	50	10·8	ESE	19
	XII	763·1	30·04	22·7	72·9	50	10·2	ESE	25

QUADRO No. VII.

TABLE No. VII.

Meses *Months*	Numero de dias de vento. *Number of days of wind.* Muito fraco *Light*	Fraco *Gentle*	Moderado *Moderate*	Fresco *Fresh*	Forte *Strong*	Muito forte tempestuoso *Stormy*
J.................	0	0	23	8	0	0
F............	0	1	22	6	1	0
M	0	1	23	6	1	0
A.................	0	1	25	3	1	0
M................	0	1	24	6	0	0
J.................	0	1	23	6	0	0
J.................	0	1	24	6	0	0
A.............. .	0	1	19	10	1	0
S.................	0	0	20	9	0	0
O.................	0	0	19	12	0	0
N................	0	0	19	10	1	0
D................	0	0	23	7	0	0
Somma ...... *Total*..........	0	7	264	89	5	0

QUADRO No. VIII.
TABLE No. VIII.

Velocidades medias do vento em kilometros ás differentes horas.
Average Velocity of Wind in kilometres at the different hours.

Horas / *Hours*	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV
Velocidade em kilometros / *Velocity in kilometres*	17·60	17·57	17·93	18·43	18·63	18·77	19·17	19·90	20·20	20·93	20·46	21·13	22·43	23·50	25·30	26·47	26·87	26·70	26·13	24·73	23·60	21·63	19·73	18·80

QUADRO No. IX.

TABLE No. IX.

Velocidades medias em kilometros nos differentes meses.
Average Velocity in kilometres in the different months.

Meses *Months*	Velocidades medias em kilometros *Average Velocity in kilometres*
J	22·26
F	20·60
M	21·43
A	19·33
M	20·57
J	19·97
J	20·23
A	21·48
S	24·08
O	23·68
N	23·56
D	21·30
Média annual *Annual average*	21·54

QUADRO No. X.
TABLE No. X

Resultante do vento.
Wind Resultant.

Meses *Months*	1909 Direcçao N : E *Direction N—E*	1909 Kilometros percorridos *Kilometres*	1910 Direcçao N : E *Direction N—E*	1910 Kilometros percorridos *Kilometres*	1911 Direcçao N : E *Direction N—E*	1911 Kilometros percorridos *Kilometres*	1912 Direcção N : E *Direction N—E*	1912 Kilometros percorridos *Kilometres*
J...........	160 (20° SE)	7:609	115° (65° SE)	7:368	138° (42° SE)	11:160	122° (58° SE)	6:079
F...........	154 (26 SE)	7:189	135 (45 SE)	5:264	116 (64 SE)	6:001	111 (69 SE)	5:648
M...........	140 (40 SE)	3:950	172 (8 SE)	9:394	140 (40 SE)	8:380	155 (25 SE)	4:788
A...........	43 (43 NE)	504	183 (3 SW)	1:839	150 (30 SE)	3:630	120 (60 SE)	2:986
M...........	265 (85 SW)	2:662	325 (35 NW)	2:883	187 (7 SW)	6:587	168 (12 SE)	518
J...........	286 (74 NW)	1:981	254 (74 SW)	2:958	230 (50 SW)	4:055	263 (83 SW)	1:599
J...........	240 (60 SW)	2:052	346 (14 NW)	3:973	298 (62 NW)	2:842	177 (3 SE)	1:931
A...........	65 (65 NE)	1:504	9 (9 NE)	1:967	162 (18 SE)	1:658	95 (85 SE)	3:400
S...........	142 (38 SE)	3:919	113 (67 SE)	2:826	115 (65 SE)	4:748	95 (85 SE)	4:386
O...........	109 (71 SE)	4:320	104 (76 SE)	7:373	84 (84 NE)	6:064	117 (63 SE)	7:597
N...........	128 (52 SE)	4:851	108 (72 SE)	7:305	89 (89 NE)	7:001	108 (72 SE)	8:252
D...........	120 (60 SE)	3:611	112 (68 SE)	6:665	91 (89 SE)	6.109	118 (62 SE)	8:226
Annos... *Years*.....	142 (38 SE)	33:311	124 (56 SE)	34:963	129 (51 SE)	48:852	119 (61 SE)	49:600

QUADRO No. XI.
TABLE No. XI.

Humidade relativa—estado de saturação = 100 (média 10 annos).
Tensão de vapor em millimetros (média 4 annos).
Relative Humidity— Saturation state=100 (average in 10 years).
Vapour Tension in millimetres (average in 4 years).

	J	F	M	A	M	J	J	A	S	O	N	D	Anno *Year*
Humidade relativa / *Relative Humidity*	71·0	73·9	74·4	76·0	72·2	70·6	69·4	69·7	67·8	68·2	70·4	70·8	71·2
Tensão de vapor / *Vapour Tension*	17·7	18·5	17·1	16·1	13·6	13·0	11·2	11·9	12·2	14·3	15·3	17·5	14·7

QUADRO No. XII.

TABLE No. XII.

Chuva (média de 14 annos).
Rainfall (average in 14 years).

Meses. *Months.*	Total. Millimetros. *Millimetres*	Total. Pollegadas. *Inches.*	Percentagem. *Percentage.*	Numero de dias de chuva. *Number of rainy days.*
J......................	126·3	4·974	18·7	10
F......................	89·1	3·509	13·4	9
M......................	63·4	2·497	9·4	8
A......................	39·2	1·544	5·8	6
M......................	30·8	1·213	4·5	5
J......................	12·8	0·505	1·9	2
J......................	13·9	0·547	2·0	2
A......................	11·3	0·455	1·7	2
S......................	29·4	1·158	4·3	6
O......................	64·8	2·552	9·3	8
N......................	88·6	3·490	13·1	10
D......................	107·3	4·226	15·9	9
Anno...... *Year*.......	676·9	26·660	—	77

QUADRO No XIII.

TABLE No. XIII

Evaporação em millimétros (média de 4 annos).
Evaporation in millimetres (average in 4 years).

J	F	M	A	M	J	J	A	S	O	N	D	Anno *Year*
105·2	84·9	96·9	76·4	83·5	90·2	90·2	99·7	119·4	120·2	125·6	126·3	1,218·5

QUADRO No. XIV.

TABLE No. XIV.

Nebulosidade e percentagem de horas de sol descoberto (media de 4 annos).

Cloudiness and percentage of sunshine hours (average in 4 years).

Meses *Months*	Quantidade de nuvens 0 a 10 *Amount of cloud 0 to 10* — Medias *Averages*				Numero de vezes de *Number of occurrences of*							Percentagem de horas de sol descoberto *Percentage of hours of sunshine*
	IX	XV	XXI	Média *Average*	Ceu limpo *Clear sky* — 0	Algumas nuvens *Few clouds* — 0-1	Pouco nublado *Not very cloudy* — 2-3	Nublado *Cloudy* 4-6	Muito nublado *Very cloudy* — 7-9	Claros *Breaks* — 10-d	En-coberto *Without breaks* — 10	
J	7·3	5·4	5.4	6·1	5	9	17	15	16	8	26	57·3
F	6·7	5·4	4·8	5·6	5	10	14	17	17	4	18	58·4
M	6·8	3·7	5·3	5·3	8	9	17	11	17	8	26	54·2
A	5·5	4·5	3·5	4·5	12	19	18	8	14	3	17	61·9
M	4·7	4·3	3·2	4·1	23	16	12	12	11	5	16	60·3
J	2·6	3·0	1·7	2·4	35	20	11	8	6	3	7	73·5
J	3·1	3·2	1·7	2 6	39	19	10	7	6	6	9	71·0
A	3·8	2·8	1·6	2·7	42	18	7	4	7	2	13	66·9
S	4·1	2·8	2 8	3·2	34	15	11	6	7	4	14	69·9
O	6·6	5 4	5·4	5 8	15	11	7	10	17	6	28	52·3
N	7·1	5 4	5·9	6·1	6	13	15	9	14	11	28	53·3
D	6·9	5·6	6·3	6·2	5	10	12	16	22	10	22	56·5
Anno *Year*	5·4	4·4	3·9	4·6	229	169	151	123	154	70	224	61·3

QUADRO No. XV.
TABLE No. XV.

Duraç o média de sol descoberto para cada hora em minutos (média de 4 annos)
Average duration of sunshine for each hour, in minutes (average in 4 years)

Horas / *Hours*	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IX-X	X-XI	XI-XII	XII-XIII	XIII-XIV	XIV-XV	XV-XVI	XVI-XVII	XVII-XVIII	XVIII-XIX
Duraãço em minutos / *Duration in minutes*	(·01)	3·2	15·5	28·5	38·6	40·4	41·6	40·7	40·9	42·7	44·0	43·9	38·0	(18·7)	(3·2)

QUADRO NO. XVI.

TABLE NO. XVI.

Graus actinometricos—Irradiação solar e nocturna.

Actinometric Degrees—Solar and Nocturnal Radiation.

Meses *Months*	1912—Graus actinometricos *1912—Actinometric Degrees* IX	XII	XV	Média *Average*	Irradiação (média de 3 annos) *Radiation (average in 3 years)* Solar maxima média *Solar average maximum* C.	F.	Nocturna minima média *Nocturnal average minimum* C.	F.
J.	41·8	43·5	43·4	42·9	63·54	146·3	18·6	65·5
F.	46·8	47·4	42·5	45·6	64·00	147·2	18·0	64·4
M.	40·0	45·0	39·4	41·5	63·15	145·7	15·7	60·3
A.	37·6	42·2	35·2	38·3	59·70	139·5	16·0	60·8
M.	38·2	40·2	30·7	36·3	56·26	133·3	12·7	54·9
J.	45·1	46·5	37·9	43·2	54·06	129·3	8·6	47·5
J.	43·4	46·1	35·8	41·8	53·95	129·1	9·3	48·7
A.	40·6	45·5	37·1	41·1	54·94	130·8	9·6	49·3
S.	48·6	47·3	38·3	44·7	56·37	133·4	9·6	49·3
O.	44·6	45·8	37·8	42·8	59·20	138·6	12·1	53·8
N.	43·3	45·0	41·5	43·2	62·21	144·0	15·3	59·5
D.	41·7	44·5	37·4	41·2	64·50	148·1	12·8	55·0
Anno *Year*	42·6	44·9	38·1	41·9	59·32	138·7	8·6	47·5

QUADRO NO. XVII.
TABLE NO. XVII.

Thermometros na relva (média de 3 annos).
Grass Thermometers (average in 3 years).

Meses *Months*	Maxima *Maximum* C.	Maxima *Maximum* F.	Minima *Minimum* C.	Minima *Minimum* F.
J	43·97	111·1	18·07	64·5
F	44·87	112·7	19·87	67·7
M	43·12	109·6	18·53	65 3
A	39·68	103·4	16·63	62 0
M	34·42	93·9	13·88	56·9
J	31·80	89·2	10·51	51·0
J	32·50	90·5	10·44	50·8
A	33·76	92·6	12·02	53·6
S	35·67	96·2	12·96	55·3
O	37·82	100·1	16 09	61·0
N	40·49	104·9	16·92	62·4
D	43·14	109·7	18·19	64·8
Anno *Year*	38·44	101·2	15·34	59·6

QUADRO No. XVIII.
TABLE No. XVIII.

Temperatura de terreno (média de 3 annos).
Temperature of the Earth (average of 3 years).

Meses. *Months.*	Na profundidade *At a depth of* 0,^{m}5 C.	0,^{m}5 F.	1^m C.	1^m F.	2^m C.	2^m F.	3^m C.	3^m F.
J	28·11	82·6	28·51	83·3	28·09	82·6	27·07	80·7
F	28·33	82·9	28·84	83·8	28·64	83·5	27·70	81·9
M	27·25	81·0	28·21	82·8	28·60	83·5	28·01	82·4
A	25 21	77·4	26·53	79·7	27·60	81·7	27·57	81·6
M	22 32	72·1	23·94	75·0	25·95	78·7	26·62	79·9
J	19·18	66·6	21·21	70·2	23·92	75·0	25·19	77·4
J	18·43	65·1	19 95	67·9	22·34	72·1	23·85	74·9
A	19 64	67·3	20·69	69·3	22·19	72·0	23 22	73·8
S	21·56	70·8	22,17	72·0	22·94	73·2	23·46	74·2
O	23·83	74·8	24·31	75·7	24·43	75·9	24·22	75·6
N	25·39	77·7	25·70	78·3	25·56	78·0	25·14	77·3
D	27·54	81·5	27·71	81·9	27·05	80·6	26·12	79·1
Anno *Year*	23·90	75 0	24·81	76·6	25·60	78·1	25·68	78·2

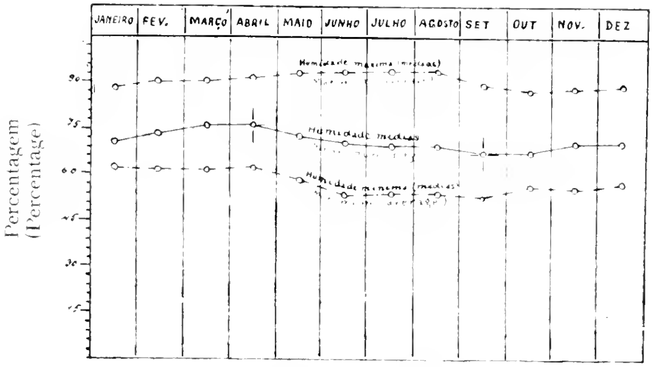
QUADRO No. XIX.

TABLE No. XIX.

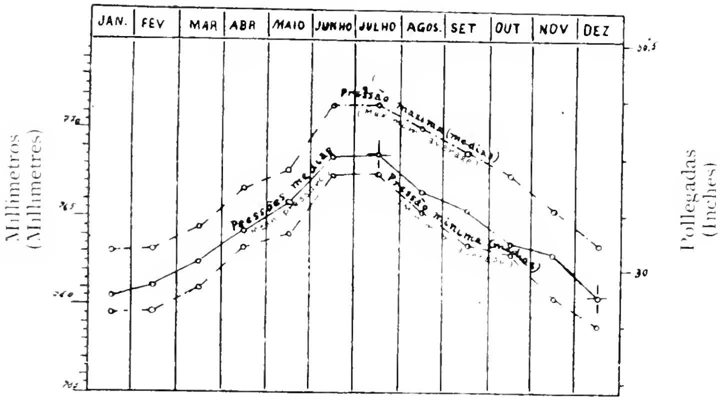
Dias de chuva, trovoada, cacimbo, etc. (média de 4 annos).

Days of rain, thunder, dew, etc. (average of 4 years).

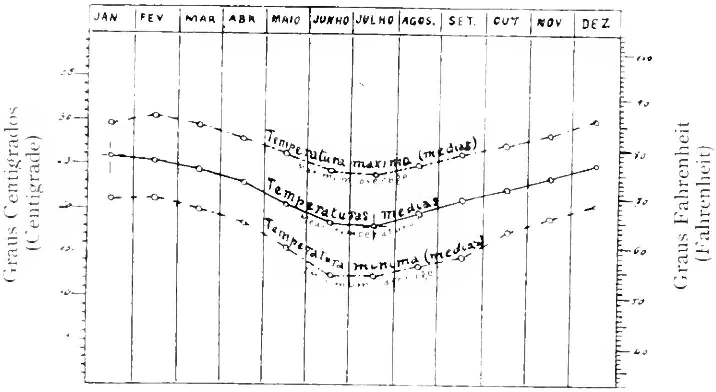
Meses *Months*	Numero de dias *Number of days*						
	Com chuva e com chuvisco *With Rain and Drizzle*	Com chuva cuja agua se medio *With Rain (measured water)*	Com trovoadas *With thunder*	Com relampagos *With lightning*	Com cacimbo *With dew*	Com nevoeiro *With fog*	Com saraiva e granizo *With hail*
J	15	12	2	4	2	0	0
F	14	11	3	6	3	1	0
M	13	10	3	4	6	0	0
A	10	9	4	4	9	2	0
M	9	7	2	4	16	3	0
J	4	4	0	0	19	3	0
J	4	4	0	0	17	4	0
A	4	2	0	0	15	3	0
S	6	5	2	2	11	1	0
O	10	8	5	5	4	2	0
N	10	7	6	5	5	0	0
D	11	11	10	7	4	0	0
Anno *Year*	110	90	37	41	111	19	0



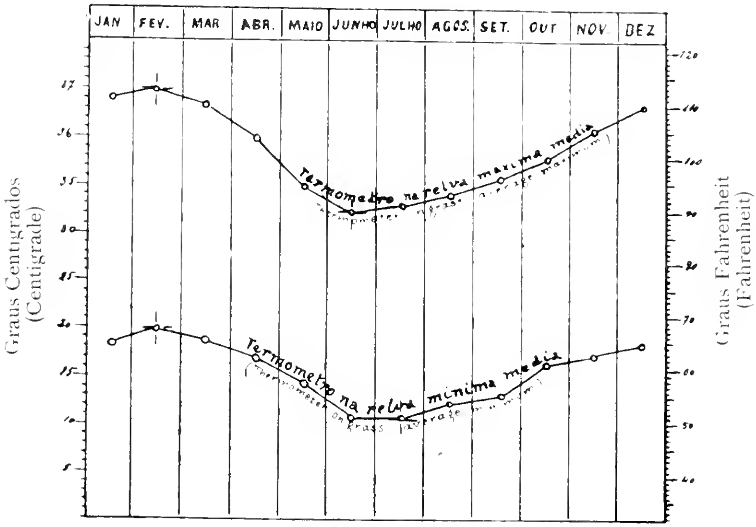
Humidade Relativa
(Relative Humidity)



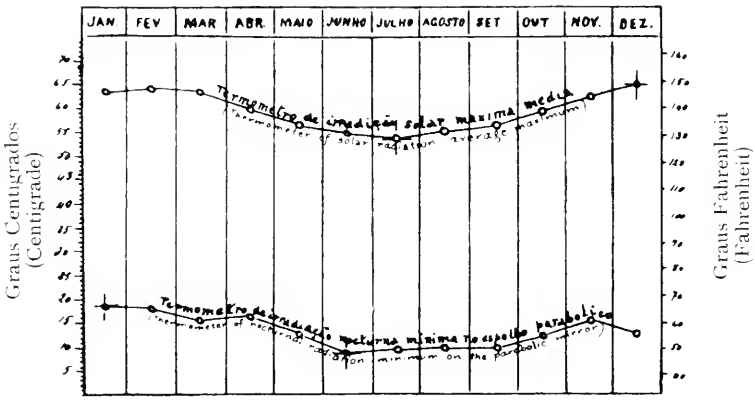
Pressão Barometrica
(Barometric Pressure)



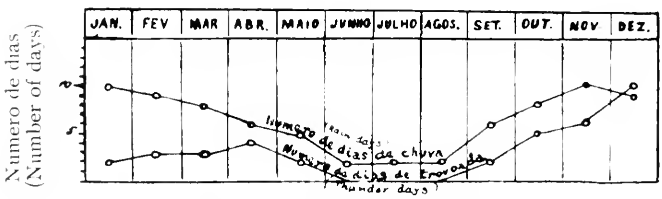
Temperatura a sombra
(Temperature in the shade)



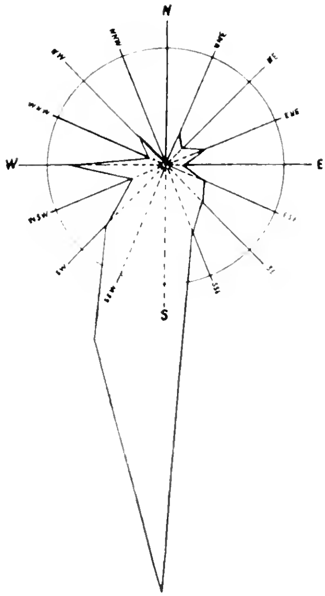
Temperatura na Relva
(Grass Temperature)



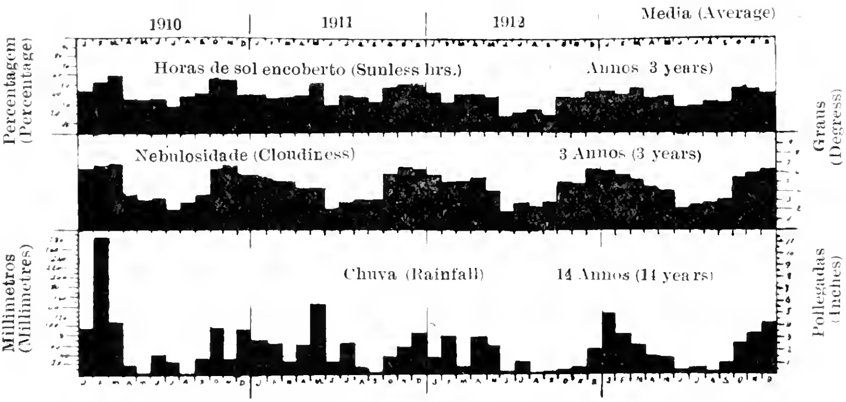
Termometros de Irradiação Solar
(Solar and Nocturnal Radiation Thermometers)



Numero de dias de Chuva e Trovoada
(Number of days of Rain and Thunder)

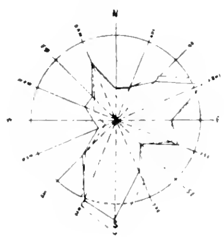


Percentagem de chuva caida segundo a direcção do vento
(Percentage of rainfall according to the direction of the wind)

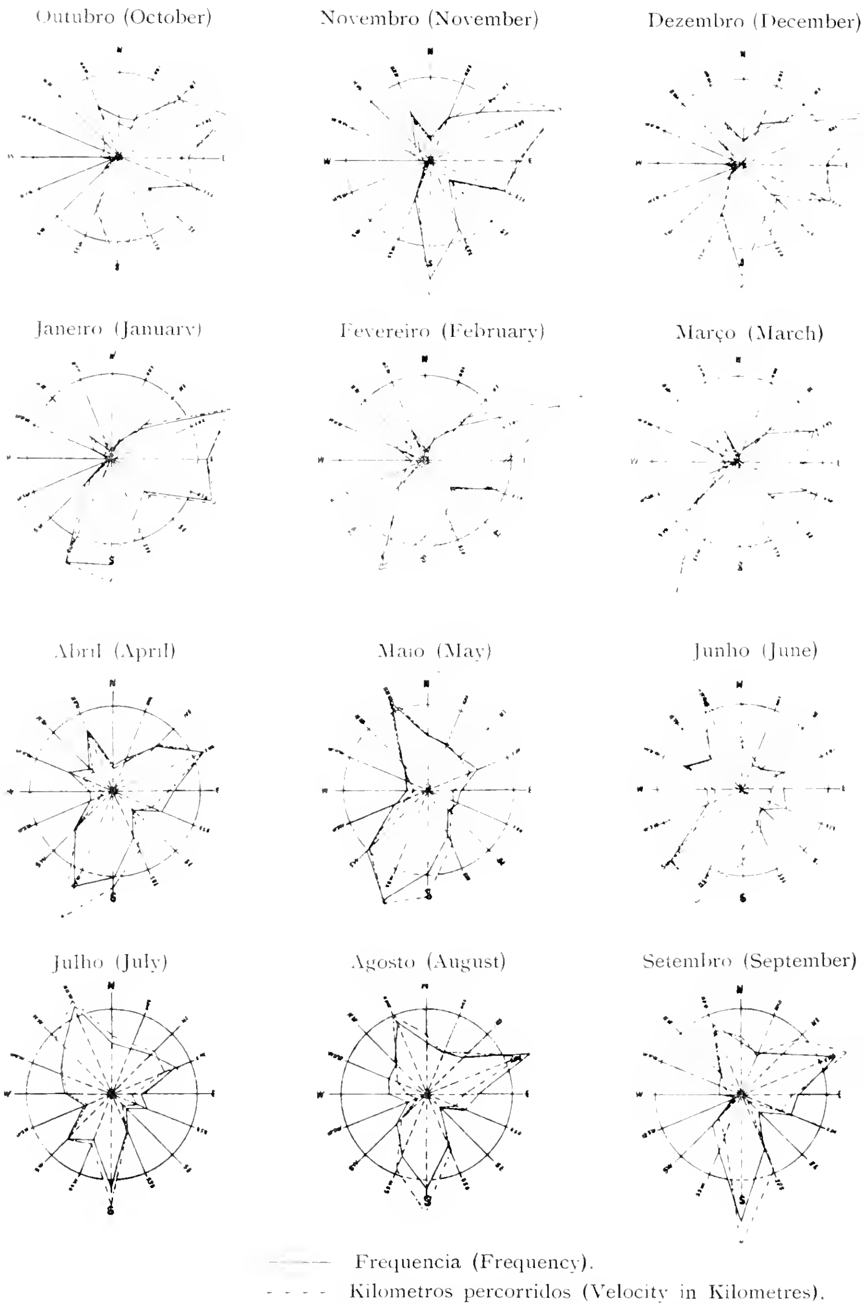


Horas de sol encoberto, Nebulosidade, e Chuva
(Sunless hours, cloudiness, and rainfall)

Anno (Year)



Percentagem da frequencia e kilometros percorridos pelo vento nos varios rumos
(Percentage of frequency and velocity of the wind (various directions) in kilometres)



Percentagem da frequencia e kilometros percorridos pelo vento nos varios rumos
(Percentage of frequency and velocity of the wind (various directions) in kilometres)

THE TRADES SCHOOL IN THE TRANSVAAL.

By William James Horne, A.M.I.C.E.

During the past twelve months there has been a keen revival of public interest in technical education as affecting the mass of the people, brought about, I think, chiefly by the conference called in November, 1913, by the Minister of Education. As I understood it, that conference was called to inform the Minister of what was being done throughout the Union; and, in my humble opinion, was correctly limited to heads of departments and officials directly connected with industrial schools and technical classes in the four Provinces. It will be understood, of course, that I am merely expressing my personal opinion as a private individual. To my mind the great good of that conference was that men engaged in the same type of work met one another, in many cases for the first time, to discuss ideas and difficulties. What these educational managers consider necessary, and want for the furtherance of their work has been focussed in some sixty or seventy resolutions which now lie open to public discussion in blue book form. (0) Therefore, when it was suggested that I should prepare a paper on the subject of the elementary technical education in this country, I thought it an opportune moment to deal generally with what is being done in South Africa and more particularly with regard to my official work in the Transvaal with Trades Schools.

In this country there is the anomalous condition of large natural wealth and great possibilities on one hand, on the other, masses of people struggling with poverty and its hardships. We are beginning to feel the evil of congested cities, and the indigent are urged by certain sociologists to "get back to the land" and become farmers; at the same time the farmers are complaining of the want of a sufficiency of unskilled labour while their children and dependents complain of unsocial conditions and flock to the towns. It is almost impossible for the adult to change the habits of a life-time; therefore, if some means are not found of training the youth of the country, sociological suggestions like the foregoing will merely end in motion round a circle. It appears to me that what humanity is striving for is to keep well and happy, to do work efficiently, to store up the products of energy against age and to make the surplus productive. For many persons to be poor in a wealthy country, to be sick in a good climate, to be inefficient among a progressive people is not necessarily a sign of inability: it points rather to a necessary part of their education having been omitted.

It is mainly by educating the youth of the country in work that holds the interest that a more desirable condition can be brought about; and I believe firmly that human nature can be ennobled by the organisation of industry in the service of education. There is abundant reason for that belief in the high mental and moral state manifest as a result of the reverse process the organisation of education in the service of industry. These two things are not synonymous; they imply two different sets of conditions: and I am of the opinion that if arrangements are made for the first set, it will be possible for greater advantage to be taken of the existing second set, that is, of the already existing organised education in the service of industry.

I am, therefore, bold enough to criticise the findings of the Indigency Commissioners when they say that they "do not think that the present conditions of the country are such as to make it either possible or necessary to establish such schools." (**5**) (*i.e.*, Trades Schools in country districts). A little before that they have placed it on record that the ordinary education does not qualify the children of the rural population to take up trades dependent on the farming industry. (**6**) I think they should have gone on to advise the establishment of schools in which education would have taken place *through* such trades.

It is not sufficient for a few thousands to take complex technical courses in university colleges qualifying them as highly trained specialists in some form of engineering or allied professions; there must be schools, as the Indigency Commissioners have pointed out, (**7**) providing industrial training of the elementary and intermediate type that is lower than that afforded by the university college, in order that there may be a body of intelligent men able to co-operate efficiently with these specialists. The men who labour with their hands will not feel the dignity and honour of their labour unless their work is well done as the result of trained intelligence; and for this to be possible the type of school which I here wish to urge is an absolute necessity under the conditions of modern industrial life. (**8**).

"The machine tool-shop has become far more important than it used to be, and labour-saving tools have greatly displaced handicraft; head work has become far more important, and if a man is not to be a mere tool-minder, he must know something of the sciences which underlie his trade. It is also important that he should be happy through interest in his work, else he will develop into a mere labour-saving tool himself, without imagination and without initiative—a poor sort of citizen. Again, reforms in workshop methods and invention depend greatly upon the ideas of the workmen, which gradually reach their superiors." (**9**).

If that is true of Great Britain and Ireland it is surely becoming more and more so for this country which is dependent on Europe and America for its machinery in all industries. And is the newly appointed European or American manager not likely to put in the latest labour-saving machinery available to enable him to save on the cost of production by (a) employing less hands (b) rendering him less subject to human error in his men—less dependent on the personal equation? They cannot possibly be philanthropists and keep on those whose efficiency has become of zero commercial value through advance in invention. And what is going to happen as machinery becomes more and more automatic, as it makes less demand upon the guiding intelligence of human agency, as it becomes more perfect in executing those mechanical processes in which it has hitherto been necessary to train workmen as apprentices? Competition does not stand still, and we shall of necessity have to look round for a cheaper labourer—and the all-pervading Kaffir is again at our elbow. Let me give an instance: The Public Works Department of Union, employ the kaffir at the automatic machines in their blue print room. I do not blame them; the work is better done by adult, if inferior, brain; there is not time to control the young and thoughtless; and there is less change in *personnel* than there would be if you had white apprentice draughtsmen doing the work for a month so to learn the working. No, it is certainly not going to pay employers to take apprentice tradesman, they have neither time nor money to spend upon them; but they need a reduced number of trained intelligences who can grasp the general principles underlying technical applications and it is going to pay them, whether they apprentice them afterwards to a man or to a machine, to have them pre-trained in a school which will provide that which has been lost in evolution and which is still necessary to control the results from it.

I cannot help thinking that there is a tendency among employers to imagine that the trades school is an attempt to substitute theoretical teaching plus *dilletante* workshop instruction for practical commercial works training; that there is an indifference to the value of practical experience. I hope to show that that fear is groundless. In the first place, I have insisted on the trades instructors at trades schools being men with long workshop experience of recent date. It is essential that we should teach processes as the boy will find them required of him in the commercial workshop when he comes to enter it at the end of his school curriculum. We do not want technical or scientific knowledge of how a thing must be made, but practical teaching of how to make it successfully. In teaching parlance, those processes are subjects of instruction and not media. The knowledge of what to teach first, and how to suit it to each boy's capabilities will come with experience and so will the best way of presenting the subject.

Let me digress for a moment to state here what I look for when appointing tradesmen instructors; these are:

1. A sound practical knowledge of the trade or industry which he has to teach gained from practical experience.
2. A liking for teaching others.
3. A fairly good education.
4. A knowledge of the trade literature as a means of following the changes in materials and processes used in his trade.
5. Previous attendance at classes similar to those he has to teach.
6. Some knowledge of science and of technical subjects relating to his trade.
7. Ability to introduce theoretical matter into his teaching.
8. Energy, enthusiasm and character.

The principal of the school must be a man who has had both teaching experience and commercial works practice, the latter predominating. If he meets difficulties beyond the range of his teaching experience his second-in-command is exclusively a professional teacher from whom he can get the assistance he may require. As to the teachers who take the classwork continuing the boy's education to standard VII, we ask that they shall give a technical bent to their tuition by taking their examples from workshop practice. Thus in arithmetic, not to deal with "stocks and shares" as if the boys were going to be brokers or bankers' clerks; but to choose a new application based on the workshop courses and on the future work of the boys.

In the second place, although the staff is chosen so that the instruction may be as practical as possible, it is not possible to create in a school that atmosphere of strenuous commercial competition so necessary to the training of the modern workman to a thorough knowledge of his trade. It is impossible to introduce the factory system into such schools, for the sufficient reason that they are teaching institutions first and manufactories only as the circumstances of the training given in them permit. Thus in no sense do I claim that the boy on leaving the trades school is a finished workman or that he has even finished as an apprentice; what I do claim is that he deserves preferential treatment over the boy who has not qualified himself for employment in a modern workshop. That preferential treatment must be left to the employer to assess. It would be monstrous to suggest anything else. I believe that the three years training in Transvaal trades schools is equivalent to two years of the apprenticeship period in some trades; and in a few others, *e.g.*, metal plate working, electric wiring, wagon-smithing,—the ex-trades school pupil should be accepted as an improver. My opinion, however, is neither here nor there; we shall be content to be judged by what we produce; all we ask is that each individual boy should be treated on his merits.

The contract of apprenticeship provides for the transfer of indentures. This is usually effected if the boy finds it necessary to earn a wage in order to keep himself; or, when nearing the completion of the school course, and to prevent some situation offered to him being filled up by other applicants, it is necessary that he should leave school at once. An actual period of three years has to be served and not a nominal period. Thus, if he be absent for any reason, whether holidays or sickness be the cause, he has to make up the time lost. If he does not do so he does not receive the completed contract of apprenticeship, and he has no evidence that he has received a training at the school. This is a necessary proviso, as under the system of education in the Transvaal there can be no compulsion above the fifth standard; that is to say, any attendance above that standard is purely voluntary. Employers can assist greatly by demanding evidence of attendance at a trades school by the production of indentures from those who claim to have been recognised pupils.

The law concerning apprenticeship as it exists in the Transvaal is given in Chapter III of Law 13 of 1880. Under the provision of that Act (Master and Servant), no apprentice may be indentured for a period longer than five years or beyond the age of twenty-one years. The limits are thus the same under the Act irrespective of the relative ease or difficulty of learning different trades. Trades schools, therefore, provide a means of overcoming this omission; since these schools, taking young boys as they do between the most important ages from an educational point of view of thirteen and seventeen years of age, enable boys to be indentured first as apprentices in the school and afterwards on a second indenture with some commercial firm. I think I may summarise the advantages of the trades school to the employer to be:—

1. Economy in the cost of material wasted and in men's time, showing the apprentice the handling of the simpler tools, etc.
2. A gain in the fact that the ex-trades school pupil is able to do work of some value to his employer at any rate sooner than the fresh from school apprentice.
3. Relief from the trial system as the boy has been found fit for the trade he has entered.

The advantages of the trades school to the boy and his parents are (1) advice as to future employment, advice on the careers offered by different trades, and advice on continuation in education; (2) personal trial in one or more trades until the most suitable one is found; (3) opportunity to see and understand the other trades taught in the school; (4) in addition to the specific training given, he is able to gauge whether any employment that may be open to him is likely to provide further training or to be of a "blind alley" nature; (5) he has been trained to the interdependence between theory and practice, and is more suitable and likely to take advantage of evening technical college courses; (6) the better moral effect on young boys of training received in special surroundings.

In an address on technical education given by Mr. Stobie, a member of the governing body of the Pietermaritzburg Technical Institute, he pointed out a grave objection to present methods of apprenticeship which is really an argument for the establishment of Trades Schools. Dealing with the serious drawbacks experienced by the technical educationist through the existing apprenticeship system, he said:

Technical instruction is an essential part of an apprentice's training, and no boy can gain a complete knowledge of a trade without it. Since then these two parts, the practical and the theoretical, are both essential, and a workshop must be considered a training school as much as the technical classes, the work that the apprentice is engaged upon on the theoretical or school side should be so organised as to run concurrently with the instruction he receives in the shop, and should be treated in the same way and regarded as part of his apprenticeship. Yet youths are paid to learn one part of their trade, the practical, and at the same time themselves pay a fee to learn another equally essential part, the theoretical.

This is an anomaly which will not bear criticism, but there is another. A boy joins as a working apprentice in the shop and attends technical classes. He passes from his first year in the shop to his second, his second to his third, and so on to the end of his time quite irrespective of the quality of his work at the technical classes. Indeed he may be in the fourth year of his apprenticeship at the shop and first year at the classes; this is actually the case at the present time (1911). He may attend both, but play the whole time and do no work at all. Nevertheless he passes out of his apprenticeship, although he may have really learnt very little either in the shop or at the classes, becomes a journeyman and is nominally classed as one who has learnt everything there is in both shops and classes. His real knowledge and qualifications count for nothing. So long as he serves his time in the shop, he becomes a journeyman at the end of his apprenticeship however ignorant he may be at the close of his indentures. The system which thus places the earnest and capable on a par with the careless and incapable is obviously a wrong one. The end of it can easily be seen. The small minority, composed of those who would get on under any circumstances, succeed, it is true, but the lazy and incapable remain lazy and incapable, with the result that the general standard is lowered.

I have quoted Mr. Stobie at length because he appears to me to set forth very clearly the need for trades schools. Embodied in his remarks are three main points: (*a*) the recognition of the need of theoretical knowledge and the necessity for the organisation of classroom subjects concurrently with workshop practice; (*b*) the question of fees; and (*c*) the necessity for the recognition in indentures of training in the theory as well as in the practice of trades.

It seems to me that these three points can best be met by the type of trades school which has been established for the Transvaal. To take the first point, it will be obvious that to organise the theoretical course to fit in with the workshop practice means definite syllabuses in the workshop instruction as in the classroom instruction. Syllabuses of practical work taken in a commercial workshop are, of course, impossible, since the first consideration is output, and also the nature of the work done depends upon the demand. Again, if the work is to be equally advanced in practice as in theory, syllabuses must necessarily modify each other. That would mean dictation as to what work could be done in the shop and the order in which it could be carried out. I think we have there at once an insurmountable difficulty, and to my mind the simpler solution is to provide the workshop at the school. In the second point we have a very vexed question. If we are to provide for the sons of those who are unable to maintain themselves and their families without some assistance—and these form the greater majority of those we ought to train in trades—it will be necessary to make grants in support. The Indigency Commission recommended that liberal provision should be made in the way of bursaries.

Together with a small sum payable quarterly to assist the parents in feeding and clothing their children.

The Commissioners went on to point out that

It is to the advantage of the community to supplement the earnings of the parent in order that in the person of the child it may obtain a more useful, because better trained and instructed citizen. (**10**)

This view appears to be very prevalent in the Transvaal—I mean assistance from the Government in the matter of training children. (**11**) Hitherto maintenance busaries have been awarded on application duly certified as deserving, and after due consideration; but with the most perfect system of enquiry, errors of judgment are made resulting in invidious comparison and dissatisfaction. I have, therefore, advocated a small daily rate of pay, advancing by grades from a minimum, on entering the school, to a maximum depending upon the progress and increase of ability in the pupil. This, of course, would only be paid to those who submitted the usual declaration of financial inability to meet the cost of maintaining their sons without such assistance. Such pay is not to be looked upon as made on the factory system of payment for work done, but as a better means of contributing to the upkeep of the boy in such a way as to provide most for those of better ability. There is the precedent of the Miners' School at Wolhuter and the Potteries Industrial School at Olifantsfontein, each of which pays a daily wage increasing half-yearly, and there is the expectation of the majority of parents that wages will be forthcoming. These facts seem to render some wages necessary. The third point, the recognition in apprenticeship of some theoretical training in the elementary technical principles underlying trades, is met by the trades school curriculum in class-room subjects. Of course the boy is not carried the whole way; the end of the trades school course does not mark the end of the technical education necessary; on the contrary, the ex-trades school pupil will still have to continue his technical studies. The point is that he has been trained to the necessity for doing so; the dangerous gap between leaving school and taking up employment has been bridged and bridged before he has quite lost what may be called school ability. Classroom subjects are a *sine qua non* in the trades school; if any boy does not attend, he is invited to leave the school and of course the workshops. The ex-trades school pupil should, of course, take up further technical study in the classroom and laboratories of the School of Mines in the evening course provided by that institution, that is as far as the Rand is concerned; if in Pretoria, he would continue in the polytechnic evening classes at the Pretoria institution. Let it be thoroughly understood that it is practical and theoretical training in technics of the artisan as an artisan that these schools, either in day classes or in evening classes, will cater for; the higher professional training necessary for the architect, the engineer, and the general works manager can only be given in an institution where all energies are concentrated on higher education and on higher education alone that is to say, in the technical side of the University College. There are three such institutions in South Africa; two that have been in existence for some years—the Engineering School of the South African College at Capetown and the South African School of Mines and Technology in Johannesburg; the third is still in its infancy in Natal—the Durban Technical Institute.

My hope is that it will be possible for the clever trades school pupils to enter one or other of these institutions for professional training by competing among themselves for bursaries in technical education offered by these higher institutions and by such bodies as the Witwatersrand Council of Education and, let me add, this Association. It is in this way, also, that a natural system of co-ordination in technical education will be evolved, a system much better than any scheme that can be laid down by regulation from a central bureau, since it will be flexible to the needs of the country, being based on the demand for highly trained workmen. The number of bursaries would fluctuate, of course, with the supply and demand. That would provide for the continuance of the technical education of the cleverer trades school boy; but it is perhaps still more urgently necessary that maintenance bursaries should be available to the brighter boys of the middle classes to enable them to enter the trades school in preference to taking up some "blind alley" occupation offering an immediate cash value, and, because a further stay at the primary school apparently leads only to the high school of which they have no hope. I would suggest that such bursaries be offered on the results of the Primary School Certificate Examination for Standard VI, which is held annually now in all primary schools. Also I would suggest the proviso that special stress be laid on success in Arithmetic, Algebra and Geometry, Science, Mechanical Drawing and Manual Training on the syllabuses laid down in the Transvaal Education Code. It is true that trades schools are intended to help the people in the education of their sons, but I think that in so doing they incidentally benefit certain trades. It is justifiable, therefore, to expect some help from trades unions in this respect. I may point to apprenticeship schools in England and Scotland, which are subsidised in such manner by trades societies: *e.g.*, the Jewellers' and Silversmiths' School at Birmingham and the Bakery Schools at the Borough Polytechnic, London, and at the Royal Technical College, Glasgow, are substantially financed by the corresponding trade societies. (**12**) Such competitive bursaries would of course be in addition to any financial assistance that the Governent might provide to individuals. I, however, would rather see Government funds applied on the principle of the greatest good for the greatest number by a system of payment for all in the wages scheme to which I have already referred. It is in this way that the best effect can be given to the recommendations of the Indigency Commissioners concerning scholarships. (**13**) There is another aspect of bursaries awarded in this way and that is, control of the number of apprentices entering different trades. The school fees are already low, to scholarship pupils they would not exist; thus scholarship pupils would predominate more and more, which would make it possible to adjust the number of trained apprentices to the needs of the industry by regulating the number of bursaries in individual trades, and thus to avoid the excessive supply found in connection with the German system. Let me add that this scheme does not contemplate the donation of moneys to the Government; these schools are controlled, like high schools, by Governing Bodies. The allocation of the money will not lie with me as a departmental official, but with the donors in consultation with the governing body, who will have the advice of the men on the spot and of the Principal of the school to guide them. Before I leave the question of bursary award I would like to draw attention to the following notices from the London County Council *Gazette* as the latest step in the training of artisans in London:—

TRADE SCHOLARSHIP FOR BOYS, 1912.

The Council will be prepared to award during 1912 about 166 trade scholarships for boys; these awards will be tenable at technical day schools. They will provide free specialised training in various skilled trades for two or three years, and, in addition, maintenance grants ranging from £16 to £40. The successful candidates will receive such instruction as will prepare them on the completion of their training to take up apprenticeships or employment in skilled trades.

Scholarships are offered in engineering, building trades, furniture-making, printing, bookbinding, silversmithing, cookery (for training boys as chefs), and general technical training.

Parents and teachers are recommended to consider carefully the exceptional opportunities that are presented in the scheme for the award of trade scholarships for boys.

PUPIL-TEACHERSHIPS OF HANDICRAFT.

The Council is prepared to award in June, 1912, 10 pupil-teacherships of handicraft, to boys who are not less than fourteen years of age on 31st July, 1912.

These awards provide free instruction (with the use of books and tools) at the L.C.C. Shoreditch Technical Institute, Pitfield Street, Hoxton, N. The course of study extends over a period of four years. In the last two years of the awards pupil-teachers attend the handicraft centres attached to elementary schools on two days a week to receive training in the art of teaching handicraft.

The awards include maintenance grants as follows:—First year £10, second year £15, third year £30, fourth year £40. Pupil-teachers of handicraft on the satisfactory completion of their four years' training, are eligible for appointment as senior assistant instructors in handicraft at a commencing salary of £60 a year. It must, however, be distinctly understood that the Council is under no obligation to find employment for pupil-teachers of handicraft upon the completion of their training.

HALF-TIME SCHOLARSHIPS IN ELECTRO-PLATING AND WATCH AND CLOCK MAKING.

The Council has decided to award in January, 1912, not more than four scholarships in electro-plating and four scholarships in watch and clock making. The awards are intended for boys who are actually apprentices or employees engaged in the trades of electro-plating or watch and clock making. Candidates must be nominated by their employers, and must obtain from them recommendations as to their conduct, industry and dexterity in their trades. (14.)

The Trades School is a public investment for national ends called into existence by national competition for national gain and for precedence in national life. It finds its justification in the fact that it will add to the producing power of the nation to its own lasting benefit. Possibly these are sordid motives enough; to me they are redeemed by a conscious sense of patriotism through the spirit of race preservation underlying them. In South Africa we may divide this national competition into two classes (*a*) the importation of the higher skilled artisan class and (*b*) the advance of the coloured races in skilled handicraft. Now nobody but a madman would attempt to stop the influx of virile white peoples into a country situated as South Africa is. It is easy to see that the existing white inhabitants would find it difficult to maintain that high level as a race to which evolution has brought them if that influx were to cease. But it is our bounden duty to see that the colonial-born are not drowned in the process; that is to say, to see that they are not swamped by a superior attainment in the new-comers. To deal with the new-comer by placing active or passive restrictions upon him is artificial and cannot last. Again, whether it benefits the individual immigrant or not, is not a matter which a Colonial Government should inquire into; its business is to bring about the well-being of the country in general and as a whole. Incidentally indeed, and almost invariably immigration does compass the good of the immigrant, since he may "break his birth's invidious bar" and rise to an eminence otherwise unobtainable, but, after all, such consequences are but fortunate happenings by the way; they are neither its purpose nor its justification. It is necessary to see that the Colonial-born are supplied with the means of attainment which have been available to the Colonist from oversea, in order that the industrial progress of the country as a whole may be assured, and the natural, almost only possible, way is by industrial education within the country itself. I submit the trades school as one small, but none the less essential, link in the chain of technical education, not alone because similar institutions exist on the Continents of Europe and America, but because the special and economic conditions in this country demand it. (**15**). By the training which it is proposed to give in these schools, a part of the male population will be placed on the way to skilled craftsmanship which will be the most natural way of reducing the importation of skilled contract labour. It will, of course, be a considerable time before this country can reach the level of manufacture attained by America or even of New Zealand in its one branch of agricultural machinery, but the inventive genius exists in the people, and, given adequate direction, it will develop, and the need for the importation of any but the branch expert will gradually diminish as this country becomes more able to do its own work with its own hands. I now come to the colour question as it affects the artisan; and here I would urge those who have not done so to read at least Chapter I of the Indigency Commission Report. I may, however briefly paraphrase the findings of the Commissioners in the light of my own fifteen years' experience in this country. Let us keep in mind that there is a very high attainment in skilled handicraft among the coloured people of this sub-continent and that very skilled work indeed is done by coloured people, especially in the Cape Province. The printing trade contains a large number of both sexes in simple composing and in machinery. The bookbinding trade employs a number of coloured females, principally in stitching. I need not remind anyone of the Malay plasterer, the best of his kind. The coloured carpenter, the coloured painter, the coloured wagonmaker, the coloured saddler are all greatly in evidence in the Western parts of the Cape Province. I was surprised to find in Natal, when visiting a certain sugar estate, in 1911, that Indian youths were employed as laboratory assistants in the testing departments; I do not mean cleaners; I mean actual assistants who could be trusted to read the scales and verniers of half-shadow polarimeters and such-like instruments, to make the actual adjustments, and to record the readings. If we read Indian for coloured in my remarks on Cape Province I think we have the conditions in Natal fairly accurately.

And in the Transvaal we are slowly but surely approaching Cape conditions; we already have our native blacksmith and native or coloured saddler. It is true that the native blacksmith is only a hammerman and the saddler what is called a "stitcher." I feel sure that the colour wedge will enter the printing trade here as it has done in Cape Colony as soon as competition becomes sufficiently keen to demand a cheaper production; if, indeed, it has not done so already. In other words we already have a little more than the thin edge of the wedge; (**16**) these people are learning here the trades controlled by whites in other countries, and, as they increase in numbers they will go further afield in search of work.

The native is rapidly qualifying himself to enter into competition with the white population in the skilled trades. (**17**)

It will not do to attempt to stop this natural expansion in ability among the coloured peoples by the adoption of preventive measures designed against them. There are native institutions giving instructions to natives, of course for natives, throughout the country, which it would raise Imperial questions to take action against; apart from these there is the educative association with the white man which, in the very nature of things, it is impossible to stop.

It is impossible to prevent the coloured worker by means of legislation from doing any skilled work for which he is qualified. (**20**)

It is said to be possible by adjusting wages (**21**) to provide sufficient scope for the European, the Eurafrican and the Native. Differentiation in wages could only take place on the basis of relative ability; thus the salvation of the European artisan can only lie in a higher skill, a better education and a more complete trade training than the coloured races are capable of. Mere craft practice, mere manual dexterity, the mere ability to repeat the stereotyped process is insufficient in the European—the white artisan must be able to write, calculate and read in the literature of his trade; anything less the coloured peoples can do and with sufficient success to displace white labour. It is to provide that necessary foundation for this improved trade training that trades schools have been established.

Having considered the trades school more or less from the aspect of the dweller in towns, it will be well to consider briefly what can be done for the rural population. The healthy development of rural education on industrial lines as one of the conditions which make rural life possible is of the utmost importance to urban communities, since there is always a steady migration from the country to the town. The object of the industrial education given to children must be two-fold—its first aim should be—

> To inspire them with a love of country life and the desire not to change it for the city or manufactories, and to inculcate the truth that the agricultural profession is the most independent of all and is more remunerative than many others for industrious, intelligent, and instructed followers. (**22**)

As, however—

> There must always be a considerable number of people brought up on the land who will look to making their living by other means than farming. . . . It is desirable that those who wish or are forced to migrate to the towns should, if possible, be able to qualify themselves to get industrial employment before they leave the land.

The second aim must be to provide an industrial—

> Training in occupations which, though dependent on the farming industry have nothing to do with the actual cultivation of the soil or the raising of stock. (**23**)

The institution in the Transvaal which combines those two aims is the Industrial School. If I were to criticise them all, I would say that the agricultural side is in need of greater development; that in addition to boys being instructed in trades with a minimum number of hours per week in the vegetable garden and at field culture, there should be boys definitely apprenticed to farming operations with a minimum number of hours in certain of the workshops. That would mean, of course, the deepening of the instruction in agricultural subjects by talks from experts (**24**) on cattle and poultry troubles, dairying, grading and co-operation, bee-keeping, arrangement of farm-buildings, simple irrigation, and so on; in other words, development in curriculum so that the first aim of the institution is agricultural education: the industrial school to become in fact the recognised "trades school" for the farming industry. The good work of these schools to the country at large cannot indeed be over-estimated. Again, it must be clearly understood that I do not propose interference or overlapping with the curriculum of agricultural schools and colleges;

the instruction should be elementary but sufficient for the skilled farm labourer, in the same manner as in the trades school I propose that the instruction there should be sufficient for the skilled artisan, with some hope of his obtaining the more highly-paid posts. The talks to which I have referred would be given by the experts on the staffs of these institutions for higher agricultural education, and they would mark any lads of special aptitude and ability likely to profit from a college course if assisted financially. Here again the bursary system comes in, and I take the liberty of suggesting to the various Agricultural Societies throughout the Transvaal, including those of Pretoria and Johannesburg, that it would be meet and proper for them to provide the necessary funds. I do not wish to press examinations; I think they can be overdone; but, in addition to a certain number of awards to bursaries made upon the advice of the experts to whom I have referred, and the Principal of the Industrial School, others might be awarded on the results of the Primary School Certificate Examination in Standard VI, stress being laid upon success in Nature Study, Manual Training, Arithmetic, and one language as detailed in the Education Code. The establishment of a developed agricultural side to all industrial schools would in time leave the agricultural colleges more free to deal with the higher aspects of agricultural education as defined by the Indigency Commissioners. (**25.**)

It would be unwise to over-develop the trade side of the instruction given in the country industrial school, as being likely to tend to the migration of the youths on the completion of their training, to the towns, in search of employment, whereas the first aim of the instruction should be to fit them for occupancy of the land. It is therefore advisable to keep the trade instruction within the limits of those trades depending on the farming industry, and such as are found flourishing in country towns. These would be: (1) Carpentry, including furniture-making and simple house-framing; (2) brick-making (if facilities exist), brick-laying and rough masonry, including dam-building; (3) blacksmithing, chiefly on the iron-work for carts, simple repairs to agricultural machinery, and the shoeing of draught animals; (4) boot-making and repairing; (5) tailoring; (6) and, in the larger schools probably, tanning. I do not propose that each and every one of these trades should be taken in every industrial school; consideration must be given to the needs of the locality served by each school. The fundamental trades are, however, carpentry, rough masonry, and blacksmithing, if the boy is to be of general use on the farm.

So far, boys only have been considered; a similar type of schools is as necessary for girls. (**40**) The instruction should, of course, have a house-keeping bent, directed towards domestic service, either in the town house or on the farm. The general education of the girls should be continued sufficiently far to enable them to keep accounts for the smaller profit-making concerns as well as those necessary in household management, and to keep poultry records and recipe books. Courses in nature study (41) and domestic hygiene should be an integral part of the instruction. The two orphanage industrial schools—Langlaagte and Potchefstroom—provide for girls. Here again, I do not criticise, but, in my opinion there is room for development in the direction of the farm-yard and the garden. It will be understood that I do not urge the further provision of orphanages in the foregoing remarks, but the provision of industrial schools for both sexes, in which instruction in farming industries predominates.

The trades school directs that desire for power ever present in the human race towards the control of materials and things, by a training in construction and a developing of the wish to create. And then the vocational instruction which is the means to that end, has a moral atmosphere of its own; thus containing the two essential attributes for any system of education which is to be satisfactory—an ethical as well as an utilitarian objective.

The teacher, realising his enormous responsibilities to the youth of South Africa, and of the importance of making the people understand that what the boy becomes so will this country be, is crying to you, as employers controlling labour, that there is a better way than has hitherto been followed. And I, an engineer by previous training and profession, stand merely as a finger-post on the road, as having experience of these things—I had almost said bitter experience—to point out the way. I, therefore, feel that no apology is necessary in bringing this subject forward, although I do apologise for the way in which I have presented it. In conclusion, I may direct attention to the following four resolutions of the Conference on Technical Education, and I beg to submit my system of trades schools to constructive criticism:—

Resolution II. A. 3.

That for the fullest advantage to accrue from the establishment of schools, it is essential that every young boy previous to working at modern form of skilled trade shall have received suitable preparation for that adult occupation in a vocational school.

Resolution II. C. 14.

That this Conference is of opinion that industrial and trades schools, at which apprentices are taught throughout their apprenticeship would not be a success, but that at least the first two years of an indentured apprenticeship should be spent at a trade school, the remainder under economic manufacturing conditions in the works. During the latter period of their apprenticeship the apprentices should be obliged to attend technical classes according to the trades for which they have entered.

Resolution II. C. 19.

That this Conference is strongly of opinion that no system of technical education will be a complete success unless Government Departments and other employers of labour thoroughly recognise the qualifications of technically trained apprentices either by means of increased wages according to the improved work done, or by promotion in the service.

Resolution IV. 60.

That in the opinion of this Conference the Trades Schools should be a direct avenue into industries, and that the main entrance to a Technical University Course should be through the science side of the ordinary High School or equivalent institution.

THE CURRICULUM.

The trades school, as a whole, is looked upon as a works where young lads are trained with a view to a future career; the rules which would be applied in a commercial works are therefore applied in the trades school, namely, that pupils attend regularly at the hours laid down, that they make satisfactory progress in their respective trades, and that they make up all absences from the school, for whatever reason, until the stipulated period of training has been completed. The qualifications for entry are that the pupil shall have satisfactorily passed the fourth standard of the Transvaal Education Code, and be not less than thirteen years of age at the time of joining the school. On first admission, all pupils go through a probationary course in general workshop practice for six months or less, at the discretion of the Principal, who has the final decision on the fitness of the pupils under his charge. On completing this probationary period, a pupil is required to be indentured for a further period of three years as an apprentice in the trade selected. While at the trades school the apprentice will work at a specific trade, under a qualified tradesman, whose first duty is to instruct the apprentice in the correct handling of the tools necessary in the various processes of his trade. The instructor does not merely do work himself, and use the apprentice to fetch and carry for him; he is there to give efficient instruction upon syllabuses of work which have been carefully drawn up for each trade. In addition to the trade instruction given, the primary education of the pupil is continued, as far as possible, from the fifth to the seventh standard. The class-room subjects comprise reading, writing and composition, history and geography, arithmetic, algebra and geometry, drawing and science, treated in such a way as to bear directly on trades: in the third year of instruction, applied mechanics, steam and the steam-engine, machine construction and drawing, building construction, electricity, etc., are added subjects in which instruction in theory will be given. The pupils are also taught to estimate the cost of carrying out work in their respective trades. The importance to tradesmen of a good general education cannot be over-estimated, and the pupils are expected, therefore, to pay as much attention to school work as they usually do to workshop instruction. After leaving the trades school, the boys' training should be continued by his entering the commercial workshops of some manufacturing firm, and by attendance at selected classes in the evening courses attached to this institution or elsewhere, according to the locality of the firm engaging his services. In these evening classes he will be encouraged to enter for the higher technological certificates of some external examining body.

The school day is divided into two periods, namely, from 8.30 a.m. to 1 p.m., and from 2 p.m. to 5 p.m.: in the forenoons, on Mondays, Tuesdays, Thursdays and Fridays, the first-year pupils will be engaged in class-room work; and on the afternoons of the same days they will be at work in the shops. On Wednesday and Saturday forenoons they will also be at work in the shops. Wednesday afternoons may be utilised for visits to various local works and places of interest to tradesmen; when no visit has been arranged, the pupils continue in the workshops. Saturday afternoon is a half-holiday. The ordinary school vacations at the end of terms are not observed. The only vacation allowed is that extending from the closing of the school in December to the resumption of work in the following January. All public holidays are, however, observed. The school fees are £1 (one pound) per term for tuition, with a small annual charge to cover the cost of books and school material for the class-room subjects. The arrangement of the course of instruction may be compared to the "sandwich" system in vogue in many university technical colleges, in which attendance at the day classes held in the college is alternated half-yearly with attendance at commercial workshops. The difference between trades schools and such colleges being:—

(*a*) That the colleges give professional training to the future captains of industry, while trades schools give artisan training to the rank and file, which properly followed up should lead to a satisfactory career;

(*b*) In the trades school the workshop practice follows in the afternoon of the school day instead of six months later as in the colleges; and

(*c*) In the college system the workshops are separate institutions, while in the trades school the workshops are attached to the school, so that the pupil may attend both at the minimum of expense to his parent.

Such institutions should be part of a connected system: the industrial school should lead to the trades school, and the trades school to the technical college: that is to say, each should be accessible to the cleverer pupils in the institution next below it.

That is the general scheme of the school. The attached analysis of the time-tables, as arranged up to the present for these schools, gives the number of hours devoted to each class-room subject, in workshop practice, and so on. The notes on that analysis give an idea of how the various subjects are to be treated: I do not give the actual syllabuses themselves, because these are still under discussion between the principals of the schools and myself; and, also, because they involve questions of detail which must be left to those responsible for the teaching and its inspection. There is, however, nothing to hide; and, as soon as these syllabuses have undergone, thoroughly, the test of experience *in this country*, I intend to recommend that they be published for general information.

It will still be urged, for some time, that commercial apprenticeship is all that is necessary for the industrial equipment of the future workman. I therefore summarise here the conclusions of a few thinkers, to prove that such training is bad educationally, and insufficient industrially. To many parents the word "apprentice" still has the old meaning, the comfortable assurance of an all-round trade training; to the employer, on the other hand, it generally means those younger employés whom he has engaged simply because they are cheaper than manhood labour, and possibly with the hope that they will learn sufficient by contact with his men to take their places as those men drop out. It is no concern of his if, through the partial training thus promiscuously gathered on his special work, they find themselves unemployable by other firms. It is scarcely to his economic advantage to train the future employés of his competitors. And here let me remind you, as Mr. Bray, in his book, "Boy Labour and Apprenticeship," has so ably pointed out, that those who talk of the interests of employers and of their boys as future workmen being identical, confuse the good of the present generation with the good of the generation that comes after. Competition is To-day and not To-morrow, and the numerous immediate business expenses, and the delayed incomings, make it impossible for the employer to follow proper methods of training in the hope that the new generation of workers will recoup him, by their increased efficiency, for his expenditure.

Some employers have definitely stated their objection to taking apprentices; thus the President of the Transvaal Carriage and Waggon-makers Association, speaking, in 1911, on the establishment of trades schools, remarked that it is generally impossible for an employer in this country to teach boys, or even to allow them to learn. The reasons he gave were, that the high wages of skilled workmen, in comparison with the rates obtaining in European countries, rendered it economically impossible for him to allow his men to attend to the instruction of boys; also that material was expensive, and that much of it had to be imported; so much so, that it was commercially out of the question for him to run the risk of loss through wasted material by training apprentices.

Again, Mr. Cullen, the General Manager of the Modderfontein Dynamite Factory, in an address to the South African Institution of Engineers, said:—

In very few, if any, establishments in the Transvaal, or, indeed, anywhere else in South Africa can apprencices ever be satisfactorily trained. Some will answer—What about the mines and their fine workshops and equally fine facilities; but, unless I am very far wrong in my observation, there is not that necessary atmosphere on the mines to permit a boy to have a good apprenticeship training. The foremen and workmen are changed about so frequently as to give the lad little chance, and many foremen and most workmen look upon apprentices as a nuisance. . . . I hardly blame them for this, for there is always a rush, the jobs are scattered and . . . there is always a "boy" to carry tools and to do odd jobs.

There must be something wrong with the system which causes one manager of a Johannesburg printing and publishing house to say:

> In the last five years there has not been one of our apprentices trained by ourselves that we have considered sufficiently qualified to continue to employ as a journeyman.

The crux of the matter is as stated by Mr. Waldorf Astor, in the April number of the *National Review*, that

> Juvenile labour is at present uneducational, is a department of the labour market and not a preparation for adult life.

If that is so in European countries, how much more so is it in this, where we have a kind of perpetual juvenile in the ubiquitous Native.

We have therefore to consider carefully for our youth first, the kind of occupation to be followed, and, secondly, how the training is to be obtained. Here I cannot do better than by again quoting South African opinion. In 1909, Mr. Samuel Evans, writing to the sub-committee of the Witwatersrand Central School Board, who were at that time reporting upon the question of trades schools, said:—

> It appears to me that the guiding principle in selecting occupations for boys in this country should be this: That the occupation should be such as to enable boys, when they grow to be men, to compete successfully with Kaffirs, whilst earning a very much larger pay than Kaffirs. It follows that if South African boys are to be taught skilled trades, this must be done as part of our scheme of public education. . . . Generally speaking, these would be trades in which a considerable amount of machinery would be employed.

That is to say, the trades for White boys in this country are those which make an increasing demand on trained intelligence, because of the evolution of improvements in those trades. As soon as a trade, or any part of it, has become stereotyped and divided into compartments in which the routine of seeing that certain processes are carried out in a certain order by more or less automatic tools is all that is necessary, that trade has ceased to be a field for the White man, for the simple reason that the skill required has been transferred from the man to the machine, and it is therefore open to the Coloured person, and, after him, the Native.

Thus the curriculum of the trades school must not be one of restriction, by keeping a boy on one kind of work as long as possible; it must provide a broad training, without sacrificing thoroughness of workmanship, in order that the future workman may rise superior to the competition of the automatic tool and Native labour. Neither must its courses be conceived to the profit of the employer, but to the progress, as rapidly as possible, of its pupil.

ANALYSIS OF PROVISIONAL TIME TABLES: TRADES SCHOOLS.

	Stand. V 1st year, or Class 1. 0-12 months.		Stand. VI 2nd year, or Class 2 12-24 months		Stand. VII 3rd year, or Class 3. 24-36 months.		Balance of time or Class 4. 36-42 months.	
CLASS-ROOM INSTRUCTION.	*Pretoria.*	*Johannesburg.*	*Pretoria.*	*Johannesburg.*	*Pretoria.*	*Johannesburg.*	*Pretoria.*	*Johannesburg.*
Mathematics:								
Arithmetic	2	3	1	3½	1 }	2½	— }	2
Mathematics ..	1	3	3	1	— }		— }	
Algebra..	1	3	1	2½	2	2	— }	
Geometry	1	1	1	1	$1\frac{1}{6}$	—	—	—
Office Practice	—	1	—	—	1	—	—	—
Science and Applied Mathematics:								
Gen. Elementary Science	4 }	6	3 }	6	$1\frac{1}{6}$ }	2	— }	2
Applied Mech...	— }			—	3 }		4 }	
Materials, Construction and Calculations..	—	1	—	1	1⅓	2	—	2
Steam	—	—	—	—	1½	—	4	—
Applied Drawing:								
Prelim. Drawing	2	2	2	—	—	—	—	—
Geom. Drawing	—	2	—	1½	1½	—	—	—
Trade Drawing	2	1½	2	2	3	2	3	3
Other Subjects:								
English	1	—	1	—	1	—	—	—
History	1	1	1	—	—	—	—	—
Geography	1	2	1	1	—	—	—	—
Hours in Class-room Instruction ..	16	26½	16	19½	18	10½	11	9
Workshop Practice	24	12	24	19½	22	30½	30	32½
Intervals and Breaks	7	8½	7	8	6	6	6	5½
Total Hours Per Week..	47	47	47	47	47	47	47	47

NOTES ON ANALYSIS OF TRADES SCHOOL TIME TABLES.

Geometry,

includes practical investigation of theorems with Euclidian proof in the third year.

Office Practice,

includes book-keeping, costing, reading specifications, and practice in tendering for work.

Materials: Construction and Calculations,

includes general questions involving explanations, with testing of materials by the teacher, to bring out differences in nature and adaptability for different purposes.

Preliminary Drawing,

includes the syllabus of the primary school code, with additions mainly of a technical nature, *e.g.*, hand sketching.

Technical (Trade) Drawing,

includes machine construction and drawing for engineer mechanics, and is a general name to include the similar drawing special to other trades.

English, History, Geography,

according to school code, but treated from an economic and industrial point of view.

Total Hours Per Week:

The school day extends from 8.30 a.m. to 5 p.m., and from 8.30 a.m. to 1 p.m. on Saturdays. The total number of hours per week is, therefore, 47.

The trades in which instruction is given both at Pretoria and Johannesburg are: (see pamphlet describing the Pretoria Trades School and Polytechnic).

1. *Blacksmithing*: Including engineering and tool smithing.

2. *Carpentry*: Including builders' joinery, furniture making, and pattern making.

3. *Electricians*: Wiring, armature winding and simple shop testing for continuous and alternating currents.

4. *Engineer-Mechanics*: Turning and fitting, including tool dressing for lathe work, etc., and some knowledge of simple foundry work.

Note.—In connection with this trade there should be a small foundry plant.

5. *Plumbers*: Including sheet metal work in iron, copper, brass and zinc, sanitation, sewerage, and water supply.

6. *Waggon Making*: Including carriage building and vehicle painting.

Note.—In connection with this trade there should be instruction in the Trades of (*a*) Sign Writing and Heraldic Painting, (*b*) Carriage Trimming.

7. *Printing and Compositors' Work*: Pretoria only; in abeyance.

Regulations Governing Award of Wages-Payment.

I. Each lad entering the school shall receive a minimum of 8 pence per working day (twenty-six working days per month).

II. There shall be four grades of ability in school subjects of general education as follows:—

	Extra Pay Per Day. d.
A.—Shall be the Junior Class of the School and equivalent to Standard IV or V according to circumstances..	—
B.—Shall be the next higher class and shall consist of those who have passed or who satisfy the Principal that they can pass the test at the end of the first school year	1
C.—Shall be the class next higher to B and shall consist of those who have passed or who satisfy the Principal that they can pass the test at the end of the second school year	2
D.—Shall consist of those who have actually passed the test at the end of the third school year	4

III. There shall be four grades of ability in applied science and technical subjects bearing upon each lad's trade, and which are taught in class-rooms as distinct from workshops, as follows:—

	Extra Pay Per Day. d.
E.—Shall consist of those who fail to reach the required standard for the next following division	—
F.—Shall consist of those who have passed the test held during the first year of the course	2
G.—Shall consist of those who have passed the test during the second year of the course	6
H.—Shall consist of those who have passed the test held during the third year of the course	8

These tests shall be by examination, including written papers.

IV. There shall be seven degrees of rating according to ability and progress in the workshops, numbered from 0 to 6. The 0 degree shall carry no extra pay; the first degree shall be worth one penny per day extra pay; the second degree, 2 pence; the third degree, 3 pence; and so on up to 6 pence per day extra pay.

V. No pupil shall be graded beyond "A" or be rated for extra pay in the workshops who has not become an indentured apprentice.

VI. All payment shall be made monthly in arrear to the pupils concerned.

VII. Full pay shall be deducted for absence for any reason. Public and school holidays and illness, medically certificated to the satisfaction of the Principal, excepted.

VIII. Fines may be levied for disobedience, wilful damage, absence without leave or other reasons at the discretion of the Principal, and shall be deducted from the monthly payments due to any pupil.

IX. Recommendations as to grading shall be made to the Governing Body, who shall submit lists periodically, with their recommendations to the Transvaal Education Department. This shall not refer to fines and deductions.

EXAMPLES OF GRADING APPLIED TO PUPILS.

(Average daily rate 1s. 1.6d.)

Pupil.	New rate of Grading.	Pay per diem. s. d.	Pay per month of 26 days. £ s. d.
K. B.	D. G. 6	1 9	2 5 6
H. F.	D. F. 4	1 5	1 16 10
B. I.	D. G. 5	1 8	2 3 4
P. B.	C. F. 6	1 5	1 16 10
S. H.	D. F. 4	1 5	1 16 10
J. W. E.	C. G. 6	1 7	2 1 2
H. van L.	C. F. 4	1 3	1 12 6
F. V. S.	D. E. 5	1 6	1 19 0
C. D.	B. F. 2	1 0	1 6 0
W. S. B.	B. F. 2	1 0	1 6 0
E. W.	B. F. 3	1 1	1 8 2
J. van Z.	C. F. 3	1 2	1 10 4
B. C.	B. E. 2	0 11	1 3 10
J. V.	C. E. 2	1 0	1 6 0
F. B.	B. F. 2	1 0	1 6 0
R. C. L. F.	C. E. 1	0 11	1 3 10
H. J. C.	B. E. 1	0 10	1 1 8
N. R.	A. F. 1	0 10	1 1 8
P. K.	A. E. 1	0 9	0 19 6
H. T.	A. E	0 8	0 17 4

This averages 1s. 1.593d. each per diem.

For the Pretoria Trades School and taking the present pupils as representative types, the average daily rate of pay works out at 13.6 pence or £1 8s. 6.6d. per month of twenty-six working days. Thus the expenditure in wages-payment for 100 boys on this basis would be, for 12 months, £1,708, an amount which compares with the present payment in bursaries. The highest daily rate of pay under this system would be 1s. 11d.

The advantages of the wages-payment system over that of the bursary-payment are:—

1. The payment is based on practical and continuous ability
2. The most money goes to the best and hardest worker.
3. The claim for partial support by the State is met by making the males prove their ability.
4. The scale of grading being published, the parent has an immediate index to the progress of his son.
5. The system makes for emulation among pupils and provides just reasons why one is entitled to more than another.
6. A system of fines is rendered possible and a better control obtained in minor delinquencies. (*N.B.* Attendance at all schools is voluntary above Standard V.)
7. Unindentured pupils receive no advance in grade: *i.e.*, they remain at 8d. per day until their parents complete the contract of apprenticeship.

Distinctions between Trades Schools, Industrial Schools, and Manual Training Centres.

In order that clear ideas may obtain it is necessary to distinguish the differences in the tuition given in Trades Schools, Industrial Schools, and in Manual Training Centres.

The Trades School:

A Trades School may be called an Industrial High School where a boy works for half the day in the shops and in the other half in the classroom; in the classroom he is given elementary technical instruction in the trade he is following under the tradesman instructor in the workshops; and also his education is continued in certain subjects from Standard V to Standard VII inclusive.

The arrangement of the course of instruction in the Trades School may be compared to the sandwich system in vogue in many of the University Technical Colleges of Europe in which attendance at the day classes of the College is alternated half-yearly with attendance at Commercial Workshops, the difference between the Trade School and such Colleges being (*a*) the College trains future captains of industry, while the Trades School trains the rank and file; and (*b*) in the College system, the workshops are separate entities, while in the Trades School the workshops are brought to the school so that the boy may attend both at the minimum of expense to his parents. A Trades School can never become self-supporting because it is primarily an educational institution and a manufactory only as the circumstances of the training given in it permit.

The Industrial School:

In an industrial school, as a rule, a boy works all day at one trade or craft; he receives no instruction in the elementary technical and scientific principles underlying the trade he is following. Two hours' school is usually given, in the late afternoon or evening, in reading, writing and arithmetic according to the fourth standard of the primary school code. As such industrial schools are nearly always intended to be self-supporting, by means of the work carried out by the pupils, the craft instruction given depends to a great extent on the nature of the contract work on hand.

The Manual Training Centres:

Manual training deals with the general principles involved in the use of tools, the methods of working materials, and the making of constructional drawings in such a way as to train the intelligence and develop the character of the pupil. It aims at giving an intelligent mastery over tools, materials and methods as well as general practical dexterity, which will be useful in any walk in life that the pupil may follow. The result of such teaching is a strengthening of the intelligence, character and productive activity of the pupil. Manual training instruction has, therefore, two sides—(1) educational, (2) utilitarian. Such training on its utilitarian side must be looked upon as preparatory to trade training—may even be called preparatory trade training—and is essential before instruction in trade processes and methods is commenced. Such training should be taken before the specific instruction given in trades schools is attempted: it should, therefore, be given in the school where the boy has received his general education up to the point of entry to a trade either through the trades school or through the shops of a commercial firm. Recent experimental psychology has shown that hand training must precede trade training if manual dexterity is to mature to perfection: thus manual training is not merely a counter irritant to book-learning, but a necessary part of education due to changed social conditions brought about by changes in industry.

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23. *Ibid.*, page 83, paragraph 154.
24. *Ibid.*, page 81, paragraph 184 and Ap. 3.
25. *Ibid.*, page 82, paragraph 150.
26. *Ibid.*, page 121, paragraph 231.
27. *Ibid.*, page 109, paragraph 208.
28. *Ibid.*, page 62, paragraph 111.
29. *Ibid.*, page 23, paragraph 112.
30. *Ibid.*, page 63, paragraph 67.
31. *Ibid.*, page 36, paragraph 68.
32. *Ibid.*, page 117, paragraph 223.
33. *Ibid.*, page 185, paragraph 376.
34. *Ibid.*, pages 15-28,29.
35. *Ibid.*, page 97, paragraph 180.
36. *Ibid.*, page 35, paragraph 67.
37. *Ibid.*, page 191, paragraph 392.
38. *Ibid.*, page 56, paragraph 103.
39. *Ibid.*, page 190, paragraph 395.
40. *Ibid.*, page 56, paragraph 103.

TRANSACTIONS OF SOCIETIES.

CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.—Saturday, April 18th: A. Richardson, M.I.M.M., President, in the chair.—"*The Witwatersrand earth tremors*": H. E. **Wood.** In 1908, interest in seismology was aroused in South Africa owing to the occurrence of a continued series of small earthquake shocks or local tremors over the Witwitwatersrand. During 1908 and subsequently, up to March, 1914, in all 171 of these shocks had been experienced. The view was expressed that these were semi-artificial in origin, and caused by the extraction of large amounts of rock and water from comparatively small depths beneath the surface. This view is confirmed by taking into account the circumstances under which similar tremors have been known to occur in Sunderland, in the Rhondda Valley, and in Germany. Seismologically the author considers South Africa to be stable, with the exception of four distinct regions of instability: the southern part of the Orange Free State, along the Cape border; the Rustenburg and Zoutpansberg districts in the Transvaal: and the eastern slopes of the Drakensberg Mountains.

Saturday, May 16th: A. Richardson, M.I.M.M., President, in the chair.—"*Notes on hydraulic classifiers and classification*": Prof. G. H. **Stanley.** The author described a series of experiments undertaken with the object of ascertaining more definitely the causes of discrepancy between theory and practice in the sorting out of mineral particles of different sizes and specific gravity by hydraulic agency, and of overcoming, as far as possible the causes of imperfect classification.—"*Rock temperatures*": E. J. **Moynihan.** The author criticised the data of Whitehouse and Wotherspoon abstracted in a previous volume,* according to which

* 1910 Report, Capetown, p. 374.

the mean rise of temperature is 1° F. for 253.9 feet vertical depth. His purpose was to show that temperatures taken by means of drill-holes of moderate depth, in stopes or development faces, are often far from the original rock temperatures; that hence the temperatures so obtained often give rock temperature gradients that are far from the actual. The view was also expressed—and reasons stating for holding it—that, unless refrigerating methods are used, one cannot hope to reduce the air temperature gradient below the natural mean temperature gradient which the air has due to compression, namely about 1° in 180 feet.

Geological Society of South Africa.—Monday, April 20th: D. P. McDonald, M.A., B.Sc., President, in the chair.—"*Metasomatism in Banket*": Prof. R. B. **Young.** The author prefaced his more general remarks by describing some particular unrecorded instances of replacement at the Rose Deep, Paarl Central, and Machavie Gold Mines. The classes of metasomatism in general were naturally arranged in two groups: (1) those in which the replacement occurs sporadically at a great number of isolated points within the rock, and (2) those in which the replacing mineral tends to form a continuous body. The former includes replacement of quartz by pyrite and other sulphides, as well as by gold and the carbonaceous substance now represented in the banket by almost pure carbon. The second group includes replacements of quartz by chlorite, sericite, and calcite. In some of the cases of metasomatism, *e.g.*, calcification and chloritisation, the decomposition of basic dykes intersected in the mines would afford an abundant supply of the replacing substances; while the existence of open fissures descending to depths of several thousands of feet, along which conspicuous solution has taken place, suggests the descent, in quantity, of meteoric waters.—"*The geology of a portion of the Belingwe District of Southern Rhodesia*": Dr. P. A. **Wagner.** The first part of the paper consisted of a description of the physiography of the area dealt with, to which were added brief accounts of the drainage and water supply, vegetation and archæology. In referring more exclusively to the geology of the district, the author gave special attention to the rocks of the banded ironstone and greenstone schist groups, which occur in narrow belts and patches, scattered like islands through a sea of gneiss. The gneisses and granites were then described, the former under the three heads of (1) foliated biotite gneiss, (2) mylonitic gneisses, and (3) magmatic or composite hornblende-biotite gneiss. In the concluding part of the paper a description is given of the great dyke of Southern Rhodesia, a vast intrusion which introduces a distinct element into the landscape in the south-eastern portion of the region dealt with in the paper, and also of the Um Vimeela dyke, running parallel to it at a distance of eight miles, and marked by a line of norite hills, along which almost exclusively in the district the presence of fine examples of the Um Vimeela tree (*Kirkia acuminata*) is to be observed.

South African Institute of Electrical Engineers.—Thursday, April 23rd: W. Elsdon-Dew, President, in the chair.—"*Additional notes on Electric furnaces*": Dr. W. **Glucksman.** The author referred to developments in the application of electric furnaces since the date of his previous paper (see this volume, p. 64), and mentioned particularly the artificial production of diamonds by Deboismenu, who had succeeded in making a diamond weighing 2½ carats.

NEW BOOKS.

Tilby, A. Wyatt.—*The English people overseas: Vol. VI.—South Africa*, 1486-1913. Post 8vo. (8½ × 5½ in.), pp. x, 632. London: Constable & Co. 1914. 7s. 6d.

Stevens, E. J. C.—*White and Black: an inquiry into South Africa's greatest problem.* 12mo., pp. vi, 284. London: Simpkin, Marshall, Hamilton, Kent & Co. 1914. 12 oz. 2s. 6d.

White, S. E.—*African camp fires.* 8vo. pp. 415. Illus. London: T. Nelson & Sons. 1914. 30 oz. 5s.

THE HYDROGRAPHER'S DEPARTMENT OF THE BRITISH ADMIRALTY.

By Howard Pim.

This victory will not be gained in the interests of Germany alone. We shall in this struggle, as so often before, represent the common interests of the world, for it will be fought not only to win recognition for ourselves but for the freedom of the seas.—(*Germany and the Next War.* By General Bernhardi, p 168).

A vain hope, for the freedom of the seas *has been won*, and belongs to-day to the whole brotherhood of seamen, without distinction of race or nationality. This has come about mainly through the work of the Hydrographer's Department of the British Admiralty, and a summary of this work is the subject of my paper. It is short, because of the limited time allowed, incomplete because I have not had access to a full series of Departmental reports, and contains few personal touches because these reports are laconic in the extreme. We are seldom allowed so much behind the scenes as in 1881, when we are told:—

The North Coast of Borneo has been so swept by Sulu pirates that now these are the only people with any real knowledge of the coast. The services of an old pirate were therefore obtained, and the names which appear on the coast survey are mainly dependent upon his information.

In order better to understand what has been accomplished, I prefix a short statement as to the position of navigation and of the knowledge of the seas up to 1795, when the Department was created.

These limitations prevent more than the merest allusion to the wonderful voyages of discovery of the Portuguese in the fifteenth and sixteenth centuries, or to the fact

That the praise of the application of the compass to these remote discoveries is due to the Portugals who first began to open the windows of the world to let it see itself.

Henry the Navigator, third son of John I of Portugal, was

The true foundation of the greatness, not of Portugal alone but of the whole Christian world in marine affairs and especially of these heroic endeavours of the English (whose flesh and blood he was)

for his mother was Phillipa, a daughter of John of Gaunt.

I deal with a later time, for discoveries came first, running surveys followed, and finally surveys executed on rigorously accurate principles, with the resulting charts and sailing directions.

The earliest known charts—and they are of remarkable accuracy—were attached to the Portulani or sailing directions for the Mediterranean, which were in general use in the thirteenth century, but must have originated long before this, and without the aid of the compass. A book of sailing directions for the coast from Scotland to Gibraltar was written in the fifteenth century. A map of the coasts of the British Isles, and of

Western Europe and Africa nearly to Cape Verde, was drawn in London in 1448.

In 1500 the Spanish pilot, Juan da la Casa drew a map of North America, from Cape Breton to Hatteras, which, traced on a bullock's hide, still hangs in the Navy Office in Madrid. Many early sailors advocated the making of charts, and in 1581 William Burrough, afterwards Comptroller of the Admiralty, published his discoveries of the Variation of the Compass, and, later, sundry charts and sailing directions.*

About the same time the celebrated Dutch cartographer, Gerardus Mercator, was at work, and also Waghenair, who compiled the collections of charts known as "waggoners," which were in use for many years. So far as the English and adjoining coasts are concerned, "waggoners" were superseded by the *English Pilot* of John Sellers, who is styled Hydrographer Royal. It consists of a collection of rude sketches of the coasts of England and the North Sea, France, Spain, etc., with sailing directions. The name "waggoner," however, survived, and in 1699 collections under this name were still in use for the East Indies, as appears from Dampier's account of his approach to the Cape.†

I should like to call special attention to this quotation, as it gives such a complete summary of the difficulties and methods of navigators before the days of charts and chronometers.

Longitude continued to puzzle navigators for 200 years more, and until the discovery of the chronometer its determination was practically impossible. What the true method was, if the instruments could be obtained, was well-known from as early as 1530, and it is clear that Gemma Phrysius expected to see an instrument capable of measuring time with sufficient accuracy in his own day. He writes as follows, about the year above-mentioned:—

> We see in these our days certain little clocks very artificially made, the which for their small quantity are not cumbrous to be carried about in all voyages. These often times move continuously for the space of 24 hours, and may with help continue their moving in their manner perpetually. By the help therefor of these the longitude may be found.

Gemma also mentions "Ephemerides and the Tables of Alphonsus," the first almanac having been published in 1457.

> The seaman's view of the matter was that there be some that are very inquisitive to have a way to get the longitude, but that is too tedious for seamen, since it requireth the deep knowledge of astronomy. Wherefore I would not have any man think that the longitude is to be found at sea by any instrument, so let no seaman trouble himself with any such rule but according to their accustomed manner let them keep a perfect account and reckoning of the way of their ship.

The navigator's general procedure was to sail until the requisite latitude, or height as they called it, was reached, and then run along this parallel east or west, as might be necessary, using

* Appendix I.

† Appendix II.

the precautions mentioned by Dampier. The instruments used were the compass, cross staff and astrolabe, log and hour-glass, followed by the vernier and quadrant, but I cannot here dwell upon them. In 1590 Edward Wright invented the method of making charts which is called the projection of Mercator.

In 1675 Greenwich Observatory was established, and Flamsteed was placed in charge. The Government provided no instruments whatever, and all he had to start with were, one iron sextant of 7 feet radius, a quadrant of 3 feet radius (the old form without mirrors), two small telescopes, two clocks, and Tycho Brahe's catalogue of 777 stars, nearly 100 years old. He did valuable work, and was succeeded, in 1720, by Halley (the Captain Halley mentioned by Dampier), who held the position until 1742.

The quadrant or sextant, in its present form, was invented by John Hadley and Sir Isaac Newton, about 1731, and independently by Thomas Godfrey, a poor glazier, in Philadelphia.

> Until this time [as it is quaintly put] all instruments in use at sea for measuring angles either depended on a plumbline or required the observer to look in two directions at once.

The chronometer was invented by John Harrison, about 1735, and the first Nautical Almanac was published by Nevil Maskelyne, in 1766.

In 1714 the body known as the Commission for the Discovery of Longitude at Sea was established, and it is to them that we owe all that was done by England for the survey of coasts, both at home and abroad, prior to the establishment of the Hydrographic Department of the Admiralty, in 1795. This Commission also bore part of the expense of Captain Cook's voyages and of the publication of their results.* This great seaman and greatest of navigators

> Was the founder of modern marine surveying and possessed qualifications rarely combined in one man, which place him first on the roll of maritime discoverers not only in his time, but for all time. He has no equal and stands alone.†

Others followed. Bligh, of the *Bounty*, Phipps, Vancouver, and many others, of whom perhaps the greatest were Matthew Flinders and George Bass. The former

> Did his work on the Australian Coast so thoroughly that he left comparatively little for his successors to do.

In 1796 the two of them, with one boy, surveyed a considerable stretch of the New South Wales Coast, in the *Tom Thumb*, a boat 8 feet long, and in 1798 Bass explored 600 miles of the same coast, in very tempestuous weather, in a whale boat, with a crew of five convicts. Later, in the sloop *Norfolk*, they circumnavigated Tasmania for the first time.

* Appendix III.
† C. R. Markham.

In 1801 Flinders was given a rotten sloop, called the *Investigator*, and in her he circumnavigated Australia, but she was condemned on the coast in 1803, and, after a series of misfortunes, he was detained by the French, a prisoner, in Mauritius for six years. This shortened his life, and he died in 1814, on the very day his book was published, at the early age of 40. He was the first to investigate the deviation of the compass caused by iron on board, and to suggest remedies. The name Australia is also due to him.

During this period the officers of the East India Company were actively engaged in survey work, and in 1786 their first catalogue, showing 347 charts between England, the Cape, India and China, was published. This catalogue was the work of H. A. Dalrymple, who in 1795 became the first Hydrographer of the Admiralty, and, with these small beginnings and a vote of £650 per annum, the work was started.

Needless to say, the want of accurate surveys was first felt along the shores of Great Britain, and Murdoch MacKenzie's chart was published in 1804.

In 1811 Captain Francis Beaufort, afterwards Hydrographer, surveyed part of the East Coast of Africa. In 1814 an expedition explored the lower reaches of the Congo, for 280 miles, and Commander Tuckey and five officers died while the work was proceeding.

Not much was done during the great War, but in 1815 the work expanded, and, while some other Governments

Participated so far as their own coasts were concerned, the English department took under its charge practically every place where the inhabitants were not able to do the work for themselves.

Since that time its career of usefulness has steadily developed, and, assisted by the work of other Governments, amongst which that of the United States is conspicuous, it not merely undertakes the constant improvement of the charts of the whole world, but also issues periodically, for the use of the whole seafaring community, without distinction of nationality, a vast amount of information on all nautical subjects.

In 1821 Captain William Fitzwilliam Owen, in command of the *Leven* and *Barracouta*, commenced the survey of the African coasts, and Table Bay was surveyed in 1822, and, later, Mozambique, Sofala, Quilimane, Zanzibar, and the Seychelles. In this work died two-thirds of his officers and half of his men, in seven months. Later, he surveyed the coast, from Walvisch Bay to Sierra Leone and the Gambia, and, after five years' work, laid down with great accuracy 30,000 miles of coast, recorded in 83 charts and plans.

He was followed by Cutfield and Boteler, who died, on the coast, in 1829. In 1826 a survey of the Straits of Magellan was made by Skyring, afterwards killed on the East Coast of Africa.

Captain Fitzroy followed, in 1831, with the survey of Patagonia, the Falkland Islands, and the West Coast of South

America to Guayaquil and the Galapagos, finding the Spanish charts many miles out in longitude.

As another instance of the want of knowledge then prevailing, I may mention that, up to 1839, different charts showed no less than six different positions for Rio Janeiro.

During these years work was proceeding round the English coast, in the Red Sea, and, by Captain Moresby, in the East Indies. Vidal was continuing Boteler's work in the Bight of Benin, and, from 1841 to 1845, he was engaged at the Azores.

In 1840 the first complete survey of the East Coast of England and the Shetlands was finished, and the survey of the Irish Channel was commenced by Beechey. This year is typical of many to come, for surveys were proceeding of the coasts of Southern Arabia, Bay of Bengal, River St. Lawrence and New Brunswick, New Jersey, Long Island, and Cape Cod, West Indies, Mexico, Yucatan, Bass and Torres Straits; and so the work continued, year by year, in all parts of the world. About 10 ships, with 70 officers and over 500 men, were engaged. The mere labour involved was stupendous. For instance, the survey of the southern part of the North Sea was completed in 1844. In this year alone, over 20,000 soundings were taken for this single survey.

In 1849 charts were published for the Mediterranean, West Indies, Canaries, England, Ireland, Australia, North America, New Guinea, West Coast of Africa, Moolmein River, Labrador, and many others. Algoa Bay also was described.

From 1847 to 1853, Evans was at work on the West Coast of New Zealand and in the Archipelago. Basil Hall charted the Loochoo Islands. Foster, surveying in the West Indies, was drowned in the Chagres River, while measuring the difference of longitude between Chagres and Panama. Collison was at work on the China coast, Blackwood on the Great Barrier Reef, and many other surveys were in progress.

In 1854 the South Coast of England was completed as far as Portland, and a chart from Hangklip to Agulhas was published. Up to this year the Nova Scotia coasts were so faultily expressed that many charts could only be considered snares, instead of guides.

In 1855, 20 ships were engaged, and during the twelve months 131,000 copies of plans and charts were published, for whoever wanted them. In this year the West Coast of Cape Colony was examined by Commander Nolloth, and an awkward Bank off Port Elizabeth discovered and charted.

In 1856 the survey of the terrible Irish coast south of the Shannon was completed, and Commander Church, worn out by the work, died immediately afterwards. In this year the coast of Siam was found to be laid down 10 miles east of its true position, and Fanning Island 32 miles.

In 1857 no less than 23 surveying parties were at work, and in this year Port Natal was surveyed.

Here I find one of the few allusions to individuals which appear in the reports I have had access to:—

Rear Admiral Bayfield retires from the command of the survey of the St. Lawrence, on which extensive work he has been engaged for upwards of a quarter of a century. It has fallen to few officers to originate and bring to a close after so many years so extended and laborious a work, where the surveyor had to contend with a rigorous climate in winter and fogs in the spring and autumn, leaving but a short season in which outdoor work could be executed. It has, however, been done in a masterly manner, as more than 100 published charts and plans, complete sailing directions, and a valuable table of geographical positions connected with Quebec, Halifax and Boston most fully testify

In 1858 we have an account of the work on the Argyleshire Coast. In the space of 90 square miles 13,000 soundings were made, the greatest depth being 97 fathoms. The cost of the survey, including soundings, when conducted in the most economical manner, is about £30 per mile of coast line. In the same year the coast about the St. John's River was charted, and a closer examination made of Table Bay.

In 1859 we are told that the survey of the coast of Scotland has occupied over 20 years, and will require five years more. The cost, when finished, will not have been less than £250,000.

In 1860 an error of 11 miles in longitude was discovered in the charts of the Spanish coast near Bilbao, and the charts of False Bay were corrected. Two shoal spots, about a mile South-West of Cape Point, were discovered, and the Cape Point Lighthouse installed. The first general chart of the Coast of China was also published.

In 1861 a cape on the North-East of Cuba was found to be charted 20 miles of longitude from its true position, and in the following year an important port in Sumatra was found to be 14 miles out in latitude. In this year the results of Captain Durham's nine years' serivce in the Australian seas were published. 200 charts, plans and drawings completed and in progress, 163 positions catalogued, variation tested 2,410 times afloat and 191 times on shore, 41 islands and 42 ocean reefs and sunken shoals surveyed, 700 miles of the edge of soundings contoured, and 23 fabulous dangers erased from our charts.

In 1863 Mossel Bay was surveyed, Vancouver completed, and a most interesting Japanese chart of their own coast obtained,

Valuable not only as a correct map (for wherever tested it has been found to be both trigonometrically and astronomically accurate to a remarkable degree, though graduated in a peculiar and original manner), but also as a work of art, illustrating the advanced stage attained by this extraordinary people in surveying, which will compare favourably with specimens of our own published in the beginning of the present century.

In this year 138,503 charts were distributed, and a note of relief is allowed to appear in Sir Roderick Murchison's summary of the surveys of the Australian coasts:—

We are now beginning to reap the fruits of those long years of toil and industry, the rewards of that skill, patience and perseverance which produced to the world the magnificent survey of 800 miles of channels within the reefs of this coast, a survey which when commenced must have appeared almost a hopeless undertaking, but which has led to the opening of a safe highway, soon to become the beaten track between India and Australia. In connection therewith let not the names of King and Blackwood and Stanley be forgotten. Well may the companions of these gifted men who still remain feel proud to have participated in a work which will ever remain a monument of their perseverance and their skill, and among nautical surveys will stand unrivalled.

In the Geographical Society's report for 1865 we again hear of Captain Fitzroy, who had died not long before. After the *Beagle* voyage (in which Charles Darwin took part as naturalist) he returned to the South American Station, being unwilling to quit it without rendering his survey in every sense complete. He hired two additional vessels, at his own cost, to finish off the examination of the Falkland Islands, and subsequently purchased a third (the *Beagle* itself, it should be noted, having been fitted out to a great extent at Fitzroy's own expense). These efforts, which cost him several thousand pounds, had not been sanctioned by the Admiralty, and he was never reimbursed. He died in impoverished circumstances. An institution by which his name should also be remembered is that of storm signals established all round our coasts.

In 1865 Plettenberg Bay and the adjoining coast was surveyed, and a total of 203,775 charts were issued to the public.

In 1866 there is a note that Captain Mansell had retired from his long and useful labours, after 32 years passed in the surveying branch of his profession, and another short paragraph about the coast of British Columbia, which gives an insight into the labour involved in survey work. Of the coast of British Columbia it says, in speaking of a single inlet:

The islands are so numerous and the coasts so much broken that although it is not more than 70 miles from the entrance to the head of the inlet, yet its shores comprise an extent of coastline amounting to upwards of 700 miles.

About this time the Agulhas Bank was sounded, and the survey was completed from Cape Infanta to Yzervark Point, and from Cape St. Francis to Receife Point. Owing to the exposed nature of the coast, difficulties of obtaining soundings were very great.

In 1867 a chart of the Agulhas Bank and the coast of the Cape Colony, from Hondeklip to Port Natal, was published.

In 1868 many hidden dangers in the neighbourhood of the Channel Islands, hitherto unknown, were discovered and placed upon the chart.

In 1869 a consecutive line of deep sea soundings was carried out from the Cape of Good Hope *via* St. Helena to the English Channel.

The making of paths through the China Sea [says the report of this year] has been the patient but persevering work of the Navy of this country for 30 years. Commenced in war and continued in peace, may well it have been considered a gigantic task to which no end could be seen when first undertaken, and yet to the end, so far as this great area is concerned, may now be clearly and definitely counted upon.

In this year many errors were found in the old charts between Capetown and Saldanha Bay.

In 1870 this work is also mentioned, and that the survey has been continued northwards to Lamberts Bay. Numerous outlying dangers, extending, in some instances, for several miles from the coast, between Saldanha Bay and St. Helena Bay, were charted, and the surveying parties continued northwards towards Orange River.

On the Australian Station, two officers died of exposure in the execution of their duties.

In 1871 the survey reached Orange River and Port Nolloth.

This year the greater part of the stretch known as the 90-Mile Beach, on the Victorian Coast, was surveyed. As a landing could not be effected with safety, it was necessary to carry on the survey by walking parties, crossing the rivers on rafts constructed of drift timber. In this manner, and in the face of many difficulties and privations, among them the absence of fresh provisions, 120 miles of coast were surveyed in less than three months.

So recently as 1872, shore parties in Pondoland found themselves on more than one occasion in considerable danger, and one party, in the neighbourhood of St. John's River, was detained by the Pondo chief for seven weeks. For over three years this party, under Lieutenant Archdeacon, working along the coast, underwent extreme privations, and worked with unremitting energy.

In 1889, when eleven ships, with a complement of nearly 800, were in service, there is an interesting note:—

In the Southern part of the Red Sea a fourth search was made for the sunken rock on which it was reported that two British steam vessels had struck. This search was crowned with success by the discovery of a small isolated patch with as little as 15 feet of water over it. It has been called the Avocet rock. The unsuspected existence of this rock with such an enormous number of vessels passing over it is one of the most remarkable instances of its kind on record.

In 1890 a surveying officer was specially engaged in obtaining the longitudes of Port Nolloth, Mossamedes, Benguela, St. Paul de Loanda, and San Thomé. This expedition, so successful in its results, terminated by the death of Commander Pullen, of malarial fever.

In 1892 a new isolated rock, 1½ miles from land, with only 20 feet of water over it, was discovered off the Anglesey Coast, directly on the highway to Liverpool.

So, year by year, this splendid work goes on, coasts are charted, seas sounded, and hundreds of dangers to navigation added to the charts; (in 1889, 230 dangers were recorded, 270 miles of coast charted, and 10,435 square miles of sea sounded; in 1890, 274 dangers, 1,223 miles of coast and 4,674 square miles of sea): and to-day the work still continues on a similar scale. To its benefits all are welcome, and the number of charts now disposed of by the Department annually exceeds 500,000.

To me, there is nothing in all our history more magnificent or worthy of remembrance than these surveys which we have made of every sea in all the world. In the slime and heat of the mangrove swamp, or the cold of Labrador, where the shore ice does not float loose till the end of August, the work has been done for all time. Once and for all we have done it, and, better still, we have held out this freedom of the seas for all the world to take, as and when we have won it for ourselves. The sum of the cost of it will never be made up, but a glimpse of what, in one sense of the word, it has been appears in the note of the Scottish survey in 1859. Gold, however, counts for nothing in this balance. What we remember, and reverently salute, is the incalculable price we have paid in devoted lives, a sacrifice only made tolerable to us and justified by what has been accomplished.

> Road was never so rough that we left its purpose dark.
> Stark was ever the sea, but our ships were yet more stark.
> We have tracked the wind of the world to the steps of their very thrones,
> The secret parts of the world are salted with our bones.

As to the temper in which the work has been done, let William Burrough repeat the instructions, very necessary and needful to be observed, which he gave to Arthur Pet and Charles Jackman in 1580,* when they set out to find Cathay:—

> But withal you may not forget to note as much as you can learn, understand or perceive of the manner of the soil, or fruitfulness of every place and country you shall come in, and of the manner, shape, attire and disposition of the people. It behoveth you to give trifling things unto such people as you shall happen to see, and to offer them all courtesy and friendship you may or can, to win their love and favour towards you, not doing or offering them any wrong or hurt. And though you should be offered wrong at their hands, yet not to revenge the same lightly, but by all means possible seek to win them, yet always dealing wisely and with such circumspection that you keep yourselves out of their dangers.
>
> Thus I beseech God Almighty to bless you, and prosper your voyage with good and happy success, and send you safely to return home again, to the great joy and rejoicing of the adventurers with you, and all your friends, and our whole country. Amen.

Appendix I.

Instructions and Notes very necessary and needful to be observed in the proposed voyage for the discovery of Cathay, eastwards, by Arthur Pet and Charles Jackman, given by William Burrough, 1580.

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* See Appendix I.

When you come to Orfordnesse, if the wind do serve you to go a seaboard the sands, do you set off from thence, and note the time diligently of your being against the said Nesse, turning then your glass, whereby you intend to keep your continual watch, and appoint such course as you shall think good, according as the wind serveth you; and from that time forwards continually (if your ship be loose, under sail, a hull or trie) do you at the end of every 4 glasses at the least (except calm) sound with your dipsin lead, and note diligently what depth you find, and also the ground. But if it happen by swiftness of the ship's way, or otherwise, that you cannot get ground, yet note what depth you prove, and could find no ground (this note is to be observed all your voyage, as well outwards as homewards). But when you come upon any coast, or do find any shoaled bank in the sea, you are then to use your lead oftener, as you shall think it requisite, noting diligently the order of your depth, and the deeping and sholding. And so likewise do you note the depths into harbours, rivers, etc.

And in keeping your dead reckoning, it is very necessary that you do note at the end of every four glasses, what way the ship hath made (by your best proofs to be used) and how her way hath been through the water, considering withal for the sag of the sea, to leewards, accordingly as you shall find it grown; and also to note the depth, and what things worth the noting happened in that time, with also the wind upon what point you find it then, and of what force or strength it is, and what sails you bear.

But if you should omit to note those things at the end of every four glasses, I would not have you to let it slip any longer time, then to note it diligently at the end of every watch, or eight glasses at the farthest.

Do you diligently observe the latitude as often, and in as many places as you may possible, and also the variation of the compass (especially when you may be at shore upon any land) noting the same observations truly, and the place and places where, and the time and times when you do the same.

When you come to have sight of any coast or land whatsoever, do you presently set the same with your sailing compass, how it bears off you, noting your judgment how far you think it from you, drawing also the form of it in your book, how it appears unto you, noting diligently how the highest or notablest part thereof beareth off you, and the extremes also in sight of the same land at both ends, distinguishing them by letters, A, B, C, etc. Afterwards when you have sailed 1, 2, 3, or 4 glasses (at the most) noting diligently what way your bark hath made, and upon what point of the compass do you again set that first land seen, or the parts thereof, that you first observed, if you can well perceive or discern them, and likewise such other notable points or signs upon the land that you may then see and could not perceive at the first time, distinguishing it also by letters from the other, and drawing in your book the shape of the same land, as it appeareth unto you, and so the third time, etc.

And also in passing alongst by any and every coast, do you draw the manner of biting in of every Bay and entrance of every harbour or river's mouth, with the lying out of every point, or headland (unto which you may give apt names at your pleasure) and make some mark in drawing the form and border of the same, where the high cliffs are and where low land is, whether sand, hills, or woods, or whatsoever, not omitting to note anything that may be sensible and apparent to you, which may serve to any good purpose. If you carefully with great heed and diligence note the observations in your book, as aforesaid, and afterwards make demonstrations thereof in your plat, you shall thereby perceive how far the land you first saw, or the parts thereof observed, was then from you, and consequently of all the rest; and also how far the one part was from the other, and upon what course or point of the compass the one lieth from the other.

And when you come upon any coast where you find floods and ebbs, do you diligently note the time of the highest and lowest water in every place, and the slake or still water of full sea, and low water, and also which way the flood doth run, how the tides do set, how much water it hieth, and what force the tide hath to drive a ship in one hour, or in the whole tide, as near as you can judge it, and what difference in time you find between the running of the flood, and the ebb. And if you find upon any coast the current to run always one way, do you also note the same duly, how it setteth in every place, and observe what force it hath to drive a ship in one hour, etc.

Item, as often and when as you may conveniently come upon any land, to make observation for the latitude and variation, etc., do you also (if you may) with your instrument, for trying of distances observe the platform of the place, and of as many things (worth the noting) as you may then conveniently see from time to time. These orders if you diligently observe, you may thereby perfectly set down in the plats, that I have given you your whole travel, and description of your discovery, which is a thing that will be chiefly expected at your hands. But withal you may not forget to note as much as you can learn, understand or perceive of the manner of the soil, or fruitfulness of every place and country you shall come in, and of the manner, shape, attire and disposition of the people, and of the commodities they have, and what they most covet and desire of the commodities you carry with you. It behoveth you to give trifling things unto such people as you shall happen to see, and to offer them all courtesy and friendship you may or can, to win their love and favour towards you, not doing or offering them any wrong or hurt. And though you should be offered wrong at their hands, yet not to revenge the same lightly, but by all means possible seek to win them yet always dealing wisely and with such circumspection that you keep yourselves out of their dangers.

Thus I beseech God Almighty to bless you and prosper your voyage with good and happy success, and send you safely to return home again, to the great joy and rejoicing of the adventurers with you, and all your friends, and our whole country. Amen.

APPENDIX II.

Dampier's approach to the Cape of Good Hope, Voyages, Vol. II, p. 409.

Two days before I made the Cape of G. Hope, my variation was 7 deg. 58 min. West. I was then in 43 deg. 27 min. East Longit. from C. Salvador, being in Lat. 35 deg 30 min. This was the first of June. The second of June I saw a large black fowl, with a whitish flat bill, fly past us, and took great notice of it, because in the East-India Waggoner, or Pilot-book, there is mention made of large fowls, as big as ravens, with white flat bills and black feathers, that fly not above 30 leagues from the Cape, and are looked on as a sign of one's being near it. My reckoning made me then think myself above 90 leagues from the Cape, according to the longitude which the Cape hath in the common sea-charts; so that I was in some doubt whether these were the right fowls spoken of in the Waggoner, or whether these fowls might not fly farther off shore than is there mentioned; or whether, as it proved I might not be nearer the Cape than I reckoned myself to be, for I found, soon after that I was not then above 25 or 30 leagues at most from the Cape. Whether the fault were in the charts laying down the Cape too much to the East from Brazil, or were rather in our reckoning, I could not tell; but our reckonings are liable to much uncertainties from steerage, log, currents, half-minute glasses, and sometimes want of care, as in so long a run cause often a difference of many leagues in the whole account.

Many of our men that kept journals imputed it to the half-minute glasses, and indeed we had not a good glass in the ship beside the half-watch or two-hour glasses. As for our half-minute glasses we tried them all at several times, and we found those that we had used from Brazil as much too short, as others we had used before were too long, which might well make great errors in those several reckonings. A ship ought therefore to have its glasses very exact; and besides, an extraordinary care ought to be used in heaving the log, for fear of giving too much stray line in a moderate gale; and also to stop quickly in a brisk gale, for when a ship runs 8, 9, or 10 knots, half a knot or a knot is soon run out, and not heeded. But to prevent danger, when a man thinks himself near land, the best way is to look out betimes and lie by in the night, for a Commander may err easily himself, besides the errors of those under him, tho' never so carefully eyed.

Another thing that stumbled me here was the variation, which, at this time, by the last amplitude I had found to be but 7 deg. 58 min. W. whereas the variation at the Cape (from which I found myself not 30 leagues distant) was then computed, and truly, about 11 deg. or more. And yet a while after this, when I was got 10 leagues to the Eastward of the Cape, I found the variation but 10 deg. 40 min. W., whereas I should have been rather more than at the Cape. These things, I confess, did puzzle me. Neither was I fully satisfied as to the exactness of the taking the variation at sea: for in a great sea, which we often meet with, the Compass will traverse with the motion of the ship, besides the ship may and will deviate somewhat in steering, even by the best Helmsman. And then when you come to take an Azimuth, there is often some difference between him that looks at the compass, and the man that takes the Altitude height of the sun, and a small error in each, if the error of both should be one way will make it wide of any great exactness. But what was most shocking to me, I found that the variation did not always increase or decrease in proportion to the degree of longitude East or West, as I had a notion they might do to a certain number of degrees of variation east or west, at such or such particular meridians. But finding in this voyage that the difference of variation did not bear a regular proportion to the difference of longitude, I was much pleased to see it thus observed in a scheme shown me after my return home, wherein are represented the several variations in the Atlantic Sea, on both sides of the Equator; and there, the line of no variation in that sea is not a meridian line, but goes very oblique, as do those also which show the increase of variation on each side of it. In that draught there is so large an advance made as well towards the accounting for those seemingly irregular increases and decreases of variation towards the S.E. coast of America, as towards the fixing a general scheme or system of the variation everywhere, which would be of such great use in navigation, that I cannot but hope that the ingenious author, Capt. Halley, who to his profound skill in all theories of these kinds, hath added and is adding continually personal experiments, will e'er long oblige the world with a fuller discovery of the course of the variation which hath hitherto been a secret. For my part, I profess myself unqualified for offering at any thing of a general scheme; but since matter of fact, and whatever increases the history of the variation, may be of use towards the settling or confirming the theory of it, I shall here once for all insert a Table of all the Variations I observed beyond the Equator in this voyage, both in going out, and returning back; and what errors there may be in it I shall leave to be corrected by the observations of others.

I add his little picture of the Stormy Petrel, for the sheer beauty of it:—

The petrel is a bird not much unlike a swallow but smaller, and with a short tail. 'Tis all over black, except a white spot on the rump. They fly sweeping like swallows and very near the water. They are not so often seen in fair weather; being foul-weather birds, as our seamen call them, and presaging a storm when they come about a ship, who for that reason don't love to see them. In a storm they will hover close under the ship's stern, in the wake of the ship (as 'tis called) or the smoothness which the ship's passing has made upon the sea. And there as they fly (gently then) they pat the water alternately with their feet, as if they walked upon it, tho' still upon the wing. And from hence the seamen give them the name of "petrels," in allusion to St. Peter's walking upon the Lake of Gennesareth.

Appendix III.

James Cook was born in 1728, the son of a labourer, in the Cleveland division of Yorkshire. Apprenticed first to a haberdasher at Staithes, he afterwards served as an apprentice on a little ship called the *True Love*, of Whitby, in the North Sea coal trade, rising to foremast hand, and then to mate.

In 1755 he joined the Navy, and, four years later, became master, and served in various small ships of war on the North American Station. He surveyed the St. Lawrence and the coast of Newfoundland, and prepared a chart, from Quebec to the sea. In 1763 he was appointed marine surveyor of the coast of Newfoundland and Labrador, and in 1768 brought out a volume of sailing directions which showed remarkable ability. As a result, he was selected, in this year, to command the *Endeavour*, despatched to observe the transit of Venus in the South Seas, and on this voyage he mapped the coast and harbours of Tahiti.

The excellent chart based on Cook's survey was the only guide in these waters for over 100 years, and the accuracy of his positions was extraordinary.

From the Fiji Islands he proceeded to New Zealand, and surveyed 24,000 miles of coast in six and a half months.

Never has a coast been so well laid down by a first explorer.

He then proceeded to New South Wales, and carried out a running survey of the East Coast of Australia with the same minuteness and accuracy, returning home by way of Batavia and the Cape. The whole of the work of this voyage was carried out without chronometers, for the *Endeavour* carried none.

In 1772 he started on his second voyage, and, after touching at the Cape, he crossed the Antarctic Circle, and proceeded to New Zealand, proving that the alleged Southern Continent did not exist. Thence he worked up and down across the South Pacific, finding no land there also, and, turning North, he sailed to Easter Island and on to the Marquesas, Tonga Islands, and Tahiti. Thence to the New Hebrides,

Of which for some of the Islands his chart is still the only one in existence and of remarkable accuracy. On several occasions up to 1893 Cook's recorded positions have saved the adoption of so-called amendments which would have been anything but amendments in reality.*

---

* C. R. Markham.

Next he discovered New Caledonia, Norfolk Island, etc., and proceeded *via* Cape Horn to the Cape of Good Hope,

From which he returned home after a voyage of over 60,000 miles, which left the main outlines of the Southern portions of the globe substantially as they are known to-day

The greatest tribute of all to his seamanship and power of organisation is that, during the whole of this voyage he lost only one man.

In 1776 he started on his third voyage, and, sailing North from New Zealand, discovered the Cook Archipelago, and re-discovered the Sandwich Islands, first seen by the Spanish Gaetano, in 1555, but concealed and forgotten. Thence he reached the American coast, a little south of where Portland, Oregon, now stands, and worked northwards, surveying as he went on, through Behring Straits and up to latitude 70° 41′, where the ice stopped him. He explored both shores of the Straits, and then returned to Hawaii, where he was killed on the 14th of February, 1779.

A Lunar Volcano.—In a bulletin of Harvard College Observatory attention has been called by Prof. W. H. Pickering to recently observed phenomena in connection with the lunar crater Einmart. The interior of the crater was very brilliant in January, 1913, but darkened considerably in March, the darkness persisting until February, 1914, when it again attained the brightness of twelve months previously, but not the brilliancy of January, 1913, when it was the brightest area of its size then visible on the moon. The crater is 25 miles in diameter, and its interior easily observed. The interior is full of brilliant detail, constantly varying, not only from night to night, but also from month to month.

DETERMINAÇÃO DA LATITUDE E LONGITUDE DO PILAR DO INSTRUMENTO DE PASSAGENS DO OBSERVATORIO CAMPOS RODRIGUES.

Por Augusto de Almeida Teixeira.

Este trabalho nã offerece novidade e se o apresentamos é só por acharmos interessante conhecer-se a concordancia dos resultados obtidos pelas observações geodesicas ligadas com a triangulação do Transvaal, e pelas observações astronomicas.

A parte mais valiosa d'este trabalho não pertence ao seu apresentante, mas ao Sr. capitão-tenente da Armada Portuguesa Gago Coutinho, chefe de missão que procedeu ao levantamento geodesico dos districtos de Lourenço Marques e Inhambane. Este official encontra-se actualmente numa nova missão para delimitação da fronteira do Barotze, e não sendo, por isso, facil consultá-lo, servimo-nos de um seu trabalho publicado ha dois annos, de onde transcrevemos o seguinte sobre a determinação das coordenadas do pilar do Instrumento de Passagens:

" Não sendo possivel incluir este pilar na triangulação principal, por se não avistar nenhum dos pontos d'esta triangulação, nem medir directamente a sua distancia á estação geodesica do Observatorio, installada na torre dos instrumentos meteorologicos, foi necessario recorrer a uma maneira indirecta, medindo no terreno uma pequena base de 48 metros, com precisão, e ligar a estação alta com o pilar por meio de uma triangulação com 5 pontos, formando dois quadrilateros. O rigor da medição e o fecho dos triangulos permittiram determinar a distancia entre as estações geodesica e astronomica com um erro provavel inferior a um millimetro, o que para o caso era mais do que sufficiente, pois cada millessimo de segundo anda por 30 millimetros. D'este trabalho resultaram as seguintes differenças entre as duas estações:

Latitude	$-1''.495$
Longitude	$+1''.647$

" Pela rêde da triangulação principal da missão geodesica que liga a estação geodesica do Observatorio com a fronteira, e que comprehende mais immediatamente 17 vertices, foi esta estação ligada com o marco da fronteira da Swazilandia, Ipoy, cujas coordenadas estão determinadas pela triangulação do Transvaal, á qual este vertice tambem pertence. As medições geodesicas, nesta parte da triangulação portuguesa, enlaçam os 17 pontos com 94 direcções, de modo que só o calculo d'esta ligação comprehenderia, como se sabe, a resolução pelos minimos quadrados, de um sistema de 47 equações a 94 incognitas, o que era excessivamente trabalhoso, e não nos compensava, pois uma grande precisão do resultado seria completamente inutil, visto que não era necessaria a posição do Observatorio com uma precisão superior ao decimo de segundo de arco, ou sejam 3 metros em extensão linear.

"Esta parte do calculo será comtudo feita quando se emprehender a compensação geral da rêde. Por agora contentámo nos sem perda do indispensavel rigor, como se verá, com uma compensação provisoria, incomparavelmente mais rapida.

"A linha do Observatorio para Ipoy é cortada em Ipoy por sete outras direcções differentes, tres das quaes, Kanghekâne, Estatuéne e M'Ponduhine, dão cada uma duas soluções independentes. Resultam portanto nove valores differentes da distancia Observatorio-Ipoy, com pesos differentes e dependentes dos senos dos angulos que serviram para se chegar a determinar os cruzamentos. A divisão de 1000, numero arbitrario, pela somma das differenças logarithmicas correspondentes a um segundo de erro nos angulos originaes, foi aceeite como peso de cada um dos referidos cruzamentos.

"Duas maneiras podiamos seguir para procurar a distancia mais provavel entre o Observatorio e Ipoy: uma, analytica elementar, a média com pesos; a outra era o estudo, graficamente, do cruzamento mais provavel, para o que me servi dos processos geometricos elementares que tenho empregado nas triangulações rapidas das fronteiras coloniaes.

"Os elementos para o calculo estão resumidos no quadro I.

"Pela solução analytica, a distancia média, com pesos, é

$$76{,}828^{m}.61 \pm 0^{m}.25;$$

a solução geometrica deu um valor ligeiramente differente

$$76{,}828^{m}.79$$

sendo portanto o valor mais provavel a aceeitar

$$76{,}828^{m}.70 \pm 0^{m}.25$$

não valendo a pena, por ser trabalhoso, concluir o erro provavel da solução geometrica.

"Este valor da distancia funda-se na base da Manhiça, que foi medida uns 80 kilometros ao norte de Lourenço Marques e cujo comprimento foi

$$12{,}090^{m}.9009 \pm 1^{mm}.1$$

sendo este comprimento provisorio, porque o comprimento definitivo depende das comparações finaes dos *fios de invar*, com que foi medida a base, as quaes estão sendo feitas no Observatorio Internacional de Pesos e Medidas de Sèvres. Ha a recear no comprimento médio dos *fios* de 24 metros um erro maximo de um decimo de millimetro, a qual perfaria nos 76,829 metros um erro possivel de 32 centimetros. Alem d'este erro ha ainda a temer, no transporte per triangulação das distancias até Lourenço Marques, um erro maximo de 1/100,000. No final estes erros perfazem um erro total inferior a

$\pm 1^m.5$

ou meio decimo de segundo de arco, o que foi aceeite integralmente para erro provavel na longitude.

"Concluidas no Observatorio estas observações de distancias azimuthaes, entre as quaes estava solidamente enlaçado o pharol da Inhaca, procedeu-se a repetidas observações de azimuths de estrellas circumpolares proximas da digressão (e dentro de limites taes que um segundo de tempo não introduzia no azimuth erro superior a 1/5″ de arco), em ligação com o mesmo pharol, aproveitando-se os periodos em que a sua luz era menos intensa, e portanto mais nitida no foco do oculo. O valor médio d'este azimuth, correcto da aberração e reduzido aproximadamente ao polo médio, foi

271° 06′ 45″.2 ± 0″.32

"Da compensação de direcções observadas, feita em Lisboa na Direcção dos Trabalhos Geodesicos pelo processo que foi usado na compensação da triangulação fundamental de Portugal, concluiu-se que o angulo entre a Inhaca e Ipoy foi

125° 24′ 50″.6 ± 0″.64

"Combinando estes dois angulos, temos para a direcção verdadeira mais provavel do Observatorio para Ipoy.

36° 31′ 35″.8 ± 0″.72

azimuth contado do S por O, como é costume em geodosia. O erro provavel ± 0″.72, á distancia de 77 kilometros, corresponde a um desvio da direcção de 27 centimetros.

"Entrando agora com o azimuth e distancia acima calculados no calculo, e adoptando a fórma da terra de que se servem os norte-americanos no *Coast and Geodetic Survey* (Clarke 1886), obtem-se as seguintes differenças entre o Observatorio e Ipoy:

Latitude	— 33′ 23″.570
Longitude	+ 27′ 31″.657

"A combinação de todos os elementos calculados atraz com a posição de Ipoy, que me foi fornecida directamente em Pretoria na Repartição do *Trigonometrical Survey* por Mr. H. E. Schoch, Surveyor-General, está resumida no quadro II."

A determinação da longitude foi confirmada por observações de *culminações lunares* feitas em Lourenço Marques pelo subdirector do Observatorio Astronomico de Lisboa, Sr. major de engenharia Frederico Oom, combinado com identicas observações simultaneas no Observatorio de Lisboa pelo Sr. major de engenharia Teixeira Bastos, astronomo de 1.ª classe do mesmo Observatorio. Encontrou-se uma pequena differença sem importancia, pois o ultimo limite de aproximação a que pode pretender o processo das culminações lunares mesmo depois de dois ou tres annos completos de observações da Lua, não é inferior a uno segundo de tempo. Não podemos dar mais eso clarecimentos sobre esta determinação de longitude, porque a sua resolução foi feita no Observatorio de Lisboa.

A latitude geodesica foi confirmada duas vezes por observações astronomicas, primeira pelo Sr. capitão-tenente Gago Coutinho, e de pois por nós.

Sobre as observações do Sr. Gago Coutinho transcrevemos novamente o seguinte:

"OBSERVACOES ASTRONOMICAS DE LATITUDE.—Esta observações foram feitas com dois theodolitos Troughton & Simms, de microscopios e lunetas de $0^m.33$ montados alternadamente sobre o pilar do instrumento de passagens. Fizeram-se quatro séries de observações, em quatro noites, utilizando-se em cada noite uma posição differente do circulo vertical, e nas duas ultimas noites um theodolito differente do das duas primeiras noites.

"Cada unidade de peso resulta da média de duas observações meridianas de estrellas, cujas coordenadas veem calculadas em um dos tres almanachs astronomicos: *Nautical Almanac*, *Berliner Jahrbuch* e *Connaissance des Temps*, sendo as suas distancias zenithaes proximamente iguaes, e uma ao N e a outra ao S do zenith, o que tinha por fim eliminar os erros do coeficiente de refracção, e todos os erros systematicos devidos aos instrumentos.

"Os resultados d'estas observações estãs resumidos no quadro III.

"Os valores extremos da latitude em 77 pares foram: 1″.0 e 9″.6; o erro provavel de cada par cêrca de ± 1″.05, devendo assim o erro provavel da média dos 77 pares ser cêrca de ± 0″.12.

"A média das quatro noites, dando a cada média de uma noite o mesmo peso, é

$$25° 58' 04''.98 \pm 0.22$$

valor este que foi o aceeite, com a reducção—0″.1 ao polo médio" (Albrecht).

Nota.—O Sr. Gago Coutinho menciona que estas observacões não são das mais precisas, entre as determinações de latitude que effectuou em 25 vertices da triangulação.

Nas nossas observações usámos o methodo do Horrebow-Talcott, servindo-nos do instrumento de passagens do Observatorio que para este fim possue dois niveis muito perfeitos, e um micrometro de girar para servir em Assensão Recta ou Declinação. Este instrumento foi construido pela casa Bamberg, de Berlim, tem o numero 2,836; o respectivo oculo tem 70 millimetros de abertura e 65 centimetros de distancia focal, possuindo oculares amplificando 44 a 86 vezes.

Todas as estrellas observadas pertencem ao "mesmo systema" usando-se o "*Preliminary General Catalogue of* 6,188 *Stars for the epoch* 1900, *by Lewis Boss.*"

Na reducção para o anno, empregaram-se os elementos d'este Catalogo, e para o dia os elementos do "*Berliner Jahrbuch.*"

A casa de observar era aberta com bastante antecedencia, afim de evitar tanto quanto possivel as variações rapidas de temperatura.

Bissectavam-se as estrellas com o fio movel em logares simetricos do campo optico antes e depois do " fio médio " afim de eliminar o defeito da inclinação do fio movel, que se não poude determinar por uma vez por meio de observações de estrellas. O reticulo d'este instrumento tem 15 fios dispostos em tres grupos; procurou-se fazer a observação a meio da distancia entre os fios I-II e, simetricamente, XIV-XV, e do mesmo modo IV-V e XI-XII, VI-VII e IX-X, desprezando-se qualquer observação de que se não fizesse a observação simetrica.

Na reducçao ao meridiano, usou-se de uma tabella em partes do micrometro, calculada segundo a formula

$$\tfrac{1}{2}\ (15^2 \text{ sen } 1'\ i^2 \text{ tang } \delta) \times \frac{1}{0''.78897}$$

sendo 0″.78897 o valor de uma parte do micrometro em arco. É claro que se tomou para valor de i a média das distancias dos dóis fios, entre os quaes se fazia a observação, ao " fio médio." Os dois niveis destinados a esta observação teem por valor de uma parte:

Nivel " A " . . . . 1p = 1″.3634
Nivel " B " . . . . 1p = 1″.1610

A tabella respectiva está calculada para se entrar com a somma das differençãs obtidas pela leitura dos quatro extremos dos dois niveis

$$\frac{1p}{16}\ (A + B) = 0''.15796$$

A tabella da correcção da refracção differencial obteve-se empregando a formula

$$\tfrac{1}{2}\ (r - r') = 29'' \text{ sen}^2 Z \text{ sen } 1'\ (Z' - Z'')$$

No quadro IV vão os resultados obtidos, somente quanto aos segundos, e os respectivos erros provaveis das médias de cada par e de cada dia, o erro provavel para cada par de estrellas e, finalmente, da média geral.

Os tres resultados entre parenthesis foram rejeitados, porque na occasião da observação se anotou não merecerem confiança, ou devido a nuvens ou a passarem as estrellas atraz de um fio do reticulo, o que muito difficultava bissectá-las com o fio movel.

Alem dos erros acima mencionados, determinaram-se mais os seguintes:

Erro provavel de declinação para um par	± 0.130
Erro provavel de declinação para uma estrella	± 0.184
Erro provavel de observação para um par	± 0.127
Erro provavel de observação para uma estrella	± 0.179

Por intermedio do Ex.mo Sr. major de engenharia, Frederico Oom, sub-director do Observatorio Astronomico de Lisboa, recebemos a nota da reducção ao polo média, que obsequiosamente foi communicada pelo Instituto Geodesico de Potsdam pelos resultados, ainda não publicados, das observações internacionaes da variação da latitude.

"Para Lourenço Marques, as reducções serão

1912—Janeiro 23-26:

$$\phi_0 - \phi = -0''.22$$

1912—Fevereiro 8-9:

$$\phi_0 - \phi = -0''.17$$ "

Applicando estas reducções, temos para valor da latitude reduzida ao polo médio

1912—Janeiro	23 =	— 25° 58′ 5″.52 ± 0″.049
	24 =	9″.52 ± 0″.046
	25 =	5″.62 ± 0″.078
	26 =	5″.43 ± 0″.049
1912—Fevereiro	8 =	5″.49 ± 0″.046
	9 =	5″.40 ± 0″.062

Valor médio adoptado para latitude do pilar do instrumento de passagens reduzido ao polo médio

25° 58′ 05″.50 ± 0″.022 S.

Assim temos para coordenadas do instrumento de passagens: longitude por observações geodesicas

32° 35′ 39″.38 ± 0″.05

confirmada como vimos por observações de culminações lunares)

Latitude por observações geodesicas:

25° 58′ 06″.06 S.

Latitude por observações astronomicas:

Distancias zenitaes meridianas (Gago Coutinho):

25° 58′ 04″.98 ± 0″.20

Methodo Horrebow-Talcott

25° 58′ 05″.50 ± 0″.022

resultados satisfatoriamente concordantes.

(Translation.)

DETERMINATION OF THE LATITUDE AND LONGITUDE OF THE PILLAR OF THE TRANSIT INSTRUMENT AT THE CAMPOS RODRIGUES OBSERVATORY.

By Augusto de Almeida Teixeira.

No new matter is dealt with in this paper, and I am introducing it only on the plea of the interest attaching to the knowledge of the agreement existing between the results obtained from the geodetic observations connected with the triangulation of the Transvaal and those obtained from astronomical observations.

The most valuable part of this work is not due to myself, but to Commander Gago Coutinho, of the Portuguese Navy, head of the mission that undertook the geodetic survey of the Districts of Lourenço Marques and Inhambane. This officer is at present engaged in a new mission delimiting the Barotse frontier, and as it would not, for that reason, be an easy matter to consult him, I have been compelled to avail myself of one of his works published two years ago, from which I transcribe the following paragraphs on the determination of the co-ordinates of the pillar of the transit instrument:—

"Seeing that it was impossible to include this pillar in the main triangulation, as none of the points of this triangulation could be sighted, and that its distance from the geodetic station of the Observatory, which is installed in the tower of the meteorological instruments, could not be measured direct, it became necessary to resort to an indirect method, by measuring with precision a small base of 48 metres on the ground, and joining this high station with the pillar by means of a triangulation with five points, thus forming two quadrilaterals. The precision of the measurements and the closing of the triangles made it possible to determine the distance between the geodetic and astronomical stations with a probable error of less than one millimetre, which was more than sufficient for the purpose, seeing that each thousandth of a second is equivalent to about 30 millimetres. The following differences between the two stations resulted from this work:

Latitude	$-1''.495$
Longitude	$+1''.647$

This station was connected with the beacon of the frontier of Swazieland, at Ipoy, the co-ordinates of which are determined by the triangulation of the Transvaal, to which this vertex also belongs, and this connection was carried out through the network of the main triangulation of the geodetic mission which joins the geodetic station of the Observatory with the frontier, and which comprises 17 vertices.

"The geodetic measurements, on this portion of the Portuguese triangulation, link in the 17 points with 94 directions, so that the calculation of this connection alone would comprise, as is known, the resolution by the method of least squares of a system of 47 equations with 94 unknown quantities. This, however, would involve an excessive amount of labour, and would not compensate us, seeing that great precision in the result would be almost useless, as it was not necessary to determine the position of the Observatory with a precision above one-tenth of a second of arc, or three metres in linear extension.

"This part of the calculations will, however, be done when the compensation for the general network is to be proceeded with. For the present we are quite satisfied (without prejudice to the indispensable accuracy as will be seen) with a provisional compensation which is incomparably more rapid.

"The line from the Observatory to Ipoy is cut at Ipoy by seven other different directions, three of which, Kanghekane, Estatuene and M'Ponduhine, give two independent solutions each.

"Nine different values result therefore for the distance Observatory-Ipoy, with different weights, and depending on the sine of the angles which served to arrive at the determination of the crossings. The division of 1,000 (an arbitrary number) by the addition of the logarithmic differences corresponding to an error of one second in the original angles was accepted as being the weight of each of the crossings mentioned.

"We could have resorted to two methods in order to find out the most probable distance between the Observatory and Ipoy: the elementary analytical one, being the average with weights; the other being the graphic study of the most probable crossing, for which I availed myself of the elementary geometrical processes which I have employed in rapid triangulations of colonial frontiers.

"The data for the calculations are summarised in Table I.

"According to the analytic solution, the mean distance, with weights, is:

$$76{,}828^{m}.61 \pm 0^{m}.25;$$

the geometrical solution gave a slightly different value:

$$76{,}828^{m}.79$$

the most probable value to accept being, therefore,

$$76{,}828^{m}.70 \pm 0^{m}.25;$$

it being hardly worth while, on account of the labour involved, to ascertain the probable error of the geometrical solution.

"This value of the distance is founded on the base of Manhiça, which was measured about 80 kilometres North of Lourenço Marques, and the length of which was

$$12{,}090^{m}.9009 \pm 1^{m}.1;$$

this length being a provisional one, as the actual length depends on the final comparisons of the invar wires, with which the base was measured. These comparisons are being made at the International Observatory of Weights and Measures of Sèvres. In the medium length of the wires, which were 24 metres long, a maximum error of one-tenth of a millimetre may be found, which would possibly bring the error in the 76,829 metres up to 32 centimetres. Besides this error, a maximum error of 1/100,000 may also be feared in the transport by triangulation of the distances to Lourenço Marques. In the end these errors make up a total of less than

$$\pm 1^{m}.5$$

or half a tenth of second of arc, which has been taken as the probable error in the longitude.

"These observations of azimuth distances having been concluded at the Observatory, amongst which the Inhaca lighthouse was thoroughly intersected, repeated observations of the azimuths of circumpolar stars in proximity to the greatest elongation were made (and within such limits that one second of time would not introduce in the azimuth an error of more than $\frac{1}{5}''$ of arc) in connection with the same lighthouse, taking advantage of the periods when its light was less intense, and therefore more clear in the focus of the telescope. The mean value of this azimuth, after correcting the aberration and approximate reduction to the mean pole, was

$$271^\circ 06' 45''.2 \pm 0''.32$$

"From the compensation of directions observed, made at the Head Department of Geodetic Works in Lisbon by the process which was used in the compensation of the fundamental triangulation of Portugal, the conclusion was arrived at that the angle between the Inhaca and Ipoy was

$$125^\circ 24' 50''.6 \pm 0''.64$$

"By combining these two angles, we get the following as the most probable true direction from the Observatory to Ipoy:—

$$36^\circ 31' 35''.8 \pm 0''.72$$

the azimuth being counted from South to West, as is customary in geodesy. The probable error 0″.72, at the distance of 77 kilometres, corresponds to a deviation in direction of 27 centimetres.

"Coming now to the calculation of the above calculated azimuth and distance, and adopting the form of the Earth used by the United States in the "Coast and Geodetic Survey" (Clarke, 1366), the following differences are obtained between the Observatory and Ipoy:—

Latitude	$-33' 23''.570$
Longitude	$+27' 31''.657$

"The combination of all above calculated data with the position of Ipoy, which was supplied to me direct in Pretoria at the Department of Trigonometrical Survey by Mr. H. E. Schoch, Surveyor-General, is summarised in Table II."

The determination of the longitude was confirmed by observations of *lunar culminations* made at Lourenço Marques by the Sub-Director of the Astronomical Observatory of Lisbon, Major Frederico Oom, of the Engineers, in combination with identical and simultaneous observations made at the Lisbon Observatory by Major Teixeira Bastos, of the Engineers, first-class Astronomer of the said Observatory. A small, unimportant difference was found, as the last limit of approximation that may be expected from the process of lunar culminations, even after two or three whole years of observations of the Moon, is not inferior to one second of time. I am unable to supply any more information concerning this determination of longitude, because its solution was obtained at the Lisbon Observatory.

The geodetic latitude was confirmed twice by astronomical observations, first by Commander Gago Coutinho and then by myself.

I again quote Commander Gago Coutinho's remarks:—

"Astronomical Observations of Latitude.—These observations were made with two Troughton and Simms theodolites, with microscopes and telescope of 33cm., alternately mounted on the pillar of the transit instrument. Four series of observations were made, during four nights, a different position of the vertical circle being utilised on each night, and a different theodolite from the one utilised during the first two nights was used during the last two.

"Each unit of weight results from the average of the two meridian observations of the stars, the co-ordinates of which appear calculated in either of the three astronomical almanacs, *Nautical Almanac*, *Berliner Jahrbuch* and *Connaissance des Temps*, their zenith distances being approximately equal—one to the North and the other to the South of the zenith—which had in view the elimination of the errors of the co-efficient of refraction, and all the systematic errors due to the instruments.

"The results of these observations were as shown in Table III.

"The extreme values of the latitude in 77 pairs were 1".0 and 9".6; the probable error in each pair about ± 1".05. Thus the probable error of the average of the 77 pairs comes to about ± 0".12.

"The average of four nights, allowing the same weight to the average of one night, is

$$25°53'04''.98 \pm 0''.22$$

this value being accepted, with the reduction of —0"1 to the mean pole (Albrecht)."

Note.—Commander Gago Coutinho mentions that these observations are not the most precise to be found amongst the determinations of Latitude effected by him on 25 vertices of triangulation.

In my observations I employed the Horrebow-Talcott method, availing myself of the transit instrument of the Observatory, which possesses two very perfect levels for this purpose, and a revolving micrometer to serve in Right Ascension or Declination. This instrument, which was made by Messrs. Bamberg, of Berlin, bears the number 2:836; the telescope has an opening of 70 millimetres and 65 centimetres of focal distance, and possesses oculars which magnify from 44 to 86 times.

All the stars observed belong to the "same system," namely, that of the "*Preliminary General Catalogue of 6,183 Stars for the Epoch* 1900," by Lewis Boss.

In the reduction for the year, the data supplied in this catalogue were used, and for the day the data of the *Berliner Jahrbuch.*

The observing room was opened with due precaution, in order to avoid as much as possible rapid variations of temperature.

The stars were bisected with the movable thread at symmetrical points of the field of view on each side of the middle thread, in order to eliminate the defect of inclination of the movable thread, which could not be determined all at once through the observations of the stars. The reticle of this instrument has 15 threads placed in three groups; I tried to make the observation at half distance between the threads I—II and, symmetrically, XIV—XV, and in the same way IV—V and XI—XII, VI—VII and IX—X, neglecting any observations which had not been made symmetrically.

In the reduction to the meridian, a table in parts of micrometer was employed and calculated according to the following formula:

$$\tfrac{1}{2}\,(15^2 \sin 1''\, i^2 \tan \delta) \times \frac{1}{0.78897}$$

0″.78897 being the value of one part of the micrometer in arc. Of course, I took as value for i the mean of the distances of the threads between which the observation to the middle thread was being made. The two levels used in this observation have the following values for one part:

"A" Level	$1p = 1''.3634$
"B" Level	$1p = 1''.1610$

The table is calculated to reckon with the total of the differences obtained by reading of the four extremes of the two levels:

$$\frac{1p}{16}\,(A + B) = 0''.15796$$

The table of corrections for differential refraction was obtained by means of the formula

$$\frac{1}{2}(r - r') = 29'' \sin^2 Z \sin 1' (Z' - Z'')$$

The results obtained are given in Table IV, which only mentions seconds; the respective probable errors of the averages of each pair and each day, the probable error of each pair of stars and, finally, of the general average, are also mentioned therein.

The three results shown in brackets were rejected. They were not considered at the time of observation as worthy of confidence, either on account of clouds, or owing to the passing of the stars across the thread of the reticle, which made their bisection with the movable thread most difficult.

Besides the above-mentioned errors, the following were further determined:

Probable error of declination for one pair	± 0″.130
Probable error of declination for one star	± 0″.184
Probable error of observation for one pair	± 0″.127
Probable error of observation for one star	± 0″.179

Through Major Frederic Oom, I received the following reduction to the mean pole, kindly transmitted by the Geodetic Institute of Potsdam, and obtained from the results, not yet published, of the international observations of the variation of latitude.

" For Lourenço Marques the reductions will be:

1912—January 23rd-26th:

$$\phi_0 - \phi = -0''.22$$

1912—February 8th-9th:

$$\phi_0 - \phi = -0''.17 \text{ "}$$

By the application of these reductions, we get the following value of the latitude reduced to the mean pole:

1912—January	23rd	— 25° 58′ 5″.52 ± 0″.049
	24th	5″.52 ± 0″.046
	25th	5″.62 ± 0″.078
	26th	5″.43 ± 0″.049
1912—February	8th	5″.49 ± 0″.046
	9th	5″.40 ± 0″.062

The mean value adopted for the latitude of the pillar of the transit instrument reduced to the mean pole is:

25° 58′ 05″.50 ± 0″.022 S

Thus we have for co-ordinates of the transit instrument's pillar:

Longitude according to geodetic observations:

$$32° \ 35' \ 39''.38 \pm 0''.05$$

(confirmed, as we have seen, by observations of lunar culminations).

Latitude by geodetic observations:

$$25° \ 58' \ 06''.06 \ S$$

Latitude by astronomical observations:

Zenith meridian distances (Gago Coutinho):

$$25° \ 58' \ 04''.98 \pm 0''.20$$

Horrebow-Falcott Method:

$$25° \ 58' \ 05''.50 \pm 0''.022$$

these results being satisfactorily in agreement.

QUADRO 1.

TABLE 1.

	Angulo de cruzamento *Angle of Crossing*	Distancia *Distance*	Peso *Weight*	Residuo *Residue*
M'Ponduhine	−50° 31	76,828^{m}·05	42	0^{m} 14
M'Ponduhine	−50 31	29 ·50	31	0 ·89
Kanghekane	+33 01	27 ·21	10	1 ·40
Kanghekane	+33 01	27 ·76	32	0 85
Muguhéne	−19 12	27 ·30	8	1 ·31
Estatuéne	−59 39	29 ·44	26	0 83
Estatuéne	−59 39	30 ·07	19	1 ·46
Santaka	+53 43	26 ·84	9	1 ·77
Xamane e Xanine	+84 14	27 ·30	7	1 ·31

QUADRO No. II.

TABLE No. II.

	Latitude.	Longtitude.
Posição inglesa de Ipoy *British Position of Ipoy*	26° 32′ 94″·366	32° 8′ 06″·076
Differença para o observatorio geodesico *Difference for the geodetic observatory*	— 33 23 ·570	+ 27 31 ·657
Posição da estação goedesica. *Position of the geodetic station*	25 58 10 ·796	32 35 37 ·733
Differença para o pilar *Difference for the pillar*	— 1 495	+ 1 647
Posição do pilar de passagens *Position of the transit pillar*	25 58 09 ·301	32 35 39 ·380
Correcção média ás latitudes geodesicas da parte leste da triangulação do Transvaal (ver Report on the geodetic survey of the Transvaal and Orange Free State) pag. 3(3) *Mean correction to the geodetic latitudes of the eastern part of the triangulation of the Transvaal (see Report on the Geodetic Survey of the Transvaal and Orange Free State, page 303*	— 3 ·240	—
Posição do pilar segundo a triangulação do Transvaal ***Position of the pillar according to triangulation of the Transvaal***	25 58 6 ·06	32 35 39 ·38

QUADRO NO. III.

TABLE NO. III.

Data *Date*	Numero do theodolito *Theodolite number*	Numero de pares de estrellas *Number of pairs of stars*	Valor da latitude *Latitude*	Seu erro provavel *Probable error*	Erro provavel de cada par *Probable error of each pair*
30 dezembro 1907 *30th Dec. 1907*	II	17	25° 58′ 05″·21	±0″·18	±0″·74
31 dezembro 1907 *31st Dec. 1907*	II	18	05 ·72	±0 ·28	±1 ·18
3 janeiro 1908 *3rd Jan. 1908*	I	21	04 ·32	±0 ·29	±1 ·34
4 janeiro 1908 *4th Jan. 1908*	I	21	04 ·68	±0 ·27	±1 ·23

QUADRO No. IV. (TABLE No. IV.)

Valores da latitude deduzidos de cada observação. Seus valores médios e respectivos erros provaveis.
Latitude as deducted from each observation. Mean values and corresponding probable errors.

Numero do par *Number of each pair*	Data—1912 *Date—1912* Janeiro 23 *Jan. 23rd*	Janeiro 24 *Jan. 24th*	Janeiro 25 *Jan. 25th*	Janeiro 26 *Jan. 26th*	Fevereiro 8 *Feb. 8th*	Fevereiro 9 *Feb. 9th*	Média de cada par *Mean of each pair*	Seu erro provavel *Probable error*	Erro provavel de cada par *Probable error of each pair*
1	4"·93	5"·01	4"·77		—	—	4"·90	±0"·048	±0"·082
2	5 ·59	5 ·47	5 ·84	5"·96		—	5 ·72	±0 ·069	±0 ·152
3	5 ·32	—	5 ·38	5 ·35	5"·67	5"·25	5 ·39	±0 ·049	±0 ·109
4	—	5 ·62	—		—	—	5 ·62		—
5	5 ·31	5 ·20	—	5 ·00	5 ·22	4 ·88	5 ·12	±0 ·053	±0 ·119
6	5 ·35	5 ·43	5 ·76	5 ·10	5 ·38	5 ·23	5 ·38	±0 ·061	±0 ·150
7	—	—	5 ·49	5 ·31	—	5 ·53	5 ·44	±0 ·045	±0 ·079
8	5 ·37	—	—	—	—		5 ·37	—	—
9	5 ·46	5 ·16	5 ·08	5 ·07	5 ·00		5 ·16	±0 ·055	±0 ·121
10	5 ·09	4 ·95	5 ·49	4 ·96	5 ·28	6 ·38	5 ·07	±0 ·052	±0 ·104
11	—	—	—	—	5 ·36	5 ·17	5 ·26	±0 ·064	±0 ·090
12	—	—	5 ·21	5 ·33	5 ·39	4 ·87	5 ·20	±0 ·090	±0 ·156
13	—	5 ·49	5 ·68	5 ·10	5 ·31	5 ·53	5 ·42	±0 ·067	±0 ·151
14	—	—	5 ·36	5 ·21	5 ·63	5 ·00	5 ·30	±0 ·089	±0 ·179
15	—	5 ·28	—	5 ·36	—	5 ·57	5 ·40	±0 ·058	±0 ·101
16	—	—	—	4 ·81	4 ·81	—	4 ·81	±0 ·000	±0 ·000
17	—	—	—	5 ·08	5 ·32	—	5 ·20	±0 ·081	±0 ·115
18	—	5 ·40	—	5 ·31	5 ·42	4 ·35	5 ·38	±0 ·023	±0 ·004
Média de cada dia... *Mean for each pair...*	5"·30	5"·30	5"·40	5"·21	5"·32	5"·23	5"·286	±0"·022	±0"·175
Seu erro provavel... *Probable error*	±0"·049	±0"·046	±0"·078	±0"·049	±0"·046	±0"·062	±0"·022		
Erro provavel de cada par *Probable error of each pair*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

NOTICIA SOBRE CADASTRO GEOMETRICO E JURIDICO DA PROPRIEDADE IMMOBILIARIA NA PROVINCIA DE MOÇAMBIQUE.

Por Pedro Luis de Bellegarde da Silva.

Não encerra novidade alguma scientifica ou administrativa a materia summariamente tratada nesta memoria.

Sobre a propriedade particular immobiliaria, constituida por concessão dos terrenos do Estado em Moçambique a portuguezes e a estrangeiros, indicamos aqui os principios fundamentaes por que se regula a constituição e regime do movimento transaccional dos terrenos tendo por base o cadastro geometrico e juridico, não apresentando, pois, doutrina que desconheçam os lidos na materia.

Por isso, a honra de ser admittida esta breve memoria á leitura ou á publicação pela "South African Association for the Advancement of Science" apenas pode justificar-se pelo seu relativo interesse noticioso, pois que, dentro da vasta jurisdição administrativa portuguesa, applicada em terras da Europa e das suas colonias, apenas na provincia de Moçambique, e recentemente na de Angola, apparece por emquanto, o cadastro mathematico e juridico estabelecido por lei e exemplificado em seus resultados finaes em Moçambique.[1]

Atravez dos seculos e dos povos, a historia da propriedade *terra* tem, como a historia da humanidade a que está estreitamente ligada, a sua evolução propria.

Com interesse meramente historico apresenta-nos e epoca medieval a renascença e aproximações com antigas praticas do collectivismo agrario no usufruto da terra. O systema feudal, diz Michelet, "era como uma religião da terra," mas naquella epoca o senhor feudal substituia a communidade dos homens livres; então havia os vassallos e o senhor da terra! que a recebia com solemnidades particulares.

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[1] A organização dos serviços administrativos de Moçambique decretada em 1907 permittiu por um comeco de descentralização de poderes e de iniciativa conferida ao governador geral que este pudesse, com probabilidade de attingir resultados praticos na administração da Provincia, estudar por si e com assistencia de seu Conselho do Governo os principaes problemas do governo interno da colonia.

Foi no exercicio d'esta faculdade que o governador geral, Ex.mo Sr. Alfredo Augusto Freire de Andrade, propoz a remodelação do regime de concessão de terrenos, estabelecendo nesta reforma conjuntamente o cadastro geometrico e juridico por base essencial do mesmo regime.

Impossivel é, nos limites d'esta nota, mencionar-se, quer em geral e muito menos em especial, os capitulos de administração tratados mediante o pro undo estudo e inquerito d'aquelle

A expansão da riqueza immobiliaria, dependendo, sem duvida, para a sua transacção e commercio da *fé publica* ligada ao proprio objecto das transacções, conduz necessariamente á necessidade de reconhecer no immovel as condições de sua existencia civil, denunciando-se não só os direitos do possuidor da terra e os encargos que sobre a mesma pesam, como o conhecimento da sua existencia essencialmente real, ou, o que é o mesmo, a sua identificação physica.

Taes são os topicos do problema que desde epoca não muito antiquada tem preoccupado a administração de quasi todes os paises.

A Revolução Francesa, abalando radical e profundamente a influencia das leis do regime feudal, apresenta no seu decreto de 9 *messidor*, anno III, a transição do regime da terra para os modernos systemas de publicidade immobiliaria que tem por base o cadastro geometrico.

Naquella lei, impunha-se ao proprietario a obrigação de declarar minuciosamente na Conservatoria a situação, area e a

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governador geral sobre a administração de Moçambique—a si nação politica e o balanço da riqueza provincial e de suas forças productivas—o estudo da questão indigena dentro da densissima rêde de phenomenos relacionados com o commercio da Metropole, administração e progresso da Provincia e dos proprios indigenas —o equilibrio financeiro e, em particular, a questão da Fazenda como organismo—a administração geral e a regional incluindo o regime dos Prazos—o commercio, industria e agricultura—os impostos e fontes de receita—o caminho de ferro atravez de Gaza a Inhambane—as camaras municipaes—a debatida questão dos vinhos—as medidas de fomento já aconselhadas, já postas em pratica como a pharolagem e muitas outras—a critica do *modus vivendi* ao tempo em vigor, etc., etc.; todas estas questões de alta administração se encontram tratadas nos seus "Relatorious sobre Moçambique", repositorio monumental de doutrina que subsistirá, porventura, atravez do tempo sem impugnação da sua verdade essencial.

Produziu tal obra que reflecte profundo saber pratico dos factos e dos homens, o funccionario que no conhecimento da Provincia começou por ajudar a conquista das terras de Gaza, e depois a percorreu por innumeros e longos itinerarios de serviço, que sabe de cór a geologia de Moçambique e os seus mais interessantes phenomenos naturaes: que conhece a technica de quasi todos os serviços provinciaes e que adquiriu a experiencia do meio pelo contacto com colonos de todas as proveniencias sociaes, portuguezes e estrangeiros, e até com indigenas.

Mas o direito romano, ao contrario, porém, das praticas retrogradas da epoca medieval, fôra já percursor do regime de publicidade dos bens particulares, iniciando o *registo publico* pelo qual os terceiros eram advertidos das mudanças da fortuna particular prevenindo-os assim contra a fraude.

natureza da parcella do immovel antes do acto da alienação da terra ou da hypotheca, e sobre esta ultima os registos publicos forneciam uma base inatacavel, pondo ao abrigo de toda a discussão os direitos dos credores hypothecarios.

É no decurso dos dois ultimos seculos que o problema do cadastro da terra, como propriedade particular, tem começo de execução scientifica; mas, sob este ponto de vista, isto é, sob o objectivo de organizar um inventario geral da riqueza immobiliaria particular, a questão foi tratada com fins meramente fiscaes a identificação geometrica parcellar e a classificação do valor das terras e de seu rendimento servia ao problema administrativo da *perequação* do imposto predial e os limites dos predios e classificação d'estes demonstravam a materia collectavel. Esquecia-se, pois, a doutrina do sabio magistrado Robernier e a do illustre geometra piemontez Ignacio Porro, cujo ponto dominante recae no principio da ligação do cadastro geometrico com o registo publico nas conservatorias dos direitos e encargos que se ligam á propriedade immobiliaria.

Esta fundamental doutrina que tem a sua consagração nos cadastros modernos, que assumem o caracter perfeito do cadastro geometrico juridico e fiscal, é confirmada pela expressão da Tersant no congresso da propriedade, sessão de 10 de agosto de 1899, quando disse : " o cadastro será para cada propriedade *um documento unico de leitura facil, contendo a planta do immovel e breves menções do seu estado juridico.*"

Sobre o desenvolvimento juridico e technico d'esta doutrina, tão simples no enunciado e tão complexa na pratica, obra alguma encontrames mais completa sob a orientação citado do que a produzida pela grande commissão extra-parlamentar do cadastro da França em 1891, constituida pelos homens da mais selecta competencia juridica naquelle pais e por eminentes geometros profissionaes nos ramos de applicação da geodesia e topographia á medição da terra.

Monsieur Rouvier, então ministro das finanças, expunha á commissão extra-parlamentar a questão do cadastro sob os seguintes quesitos :

" La propriété doit etre determinée d'abord physiquement puis juridiquement

La determination juridique doit faire connaître les droits qui existent sur l'immeubles, principalement le droit de propriété. Il y aura lieu d'examiner si l'on doit adopter le systéme ayant pour base une absolue et compléte publicité de la propriété fonciére e de ses démembrements et si l'on doit y ajouter l' obligation de la specialisation de tous les priviléges et hypothèques."

" Les effects de la determination physique et juridique de l'immeuble doivent étre constatées dans un document publique et authentique *c'est le titre de propriété* quelle será la valeur de ce titre ? "

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"De même toute modification du droit de propriété soit a l'égard du titulaire soit en ce qui concerne l'étendue du droit lui même, parait devoir étre notée tout à la fois sur le titre e sur le livre foncier. De là resulte l'obligation de determiner les formalités à prescire pour les inscriptions e les transmissions des titres e à cette question se rattache encore l'étude de la création de cedules hypothécaires."

"On ne devra pas perde de vue que le but à atteindre consiste à créer un titre foncier dont la valeur juridique incontestable en assurant la facilité de transmissions, ainsi que la securité des detenteurs du sol, des creanciers hypothécaires, permettra de jeter les bases du credit agricole."

Monsieur Poincarré na sessão de 2 de dezembro de 1890 tinha já explicado, como relator da commissão de orçamento, que o emprehendimento não visava só a questão da *perequação no imposto predial*, antes devia ser principalmente considerado sob o alto ponto de vista dos serviços que o cadastro pode prestar á propriedade, organizando seus titulos onde se consignem todos os actos relativos aos immoveis e cuja inscrição tenha para todos os effeitos um valor juridico incontestavel.

Atravez da discussão produzida entre as competencias que formaram a grande commissão extra-parlamentar, cujo texto se encontra nos oito grossos volumes que dão o *compterendu* verbal das sessões, resultou, consubstancialmente o seguinte parecer :

Será organizado por communa o livro predial, tendo por unidade *o predio*. A primeira parte conterá a determinação physica do immovel conforme o cadastro geometrico sempre em dia.

Conterá a indicaçao da area do predio do numero de parcellas e das construcções ali existentes.

A segunda parte conterá :

1.° O nome dos proprietarios com indicação das causas e datas inscrições dos actos juridicos que recaem na propriedade.

2.° As restricções e encargos.

3.° Os previlegios e hypothecas.

Organizar-se-ha um indice pessoal destinado a facilitar as buscas.

Sob a parte geometrica propõe a commissão, após o assunto largamente discutido : "que se faça a identificação geometrica de cada predio, sendo por um lado, todos os marcos que limitem os predios e, por outros, todas as estações do levantamento, *determinadas por coordenadas rectangulares*."

Eis aqui em sua maxima pureza os principios da technica geometrica do cadastro dos predios e das terras em geral e os juridicos que de facto teem presidido à confecção dos cadastros mais perfeitos de actualidade. Comprehende-se todavia as differenças regulamentares e que a adaptação de tal doutrina ao cadastro da propriedade nos paises seculares seja tanto mais facil quanto seus codigos encerrem preceitos de publicidade real e do registo mais concordantes com as regras a que acabamos de nos referir.

Assim succede com o codigo predial português cujos principios do registo predial justamente são: a descrição separada dos predios como base essencialmente real, e a inscrição de todos os actos juridicos que recaem no propriedade; a organização do cadastro geometrico poderá, pois, realizar-se sem conflicto com os principios essenciaes do nosso codigo.

Mr. Besson, na sua obra obra em que profundamente trata do regime da propriedade desde sua origem pelo estudo historico e critico sobre a publicidade das transmissões immobilarias, divide o codigo predial da actualidade em tres grandes grupos. O do *regime francês* o do *Livro Predial do grupo germanico* e o *australiano.*

Classificam os competentes as leis prussianas de 1878 que organizam o regime das transmissões da propriedade pelo Livro Predial, a legislação typo do grupo germanico, assim como no australiano o *Real property act*, mais conhecido por *Acto Torrens*, emanação e aperfeiçoamento do Livro Predial. se considera o mais avançado regime de publicidade e que melhor realiza o credito e a facil transmissão dos seus immobiliarios.

Os principos da lei prussiana, relativos á publicidade absoluta dos direitos reaes por meio da inscrição, á descrição physica dos predios feita pelo cadastro geometrico e á força probatoria das inscrições como garantia dos que contratam sobre a terra na fé das mesmas inscrições, estabelecem na parte juridica analogias com e lei portugnesa, a qual Mr. Besson, autor já citado, classifica em sua obra de legislação comparada no grupo germanico, pondo todavia em relevo os defeitos pelos quaes nossa lei se afasta da legislação modelar do Livro Predial prussiano.

Estas differenças consistem em não ser obrigatorio pala lei portuguesa o registo das transferencias para a sua validade *inter-partes*, e principalmente na identificação dos predios não ter por base o cadastro geometrico e por conseguinte não poder existir a ligação do cadastro com o registo da Conservatoria, o que é fundamentalmente previsto na lei prussiana de 1872 pela qual se dispõe, que toda a inscrição da propriedade seja communicada ao cadastro e por sua vez este envie ao *Grundbuchrichter* os documentos das alterações materiaes relativos aos immoveis das circumscripções. D'esta forma, o cadastro e o registro publico da propriedade contraprovam-se e mutuamente se completam.

Parece, pois, que as alterações legislativas necessarias para converter a lei portuguesa á feição do regime typo do seu grupo, apenas consistiriam: *na organização* do cadastro na sua *ligação* com a Conservatoria do registo predial e, emfim, na entrega de um titulo aos proprietarios contendo a prova dos direitos e a identificação parcellar do immovel.

Taes foram as bases apresentadas pela Direcção da Agrimensura sobre as quaes, sequindo-se a discussáo e exame em estações superiores, foi introduzido o cadastro geometrico e juridico em nossa legislação pelo decreto de 9 de julho de 1909 que lhe deu começo de execução na Provincia de Moçambique.

Quanto ao registo obrigatorio, já o mesmo fôra estabelecido por lei no Ultramar portuguès.

A organização do cadastro em qualquer pais, antes de sua mera conservação, importu larvo dispendio. As exigencias technicas do problema traduzem-se na necessidade de recrutar pessoal devidamente habilitado e adextrado em trabalhos da especialidade que, sendo o pais desprovido ou quasi desprovido dos subsidos geometricos da suo descrição, são complexos e por vezes difficeis.

Em nossa recente visita á direcção dos serviços do cadastro em Pretoria, reconhecemos a maneira executiva dos trabalhos geometricos em perfeita analogia e parellelo com o plano e regime adotado em Moçambique. Mas os servicos na séde da Direcção são ali commettidos a um pessoal permanente de trinta e cinco pessoas entre director, sub-director, adjuntos, desenhadores, calculadores e amanuenses.

Dependente d'este centro de serviços estavam em exercicio no campo noventa geometros habilitados em Londres ou pela Universidade do Cabo da Boa Esperança.

São estes funccionarios de categoria analoga á dos nossos agrimensores ajuramentados.

O dispendio com as operações do cadastro a fazer por uma só vez, antes de sua simples conservação, tem preoccupado quasi todos os paises do mundo sem que o sacrificio dos gastos prejudique a pratica do emprehendimento.

E' certo que, para fins meramente fiscaes, para o effeito do imposto sobre a propriedade immobiliaria, muitos cadastros foram melhor ou peor organizados; mas o alto ponto de vista da segurança dos direitos de propriedade em mãos do possuidor e da sua indiscutivel situação e area sobreleva aos interesses do thesouro publico; de resto é evidente que um perfeito cadastro geometrico e juridico é ao mesmo tempo a base do regime fiscal que melhor assegura a *perequação* tributaria.

Na Italia foram tão bem comprehendidos os effeitos da lei do cadastro de 1886, que circumscrições territoriaes houve que adiantaram fundos precisos para os trabalhos do cadastro se realizarem sem demora nas mesmas circumscripções.

Nos paises novos da colonização, onde interresses da especulação por transferencias das terras concedidas pelo Estado demoram, em regra, a evidencia material da posse da terra pela sua agricultura, a liquidação dos direitos de propriedade e a identificação das terras, ainda que ermas, é um ponto da maior importancia administrativa e que só o cadastro pode resolver.

Algures dizemos já, que as difficuldades successivamente avolumadas para evidenciar o estado da propriedade na colonização ingleza é que levaram Sir Robert Torrens, registador geral, á concepção do systema conhecido por seu nome e que começou por introduzir-se na Australia do Sul; foi igualmente devido ás dilligencias de Maxwell, director dos Serviços da propriedade em Singapura, que o mesmo regime vigora nos estabelecimentos inglezes e, do mesmo modo na Argelia, é Mr. Firman que, para desembaraçar a terra dos grandes obstaculos que se oppunham á sua mobilização, consegue a pratica de um regime moldado no processo Torrens.

Tambem na colonia portugueza de Moçambique, a legislação sobre terrenos anterior á de 1909, desprovida de medidas tendentes á organização do cadastro geometrico e estranha á moderna orientação sobre a garantia da segurança dos direitos immobiliarios, conduziu a difficuldades successivamente avolumadas e só a lei de 1909 lhe vem dar começo de solução.

Depende todavia do equilibrio orçamental entre as despesas da colonia, a distribuir por serviços não menos importantes, a celeridade e os resultados correspondentes do cadastro que o Governo Central cura de attender.

Com recursos apenas iniciaes, o serviço da agrimensura exemplifica seus trabalhos do cadastro dentro do plano geral cartographico e no parcellar da identificação geometrica dos predios e segurança dos direitos individuaes conforme os titulos de propriedade, cuja estampa referente a um predios juntamos a esta memoria.

TITULOS DA PROPRIEDADE

Na sua forma legal, comprehendem quartro partes. Está ainda em projecto a quinta parte em via de discussão, relativa á parte fiscal do imposto sobre a propriedade immobiliaria.

A primeira parte—alvará—é o documento legal da propriedade assegurado pela sua validade em juizo.

A segunda parte contem a identificação material do predio por seus limites e planta acompanhada de um diagramma numerico que traduz a mesma identificação e a posição absoluta da parcella nas cartas do cadastro.

A terceira parte esclarece por simples extracto das inscrições todos os actos juridicos que recaem no predio.

A quarta parte destina-se ao endosso, ou, o que é o mesmo, á facile mobilização do predio por transferencia, mediante a autorização do governador geral.

Taes direitos são inicial e formalmente assegurados pelo alvará, e a seguir, todas as mutações da propriedade, relativas a transferencias, hypothecas e mais encargos, privilegios e tudo o mais que importa alteração na existencia juridica da propriedade, é consignado no titulo e bem como as alterações physicas de area, sendo tal regime garantido pelas mutuas relações entre a conservatoria do registo predial e a repartição do cadastro.

Portanto, os titulos de propriedade na provincia de Moçambique obedecem, segundo nos parece, á mais larga e moderna concepção do cadastro moderno no regime do Livro Predial.

O titulo do predio é um documento unico de leitura facil, pelo qual qualquer interessado no commercio das terras pode em poucos minutos reconhecer, a respeito do mesmo predio, todas as condições da sua existencia civil, a situação, area, encargos, etc. Tal era a definição theorica de Tersant a que já nos referimos, expressa no congresso de propriedade na sessão de 10 de agosto de 1889.

Emfim, a quinta parte *ainda em projecto*, alem de interessar particularmente ao Estado na parte de seu cadastro fiscal, mostra tambem quaes os encargos que pelo tributo sobre a terra pesam, seu estado corrente de pagamento, de encargos, e, porventura, a classificação das terras, rendimento e o mais que interesse á parte privativamente fiscal no *perequação* do imposto.

Vejamos agora summariamente no conjunto o projecto em começo de execução do cadastro geral dos terrenos.

A reunião dos titulos prediaes constitue o Tombo Geral da Propriedade, como resultante immediata do cadastro geometrico.

Dos titulos entregues aos concessionarios e após o registo na Conservatoria dos direitos do proprietario dos do Estado, tira-se uma copia authentica que fica fazendo parte do Tombo da Propriedade archivado na Direcção da Agrimensura.

Depois, todas as inscripções feitas nos titulos, em mão dos possuidores, dos terrenos são communicadas ao cadastro que immediatamente as passa por copia aos titulos em archivo systematicamente arrumados. Por sua vez, o cadastro communica, como já dissemos, á Conservatoria todas as alterações que recaem na parte physica dos predios. *Assim se verificará a conservação do cadastro pelo qual a administração e os interessados podem reconhecer dia a dia o estado corrente de cada predio por facil exame.*

Algumas centenas de titulos já conferidos, após a introducção do cadastro geometrico na lei de terrenos, demonstram, a nosso ver, as qualidades do regime e correspondentemente resultados previstos nas linhas theoricas que presidem á sua organização; mas faltariamos á verdade que acompanha esta memoria, querendo persuadir que o nosso regime vigora desde já em toda a extensissima provincia de Moçambique como se fôra um organismo feito e completo em seus meios de acção.

Não desconhecem os profissionaes que a solidez do regime depende essencialmente dos trabalhos de numeroso pessoal convenientemente adextrado, e este não é facil nem rapidamente recrutavel.

No simples extrato que segue, resumimos o plano geral dos trabalhos geometricos para a organização das cartas do cadastro.

A triangulação de primeira ordem a cujo comeco de execução procedeu a Missão Geodesica da Africa Oriental, presidida pelo capitão-tenente da armada Sr. Gago Coutinho, cobre o districto de Lourenço Marques, uma parte das costas maritimas de Gaza e Inhambane, interessando para o interior uma parte de territorio e extende-se ainda numa estreita faixa até ao Bazaruto.

A Direcção da Agrimensura obteve d'aquella missão scientifica os dados fundamentaes geographicos, medidas de bases, as direcções reduzidas ao centro de todos os lados da triangulação observados das estações geodesicas e com estes elementos se calcularam *valores provisorios* das coordenadas geographicas e distancias á meridiana e á perpendicular dos pontos trigonometricos, para a região abrangida pela triangulação

No plano geral das cartas organizam-se estas separadamente por districtos porque a falta de subsidios da triangulação geral do pais importa este restricção.

Cada uma d'estas é dividida theoricamente em compartimentos (quadrados de 40 kilometros de lado) formados por linhas parallelas aos eixos geraes das cartas, meridiano central e sua perpendicular no ponto de cruzamento d'aquelle meridiano com o parallelo medio.

Os compartimentos subdividem-se em folhas para publicação na escala 1 : 25000 que, em regra, é a normal e sufficiente para mostrar a posição relativa das parcellas dos terrenos concedidos e os do Estado e nestes a sua divisão em blocos destinados a alienação por aforamento ou venda, e ainda, mediante serviço da agricultura, se mostrará a classificação generica das terras. A propriedade urbana das cidades, villas, povoações e suburbios e a extramamente parcellada e é tratada em maior escala nas cartas de detalhe.

A topographia parcellar dos predios e todo o seu contorno perimetral definido por coordenadas rectangulares referidas á origem da triangulação local, completa-se nos titulos pelas respectivas plantas e identificação numerica como mostram os diagrammas.

Empregamos o systema de coordenadas rectagulares planas mais accommodado aos trabalhos parcellares do cadastro, dentro dos limites de erro admissiveis para os pontos mais affastados da origem dos eixos coordenados.

A projecção das cartas é traçada no plano tangente ao ponto central origem de eixos a que se referem todos pontos do levantamento.

Para os calculos correntes da transmissão da posição geographica, transformação de coordènadas, etc., adoptaram-se as dimensões de ellipsoide de Clarke que entram nos dados numericos de varias taboas communmente usadas na geodesia expedita.

A triangulação geodesica de 1.ª ordem, cobrindo o districto de Lourenço Marques, permittiu que o plano da carta do districto se apoiasse naquella triangulação a que se ligam os trabalhos subsidiarios e parcellares do esqueleto cadastral formada por triangulação secundaria e travessas em parte do districto realizadas.

Nas regiões do districto de Inhambane e do antigo districto de Gaza, igualmente cobertas pela triangulação geodesica e que coincide aproximadamente com zonas territoriaes de maior procura e movimento de terras, igual criterio presidiu ao projecto das cartas e organização do esqueleto topographico.

Está, porém, a maior parte da Provincia desprovida de triangulação fundamental. Estes trabalhos importam despesas muito consideraveis a parte já realizada importou em 120.000.000 réis. Os trabalhos de campo são de irreductivel lentidão atravez das difficuldades de toda a ordem que surgem por variedissimas circumstancias; a rêde de calculos que são precisos para completo acabamento do trabalho em resultados numericos e finaes gasta muitos meses, e até annos; por outro lado, exigencias administrativas dos serviços da propriedade e seu cadastro, discordantes da lentidão dos trabalhos geodesicos de 1.ª ordem, aliás os verdadeiramente fundamentaes, remettem o problema technico para o campo da geodesia expedita e topographia numerica cadastral.

Neste ponto de vista, uma das soluções será a pratica das pequenas triangulações independentes a ligar a todo o tempo á triangulação geodesica, e conforme o nosso plano de cartas parcellares, são as triangulações separadas dos compartimentos districtaes do cadastro já referidos, as que antes de qualquer outro trabalho devem emprehender-se para sufficiente garantia da rigidez do plano geometrico. De facto, a identificação da propriedade não está apenas garantida pelos marcos periphericos de seu contorno perimetral; é preciso que a demarcação geometrica do pais á custa do Estado que se mostra pelos sinaes materiaes erguidos nos vertices de suas triangulações, seja conservada, porque da sua existencia e do conhecimento pelo calculo da posição de seus vertices, depende a reconstituição em todo o decurso do tempo das marcas da propriedade por qualquer causa destruidas, mas cuja identificação é assegurada pelo diagramma que acompanha os titulos.

O systema das triangulações independentes é o mesmo que verificamos realizar-se no cadastro do Transvaal, onde a triangulação de 1.ª ordem não cobre todo o pais e sendo o plano geometrico do cadastro bastante aproximado do nosso no regime technico e no resultado final: *o titulo da propriedade*.

Se os meios executivos são naquella colonia, nossa vizinha, numerica e incomparavelmente superiores aos nossos, a analogia ainda se mantem nas categorias do quadro permanente e na dos geometros particulares, e facil será de futuro chegarmos a completo parallelismo com aquelles importantes serviços, melhorando-se o quadro permanente no que precisa ser melhorado, e criando uma escola de instrucção theorica e pratica de geometros particulares do cadastro que, a julgar pelo movimento transaccional de propriedade, garantirá sufficiente remuneração aos que se habilitarem com os respectivos diplomas aos trabalhos do cadastro geometrico.

Com o exposto, temos concluido o que em *memoria* é possivel condensar sobre o cadastro da propriedade immobiliaria de Moçambique, cujo interesse, apenas noticioso, repetimos, consiste em ser privativa d'esta provincia do Ultramar português a pratica de um regime que trata a propriedade sob as bases do cadastro geometrico e juridico e cuja parte fiscal encontrará de futuro no mesmo cadastro os necessarios elementos da mais simples execução.

PROVINCIA DE MOÇAMBIQUE

Titulo de Concessão

POR

Aforamento.

Passado em favor de Francisco Roque da Aguiar

Processo de concessão n.º 753

Direcção dos Serviços da Agrimensura em Lourenço Marques
em 4 de novembro de 1912.

Ficou o predio a que se refere este titulo com o n.º 4,
Compartimento n.º 3
do cadastro e descripto no **Tombo Geral** *da propriedade.*

Pedro Luiz de Bellegarde da Silva
Coronel d'art.ª e Dir.or da agrim.
[illegible]

I PARTE

ALVARÁ DE CONCESSÃO

José Alfredo Mendes de Magalhães, Governador Geral da Prov. de Moçambique ...

Faço saber que por meu despacho de 28 de Outubro ultimo, lavrado a fls 19 do respectivo processo, archivado na direcção da Agrimensura desta provincia, concedi por aforamento nos termos do artigo 54 combinado com o artigo 58, do regimen provisorio para a concessão de terrenos do Estado na provincia de Moçambique approvado por decreto de 9 de julho de 1909, a Francisco Roque de Aguiar major de infantaria do exercito, de 58 annos de idade, solteiro natural de Arruda e residente em Lourenço Marques, o terreno do Estado, de 2.ª classe, descripto na 2.ª parte d'este titulo, com a area de 1900000 $m^2$0000, competentemente cadastrado com o n.º 4 no compartimento n.º 3, do plano do Cadastro Predial do districto de Lour.º Marques ...

E em harmonia com as disposições do regimen supracitado lhe mandei passar o presente titulo que vae por mim assignado e que depois de registado fará prova plena em juizo nos termos do artigo 164 do mesmo regimen.

Pagará annualmente no cofre da Fazenda do respectivo districto desde a data deste titulo o foro annual de setenta e seis mil reis correspondente á referida area. Poderá gosar dos direitos que lhe confere o mencionado regimen sobre a concessão de terrenos do Estado nesta Provincia e fica obrigado ao cumprimento de todas as suas prescripções que dizem respeito á presente concessão ...

Governo Geral da Provincia de Moçambique em Lourenço Marques, 4 de novembro de 1912 ...

O Governador Geral

(ass.) Alfredo de Magalhães

II PARTE

Calculo da superficie pelo conhecimento das coordenadas

$$S = \tfrac{1}{2}\,(y^1 + y^2)\,(x^1 - x^2) + (y^2 + y^3)\,(x^2 - x^3) + \quad .\ (y^n + y^1)\,(x^n - x^1)$$
$$S = \tfrac{1}{2}\,(x^1 + x^2)\,(y^1 - y^2) + (x^2 + x^3)\,(y^2 - y^3) + \ .\ .\ .\ (x^n + x^1)\,(y^n - y^1)$$

Bellegarde Lobo
Caldas Vianna

Pontos	Coordenadas		Sommas		Differences		1° calculo Productos		2.° calculo Productos	
	X	Y	XX	YY	XX	YY	+	−	+	−
1	00.00	00.00								
2	− 385.47	+ 532.84	− 385.47	+ 532.84	+ 385.47	− 532.84	2053938348		2053938348	
3	+ 649.90	+ 910.49	+ 264.43	+ 1443.33	− 1035.37	− 377.65		14943805827		998679895
4	+ 588.89	+ 1849.50	+ 1238.79	+ 2759.99	+ 61.01	− 939.01	1683869899			16632367979
5	+ 992.46	+ 2029.98	+ 1581.35	+ 3879.48	− 403.57	− 180.48		15656417436		2854020480
6	+ 1452.33	+ 1939.39	+ 2444.79	+ 3969.37	− 459.87	+ 90.59		18253941818	2214735261	
7	+ 666.55	+ 2961.03	+ 2118.88	+ 4900.42	+ 785.78	− 1021.64	38506520276			21647325632
8	+ 94.42	+ 3354.69	+ 760.67	+ 6315.72	+ 572.43	− 393.66	36153075996			2994453522
9	− 516.59	+ 4181.01	− 422.47	+ 7535.70	+ 610.71	− 826.32	46021273470		3490954.04	
10	− 1163.88	+ 4966.87	− 1680.47	+ 9147.88	+ 647.29	− 785.86	59213312432		13206141542	
11	− 1552.08	+ 5129.03	− 2715.96	+ 10095.90	+ 388.20	− 162.16	39192283800		4404200736	
12	− 2574.16	+ 5654.05	− 4126.24	+ 10783.08	+ 1022.08	− 525.02	110211704064		21063585248	
13	− 4133.73	+ 5656.90	− 6707.89	+ 11310.95	+ 1559.57	− 2.85	176402182915		19117486.5	
14	− 4930.28	+ 5403.78	− 9064.01	+ 11060.68	+ 796.55	+ 253.12	88103846540			22942822112
15	− 4842.21	+ 4100.06	− 9772.49	+ 9503.84	− 88.07	+ 1303.72		8370031888		127405906628
16	− 4855.33	+ 2986.10	− 9697.54	+ 7086.16	+ 13.12	+ 1113.96	929704492			108026710584
17	− 2462.99	+ 2389.95	− 7318.32	+ 5376.05	− 2392.34	+ 596.15		128613394570		43628164680
18	− 1120.75	+ 1391.12	− 3583.74	+ 3781.07	− 1342.24	+ 998.83		50751033968		35795470242
19	− 1272.16	− 07.31	− 2392.91	+ 1383.81	+ 151.41	+ 1398.43	2095526721			33463171313
20	− 2171.51	− 394.37	− 3443.67	− 401.68	+ 899.35	+ 387.06		36125090080		1332906.9102
21	− 3245.30	− 192.51	− 5416.81	− 586.88	+ 1073.79	− 201.86		63010658752	7093437.2666	
22	− 3977.28	− 764.50	− 7222.58	− 957.07	+ 731.98	+ 572.05		70055609866		41316768890
23	− 3492.96	− 909.48	− 7470.24	− 1674.04	− 484.32	+ 144.92	810.7710528			7082587.1808
24	− 2256.22	− 898.12	− 5749.18	− 1807.60	− 1236.74	− 11.36	22355312240		6531068.48	
25	− 834.32	− 370.78	3090.54	− 1268.88	− 1421.90	− 527.36	16042204720		7622827.7744	
1	00.00	00.00	− 834.32	− 370.76	− 834.32	− 370.76	3093324832		3093324832	

Somma . . . . . 652165490993 | 2535085554320 | 7820380618.4 | 476860742867

Differença . . . 399656936673 | 399656936673

Superficie rectilinea . . . . . . m^2 199328468336

132714.7000

Area cultivada (aprox^da) 40 0732 1336

Area ocupada p lagoas (aprox^da) 400000 0000

80 0732 1336

II PARTE

Diagramma para identificar a posição e o contorno perimetral do predio

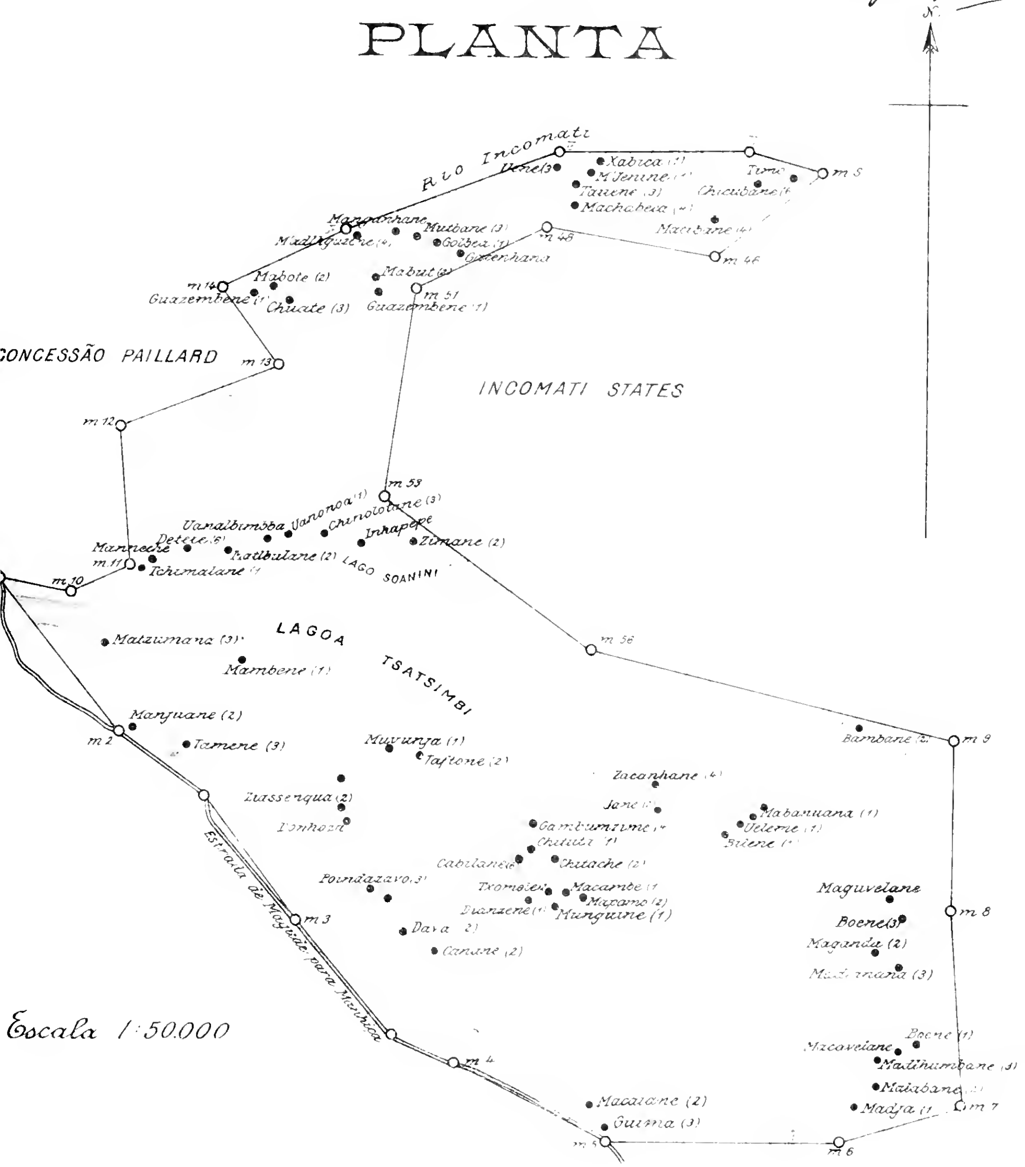
[illegible]

Pontos de polygonal	Pontos	Lados		Azimuths dos lados	Angulos internos	Coordenadas						Marcos	
						A estação			A origem				
		Pontos extremos	Comprimentos			x	y	z	X	Y	Z		
...	1	...	....	...	...				− 20 805 60	− 108 428 63	+ 77.10	14 n	Concessão Paillard
....	2	1-2	657.65	324°07'01"	106°19'18"	− 385.47	+ 532.84	− 3 73	21 191 07	107 895 79	73 37	13 n	
...	3	2-3	1102.10	69°57'39"	249°37'23"	+ 1035.37	+ 377.65	− 0.41	20 155 70	107 518 14	74 96	12 n	
..	4	3-4	940.99	356°16'57"	245°14'19"	− 61.01	+ 939.01	+ 1.60	20 216 71	106 579 13	76 62	11 n	
..	5	4-5	442.09	65°54'20"	41°13'37"	+ 403.57	+ 180.48	− 0.37	19 813 14	106 398 65	76 45	10 n	
....	6	5-6	468.70	101°08'39"	162°08'43"	+ 459.87	− 90.59	+ 0.49	19 353 27	106 489 24	76 94	9 n	
...	7	6-7	1287.01	322°22'16"	199°01'00"	− 785.78	+ 1021.64	+ 2.00	20 139 05	105 467 60	78 94	2	Concessão Aguiar
...	8	7-8	694.72	304°30'59"	176°59'23"	− 572.43	+ 393.66	− 0.55	20 711 48	105 073 94	78.39		
....	9	8-9	1027.50	323°31'59"	152°08'55"	− 610.71	+ 826.32	− 0.68	21 322 19	104 247 62	77 71	3	
..	10	9-10	1018.11	320°31'22"	184°31'02"	− 647.29	+ 785.86	− 5.44	21 969 48	103 461 76	72.27		
..	11	10-11	420.71	292°40'17"	152°54'58"	− 388.20	+ 162.16	+ 2.70	22 357 68	103 299 60	74 97	4	
...	12	11-12	1149.04	297°11'19"	162°16'00"	− 1022.08	+ 525.02	+ 1.72	23 379 76	102 774 58	76 69	5	
..	13	12-13	1559.57	270°06'17"	163°45'50"	− 1559.57	+ 2.85	− 5.16	24 939 33	102 771 73	71 53	6	
.	14	13-14	835.80	252°22'47"	184°32'22"	− 796.55	− 253.12	+ 0.13	25 735 88	103 024 85	71 66	7	
..	15	14-15	1306.70	176°08'07"	103°49'04"	+ 88.07	− 1303.72	+ 1.52	25 647 81	104 328 57	73 18	8	
..	16	15-16	1114.04	180°40'29"	202°39'45"	− 13.12	− 1113.96	− 0.19	25 660 93	105 442 53	72 99	59	
..	17	16-17	2465.50	103°59'33"	239°31'28"	+ 2392.34	− 596.15	2.00	23 268 59	106 038 68	74 99	50	Incomati States
....	18	17-18	1673.10	126°39'18"	240°32'05"	+ 1342.24	− 998.83	+ 1.00	21 926 35	107 037 51	75 99	53	
....	19	18-19	1406.60	186°10'46"	213°55'57"	− 151.41	− 1398.43	+ 0.70	22 077 76	108 435.94	76.69	51	
....	20	19-20	979.10	246°42'51"	131°20'44"	− 899.35	− 387.06	− 0.80	22 977 11	108 823 00	75.89	48	
..	21	20-21	1092.60	280°38'48"	[illegible]4°39'58"	− 1073.79	+ 201.86	− 1.50	24 050 90	108 621 14	74 39	40	
.	22	21-22	929.00	231°59'32"	162°48'55"	− 731.98	− 572.05	+ 1.10	24 782 88	109 193 19	75 49	S	
..	23	22-23	505.54	106°39'30"	160°40'39"	+ 484.32	− 144.92	—	24 298 56	109 338 11	—		
..	24	23-24	1236.79	89°28'25"	176°23'21"	+ 1236.74	+ 11.36	—	23 061 82	109 326 75	—		
.	25	24-25	1516.54	69°39'04"	78°04'36"	+ 1421.90	+ 527.36	—	21 639 92	108 799 39	—		
....	1	25-1	912.99	66°02'25"	—	+ 634.32	+ 370.76	—	20 805 60	108 428.63	77.10		

Levantamento topografico e calculo por
Almeida Pinheiro
1º tenente d'arm.
Agr.or ajuramentado

II PARTE

PLANTA



A parcella identificada n'esta planta e seu diagramma confronta, na data do levantamento topographico, por Norte com a zona de vinte metros e o Rio Incomati, Este com a concessão de Incomati States e baldios, Sul baldios e Oeste com a concessão Paillard, baldios e Estrada de Magude á Manhiça.

A origem das coordenadas é o ponto de encontro do meridiano 32°30' com o parallelo [illegible]°30'

O eixo do y y coincide com aquelle meridiano

Os azimuths são contados de Sul para o Norte passando por Oeste

Os vertices d'esta parcella foram assignalados no terreno por marcos de [illegible] e d'isto tomou conhecimento o proprietario conforme consta do respectivo processo

III. PARTE

Bellegarde Cabe
Tabelião

Extractos das inscripções e averbamentos feitos na Conservatoria do Registo Predial da comarca de Lourenço Marques ... acêrca do predio descripto na II parte

Numero de ordem	Inscripções	Averbamentos
1	Em virtude de apresentação nº 19 de 6 de dezembro de 1912 — inscripção nº 3106 a fls. 151 do livro F 4 — a favor do Estado o dominio directo com o foro annual de 76.000 reis — Lourenço Marques, 9 de dezembro de 1902 O Conservador, ass. Bernardo Augusto da Amaral Polonio	
2	Em virtude de apresentação nº 20 de 6 de dezembro de 1912 — inscripção nº 3107 a fls. 151 do livro F 4 — a favor de Francisco Roque de Aguiar, solteiro, major de infantaria, natural de Arruda e residente em Lourenço Marques. Lourenço Marques, 9 de dezembro de 1912 O Conservador, ass. Bernardo Augusto da Amaral Polonio.	

IV. PARTE

ENDOSSOS

Numero de ordem	Endossos	Observações

Bellegarde
Faustino

V. PARTE em projecto

Estado corrente dos encargos

Classificação	Contribuição predial	Estado do pagamento			Observações
		Da contribuição predial	Dos foros	Das rendas	
Terrenos { classe		19			
Terrenos { ordem		19			
Construcções					

Observação. — A forma definitiva d'esta V parte dependerá da lei da contribuição predial. A importancia das rendas e foros são expressas na I. parte dos titulos.

Pes Max Kirch

BRIEF NOTES ON THE EFFECTS OF GEOMETRICAL SURVEY AND LEGAL REGISTRATION OF LAND IN RELATION TO THE SECURITY OF RIGHTS OVER IMMOVABLE PROPERTY AND ITS IDENTIFICATION.

By Pedro Luis de Bellegarde da Silva.

(Translation.)

The matter briefly dealt with in this paper contains no scientific or administrative novelty.

With reference to private immovable property, which is constituted by the concessions of State land in Mozambique to nationals and foreigners, I shall mention herein the fundamental principles governing the constitution and system of land transactions having for a basis the principles of Geometrical Survey and Registration of Land, but this does not imply any doctrines unknown to those who are conversant with the subject.

For this reason, the reading of this brief paper before the Congress of the South African Association for the Advancement of Science may only be justified by its comparative "news value," as within the vast Portuguese administrative jurisdiction in Europe and the colonies, only in the Province of Mozambique, and just recently in Angola, have mathematical and legal Survey and Registration been established by law, exemplified as to its final results in Mozambique.[1]

Right through the centuries and generations the history of landed property is on a par with the history of humanity with which it is intimately connected, and possesses its own evolution.

With a merely historical interest, the mediæval epoch shows us the Renaissance and some approaches to old practices of agrarian collectivism in the usufruct of land. The feudal system, says Michelet, "was something like a religion of the lands," but in those times the feudal lord represented the community of free

[1] The 1907 organization of the administrative services of the Province of Mozambique, by granting a certain decentralization of powers and initiative to the Governor-General permitted, with the probability of attaining practical results in the Administration, of his studying with the assistance of the Government Council the principal problems of the internal government of the Colony.

It was in terms of these powers that Governor Freire de Andrade proposed the remodelling of the Land Concessions Law and established in this reform the principles of Geometrical Survey and Registration as its essential basis.

It would be impossible to mention, within the limits of these remarks, not even generally and much less in detail, the chapters of administration dealt with as a result of the deep study and enquiry made by that Governor-General into the Administration of Mozambique; the political situation and the inventory of the Provincial wealth and productive powers; the study of the native question in its close connection with he most varied aspects of Home trade, administration, and progress of the Province and of the natives themselves; the financial equilibrium, and, men: then there were the vassals and the lord of the land, who received it with particular solemnity!

Roman Law, however, in opposition to the retrograde practices of the Middle Ages, had been the forerunner of the system of publicity as to private property, and initiated the Private Register, through which third parties were informed of the changes occurring in private fortunes, thus warning the people against fraud.

The expansion of immovable wealth, depending, no doubt, in its transactions and trade, upon the public faith which is bound with the object itself of such transactions, necessarily leads to the necessity of recognising the conditions of civil existence of immovables by announcing not only the rights of the holder and the charges onerating the land, but the knowledge of its essentially real existence which amounts to physical identification.

Such are the topics of the problem which from not too distant a date has preoccupied the Administration of nearly every country.

The French Revolution, which radically and profoundly shook the influence of the laws of the feudal regime, produces in its decree of the 9th *Messidor*, year III, the transition of the land regime to the modern systems of publicity as to immovable property, which have for a basis the Geometric Survey.

This law imposed upon the owner the obligation of stating with the utmost detail the position, area, and nature of the holding at the Deeds Office before the land could be alienated or hypothecated, and, as to mortgages, the public registers offered an unassailable basis by placing beyond all discussion the rights of mortgagers.

It is in the course of the last two centuries that the problem of the registration of private property begins to be scientifically carried out. From this standpoint, however—that is to say, with the object in view of organising a general inventory of private

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especially, the question of the Treasury as machinery; general and district Administration, including the "Prazos" system; commerce, industry, and agriculture; taxes and sources of revenue; the railway through Gaza to Inhambane; Municipal Administration; the debated question of wines; measures of development either recommended or actually carried out, such as the question of lighthouses and many others; the critical study of the *Modus Vivendi* in force at the time, etc., etc. All these questions of high administration are dealt with in his "Reports on Mozambique," which form a monumental repository of doctrines that will very likely subsist throughout the ages without denial as to their essential truth.

This work which reflects a deep practical knowledge of facts and men, was produced by that official who began his career in the Province by assisting in the conquest of Gazaland, and later went through the territory by long and innumerable itineraries—who knows by heart the geological constitution of Mozambique and its most interesting natural phenomena, who is acquainted with the technical side of nearly all the Provincial services, and who acquired his experience by contact with colonists of all social grades, Portuguese and foreign alike, and even with the natives.

immovable wealth—the question was dealt with for merely fiscal purposes; the geometric identification of plots and the classification of the value of land and the revenue it yields assisted in the solution of the administrative problem of assessing the property tax, while the boundaries and classification of properties showed the taxable matter. The doctrine of the learned magistrate, Robernier, and that of the distinguished Piedmontese geometrician, Ignacio Porro, the main point of which lies in the principle of the connection between the Geometrical Survey and public registration in the Deeds Office of the rights and encumbrances of immovable property, were thus forgotten.

This fundamental doctrine, which is now endorsed in the surveys of the present day, and assumes the perfect character of a legal and fiscal registration, is confirmed by Tersanst's words at the Property Congress on the 10th August, 1899, when he said: "Registration should consist for each property of one single document, easy to read, and containing the plan of the immovable property and brief references as to its legal status."

As to the legal and technical aspect of this doctrine, so simple in its enunciation, but so complex in actual practice, I have found nothing more complete than the work prepared by the extra-Parliamentary Grand Commission of Land Registration in France in 1891, which was formed by men of the highest judicial competence in that country and by eminent professional geometricians and experts in the branches of the application of geodesy and topography to the measurement of the ground.

Monsieur Rouvier, then Minister of Finance, put the question to the extra-Parliamentary Commission under the following points:—

La propriété doit être determinée d'abord physiquement, puis juridiquement.

La determination juridique doit faire connaitre les droits qui existent sur l'immeubles, principalement le droit de propriété. Il y aura lieu d'examiner si l'on droit adopter le systéme ayant pour base une absolue et compléte publicité de la propriété foncière et de ses démembrements et si l'on doit y ajouter l'obligation de la specialisation de tous les privilèges et hypothèques.

Les effects de la determination physique et juridique de l'immeuble doivent être constatées dans un document publique et authentique, *c'est le titre de propriété* quelle será la valeur de ce titre?

De même toute modification du droit de propriété soit à l'égard du titulaire soit en ce qui concerne l'étendue du droit lui même, parait devoir être notée tout à la fois sur le titre e sur le livre foncier. De lá resulte l'obligation de determiner les formalités à prescrire pour les inscriptions e les tranmissions des titres e à cette question se rattache encore l'étude de la création de cedules hypothécaires.

On ne devra pas perdre de vue le but á atteindre consiste à créer un titre foncier dont la valeur juridique incontestable en assurant la facilité de transmissions, ainsi que la securité des dententeurs du sol, des creanciers hypothécaires, permettra de jeter les bases du credit agricole.

Monsieur Poincarré, in his position as reporter to the Budget Commission, had already explained at the meeting of the

2nd December, 1890, that the undertaking did not only affect the question of the *assessment of the property tax*, but should be principally considered from the high standpoint of the services that registration could render to property by organising its title so as to record all acts relating to immovables, and to give their registration an indisputable legal value.

From the discussion which took place among the most competent persons who formed the extra-Parliamentary Grand Commission, the text of which is to be found in the eight thick volumes that give the *compte-rendu* of the meetings, the following report resulted in substance:

The property Book shall be organized by communes, and shall have as its unity the "property." The first part shall contain the physical determination of the immovable always up to date and according to the Geometrical Survey.

It shall mention the area of the property, the number of holdings and existing buildings.

The second part shall contain:

1. The name of the proprietor, stating the reasons for and dates of registration of all legal acts relating to the property;

2. Restrictions and encumbrances;

3. Privileges and mortgages.

A personal index for the purpose of facilitating searches shall be organized.

As to the geometrical part, and after the matter had been widely discussed, the Commission proposed "that the geometrical identification of each property be made, all beacons delimitating the property and all surveying stations *being determined by rectangular co-ordinates*."

Here we find in their utmost purity the geometrical principles of Property and Land Survey in general and the legal principles which have guided the preparation of the most perfect registers of the present times. One understands all the same the divergencies that are to be found in different Regulations, also that the adaptation of this doctrine to the registration of property in secular countries should be so much easier when their legal codes endorse precepts of real publicity and registration in agreement with the rules to which we have just referred.

Such is the case with the Portuguese Property Code, the principles of which as regards registration of property are:— separate description of properties as an essentially real basis and the recording of all legal acts respecting to property. The organization of the Geometrical Survey and Registration can, therefore, be carried out without conflicting with the essential principles of our code.

Mr. Besson in his work dealing with the property regime from its very origin makes a critical and historical study as to the publicity of the transfer of immovables, and divides the property code of the present time into three large groups—*The French Regime*, *The Property Book of the German Group*, and *the Australian system*.

Experts classify the Prussian laws of 1878, which organized the system of transfer of property by means of the Property Book, as the typical legislation of the German Group, just as in the case of the Australian Group, the "Real Property Act," better known as the "Torrens' Act," and which is really an improvement on the Property Book from which it originates, is considered as the most advanced system of publicity and the one that best permits of the realization of credit and easy transfer of immovables.

The principles of the Prussian law relating to the absolute publicity of real rights by means of registration, to the physical description of property by means of the Geometrical Survey, and to the proof value of registers as a guarantee to those entering into contracts in respect of land by placing their faith in these registers, are analogous in their legal part to the Portuguese law, which Mr. Besson, in his work on comparative legislation, places in the German group, emphasising, however, the defects on account of which our laws differ from the model Prussian Property Book.

These differences are due to the fact that Portuguese law does not make it compulsory to register all transfers before giving them validity *inter partes*, and principally in the identification of property not having for a basis the Geometric Survey; consequently no relation can exist between the Survey Department and the registration at the Deeds Office which is fundamentally foreseen in the Prussian law of 1872, which provides for all registrations of property to be communicated to the Survey Department, and on the other hand that the latter should send to the *Grundbuchrichter* the documents relating to material alterations respecting immovables in the circumscriptions. Thus the Survey Department and the Public registration of property mutually check and complete each other.

It seems, therefore, that the necessary legislative alterations required to convert Portuguese law to the typical features of its own group, would merely consist of the following organization of Survey in its relation to the Deeds Office, and finally in the delivery of a title to the proprietor containing the proof of his rights and the identification of the immovable.

Such were the bases presented by the Surveyor General's Department and, after discussion and examination at the higher stations, Geometric Survey and legal Registration were introduced in our legislation by decree of the 9th July, 1909, which was put into execution in the Province of Mozambique.

As to compulsory registration, this had already been established by law for the Portuguese oversea dominions.

The organization of a survey in any country, before its mere maintenance, is a very expensive matter. The technical exigencies of the problem are the necessity for recruiting an able and trained staff of experts in this special work, and owing to the practical absence of geometrical subsidies in the country this becomes complex and sometimes very difficult.

In my recent visit to the Survey Department of the Transvaal, I found that the system employed in geometrical work was in perfect analogy and parallel to the methods adopted in Mozambique. But the services in the Head Department at Pretoria are in charge of a permanent staff of thirty-five officials, including one Surveyor-General, one under-Surveyor-General, assistants, draughtsmen, calculators, and clerks.

Subordinate to this Head Office there were ninety geometricians of the London or Cape of Good Hope Universities doing camp work. These officials occupy a similar position to that of our sworn surveyors.

The initial expense involved in the Survey operations besides its mere upkeep, has preoccupied nearly all the nations of the world, but the question of monetary sacrifice has not prejudiced the carrying out of the undertaking.

It is true that for merely fiscal purposes in the taxation of immovable property, many Surveys have been organised, but the high standpoint of the security of the rights over property in the possession of the holder, and its unquestionable position and area, far surpasses the interests of the Public Treasury; besides, it is quite evident that a perfect Survey and legal Registration, at once the basis of the fiscal system, is better suited to assure the taxation assessment.

The effects of the Land Registration law of 1886 were so well understood in Italy that many territorial circumscriptions advanced the funds required to permit of the work being carried out without delay in those same circumscriptions.

In newly settled countries where the interests of speculation on the transfer of lands granted by the State delay as a rule the material evidence of the possession of holder of the land which would be afforded by its cultivation, the settlement of rights to property and the identification of the land, even when unoccupied, is a point of the highest importance and which can only be solved by the Geometrical Cadastre.

I have already stated that the ever-increasing difficulties which prevented the definition of the status of property in the British colonies led Sir Robert Torrens (Surveyor-General) to conceive the system known by his own name and which was first introduced in Southern Australia. It was also due to the efforts of Mr. Maxwell, director of the Property Services at Singapore, that the same system was adopted in British settlements, and in Argelia, Mr. Firmau, in order to free landed property from the great obstacles that opposed its mobilization, had a system based on the Torrens' method instituted.

Similarly in the Portuguese Colony of Mozambique, legislation relating to land previous to that of 1909 contained no provisions as to the organization of the geometrical cadastre and ignored modern tendencies as to guaranteeing the security of immovable property, this leading to ever-increasing difficulties which only began to be solved by the law of 1909.

Celerity of the Survey Works and the resultant benefits, which the Central Government is trying to pay attention to, depends, however, on the equilibrium between the revenue and the expenditure that must be distributed over other no less important services.

With its limited resources the Survey Services show their work within the general cartographic plan and in the geometrical identification and security of individual rights by a specimen of the titles which is attached to this paper.

TITLES OF PROPERTY.

Taken under their legal aspect, these comprise four parts.

A fifth part which relates to the branch of fiscal taxes on immovable proverty is still to be discussed.

The first part—the "alvará" (ordinance)—is the legal document of the property, and a guarantee for all purposes of law.

The second part contains the material identification of the property, through its boundaries and the respective plant, accompanied by a numbered diagram, interpreting the same identification and the absolute position of the plot in the cadastral maps.

The third part will explain, by means of a mere extract from the cadastral records, all legal acts affecting the property.

The fourth part is reserved for the endorsement, or, which is the same, to the easy mobilisation of the property by transfer, subject to the Governor General's authorisation.

Such rights are initially and formally guaranteed by charter, and after that, all changes of proprietorship relating to transfer, mortgages and other burdens, privileges and anything else implying alteration in the legal existence of the property, is endorsed on the title itself together with any physical alteration of the area, this regime being guaranteed by the mutual relations existing between the Deeds Office and the Cadastral Office.

Property titles in the Province of Mozambique, therefore, agree, in my opinion, with the broadest and most up-to-date conception of a modern Cadastre under the "Property Book" system.

The title of the property here is a single document of easy reading, showing in a few minutes to anyone who is interested in the property in question, all the conditions of its civil existence, its situation, area, owners, etc.

Such was the theoretical definition by Tersant, already alluded to, as expressed by him at the meeting of the Property Congress on the 10th August, 1889.

Finally, the fifth part, *still in project*, besides its particular interest to the State as regards fiscal records will also show the onus of taxation weighing on the property, its account current as to payment of liabilities, as well as the classification of lands, revenue and all that may be of interest to the essentially fiscal part in the assessment of taxes.

Let us now summarily examine, as a whole, the project of the general cadastral records of lands, which is just coming into execution.

The whole collection of the titles of property constitutes the General Registry of Property, being the immediate resultant of the geometrical records.

Following on registration at the Deeds Office of the rights of the owner and those of the State, a certified copy is extracted from the titles delivered to the respective concessionaires, and this is filed to constitute a part of the Registry of Property in the archives of the General Survey Department.

Afterwards, all endorsements made on the titles in the possession of the holders of the ground, are reported to the Record Office, when they are immediately copied into the other systematically filed titles. On the other hand, the Record Office will inform, as already explained, the Deeds Office of all alterations materially affecting the estates.

This will thus allow for the verification of the records, enabling both the Administration and all interested parties to be daily acquainted with the current state of the property.

Some hundreds of titles which have already been granted since the introduction of the geometrical cadastre into the Land Law, serve to demonstrate the merits of the system and, correspondingly, the foreseen results of the theoretical outlines under which its organisation was undertaken; but I should not be telling the truth if I attempted to persuade the readers of this paper that the system was already in force throughout the vast Province of Mozambique.

Professionals are well aware of the fact that this system essentially depends on the labours of a numerous, trained staff, which cannot be easily or rapidly recruited.

In the following simple extract, I resume the General plan of the Geometrical Work for the organisation of the Cadastral Charts.

The first class triangulation initiated by the Geometrical Mission of East Africa, led by Commander Gago Coutinho, of the Portuguese Navy, covers the district of Lourenço Marques, a part of the sea coasts of Gazaland and Inhambane, intersects a part of the territory towards the interior, and extends further in a narrow strip up to Bazaruto.

The Surveyor-General's Department obtained from that scientific mission the fundamental geographical data, the measurements of bases, the directions reduced to the centre of all sides of the triangulation observed from the geodetical station, and with these elements the *provisional values* were calculated for the geographical co-ordinates and distances to the meridian line and to the trigonometrical points, for the region covered by the triangulation.

In the general plan of the charts, these are separately organised by districts, as the absence of subsidies for the general triangulation of the country made this restriction compulsory.

Each one of these charts is theoretically divided into compartments (squares 40 kilometres wide) formed by lines parallel to the central meridian, and its perpendicular to the crossing point of that meridian with the medium parallel.

The compartments are subdivided into sheets for qualification, in the scale of 1 : 25,000, which, as a rule, is considered normal, and is sufficient to show the relative position of the plots granted and Government lands, and ultimately their division into blocks reserved for concession on quit-rental or alienation by sale, and, furthermore, through the assistance of the Agricultural Department, they will show the generic classification of the lands.

Property in towns, villages, suburbs and other settlements and all extremely subdivided property is dealt with on a larger scale in the detail charts.

The topography of each estate and all its perimetrical contour, as defined by rectangular co-ordinates referred to the origin of local triangulation, is completed on the titles by the respective plants and numerical identification as shown by its diagrams.

We employ the system of plane rectangular co-ordinates which is more adaptable to the partial work of the cadastre, within the limits of admissible error for the points most distant from the origin of the co-ordinate axes.

The projection of the charts is traced on the plane tangent to a central point being the origin of the axes to which all points of survey refer.

For the current calculation of the transfer of the geographical position, transformation of co-ordinates, etc., the dimensions of Clarke's ellipsoid were employed, these entering in the numerical data of the various tables commonly used in expedite geodesy.

The first-class geodetical triangulation, covering the District of Lourenço Marques, permitted of the plan of the district being made according to that triangulation to which is joined the subsidiary and partial work of the network formed by the secondary triangulation and traverses in part executed in a portion of the district.

In the regions of the district of Inhambane and of the old district of Gaza, likewise covered by the geodetical triangulation and which approximately coincides with the territorial zones of greater demand and movement of lands, the same judgment presided to the project of the charts and organisation of the topographical networks.

The greater part of the Province, however, is not provided with fundamental triangulation. Work of this nature involves considerable expense—the portion which has been carried out having already cost 120,000,000 réis. Field work is, unfortunately, exceedingly slow, on account of all kinds of difficulties arising from most varied circumstances; the network of calculations required to complete the work, in so far as concerns the working out of figures and final results, takes many months, and sometimes even years, to conclude; on the other hand, the administrative requirements of the services of the Property Registration Department, inconsistent with the slowness of geodetic work of first class, which is really the fundamental one, remits the technical problem to the field of expedite geodesy and numerical cadastral topography.

From this point of view, one of the solutions would be the carrying out of small independent triangulations to be connected at any time with the geodetical triangulation; and, according to our plan of partial charts, triangulations are separated from the district compartments of the previously-mentioned records which require to be made before any other work is undertaken, in order to guarantee the precision of the geometrical plan. In fact, the identification of property is not merely guaranteed by the peripherical beacons of its perimetral contour. It is necessary to preserve the geometrical Survey of the country done at the State's expense, and which is shown by material indications erected on the vertices of its triangulations, because from the knowledge by calculation of the position of its vertices, depends the reconstitution at any time of the property beacons obliterated through any cause, and the identification of which is ensured by the diagram accompanying the titles.

The system of independent triangulation is the same which I found in the Transvaal, where the first class triangulation does not cover all the country, the geometrical plan of the cadastral records there being very similar to our technical system, and having as a final result *the title of property*.

Although the staff, etc., in our neighbouring colony, is numerically and incomparably superior to ours, the analogy is still to be found in the categories of the permanent staff and private geometricians, and it will not be difficult in future to arrive at a complete parallel with those important services, by improving our permanent staff, wherever necessary, and by the creation of a school for the theoretical instruction of private surveyors. This school, judging by the dealings which are taking place in landed property, will guarantee sufficient remuneration to those obtaining the respective diplomas for geometrical survey work.

With the above, I have concluded all that is possible to condense in a *paper* concerning the cadastre of immovable property in Mozambique, the interest of which, as mere "news value," consists in the fact that a system which deals with property on the basis of legal and geometrical survey and registration and the fiscal part of which will in the future find in the same records the required data, is exclusive to this Portuguese Oversea Province.

The Constitution of Nebulae.—At a recent meeting of the Royal Astronomical Society, Prof. J. W. Nicholson, M.A., D.Sc., said that it is probable that the main constituent of the planetary nebulæ, and of others, such as the great nebula in Orion, is an element, to which the name Nebulium is assigned, with a precisely indicated atomic structure. It may not be strictly an element of the type found in the Periodic Table, but must be regarded as an origin from which other elements may spring. From his investigations Dr. Nicholson infers that nebulæ consist of (1) simple-ring systems, with simple nuclei; (2) the first products of an evolution of some form from these systems; and (3) hydrogen and helium, the simplest terrestrial elements. The chemical substance of the nebulæ, therefore, consists of the very beginnings of matter, and spectrum of a nebula may be described as the spectrum of chaos. Whatever may occur with terrestrial atoms, the electrons in a nebula are not held very firmly in the atoms, and a continued interchange of electrons must be taking place, with a necessary bombardment of atoms by free electrons, to which the luminosity is probably due. The physical state of a nebula must be analogous to that of a very exhausted vacuum tube of enormous extent. Two days prior to Dr. Nicholson's communication to the Royal Astronomical Society MM. Bourget, Fabry, and Buisson published in *Comptes Rendus* some results of their investigations into the subject of the atomic weight of nebulium and the temperature of the Orion nebula. Referring to the spectrum of the nebula, they say that the very marked double line 3726—3729 in the ultra-violet part of the spectrum is not attributable to any known gas. From a calculation of the limiting order of interference—a function of the atomic weight and the absolute temperature—it is found that the atomic weight of the unknown gas—nebulium—is about 3. The maximum temperature of the luminous gas is about 15,000°. A strong green ray, also due to an unknown gas, is emitted by a gas of atomic weight greater than that of hydrogen, but less than that of the gas emitting the ultra-violet ray. This is of interest in view of the fact that, in Rydberg's recent classification of the elements, there are two unknown elements between hydrogen and helium whose atomic weights are respectively 2 and 3.

NOTES ON THE APPLICATION OF THE RADIO-TELEGRAPHIC SERVICE TO EXPEDITIOUS METHODS OF GEODETIC SURVEY.

By Pedro Luis de Bellegarde da Silva.

(ABSTRACT.)

The author suggests that, as the introduction of wireless stations over the Province of Mozambique is likely to take place in the near future, such stations will be of great use in enabling the longitudes of secondary survey points to be determined rapidly and with great accuracy.

At the present time, owing to the practical difficulties introduced by the rough nature and heavy afforestation of portions of the territory, the existing methods of surveying cannot keep pace with the demands for land measurements. However, the erection of a distributing wireless station *e.g.* in the vicinity of the Observatory at Lourenco Marques together with the possession of a portable disributing and receiving wireless outfit, or even of a small portable receiving outfit only, would enable the Survey Department to determine the longitudes of many points throughout the Province. The determination of the precise longitude of any point requires two things, (i) a knowledge of the local time, and (ii) a knowledge of the corresponding simultaneous local time at a point whose longitude is already known. The first requirement is obtained by observations of stars with a transit theodolite and presents no special difficulties anywhere. The second part has hitherto presented many difficulties, frequently involving the transport of many delicate chronometers. The introduction of wireless telegraphy will simplify this and lead to much greater accuracy as all that is necessary is that the surveyors at the outstations should receive, through their wireless apparatus, signals from the clock at the Lourenco Marques Observatory and so obtain at once with an accuracy approaching 1/100th of a second the difference between the simultaneous local times at the two places. The method has already been frequently utilized in Europe, thus the difference of longitude between Paris and Bizerta has been determined with an accuracy of between 1/100th and 1/200th of a second. The author of the paper hopes that in the near future these methods may be actually employed in the Survey of the Province of Mozambique.

THE MEASURING OF AIR WITH SPECIAL REFERENCE TO COMPRESSORS.

By Carl Janssen.

The measuring of large quantities of air, although of great importance to mining and industrial firms using compressed air for various purposes, has not been brought to a satisfactory state of accuracy until lately. The reasons for this are twofold: firstly the great difficulties met with as soon as comparatively larger quantities of air had to be measured, and secondly, the feature that the reciprocating compressor could work as a displacement air meter of, at first sight, considerable accuracy, so that the necessity for creating new methods of measuring air was not felt to such an extent as to induce improvement.

With reciprocating compressors it seemed sufficient to count the revolutions during a certain time and to find the volumetric efficiency in order to determine the amount of air drawn into the machine—the volumetric efficiency being defined as the ratio of the length of suction line as shown by the indicator diagram and the total length of diagram.

This method however does not give the actual weight of air which is in the low pressure cylinder at the beginning of the compression stroke. With high power reciprocating compressors the jacket cooling has very little influence on the air drawn into the machine. Its main purpose is to prevent the oil on the cylinder liner from carbonizing. The temperature of the cylinder walls during the suction stroke is higher than the temperature of the entering air, so that the air will be heated during the suction stroke and the temperature of the air inside the cylinder at the beginning of the compression stroke will, therefore, be considerably different from the temperature measured during the suction stroke at the compressor inlet flange or in the suction chamber. The density of the air inside the cylinder being, on account of its higher temperature, lower than the density of the air outside the compressor, the weight of air calculated from the temperature in the suction chamber, is therefore, too high, *i.e.*, the weight of air discharged by the compressor must be smaller than the weight found from the inlet temperature and the volumes determined from indicator cards.

Assuming an atmospheric pressure of 12 lb. and an increase of temperature from 75° F. to 85° F., when the air is flowing through the suction chamber and the port to the cylinder, we find the weight of 1 cu. ft. of air to decrease from 0.0606 lb. to 0.0595 lb. and the error resulting from this to be equal to 1.8%. The weight of air actually drawn in will be further reduced on its way through the compressor through leakages, condensation of vapour, etc., so that the weight discharged by the compressor differs still more from the weight calculated from the temperature of the suction chamber. The consumer of compressed air is only interested in the weight of air discharged by his compressor. Although the indicator diagram shows the volume of air discharged by the machine, it does not give any means of determining the actual weight discharged, for the same reason as above, *i.e.* that it is impossible to determine the temperature during the discharge stroke. This temperature is highest when the discharge valves open and will decrease towards the end of the discharge stroke.

The difficulties of measuring air were increased as soon as the rotary or turbo compressor appeared as a competitor of the reciprocating compressor. The turbo compressor draws in and discharges the air in one continuous flow and the only means of measuring the output of a turbo-compressor were the methods known as nozzle or orifice measurements. These methods have improved considerably since the turbo-compressor has come forward and ways have been found to adapt these methods also to reciprocating compressors.

The measuring of air through nozzles or orifices depends on the exact measurement of the pressure, velocity, and temperature of air, when flowing through the nozzle or orifice. Of these measurements the measuring of pressure and velocity, although simple at first sight, however, require great care, if reliable results are to be obtained at all. The difficulty of observing and understanding hydro-dynamic phenomena, the inaccuracy of the co-efficients of friction and of contraction resulting therefrom, have led to most varying justifications of methods for measuring velocity and pressure. Furthermore, there exists a certain discrepancy regarding the definition of pressure inside a flowing liquid, which accentuates the above mentioned difficulties.

In physics we decide since Daniel Bernouilli regarding the pressure inside a liquid between, firstly, the hydrostatic pressure, which is defined as the pressure existing between two particles of the liquid when it is not moving, secondly, the hydro-dynamic pressure, which is defined as the pressure between two particles of the liquid during motion.

Bernouilli's equation for motion of liquids is:—

$$dh + \frac{c.dc}{g} + \frac{dp}{\gamma} = 0$$

—assuming absence of friction and whirls—, where

h = height above datum level
c = velocity
p = pressure
γ = density

with horizontal flow and incompressible liquids where h and γ are constant, we obtain after integrating

$$\frac{c^2}{2g} + \frac{p}{\gamma} = \text{constant}.$$

For compressible liquids where $\gamma = f(p)$ we find

$$\frac{c^2}{2g} + \int \frac{dp}{\gamma} = \text{constant}$$

where the term $\int \frac{dp}{\gamma}$ has to be integrated for the existing relation between p and γ.

In these equations p is the hydrodynamic pressure, according to Bernouilli's definitions, and changes into the hydrostatic pressure when the motion of the liquid ceases, in which case $c = 0$.

It may be mentioned that the error resulting from the assumption of γ = constant for compressible liquids is very small under the conditions prevailing when air of a pressure such as is used for running purposes is measured. Assuming for example, 100 lb. absolute pressure and 650° F. absolute temperature (190.6° F.) for the air main and a drop of pressure across the orifice of 1 lb. or 27.75 inch water column, which is ample for exact readings, the density will decrease from 0.4155 lbs. to 0.4125 lbs. per cub. ft. with adiabatic expansion. If γ be taken to be constant the error is, therefore, 0.72%.

Contrary to Bernouilli's definitions three different pressures of a liquid in motion are usually defined in technics, *i.e.* the static, the dynamic and the total pressure. The total pressure is the pressure shown by a Pitot tube, bent parallel to and towards the stream. The kinetic energy of the liquid $\frac{c^2}{2g}$, is defined as dynamic pressure and by subtracting the dynamic pressure from the total pressure, the static pressure is obtained, which therefore is the same as the above defined hydrodynamic pressure. Hence we have the equation

$$p_t = p_{st} + p_d$$

$$\text{or } p_t = p_{st} + \gamma \cdot \frac{c^2}{2g}$$

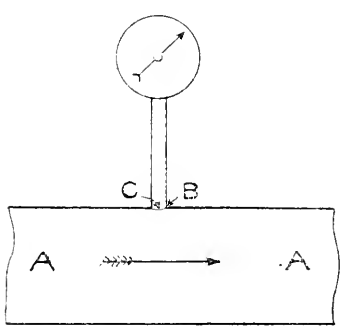
With the exception of the static pressure p_{st} (or hydrodynamic pressure when using the first definitions given above) this equation does not contain any pressures at all. The term $\gamma \cdot \frac{c^2}{2g}$ represents the kinetic energy of the unity of volume *i.e.* the capacity to perform work resulting from the velocity of the liquid. By inserting, for instance, a pitot tube into a stream of water, where $p_{st} = 0$, a certain amount of the liquid is separated from the stream and forced to produce work by keeping the water level inside the pitot tube at a certain height above level of stream. The pressure p_{st} represents potential energy and p_t therefore equals the sum of the potential and kinetic energy of the unit of volume *i.e.* the total energy of the liquid.

It will further be noticed that the dynamic pressure as defined technically does not change into static pressure, when the motion ceases, as should be logically expected.

The definitions given as used technically are, therefore, misleading and when using them, care should be taken always to remember their actual meaning.

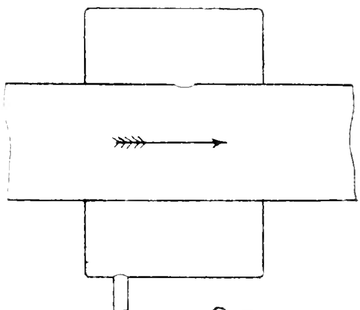
If the pressure of a liquid, flowing through a pipe, has to be observed for the purpose of measuring, it is first of all necessary to define exactly the point where the pressure has to be measured and further, it has to be assumed for the purposes of a test that the flow is stationary, *i.e.* is not a function of the time. According to the first definitions given above, the pressure so determined can be only the hydrodynamic pressure, *i.e.* the pressure which a gauge flowing with the liquid would show when passing the abovementioned point. As all problems of measuring large quantities of air in technics only have to deal with air in motion, the static pressure as defined above according to Bernouilli does not come into question at all, as this definition refers only to the pressure of liquids when motionless.

When measuring the pressure, special attention must be given to the manner in which the pressure is transferred from the stream of gas to the instrument recording the pressure.



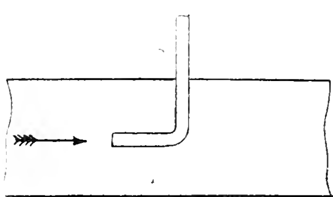
—FIG. 1.—

It is generally accepted that a connection as shown in Fig. 1 gives the exact hydrodynamic pressure of the gas flowing through pipe A A as long as no disturbances of the stream lines occur. The down stream side B of the opening C, however, is bound to disturb the stream lines to a certain extent, which can be expressed in percentage of the kinetic energy $V.\frac{c^2}{2g}$. If the piping connecting C with the instrument has the same diameter as C the error resulting from the disturbances will be transferred to the instrument. Under the conditions under which compressed air for mining purposes is generally transmitted, the term $V.\frac{c^2}{2g}$ is very small in comparison with the hydrodynamic pressure. If, for example, 20lbs. per second of air of 100lbs. absolute pressure, 650° F., absolute temperature and a density



—FIG. 2.

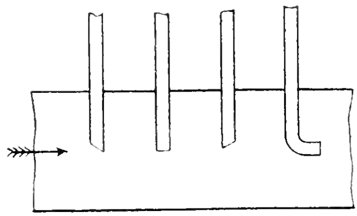
of 0.4155 lb per cubic ft. are flowing through a 12 inch pipe line, we find the velocity to be 61.3 ft. per second and the kinetic energy 24.35 lbs. per sq. ft. respectively, or 0.169 lbs. per sq. in. The kinetic energy is therefore 0.168 % of the hydrodynamic pressure and as the error can be only a small percentage of the kinetic energy, it is negligible. Furthermore it can be altogether done away with by providing as shown in Fig. 2 round the pipe a circular space of such size that the shocks due to the air striking the down stream edge of the opening are completely annihilated through eddies.



— FIG. 3. —

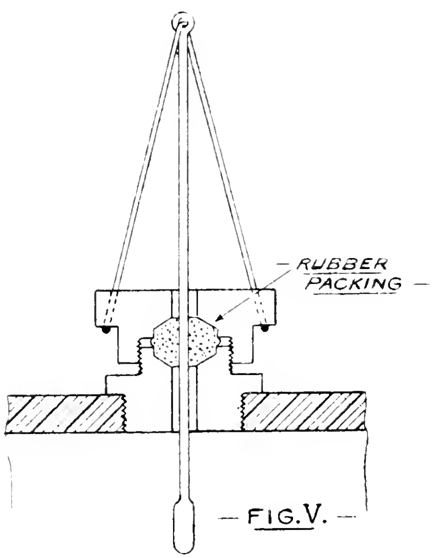
With the exception of the pitot tube as shown in Fig. 3, which gives the hydrodynamic pressure plus kinetic energy, all connections, projecting into the stream lines for instance, such as shown in Fig. 4.—give readings which are more or less different from the actual pressure on account of disturbances of the flow and should not be used.

The measuring of velocity depends on the measuring of two different pressures on either side of an orifice or on the up-stream side and in the throat of a venturi tube. From the difference of these two pressures, the drop across the instrument—the velocity can be calculated and therefrom the weight or volume of air passing.



—FIG. 4.—

Regarding the calibrating of orifices or nozzles, special reference has to be made to the calibration plant of the Central Mining and Investment Corporation, erected at the Ferreira Mines, a short description of which appeared in the *Journal of the South African Institution of Engineers* (1911) 10.



—FIG. V.—

All temperatures should be measured by inserting the mercury bulb direct into the stream. Thermometer pockets should be avoided whenever possible. An arrangement as shown in Fig. 5 has proved satisfactory for use with highly compressed air

The theory generally given for measuring air through an orfice is to equate the change in kinetic energy through the orifice to the work done by the expansion of the gas from the pressure p_1 existing on the upstream side of the orifice to the pressure p_2 on the downstream side. If c is the coefficient of contraction of the stream, this leads to the equation known as the formula of Saint Venant

$$W = c.a.p_2 \sqrt{\frac{2g}{R.T} \cdot \frac{\kappa}{\kappa-1} \cdot \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} \left\{\left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} - 1\right\}}$$

where W is the weight delivered per second.

a is the area of the orifice.

p_1, p_2 are the up and downstream pressures.

g is the acceleration of gravity.

RT is the equivalent of pv in the gas equation and

κ is the ratio of the specific heats.

The above equation is only correct, if the velocity of approach of the gas to the orifice is zero or can be assumed to be approximately zero. As the velocity in the discharge pipe of a compressor cannot be neglected, the correct equation has to be deducted as follows :—

The equation of continuity is: (Weight per second) × specific volume) = (area of channel) × (velocity).

If u *indicates velocity*
W *weight per second*
a *area of channel and orifice*
v *volume*
p *pressure*
κ *ratio of specific heats*

and 1 and 2 are suffixes indicating respectively the upstream and downstream side of the orifice, then the change in kinetic energy is $\frac{1}{2}\frac{W}{g}\left(u_2^2 - u_1^2\right)$ and the work of expansion is $\int_{p_2}^{p_1} v \,.\, dp$.

In order to integrate this expression we assume an adiabatic expansion with the relation between p and v of

$$p \,.\, v^{\kappa} \quad \text{constant.}$$

Hence

$$\frac{W}{2g}\left(u_2^2 - u_1^2\right) = p_1^{\frac{1}{\kappa}} v_1 \int_{p_2}^{p_1} p^{\kappa}\, dp$$

or with W = 1

$$\frac{1}{2g}\left(u_2^2 - u_1^2\right) = p_1^{\frac{1}{\kappa}} v_1 \,.\, \frac{\kappa}{\kappa-1} \left\{ p_1^{\frac{\kappa-1}{\kappa-1}} - p_2^{\frac{\kappa-1}{\kappa}} \right\}$$

Since the equation of continuity is now:

$$u_2 = \frac{W.v_2}{a_2} \qquad\qquad u_1 = \frac{W.v_1}{a_1}$$

$$u_2^2 - u_1^2 = W^2 \left\{ \frac{v_2^2}{a_2^2} - \frac{v_1^2}{a_1^2} \right\}$$

$$u_2^2 - u_1^2 = W^2 \left(\frac{v_2}{a_2}\right)^2 \left\{ 1 - \left(\frac{a_2}{a_1}\right)^2 \left(\frac{v_1}{v_2}\right)^2 \right\}$$

$$\text{and} \quad \left(\frac{v_1}{v_2}\right)^2 \quad \left(\frac{p_2}{p_1}\right)^{\frac{1}{\kappa}}$$

Hence

$$W^2 = \frac{a_2^2}{\left\{ 1 - \left(\frac{a_2}{a_1}\right)^2 \left(\frac{p_2}{p_1}\right)^{\frac{2}{\kappa}} \right\}} \cdot \frac{v_1}{v_2^2} \cdot 2g \cdot \frac{\kappa}{\kappa - 1} \cdot p_1^{\frac{1}{\kappa}} \cdot p_2^{\frac{\kappa-1}{\kappa}} \left\{ \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} - 1 \right\}$$

$$\text{But} \quad \frac{v_1}{v_2^2} \cdot p_1^{\frac{1}{\kappa}} \cdot p_2^{\frac{\kappa-1}{\kappa}} = \frac{p_2^2}{p_1 \cdot v_1} \cdot \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}}$$

Hence

$$W^2 = \frac{a_2^2}{\left\{ 1 - \left(\frac{a_2}{a_1}\right)^2 \left(\frac{p_2}{p_1}\right)^{\frac{2}{\kappa}} \right\}} \cdot 2g \cdot \frac{\kappa}{\kappa - 1} \cdot \frac{p_2^2}{R.T_1} \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} \left\{ \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} - 1 \right\}$$

In this equation a_1 is the measured area of the stream approaching the orifice and a_2 is the contracted area of the stream leaving the orifice.

If A is put for the upstream area of the pipe instead of a_2 and a for the measured area of the orifice and C the coefficient of contraction, then $a_2 = ca$. and we obtain in taking the square roots of both sides:

$$W = \frac{ca}{\sqrt{1 - \left(\frac{ca}{A}\right)^2 \left(\frac{p_2}{p_1}\right)^{\frac{2}{\kappa}}}} \cdot p_2 \sqrt{\frac{2g}{RT_1} \cdot \frac{\kappa}{\kappa - 1}} \left[\left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} \left\{ \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} - 1 \right\} \right]^{\frac{1}{2}}$$

This form of the equation introduces the correction term for the velocity of approach and it is necessary to examine any particular case to see whether the correction term is important or not.

In order to reduce this equation to a form adapted to numerical calculation we have $p_1 = p_2 + h$ where h is the pressure drop across the orifice and

$$\frac{p_1}{p_2} = 1 + \frac{h}{p_2}$$

Hence expanding $(1 + x)^n$ where

$$x = \frac{h}{p_2} < 1 \qquad \text{and} \qquad n = \frac{\kappa - 1}{\kappa}$$

we have

$$\left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} = 1 + \frac{n.h}{p_2} + \frac{n(n-1)}{1.2}\left(\frac{h}{p_2}\right)^2 + \cdots$$

and

$$\left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} - 1 = \frac{n.h}{p_2}\left\{1 + \frac{n-1}{1.2}\,\frac{h}{p_2} + \cdots\right\}$$

The square root of the product of these terms is

$$\sqrt{\frac{nh}{p_2}}\left(1 + \frac{3n-1}{4}\,\frac{h}{p_2} + \text{smaller terms.}\right.$$

$$\text{Multiplying by } p_2\sqrt{\frac{2g}{RT_1}\cdot\frac{\kappa}{\kappa-1}}$$

$$\text{we get } \sqrt{\frac{2g}{R}}\left(\frac{p_2.h}{T_1}\right)^{\frac{1}{2}}\left\{1 + \frac{h}{\frac{4}{3n-1}\,p_2}\right\}$$

and find the formula for calculating the weight of air passing through the orifice to be:

$$W = \frac{ca}{\sqrt{1 - \left(\frac{ca}{A}\right)^2\left(\frac{p_2}{p_1}\right)^{\frac{2}{\kappa}}}}\cdot\sqrt{\frac{2g}{R}}\left(\frac{p_2 h}{T_1}\right)^{\frac{1}{2}}\left\{1 + \frac{h}{\frac{4}{3n-1}\,p_2}\right\}$$

This formula has been derived by Mr. G. M. Clark of the Victoria Falls and Transvaal Power Coy. and the author for the purposes of the test at the 215 Drill Turbo-Compressor, referred to later on. This test has also been made jointly by Mr. G. M. Clark and the author, whilst the test of the 75 Drill reciprocating compressor, also rèferred to later, has been made jointly by Mr. H. Collens of the Victoria Falls and Transvaal Power Coy., and the author.

By the use of this formula in the last form the numerical calculations become quite simple. The final term $\left\{1 + \frac{h}{\frac{4}{3n-1}\cdot p_2}\right\}$ as well as the correction term for adiabatic expansion $\left(\frac{p_2}{p}\right)^{\frac{2}{\kappa}}$ in the term introducing the velocity of approach may be frequently neglected. When using this simplified formula, it should be always remembered that it can only give correct results as long as $\left(\frac{h}{p_2}\right)$ is sufficiently small to allow the third and following terms of the series used in deriving the formula to be neglected.

In the following the theoretical statements given before will be applied to two Tests made on high power air compressors, the one being an electrically driven turbo-compressor the other one a steam driven reciprocating compressor.

(I.) TURBO COMPRESSOR TEST.

This test was made on June 9th, 1912, on the Pakorny and Wittekind compressor at the Robinson Compressor Station of the Victoria Falls and Transvaal Power Co. Ltd. The compressor delivers approximately 20 lbs. of air per second or 21,500 cu. ft. of free air per minute at a pressure of 9 atmospheres absolute (128 lbs. abs.) and requires 3,000 K.W. electric input to the motors.

In order to secure that the Compressor was run at steady loads during each test and to enable these loads to be varied voluntarily, the section of the pipe line from Robinson Compressor Station westwards to the first valve pit at "X" (about 1,000 yards) was isolated and a cover removed from the water collector about 300 yards from the Station. The discharge from the Compressor was throttled at the valves near the Station to secure the desired pressure on the machine and the whole discharge took place noiselessly through the water collector.

The compressor was tested under ordinary working conditions and was not cleaned or specially prepared in any way for the test. It had been cleaned so far as the intercooler and jackets were concerned on December 11th, 1911. Since that date it had run on load for 2,600 hours and had been standing for 2,100 hours. It had been previously in use after erection for 1,100 hours out of 2,600 hours.

The compressor was started up about 7. a.m. running lightly loaded for an hour, after which normal load was put on. The first set of measurements commenced at 10.05 a.m. The first test was run for an hour, the second, third and fourth for 40 minutes each and the fifth and last test for 30 minutes. Between the second and third tests there was an interval of one hour and a half during which time the machine was kept running at full load. The readings taken on each test show the extent to which the conditions were steady.

All instruments were specially calibrated before the test. Measurements of air pressure were made whenever possible by means of water or mercury manometers, but in the cases of the highest pressures, where spring controlled gauges had to be used, these were carefully compared with a standard gauge that had itself been calibrated with a dead-weight tester.

Measurements of temperature were in all cases made with ordinary mercury in glass thermometers and these have not been standardised—no exceptionally high temperatures occur in this work—but there can be no gross errors as most temperatures were taken in duplicate.

The amount of air passing through the compressor was measured on the intake as well as on the discharge side. As the compressor has two low pressure cylinders, working in parallel, two orifices of the same design had to be used for the intake side. These orifices are very similar to the upstream portion of a Venturi tube. By comparison with the standard capacity meter at Ferreira Mines the coefficient of contraction for Venturi tubes was found to be 0.985 and, therefore, this coefficient has been taken as the most probable value for this type of orifices.

The value of A for the intake orifices has been taken as infinity though the floor level was only about 2′ 6″ below the mouth of the orifice and there was a wall about 15″ from the line joining the centres of the two orifices.

It may be considered correct to treat the orifices as though they were situated in free space.

Besides having a proper approach for the air to these orifices, it is also necessary to have an uninterrupted discharge on the downstream side of the orifice.

The arrangement of the butterfly valve in the downstream side of these orifices is not ideal, and involves a certain interference in the stream lines which showed in the readings of the water columns which were used for measuring the drop of pressure across the intake orifices.

On account of the comparatively large area of the intake pipes, four water manometers were used for each orifice.

Although these four manometers were arranged symmetrically with regard to the orifice they could not be symmetrical with regard to the butterfly valve and this want of symmetry was reflected in the readings of the water columns.

The four water columns at each orifice were of slightly different height, so that it would have been necessary to use four observers per orifice in order to obtain a correct observation. It was, however, not feasible to put four observers to each orifice and the difficulty was overcome in the following way.

The four pipes were fixed on a board close together and the observer found the average height of the four water columns by means of a glass plate on which a dark line was cut, by following closely the movement of the water columns.

Some control observations made occasionally by measuring the height of the four water columns separately, proved this method to give correct results.

The diameters of these orifices were measured with micrometer gauges on four diameters by two observers and the means were taken.

On H.P. side 10.635 inches: Area 88.831 sq. inches
On M.P. side 10.642 inches: Area 88.948 sq. inches.
Hence with the value of c. = 0.985 A = infinity.
Equivalent area H.P. side = 87.50 sq. inches.
M.P. side = 87.61 sq. inches.

As the orifices were used under conditions of atmospheric temperature and calibrated under similar conditions, there are no temperature corrections to be applied to the areas.

The orifice used on the discharge side of the Compressor was a plate orifice. It is a most important detail that the pressure connections should be in the dead spaces, as should the pressure pipes be in the stream lines, entirely erroneous readings must result. This orifice was situated in a pipe 12⅛ inches diameter and had an uninterrupted approach of more than 12 feet or 16 orifice diameters. On the downstream side there was a straight run of 5 orifice diameters before reaching a right angle bend in the pipe line and the conditions of use of this orifice are therefore correct. As this orifice is used at a temperature of 80 C to 90 C, it was calibrated with micrometer gauges both at atmospheric temperature and also 85°C. The two sets of observations agreed when reduced to the same temperature using the usual coefficient of expansion of brass the metal of which the orifice was constructed. For this orifice we have at 85°C.

D = 12.125 inches: A = 115.4 sq. inches
d = 9005 (at 85°C): a = 63.69 sq. inches

For the coefficient of contraction of this orifice a comparison has been made of the orifice against the standard displacement meter belonging to the Central Mining and Investment Corporation which gave the value as 0.675.

Hence for the equivalent area of this orifice we have

$a = 63.69$ $\qquad c = 0.675$ $\qquad ca = 42.99$
$A = 115.4$ $\qquad ca/A = 0.3726$ $\qquad (ca/A)^2 = 0.1388$

$$\sqrt{1-(ca/A)^2} = \sqrt{0.8612} = 0.9280$$

$$\text{and } ca\,\sqrt{1-(ca/A)^2} = 46.33 \text{ sq. inches.}$$

This calculation of the equivalent area assumes the term $(p_2/p_1)^{\frac{2}{\kappa}}$ to be unity. It will be shown later in the Report that the effect of the difference from unity is nearly negligible.

A matter of considerable importance in all compressor tests is the humidity of the atmosphere, for the thermal transferences at the different stages are dependent upon it.

The following Tables I (a) to I (e) give the details of the observations and reduction of the Hygrometer readings. These reductions have been made by aid of the tables published by the Smithsonian Institution. An Assman Hygrometer was used, which draws a current of air over the wet and dry bulbs at a uniform velocity. The upper portion of the tables gives the observations and the lower portion the reduction. Table I (f) gives the Summary.

For the purpose of determining the mean temperature of the intake air, the readings of the dry bulb of the Assman Hygrometer have been taken in preference to those of the Thermometer attached to the Barometer. These latter readings would be too high on account of the proximity of the instrument to the observers and to the electric lights used for reading the instruments.

REDUCTION OF HYGROMETER READINGS.

TABLE I (a).

Test No.	Time a.m.	Barom. Inches.	t° of Bar. F.	Dry Bulb °C.	Wet Bulb °C.
1	10.05	—	—	15.4	8.9
	.10	24.890	—	14.8	5.8
	.15	.890	—	16.1	5.2
	.20	.890	—	14.8	5.0
	.25	.890	62.0	16.0	—
	.30	.890	.2	16.1	5.4
	.35	.890	.6	16.0	5.3
	.40	.890	.8	16.2	5.3
	.45	.892	.8	16.1	5.4
	.50	.894	63.0	17.0	5.8
	.55	.894	.1	16.5	5.5
	11.00	.894	.4	16.9	6.2
	.05	.894	.8	17.5	5.8
Averages over test		24.892	62.6	16.1	5.8
Temp. correction		0.076			
Corrected Barometer.		24.816			

Dry Bulb °F. $= 61.0 = t$
Wet Bulb °F. $= 42.4 = t_1$
$t - t_1$ °F. $= 18.6$

Pressure of saturated aqueous vapour (t_1) $= 0.270 = f_1$
$0.000367\ B\ (t - t_1)\ (1 + (t - t_1) / 1571) = 0.172 = f_2$
Vapour pressure $(f_1 - f_2)$ $= 0.098 = f$
Pressure of saturated vapour (t) $= 0.536 = F$
Relative Humidity. $= 18.3 = f/F$

TABLE I (b)

Test No.	Time a.m.	Barom. Inches.	t° of Bar. F.	Dry Bulb °C.	Wet Bulb °C.
II	11.20	24.894	63.4	17.8	6.5
	.25	.894	54.0	18.0	6.2
	.30	.892	65.0	18.2	6.2
	.35	.892	.2	17.8	6.0
	.40	.890	.6	17.8	6.0
	.45	.890	.8	18.2	6.2
	.50	.892	66.0	18.2	6.0
	.55	.892	.3	18.2	6.0
	12.00	.892	.3	18.2	6.1
Averages over test		24.892	65.3	18.0	6.1
Temp. correction		− 0.083			
Corrected Barometer		24.809			

Dry Bulb °F. = 64.4 = t
Wet Bulb °F. = 43.0 = t_1
$t - t_1$ = 21.4

Pressure of saturated aqueous vapour (t_1) = 0.277 = f
0.000367 B $(t - t_1)$ $(1 + (t - t_1) / 1571)$ = 0.199 = f_2
Vapour pressure $(f_1 - f_2)$ = 0.078 = f
Pressure of saturated vapour (t) = 0.604 = F
Relative Humidity. = 12.9% = f/F

TABLE I (c)

Test No.	Time p.m.	Barom. Inches.	t° of Bar.	Dry Bulb °C.	Wet Bulb °C.
III	1.35	24.884	68.3	20.2	—
	.40	.884	68.8	20.4	6.6
	.45	.884	69.4	20.2	6.6
	.50	.884	69.8	20.2	6.6
	.55	.884	69.9	20.6	6.8
	2.00	.884	70.0	20.8	7.0
	.05	.884	.0	20.8	7.0
	.10	.884	.4	20.8	7.0
	.15	.884	.4	20.6	6.8
Averages over test		24.884	69.7	20.5	6.8
Temp. correction		− 0.092			
Corrected Barometer.		24.792			

Dry Bulb F. = 68.9 = t
Wet Bulb °F. = 44.2 = t_1
$t - t_1$ = 24.7
Pressure of saturated aqueous vapour (t_1) = 0.289 = f_1
0.000367 B $(t - t_1)$ $(1 + (t - t_1) / 1571)$ = 0.230 = f_2
Vapour pressure $(f_1 - f_2)$ = 0.059 = f
Pressure of saturated vapour (t) = 0.705 = F
Relative Humidity. = 8.4% = f/F

TABLE I (d)

Test No.	Time p.m.	Barom. Inches.	t° of Bar. F.	Dry Bulb °C.	Wet Bulb °C.
IV	2.25	24.884	70.2	21.0	7.2
	.30	.884	70.2	20.8	6.8
	.35	.884	70.2	20.8	6.8
	.40	.884	70.2	21.0	7.0
	.45	.884	70.4	20.8	6.8
	.50	.885	70.4	20.6	6.8
	.55	.885	70.3	20.8	6.8
	3.00	.855	70.3	20.8	7.0
	.05	.885	70.3	20.6	6.8
Averages over test		24.884	70.3	20.8	6.9
Temp. correction		–0.094			
Corrected Barometer		24.790			

Dry Bulb °F. = 69.4 = t
Wet Bulb °F. = 44.4 = t_1
$t - t_1$ = 25.0
Pressure of saturated aqueous vapour (t_1) = 0.292 = f_1
0.000367 B $(t - t_1)$ $(1 + (t - t_1) / 1571)$ = 0.233 = f_2
Vapour pressure $(f_1 - f_2)$ = 0.059 = f
Pressure of saturated vapour (t) = 0.717 = F
Relative Humidity. = 8.2% = f/F

TABLE I (e)

Test No.	Time p.m.	Barom. Inches.	t° of Bar. F.	Dry Bulb °C.	Wet Buld °C.
V	3.15	24.885	70.0	20.8	6.8
	.20	.886	70.0	20.6	6.6
	.25	.886	70.0	20.8	6.6
	.30	.888	70.0	20.8	6.8
	.35	.888	69.8	20.6	7.0
	.40	.890	69.8	20.6	6.8
	.45	.890	70.0	20.4	6.8

Averages over test	24.888	70.0	20.7	6.8
Temp. correction	− 0.093			
Corrected Barometer	24.795			

Dry Bulb °F. $= 69.3 = t$
Wet Bulb °F. $= 44.2 = t_1$
$t - t_1 = 25.1$

Pressure of saturated aqueous vapour $(t_1) = 0.289 = f_1$
$0.000367\ B\ (t - t_1)\ (1 + (t - t_1)\ /\ 1571) = 0.233 = f_2$
Vapour pressure $(f_1 - f_2) = 0.057 = f$
Pressure of saturated vapour $(t) = 0.715 = F$
Relative Humidity. $= 8.0\% = f/F$

Note: In tables I (a) to I (e) all pressures are in inches of mercury under standard value of gravity.

TABLE I (f)

Test No.	Table.	Bar.	Dry Bulb t °C.	Humidity.	f inches.
I	I (a)	24.816	16.1	18.3%	0.098
II	I (b)	24.800	18.0	12.9%	0.078
III	I (c)	24.792	20.5	8.4%	0.059
IV	I (d)	24.790	20.8	8.2%	0.059
V	I (e)	24.795	20.7	8.0%	0.057

In order to reduce pressures to standard value of gravity the following standard constants have been accepted.

1 inch Hg. column at 32° F. = 0.491 lbs. sq. in. under standard value of gravity g = 32.17 ft./sec.^{2}

The local value of g = 32.11 ft./sec.^{2}

Hence 1 inch Hg. column = $0.491 \times 32.11/32.17$
= 0.490 lbs/sq.in. at 32° F.

Absolute temperature = $459.4 + t$° F.

The above Table I (f) reduces to

TABLE II.

Test No.	Barometer lbs/sq.in.	Air °F.	Temperature °F.(abs)	f Lbs/sq.in.
I	12.160	61.0	520.4	0.048
II	12.156	64.4	523.8	0.038
III	12.148	68.9	528.3	0.029
IV	12.147	69.4	528.8	0.029
V	12.150	69.3	528.7	0.028

From the foregoing data and from No. 28 of Smithsonian Tables the weight of moisture present in the air taken in by the Compressor has been calculated and the results are stated in Table III.

TABLE III.

Weight of moisture present.

Test	Humidity	Grs/cu.ft.	Lbs/cu.ft.
I	18.3	1.093	0.000156
II	12.9	0.858	0.000126
III	8.4	0.647	0.000092
IV	8.2	0.642	0.000092
V	8.0	0.624	0.000089

In order to calculate the weight of dry air per cubic foot, it must be remembered that the atmospheric pressure is made up of the pressure due to the dry air *plus* that of the water vapour present and that it is only the former that can be applied to the state equation of dry air. For this calculation the following physical constants have been taken:

Weight of 1 cubic foot of dry air at 32° F. is 0.08073 lbs. under a pressure of 14.696 pounds per square inch and the standard value of gravity.

Hence the weight of 1 cub. ft. $= 2.699\, p/T$.
where p is the pressure of the dry air in lbs/sq inch.
and T the absolute temperature in degrees Fahrenheit.

TABLE IV.

Weight of working air.

Test No.	$p = pa - f$	Ta	Weight of dry air $2.699\, p/T$.	Weight of moisture.	Total weight of working air.
I	12.102	520.4	0.06276	0.00016	0.06292
II	12.118	523.8	0.06244	0.00013	0.06257
III	12.119	528.3	0.06191	0.00009	0.06200
IV	12.118	528.8	0.06185	0.00009	0.06194
V	12.122	528.7	0.06188	0.00009	0.06197

In the second column of the above Table pa is the observed barometric pressure (see Table II) and f is the partial pressure due to the water vapour (Table II).

The correct value of R in the state equation of $pv = R.T.$ can now be calculated. In English measures:—

$p = 14.696$ lbs/sq.in. $= 14.696 \times 144$ lbs/sq.ft.
$T = 491.4$
and since the weight of a cub. ft. of dry air $= 0.08073$ pounds
$v = 1/0.08073$ cubic feet per pound.

Hence $R = \dfrac{14.696 \times 144}{491.4 \times 0.08073} = 53.36$

Also R can be found from the thermodynamical equation

$R = J\ (c_p - c_v)$

J = mechanical equivalent of heat = 778 ft. lbs.

c_p = spec. heat at const. temp. = 0.2374

c_v = „ „ „ vol. = 0.1688

Hence $R = 778\ (0.2374 - 0.1688) = 53.37$

The value for R for dry air may be taken as 53.36. For unsaturated water vapour as it occurs in air the value of R may be taken as 85.6.

For a mixture of dry air and water vapour the constant R must be calculated from the weight of each constituent present per cubic foot.

Thus if there are A pounds of dry air for which R = 53.36 and B pounds of water vapour for which R = 85.6 the value of R for the mixture is

$(A + B)\ R = 53.36\ A + 85.6\ B$

or $R = 53.36 + 32.24\ B/A$ + smaller terms, since the ratio of B/A is already a small fraction.

Hence the value of R to use for the air taken in by the Compressor is

TABLE V (a).

Test No.	A.	B.	$32.24B/A$.	R
I	0.06276	0.00016	0.082	53.44
II	0.06244	0.00013	0.067	53.43
III	0.06194	0.00009	0.047	53.41
IV	0.06185	0.00009	0.047	53.41
V	0.06188	0.00009	0.047	53.41

Since the humidity is so low, there is no condensation of water in the intercooler and the weights of air and water have the same ratio to each other on the delivery side and on the intake side of the compressor; hence the same value of R is to be used for all the orifices.

In a somewhat similar manner to that used for finding the value of R for a mixture of dry air and water vapour, the values of the two specific heats—*viz* that at constant pressure and that at constant volume—can be found for a mixture.

The values of the specific heats of dry air have already been given for the calculation of R.

$c_p = 0.2374$

$c_v = 0.1688 \qquad c_p / c_v = 1.4064$

whilst for the specific heat of water vapour one may take

$c_p = 0.48$

$c_v = 0.37 \qquad c_p / c_v = 1.3$

To find the specific heat of a mixture of A pounds of dry air and B pounds of water vapour

$$(A + B)\ c_p = 0.2374\ A + 0.48\ B$$
$$(A + B)\ c_v = 0.1688\ A + 0.37\ B$$
$$c_p = 0.2374 + 0.24\ B/A$$
$$c_v = 0.1688 + 0.20\ B/A$$
$$\kappa = c_p/c_v = 1.4064 - 0.24\ B/A$$

Another expression that occurs in orifice calculations is $\frac{\kappa - 1}{\kappa}$ and the value of the rate of change of this quantity is half the rate of change of κ.

Hence $\frac{\kappa - 1}{\kappa} = 0.2890 - 0.12\ B/A$

The values of these constants for each test are given in Table V. (b).

TABLE V (b).

Test No.	A	B	0.24B/A	$\kappa = c_p/c_v$	$\frac{\kappa - 1}{\kappa}$	$\frac{(3n-1)}{4}$ (negative)	recip. (negative)
I	.06276	.00016	.0006	1.4058	.2887	.03347	29.88
II	.06244	.00013	.0005	1.4059	.2888	.03346	29.94
III	.06191	.00009	.0003	1.4061	.2889	.03333	30.00
IV	.06185	.00009	.0003	1.4061	.2889	.03333	30.00
V	.06188	.00009	.0003	1.4061	.2889	.03333	30.00

The reciprocal of the value of $(3n - 1)/4$ where $n = (\kappa - 1)/\kappa$ occurs in the formula for calculating the weight of air delivered through an orifice.

The following Tables VIa to VIg give the observations of the temperatures at inlet and discharge of compressor and at orifice.

The observations are given as observed whether read in Centigrade or Fahrenheit and the averages are stated in both systems.

TEMPERATURES

TABLE VI (a)

Test No.	Time a.m.	Inlet Bar. °F.	air Hyg. °C.	H.P. Disch. °C.	Disch. Orifice °C.
I	10.05	—	15.4	89.0	86.5
	.10	—	14.8	89.0	87.0
	.15	—	16.1	89.5	87.2
	.20	—	14.8	90.0	87.5
	.25	62.0	16.0	90.0	88.0
	.30	62.2	16.0	90.0	88.0
	.35	62.6	16.1	90.0	88.0

	.40	62.8	16.2	90.0	88.0
	.45	62.8	16.1	90.0	88.3
	.50	63.0	17.0	91.0	88.0
	.55	63.1	16.5	91.0	88.5
	11.00	63.4	16.9	90.5	88.5
	.05	63.8	17.5	90.0	88.0
Average C°		17.0	16.1	90.0	87.8
F°		62.6	61.0	194.0	190.0

TEMPERATURES.
TABLE VI (b)

Test No.	Time a.m.	Inlet Bar. °F.	air Hyg. °C.	H.P. Disch. °C.	Disch. Orifice C.
II	11.20	63.4	17.8	92.5	90.5
	.25	64.4	18.0	93.0	91.0
	.30	65.0	18.2	93.0	91.0
	.35	65.2	17.8	93.0	91.0
	.40	65.6	17.8	92.5	91.0
	.45	65.8	18.2	92.5	91.0
	.50	66.0	18.2	93.0	91.2
	.55	66.3	18.2	93.0	91.8
	12.00	66.3	18.2	93.0	92.0
Average °C		18.5	18.0	92.8	91.2
°F		65.3	64.4	199.0	196.2

TEMPERATURES.
TABLES VI (c).

Test No.	Time p.m.	Inlet Bar. °F.	air Hyg. °C.	H.P. Disch. °C.	Disch. Orifice °C.
III	1.35	68.3	20.2	92.0	90.5
	.40	68.8	20.4	92.5	90.5
	.45	69.4	20.2	93.0	90.8
	.50	69.8	20.2	93.0	91.0
	.55	69.9	20.6	93.0	91.0
	2.00	70.0	20.8	93.0	91.0
	.05	70.0	20.8	92.0	90.5
	.10	70.4	20.8	92.0	90.2
	.15	70.4	20.6	92.0	90.0
Average °C.		20.9	20.5	92.5	90.6
°F.		69.7	68.9	198.5	195.1

TEMPERATURES.
TABLE VI (d)

Test No.	Time p.m.	Inlet Bar. °F.	air Hyg. °C.	H.P. Disch. °C.	Disch. Orifice °C.
IV	2.25	70.2	21.0	89.5	88.0
	.30	70.2	20.8	89.0	87.6
	.35	70.2	20.8	89.0	87.3
	.40	70.2	21.0	89.0	87.2
	.45	70.4	20.8	89.0	87.2
	.50	70.4	20.6	89.0	87.1
	.55	70.3	20.8	80.0	87.1
	3.00	70.3	20.8	89.0	87.0
	.05	70.3	20.6	89.0	87.0
Average °C.		21.3	20.8	89.1	87.3
°F.		70.3	69.4	192.4	189.1

TEMPERATURES.
TABLE VI (e)

Test No.	Time p.m.	Inlet Bar. °F.	air Hyg. °C.	H.P. Disch. °C.	Disch. Orifice °C.
V	3.15	70.0	20.8	84.0	83.2
	.20	70.0	20.6	83.5	82.5
	.25	70.0	20.8	83.0	82.0
	.30	70.0	20.8	83.0	81.8
	.35	69.8	20.6	83.0	81.5
	.40	69.8	20.6	83.0	81.4
	.45	70.0	20.4	83.0	81.3
Average °C.		21.1	20.7	83.2	81.5
°F.		70.0	69.3	181.8	178.6

SUMMARY.
TABLE VI (f)

Test No.	Inlet Bar.	air Hyg.	H.P. Disch.	Discharge Orifice
	FAHRENHEIT.			
I	62.6	61.0	194.0	190.0
II	65.3	64.4	199.0	196.2
III	69.7	68.9	198.5	195.1
IV	70.3	69.4	192.4	189.1
V	70.0	69.3	181.8	178.6

SUMMARY.

TABLE VI (g)

Test No.	Inlet Bar.	air Hyg.	H.P. Disch.	Discharge Orifice
		CENTIGRADE.		
I	17.0	16.1	90.0	87.8
II	18.5	18.0	92.8	91.2
III	20.9	20.5	92.5	90.6
IV	21.3	20.8	89.1	87.3
V	21.1	20.7	83.2	81.5

The reductions of the readings of the manometers and pressure gauges are tabulated according to the nature of the gauge used for observing the pressures. These were: —

(1) Water gauges read in m.m.

(2) Spring Pressure gauges.

For the reduction of the readings we have taken:—

1 inch = 25.40 m.m.
Local g = 32.11 ft./sec^2
Standard g = 32.17 „
27.69 inches water = 1 lb./sq.in. at standard g & 32° F.
27.74 „ „ = „ „ local g & „
27.79 „ „ = „ „ „ g & 70° F.
Average temperature of manometers = 70° F.

By this means all the pressures are reduced to the standard value of gravity.

Tables VII (a) to VII (f) give the reduction of the observations of the water gauges used for measuring the drop across the orifices. As has already been stated two were on the L.P. intakes and one on the H.P. discharge.

The differences observed between the readings of the two manometers on the L.P. intake on the H.P. and M.P. sides is due to the different setting of the butterfly valve regulating the admission of air to the two sides of the Compressor.

The readings on the discharge H.P. orifice were taken independently by two observers on the top and bottom of the U manometer.

Table VII (f) gives the Summary of these readings reduced to pounds per sq. inch.

TABLE VIIa. Test No. I.

Time	L.P. Intake H.P. m.m.	L.P. Intake M.P. m.m.	H.P. Discharge. Top Inches	H.P. Discharge. Bottom Inches
10.05	225	306	27.7	27.6
.10	220	303	27.8	27.8
.15	218	303	27.3	27.3
.20	222	307	27.9	27.9
.25	222	305	27.4	27.4
.30	220	306	27.4	27.6
.35	221	304	27.4	27.4
.40	221	303	27.4	27.4
.45	223	307	27.7	27.7
.50	222	307	27.5	27.5
.55	223	306	27.6	27.7
11.00	221	305	27.6	27.7
.05	218	298	27.4	27.5
Average	221	305	27.55	27.58
Zero	75	135		
Total m.m.	296	440		
Total inches	11.65	17.32	27.57	

TABLE VIIb. Test No. II.

Time	L.P. Intake H.P. m.m.	L.P. Intake M.P. m.m.	H.P. Discharge. Top Inches	H.P. Discharge. Bottom Inches
11.20	368	314	30.5	30.8
.25	365	313	30.4	31.0
.30	368	314	30.4	30.8
.35	364	310	30.2	30.6
.40	367	316	30.3	30.7
.45	370	318	30.4	30.8
.50	372	313	31.0	31.4
.55	371	319	30.6	31.0
12.00	375	322	30.7	31.2
Average	369	315	30.50	30.92
Zero	75	137		
Total m.m.	444	452	30.71	
Total inches	17.48	17.80		

TABLE VIIc. Test No. III.

Time	L.P. Intake		H.P. Discharge.	
	H.P. m.m.	M.P. m.m.	Top Inches	Bottom
1.35	293	286	31.8	32.6
.40	295	286	32.4	33.0
.45	296	285	32.0	32.6
.50	299	291	32.3	32.8
.55	297	290	31.9	32.4
2.00	296	288	32.0	32.8
.05	293	285	32.0	32.6
.10	289	279	31.8	32.6
.15	286	273	31.4	32.0
Average	294	285	31.96	32.60
Zero	77	138		
Total m.m.	371	423		
Total inches	14.61	16.65	32.28	

TABLE VIId. Test No. IV.

Time	L.P. Intake		H.P. Discharge.	
	H.P. m.m.	M.P. m.m.	Top Inches	Bottom
2.25	142	285	28.4	28.8
.30	154	280	28.8	29.2
.35	145	284	28.3	28.8
.40	154	278	28.5	29.0
.45	144	284	28.0	28.7
.50	144	287	28.2	28.6
.55	146	289	28.1	28.6
3.00	140	283	28.0	28.8
.05	142	283	27.8	28.8
Average	146	284	28.23	28.81
Zero	75	140		
Total m.m.	221	424		
Total inches	8.70	16.69	28.52	

TABLE VII. (e) Test No. V.

Time	L.P. Intake		H.P. Discharge	
	H.P. m.m.	M.P. m.m.	Top	Bottom Inches.
3.15	57	255	25.2	25.7
.20	58	253	25.0	25.4
.25	56	256	24.9	25.4
.30	57	258	25.3	25.8
.35	56	258	25.1	25.6
.40	57	258	25.5	25.8
.45	57	257	25.2	25.6
Average	57	257	25.17	25.61
Zero	74	140		
Total m.m.	131	397		
Total Inches	5.16	15.63	25.39	

TABLE VII. (f)

Summary of Pressure Drops across Orifices.

Test	L.P. Intake H.P.	M.P.	H.P. Orifice lbs sq.in.
I	0.419	0.623	0.902
II	0.629	0.640	1.105
III	0.526	0.599	1.162
IV	0.313	0.601	1.026
V	0.186	0.562	0.914

The pressures at the discharge orifice have been measured with a standard spring pressure gauge, which was compared with a dead weight (Crosby) tester. It is presumed that these dead weights (masses) give the correct pressure at the standard value of g and, therefore, the indicators of such an instrument have to be corrected by multiplying by the ratio of local g and standard g.

Tables VIII a to VIII e give the statement of the observations and the reduction to pounds per sq. inch absolute at the standard value of g. The pressure at the terminus of the compressor and at the orifice would in the ordinary working only differ by a small amount. On the test part of the regulation was done at the valve between the two, so that by dropping the density of the air at the orifice, nearly the same orifice head was obtained at all loads.

TABLE VIII. (a)

Test No. I.

Time a.m.	Terminus lbs/sq.in.	Orifice lbs/sq.in.
10.05	109.5	103.75
.10	109.5	103.5
.15	109.5	104.0
.20	110.0	104.25
.25	110.0	104.25
.30	110.0	104.5
.35	110.0	104.25
.40	109.5	104.0
.45	110.0	104.25
.50	110.0	104.75
.55	110.0	104.75
11.00	110.0	104.25
.05	109.0	104.0
Average	109.8	104.2
Absolute	118.0	
Corr.	— 0.4	— 0.4
Lbs/sq. in abs.	117.6	103.8

TABLE VIII. (b)

Test No. II.

Time a.m.	Terminus lbs/sq.in.	Orifice lbs/sq.in.
11.20	111.0	116.0
.25	112.0	116.5
.30	112.0	116.5
.35	111.5	116.0
.40	111.0	116.0
.45	112.0	116.25
.50	112.0	116.75
.55	112.0	117.0
12.00	112.0	116.75
Average	111.7	116.4
Absolute	120.0	
Corr.	— 0.4	— 0.4
Lbs sq. in. abs.	119.6	116.0

TABLE VIII. (c)

Test No. III.

Time p.m.	Terminus lbs/sq.in.	Orifice lbs/sq.in.
1.35	117.5	97.0
.40	117.5	96.75
.45	118.0	97.0
.50	118.0	97.25
.55	118.0	97.5
2.00	117.5	97.0
.05	117.0	96.5
.10	116.5	96.5
.15	116.0	95.25
Average	117.3	96.8
Absolute	125.3	
Corr.	— 0.4	— 0.4
Lbs/sq. in. abs.	125.7	96.4

TABLE VIII. (d)

Test No. IV.

Time p.m.	Terminus lbs/sq.in.	Orifice lbs/sq.in.
2.25	110.0	85.25
.30	110.0	85.25
.35	110.0	85.75
.40	110.0	86.0
.45	109.9	85.25
.50	110.0	85.5
.55	109.8	85.0
3.00	109.5	85.0
.05	109.5	85.25
Average	109.9	85.4
Absolute	118.5	
Corr.	— 0.4	— 0.4
Lbs/sq. inch	118.1	85.0

TABLE VIII. (e)

Test No. V.

Time p.m.	Terminus lbs/sq.in.	Orifice lbs/sq.in.
3.15	68.5	76.0
.20	69.0	76.0
.25	69.0	76.0
.30	68.5	76.0
.35	68.5	76.0
.40	69.0	76.0
.45	68.2	76.0
Average	68.5	76.0
Absolute	77.3	
Corr.	— 0.3	— 0.3
Lbs sq. inch	77.0	75.7

TABLE IX.

Summary of Absolute Pressures.

	I.	II.	III.	IV.	V.
Barometers	12.160	12.156	12.148	12.147	12.150
After orifice H.P. Side	11.741	11.527	11.622	11.834	11.964
After orifice M.P. Side	11.537	11.516	11.549	11.546	11.588
H.P. Discharge	117.6	119.6	125.7	118.1	77.0
At orifice pipe line (p_2)	103.8	116.0	96.4	85.0	75.7

We have now all the data for calculating the weight of air taken into the compressor as measured on the inlet orifices. Tables X (a) and X (b) give the data collected from the other Tables and the calculation of the weight per second from the formula of page 431.

Table X (c) gives the summary of the total weight for each test measured in this manner.

TABLE X (a).

H.P. SIDE.

Test	$f(a)$.	g.	R.	h.	p_2	T.	m.
I.	87.50	32.17	53.44	0.419	11.741	520.4	9.32
II	87.50	32.17	53.43	0.629	11.527	523.8	11.28
III	87.50	32.17	53.41	0.526	11.622	528.3	10.31
IV	87.30	32.17	53.41	0.313	11.834	528.8	8.03
V.	87.50	32.17	53.41	0.186	11.964	528.7	6.23

TABLE X (b).

M.P. SIDE

Test	$f(a)$.	g.	R.	h.	p_2	T.	m.
I	87.62	32.17	53.44	0.623	11.537	520.4	11.27
II	87.62	32.17	53.43	0.640	11.516	523.8	11.38
III	87.62	32.17	53.41	0.599	11.549	528.3	10.98
IV	87.62	32.17	53.41	0.601	11.546	528.8	10.99
V	87.62	32.17	53.41	0.562	11.588	528.7	10.66

TABLE X (c).

SUMMARY WEIGHT OF AIR TAKEN IN.

Test No.	H.P. side	M.P. side	Total
I	9.32	11.27	20.59 lbs/sec.
II	11.28	11.38	22.66
III	10.31	10.98	21.29
IV	8.03	10.99	19.02
V	6.23	10.66	16.89

From the measurements taken on the orifice on the discharge from the compressor, Table XI is compiled and this gives the result of the calculation of the weight delivered per second from the formula of page 431.

TABLE XI

WEIGHT OF AIR DELIVERED.

Test	$f(a)$	g	R	p_2	h	T	W
I	46.33	32.17	53.44	103.8	0.992	649.4	20.24
II	46.33	32.17	53.43	116.0	1.105	655.6	22.47
III	46.33	32.17	53.41	96.4	1.162	654.5	21.04
IV	46.33	32.17	53.41	85.0	1.026	648.5	18.65
V	46.33	32.17	53.41	75.7	0.914	638.0	16.75

As no condensed water vapour was taken from the inter-cooler during the test the same values of R and K are used here as for calculating the air taken in.

In the calculation of the weight of air taken in, it was shown that the term $(p_2/p_1)^2/\kappa$ could have no influence on the result as A is infinite and ca/A is zero. This is not the case on the discharge side where the value of $(ca/A)^2$ is 0.1388. Table XI(a) gives the value of $(p_2/p_1)^2/\kappa$ for the discharge orifice. The resulting value of the equivalent area, $f(a)$, is given in Table XI(b) which also gives the weight of air delivered given in Table XI corrected for the new value of the equivalent area; it is seen that this correction is only 1 part in 1,000.

TABLE XI (a).

Test	p_2	h	$1-p_2/p_1$	$(p_2/p_1)^2/\kappa$
I	103.8	0.992	.0095	.9865
II	116.0	1.105	.0095	.9865
III	96.4	1.162	.0120	.9829
IV	85.0	1.026	.0121	.9828
V	75.7	0.914	.0121	.9828

TABLE XI(b).

Test	$(p_2/p_1)^2/\kappa$	$f(a)$	Weight corrected
I	.9865	46.27	20.21
II	.9865	46.27	22.44
III	.9829	46.25	21.00
IV	.9828	46.25	18.62
V	.9828	46.25	16.72

We are now in a position to compare the "Weight of air taken in" of Table X measured with a pair of shaped orifices with air at low pressure with the "Weight of air delivered" of Table XIII measured with a single plate orifice with air at high pressure. This comparison is given in Table XIV.

TABLE XIV.

Test No.	Air taken in lbs/sec.	Air sent out lbs/sec	Diff.	Mean Weight. lbs/sec.
I	20.59	20.21	+ 0.38	20.40
II	22.66	22.44	+ 0.22	22.55
III	21.29	21.00	+ 0.29	21.15
IV	19.02	18.62	+ 0.40	18.82
V	16.89	16.72	+ 0.17	16.81
Totals	100.45	98.99	1.46	99.73

In comparing these measurements, it is to be remembered that the reading of the Barometer is the only one common to both sides and that even this enters very differently in the two calculations.

It is to be remembered that the quantity of air taken in should be greater than the quantity sent out by the leakage from the glands of the compressor. Moreover there is a slight uncertainty as to the effect of the butterfly valve on the down stream side of the orifice. On the discharge side of the compressor there is some evidence that the coefficient 0.675 used for the plate orifice should be increased by about ½ per cent., had this been done the agreement would have been even closer than it is now. From this test can be concluded:

(1) that in a well designed turbo compressor the leakage through the labyrinth glands is a negligible quantity being less than the deviation of the measured quantities. No leakage was observed at any of the glands or flanges.

(2) that when the tests are properly conducted and orifices used with the necessary precautions, the measurement at low (normal atmospheric) pressure and of the same quantity of air at high (delivery) pressure agree.

(3) that the order of agreement, *i.e.*, the certainty with which air can be measured, is as high as with electric measurements.

II. RECIPROCATING COMPRESSOR TEST.

The test has been made on May 11th, 1913, on No. 3 Pakorny and Wittekind Compressor of the Brakpan Compressor Station. The compressor delivers 7,500 cu. ft. of free air per minute at a pressure of 90 lbs. gauge when running with 75 revolutions per minute.

The air discharged by the compressor was measured by a Venturi tube, which had been arranged on the downstream side of the large station air receiver. (See fig. No. 5.) The capacity of this receiver is 1080 cu. ft. or 57 times the capacity of the H.P. air cylinder. Its size was sufficient to stop completely the fluctuations of pressure, due to the intermittent discharge of the compressor, so that perfectly steady readings were obtained at the Venturi tube.

A throttle valve was arranged between receiver and Venturi tube in order to regulate the pressure at the engine terminus. After passing the Venturi tube the air is throttled down to atmospheric pressure by four orifices arranged in series.

The test was made under ordinary working conditions. No special preparations were made except that the intercooler was boiled out three weeks before the test and slight readjustments were made on the steam valve gear. The compressor had been in commission since May 1912, and the average running hours worked out about 18 hrs per diem.

The compressor was started up at 4 a.m. and was running under normal load conditions until the first test (No. 2) was made. The pressure gauges and thermometers used in the test were all carefully calibrated. The results of four different tests *i.e.*, Nos. 2, 4, 5 and 6 are dealt with in the following. No. 1 test is omitted as this was a steam consumption test only, made at a previous day, whilst No. 3 test did not give any reliable results owing to the unstable conditions that existed during the test and which were due to the attempt to run the compressor with blocked governor.

In the following calculations the same standard constants have been used and the same reductions have been made as under the turbo compressor test.

Furthermore in order to simplify matters and to avoid repetitions the arrangement and marking of tables correspond as much as possible to this test.

The following tables I (a) and (b) give the details of barometer and hygrometer observations and reduction and Table I (c) gives the summary.

TABLE I (a).

Barometer and Hygrometer Readings.

Test No.	Time.	Barom. Inches.	*t* of Barom. F.	Dry Bulb. °C.	Wet Bulb. °C.
II	10.55 a.m.	—	—	—	—
	11.10	25.020	71.0	19.9	11.4
	11.25	25.016	72.0	20.4	12.2
	11.40	25.015	71.5	19.9	11.5
	11.50	25.015	73.5	21.4	12.4
	11.55	—	—	—	—
Average over test		25.016	72.0	20.4	11.9
Temp. corrections		— 0.098			
Corrected Barometer		24.918			

IV	2.00 p.m.	—	—	—	—
	2.05	24.980	76.0	22.2	11.7
	2.15	24.975	76.8	22.2	12.2
	2.25	24.970	76.8	22.3	12.0
	2.30	—	—	—	—
Average over test		24.975	76.5	22.2	12.0
Temp. correction		— 0.108			
Corrected Barometer		24.867			
V	2.50	—	—	—	—
	2.55	24.974	77.8	23.2	12.8
	3.5	24.968	76.8	23.2	13.4
	3.15	24.968	76.0	22.4	12.4
	3.20	—	—	—	—
Average over test		24.970	76.9	22.9	12.9
Temp. correction		— 0.109			
Corrected Barometer		24.861			
VI	3.35	—	—	—	—
	3.45	24.965	73.5	21.9	12.2
	4.00	24.960	72.5	21.4	11.1
	4.5	24.960	72.2	21.1	11.0
Average over test		24.962	72.7	21.5	11.4
Temp. correction		— 0.099			
Corrected Barometer		24.863			

TABLE I (b).

Reduction of Hygrometer Readings.

Test No.	II	IV	V	VI
Dry Bulb °C.	20.4	22.2	22.9	21.5
Wet Bulb °C.	11.9	12.0	12.9	11.4
Dry Bulb °F. (t)	68.7	72.0	73.2	70.7
Wet Bulb °F. (t_1)	53.4	53.6	55.2	52.5
$(t - t_1)$	15.3	18.4	18.0	18.2
Pressure of saturated aqueous vapour t_1 (f_1)	0.408	0.411	0.435	0.395
$0.000367\ B\ (t - t_1)$ $\left(1 + \frac{t - t_1}{1571}\right)(f_2)$	0.142	0.171	0.167	0.169

Vapour Pressure $(f_1 - f_2) = f$	0.266	0.240	0.268	0.226
Pressure of saturated vapour t (F).	0.700	0.783	0.816	0.750
Rel. Humidity $\frac{f}{F}$ in %	38.0	30.7	32.8	30.7

TABLE I (c)

Test No.	Barometer inches	Dry Bulb $t°$ C.	Humidity %	f inches
II	24.918	20.4	38.0	0.266
IV	24.867	22.2	30.7	0.240
V	24.861	22.9	32.8	0.268
VI	24.863	21.5	30.7	0.226

The Table I (c) reduces for standard value of gravity to:

TABLE II.

Test No.	Barometer pa lbs/sq.in.	Air F.	Temperature °F(abs)	f lbs sq.inch
II	12.210	68.7	528.1	0.130
IV	12.184	72.0	531.4	0.118
V	12.182	73.2	532.6	0.131
VI	12.183	70.7	530.1	0.111

From these data and from No. 28 of Smithsonian tables we find the weight of moisture present as per Table III. The weights of working air are given in table IV and the values of R, κ and $\frac{+}{3n-1}$ for each Test are calculated in table V (a) and (b).

TABLE III.

Weight of moisture present.

Test	Humidity	Grs/cu.ft.	lbs/cu.ft.
II	38.0	2.908	0.000415
IV	30.7	2.612	0.000373
V	32.8	2.899	0.000414
VI	30.7	2.506	0.000358

TABLE IV

Weight of working air.

Test No.	$p = p_a - f$	T_a	Weight of dry air. $2.699.\frac{p}{t}$	Weight of Moisture	Total Weight of working air.
II	12.080	528.1	0.06176	0.00042	0.06216
IV	12.066	531.4	0.06129	0.00037	0.06166
V	12.051	532.6	0.06108	0.00041	0.06149
VI	12.072	530.1	0.06148	0.00036	0.06184

TABLE V (a).

Value of R for air taken in by the compressor.

$$R = 53.36 + 32.24\frac{B}{A}$$

A = weight of dry air, B = weight of moisture.

Test	A	B	$32.34\frac{B}{A}$	R
II	0.06176	0.00042	0.2193	53.58
IV	0.06129	0.00037	0.1946	53.55
V	0.06108	0.00041	0.2164	53.58
VI	0.06148	0.00036	0.1890	53.55

TABLE V (b).

Value of κ and $\frac{4}{3n-1}$

$$\kappa = 1.4064 - 0.24\frac{B}{A}$$

Test No.	A	B	$0.24.\frac{B}{A}$	κ	$\frac{\kappa-1}{\kappa}$	$\frac{4}{3n-1}$ (negative)
II	0.06176	0.00042	0.0016	1.4048	0.2882	29.55
IV	0.06129	0.00037	0.0015	1.4049	0.2883	29.61
V	0.06108	0.00041	0.0016	1.4048	0.2882	29.55
VI	0.06148	0.00036	0.0014	1.4050	0.2884	29.68

The tables VI (a) to VI (e) give the observations of the temperatures of atmosphere, at L.P. inlet, H.P. discharge and at venturi.

TABLE VI (a).

Test No.	Time	Hygr. °C.	L.P. Inlet °C.	H.P. Dis. °C.	Venturi °C.
II	10.55 a.m.	—	26.7	141.0	94.0
	11.00	—	27.0	141.0	94.0
	.05	—	27.2	141.0	94.0
	.10	19.9	27.3	141.0	94.0
	.15	—	27.3	140.8	94.5
	.20	—	27.4	140.8	95.0
	.25	20.4	27.5	140.8	95.0
	.30	—	27.5	140.8	95.0
	.35	—	27.6	140.8	95.0
	.40	19.9	28.0	140.8	95.5
	.45	—	28.3	140.8	95.3
	.50	21.4	29.0	140.8	95.2
	11.55	—	29.2	140.8	95.5
Averages		20.4	27.7	140.9	94.8
Corr.					— 0.8
					94.0

TABLE VI (b).

Test No.	Time	Hygr. °C.	L.P. Inlet °C.	H.P. Dis. °C.	Venturi °C.
IV	2.00 p.m.	—	31.0	156.0	108.0
	.05	22.2	30.8	156.3	108.5
	.10	—	30.8	157.0	109.0
	.15	22.2	31.0	157.0	109.0
	.20	—	31.1	157.2	110.0
	.25	23.3	31.0	157.4	110.0
	2.30	—	31.0	158.0	111.0
Averages		22.2	31.0	157.0	109.4
Correction					— 0.8
					108.6

TABLE VI (c).

Test No.	Time	Hygr. °C.	L.P. Inlet °C.	H.P. Dis. °C.	Venturi °C.
V	2.50 p.m.	—	31.0	141.0	104.0
	.55	23.2	31.2	141.0	102.3
	3.00	—	31.0	140.8	101.0
	.05	23.2	31.0	140.7	99.5
	.10	—	31.0	140.7	98.5
	.15	22.4	30.8	140.6	97.5
	3.20	—	31.0	140.5	97.0
Averages		22.9	31.0	140.8	100.0
Correction					— 0.8
					99.2

TABLE VI (d).

Test No.	Time	Hygr. C.	L.P. Inlet C.	H.P. Dis. C.	Venturi C.
VI	3.35 p.m.	—	30.4	128.5	93.0
	.40	—	30.3	128.5	92.8
	.45	21.9	30.2	128.2	92.0
	.50	—	30.0	128.0	91.0
	.55	—	30.0	125.1	91.0
	4.00	21.4	30.0	124.8	90.0
	4.05	21.1	30.0	124.8	90.0
Averages		21.5	30.1	126.8	91.4
Correction					— 0.8
					90.6

TABLE VI (e).
SUMMARY

Test	Hygr.	L.P. Inlet	H.P. Dis.	Venturi
		CENTIGRADE		
II	20.4	27.7	140.9	94.0
IV	22.2	31.0	157.0	108.6
V	22.9	31.0	140.8	99.2
VI	21.5	30.1	126.8	90.6
		FAHRENHEIT		
II	68.7	82.0	285.5	201.2
IV	72.0	87.8	314.6	227.4
V	73.2	87.8	285.4	210.6
VI	70.7	86.2	260.2	195.1

Table VII gives the drop of pressure across the Venturi measured in inches water column and the reduction to lbs/sq. in. and standard gravity and temperature.

TABLE VII
Venturi head measured by water gauge.

Test No.	II.		IV.		V.		VI.	
	Time a.m.	Head inch	Time p.m.	Head inch	Time p.m.	Head inch	Time p.m.	Head inch
	10.55	8.6	2.00	9.45	2.50	9.8	3.35	9.3
	11.00	8.6	.05	9.5	.55	9.7	.40	9.4
	.05	8.6	.10	9.5	3.00	9.75	.45	9.4
	.10	8.6	.15	9.5	.05	9.75	.50	9.4
	.15	8.6	.20	9.5	.10	9.7	.55	9.15
	.20	8.6	.25	9.5	.15	9.7	4.00	9.3

	.25	8.6	2.30	9.5	3.20	9.7	4.05	9.3
	.30	8.6	—	—	—	—	—	—
	.35	8.6	—	—	—	—	—	—
	.40	8.6	—	—	—	—	—	—
	.45	8.6	—	—	—	—	—	—
	.50	8.6	—	—	—	—	—	—
	11.55	8.5	—	—	—	—	—	—
Average		8.592		9.493		9.729		9.321
Correction	+	0.26						
		8.852						
lbs/sq. in.		0.3186		0.3416		0.3501		0.3354

Table VIII gives the pressures at engine terminus and at venturi in lbs. per sq. inch corrected for the standard value of g.

TABLE VIII.

Pressures at Compressor Terminus and Venturi.

	Test No. II. Time. a.m.	Terminus gauge.	Venturi abs.		Test No. IV. Time p.m.	Terminus gauge.	Venturi abs.
	10.55	73	66.0	..	2.00	90	71.0
	11.00	73	66.0	..	.05	91	71.5
	.05	73	66.0	..	.10	90	71.3
	.10	73	65.7	..	.15	90	70.8
	.15	73	65.7	..	.20	90	71.3
	.20	73	66.0	..	.25	90	71.5
	.25	73	66.0	..	2.30	90	71.3
	.30	73	66.0	..	—	—	—
	.35	73	66.0	..	—	—	—
	.40	73	66.0	..	—	—	—
	.45	73	66.0	..	—	—	—
	.50	73	66.0	..	—	—	—
	11.55	73	64.5	..	—	—	—
Average.		73.0	65.8			90.1	71.2
Correction . . .		1.2	0.1			1.2	0.1
		74.2	65.9			91.3	71.3

Test No. V. Time. a.m.	Terminus gauge.	Venturi abs.		Test No. VI. Time. p.m.	Terminus gauge.	Venturi abs.
2.50	59	71.8	..	3.35	56	68.5
.55	59	71.0	..	.40	55	68.5
3.00	59	71.0	..	.45	56	69.0
.05	59	71.0	..	.50	56	68.8

.10	58	71.0	..	.55	55	67.5
.15	58	71.0	..	4.00	55	67.0
3.20	58	71.0	..	4.05	55	67.6
Average.	58.6	71.1			55.4	68.1
Correction.. ..	0.6	0.1			0.8	0.1
	59.2	71.2			56.2	68.2

TABLE IX

Summary of absolute pressures in lbs/sq. inch.

Test No.	II.	IV.	V.	VI.
Barometer	12.210	12.184	12.182	12.183
Engine terminus	86.41	103.48	71.38	68.38
Venturi	65.90	71.31	71.20	68.15
Drop across Venturi	0.3186	0.3416	0.3501	0.3354
Venturi throat (p_2)	65.58	70.97	70.85	67.81

As stated before the compressor has a suction capacity of 7,500 cu.ft./min. at 75 revolutions per minute. Table X gives the average number of revolutions per minute for the different tests and from these the weights of air drawn per sec. are calculated.

The temperature measured in the suction chamber of the L.P. Cylinder is taken for this calculation as being the temperature inside the cylinder at the beginning of the compression stroke· although as pointed out before, these temperatures cannot be equal. By special indicator cards, taken with a very weak spring during the tests, it was proved that the pressure inside the cylinder at the beginning of the compression stroke is equal to the barometric pressure and this pressure is therefore used for the purposes of Table X.

TABLE X.

Weight of air taken in.

Test	II.	IV.	V.	VI.
Revs. per min.	71.45	76.80	77.54	75.14
Cu.ft. of air drawn in per min.	71.45	76.80	77.54	75.14
Temperature at L.P. suction chamber °F.	82.0	87.8	87.8	86.2
Absolute Temperature °F.	541.4	547.2	547.2	545.6
Stm. pressure	12.21	12.18	12.18	12.18
lbs of air per sec.	7.25	7.693	7.768	7.55

The dimensions of the Venturi were found by careful calibration with micrometer gauges to be:

Upstream diameter: 9.9323 inches: $A = 77.48$ sq. inches
Throat diameter: 6.5003 inches: $a = 33.185$ sq. inches

The coefficient of contraction was taken as 0.99 instead of 0.985 as given for the inlet nozzles of the turbo compressor test because the Venturi had been designed for a capacity considerably larger than that of the compressor under test.

We can now compile table XI which gives the result of the calculation of the weight of air delivered per second.

TABLE XI

Weight of air delivered.

Test	II.	IV.	V.	VI.
g	32.17	32.17	32.17	32.17
R	53.58	53.55	53.58	53.55
K	1.4048	1.4049	1.4048	1.4050
p_1	65.90	71.31	71.20	68.15
p_2	65.58	70.97	70.85	67.81
h	0.3186	0.3416	0.3501	0.3354
T	660.6	686.8	670.0	654.5
W	7.062	7.464	7.642	7.405

The same values of R and K are used here as found for air of atmospheric pressure as no condensed water vapour was taken from the intercooler during the test.

Table XII gives a comparison of the air taken in with the air discharged in reference to the pressure at engine terminus.

TABLE XII

Test	II	IV	V	VI
Gauge Pressure at engine terminus	74.2	91.3	59.2	56.2
Air taken in	7.25	7.693	7.768	7.550
Air sent out	7.062	7.464	7.642	7.405
Difference in %	2.59	2.98	1.62	1.92

As mentioned before, the heating up of the air when flowing into the cylinder may introduce an error into the comparison of air taken in and air sent out. It is interesting to find out what increase in temperature from suction chamber to inside of cylinder is necessary in order to explain the above discrepancies between the measurements at air inlet and air discharge.

From the weights of air sent out as given in table XII we can find the temperatures which, when existing at the beginning of compression stroke inside the cylinder, would make the weights of air taken in equal to the weights of air sent out for the different tests. These figures are given in table XII (a) which shows also the temperatures of atmosphere. By comparing the actual increase of temperature from atmosphere to suction chamber with the hypothetical increase of temperatures from suction chamber to inside cylinder it stands to reason that the discrepancies as per table XII are not only due to leakage but also to the heating up of the air when entering the L.P. cylinder.

TABLE XII (a)

Test	II	IV	V	VI
Temperatures in Centigrade.				
Atmosphere	20.4	22.2	22.9	21.5
Suction Chamber	27.7	31.0	31.0	30.1
Cylinder	35.8	40.2	35.9	35.9
Temperatures in Fahrenheit.				
Atmosphere	68.7	72.0	73.2	70.7
Suction Chamber	82.0	87.8	87.0	86.2
Cylinder	96.3	104.4	96.5	96.5

TRANSACTIONS OF SOCIETIES

South African Institution of Engineers.—Saturday, May 9th: W. J. Calder, President, in the chair.—"*The principle of similarity, and its application in machine design*": W. **Alexander.** The author is not aware of any paper or work on machine design in which the relations between different-sized engines of similar type are adequately explained. It was therefore sought to rectify this defect. Amongst the points of similarity discussed were conditions producing the same stress intensities in corresponding parts of machines, centrifugal whirling, speed regulators, lubrication, centrifugal pumps, turbines, and automobile engines, etc.

South African Society of Civil Engineers.—Wednesday, May 13th: F. O. Stephens, M.I.C.E., President, in the chair.—"*Railway signalling in South Africa*": F. **Dutton.** The fundamental differences in working between English and South African single line railways were pointed out, the important requirements for signalling on single line systems, such as that characterising practically the whole South African mileage, were stated and discussed, and the distinguishing features of the signalling adopted as standard by the South African Railway Administration were described and illustrated.—"*The destruction by floods of bridges on the Natal coast lines, and the erection of temporary structures*": J. **Mackenzie.** During March, 1913, great floods caused the destruction of several railway bridges on the Natal coast lines, over an area extending along the whole Natal coast from the Pondoland border to a hundred miles into Zululand. Details of structure of six bridges so destroyed were given, together with descriptions of four of the temporary bridges subsequently erected.

Royal Society of South Africa.—Wednesday, May 20th: L. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Phosphorescent bacteria from the sea round Robben Island*": Dr. H. **Bayon.** Pure cultures were exhibited, showing various degrees of luminosity. The identification of the bacteria not being completed, exhibitor was not ready to state that these vibrios differed sufficiently from the micro-organisms observed in other parts of the world, to allow the classification of a separate variety. Attention was brought to the various conditions under which these bacteria lost and acquired again their luminous properties, both in relation to special media and aerobic conditions.—"*A trypanosome and hæmogregarine from the mole shark (scilliorhinus edwardsii.)*": Dr. H. **Bayon** Microscopical specimens of these two new blood parasites were exhibited, and their life-cycle and transmission through an intermediate host (probably of the nature of a leech) were explained.—"*Properties of Pfaffians and their analogues in determinants*": Dr. T. **Muir.**—"*The secular variation of the magnetic elements in South Africa during the period* 1900-1913. Prof. J. C. **Beattie.** The annual changes in the magnetic declination vary from an average decrease of 1.5′ of westerly declination at Mauritius during 1900-1909—a change which has turned into an increase of 1.4′ per year between 1907-1909—to a decrease of 14′ per year in the neighbourhood of Durban; from the latter place the decrease becomes less as we go in a north-westerly direction and attains a value of 5′ at Laonda; the decrease as we go west or south-west is also quite definite, though not so great, and at Capetown has the value of 8′. It appears also that the absolute value of the decrease is increasing all over South Africa at the present time. A comparison of the results given with those of the American and British Admiralty declination charts for approximately the same epoch shows no continuity between the land values of the secular change and those over the sea, the hi h values over the land find no place over the sea except in the case of the result obtained from the *Gauss* and *Carnegie* observations. The greatest annual change of dip is found in the south-western part of the continent in the neighbourhood of Capetown; it amounts to an increase of southerly dip of 8′ per year. The line of no change passes through Madagascar. east of that there is a decrease of southerly dip. The annual change in the horizontal intensity shows a decrease in absolute magnitude towards the north; over the greater part of the Union it has a value of from 80 γ to 100 γ yearly, and is a decrease.

TITLE PAGE AND INDEX.

The Index to Volume X is in course of preparation, and will be forwarded to Members and Subscribers in due course, with the Title Page, Contents and Report. At the same time particulars with regard to arrangements for binding the volume will be announced.

THE SANITARY STATE OF THE STOCK OF THE LOURENÇO MARQUES DISTRICT.

By Lieut. J. B. Botelho.

(Not printed.)

A DECIMAL COINAGE FOR SOUTH AFRICA.

By Prof. W. A. Macfadyen, M.A., LL.D.

(Not printed.)

ON EXTRANEOUS EDUCATION.

By H. L. Lake.

(Not printed.)

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A

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1ST JULY, 1914

* Indicates Foundation Members (30th June 1902)
† Indicates Life Members.
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Names of MEMBERS OF COUNCIL for the 1914 Session are printed in SMALL CAPITALS.
Names of Members whose addresses are incomplete or not known are printed in *italics*.

Members are requested to notify the Assistant General Secretary (P.O. Box 1497, Cape Town) of any changes in address, or additions which may be necessary as soon as possible.

Year of Election.

1902. †à-Ababrelton, Robert, F.R.G.S., F.R.E.S., F.S.S., Royal Institute, Northumberland Avenue, London, W.C.
1902. *Aburrow, Charles, P.O. Box 534, Johannesburg.
1905. Adamson, John E., M.A., Education Department, Pretoria.
1904. Aiken, Alexander, P.O. Box 2636, Johannesburg.
1904. Ainsworth, Herbert, P.O. Box 1553, Johannesburg.
1905. Albu, Sir George, P.O. Box 1242, Johannesburg.
1914. Alderson, Ernest Cecil, De Beers Office, Kimberley.
1913. Alexander, William, A.M.I.C.E., A.R.T.C., South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1910. ANDERSON, ALFRED JASPER, M.A., M.B., D.P.H., M.R.C.S., City Hall, Capetown.
1902. *Andrews, G. S. Burt, M.I.C.E., M.I.Mech.E., M.S.A., P.O. Box 1049, Johannesburg.
1914. Angus, David, P.O. Box 230, Kimberley.
1914. Anstey, Norman, P.O. Box 1003, Johannesburg.
1903. Arnold, Dr. F., P.O. Box 211, Pretoria.
1908. Arnott, William, Gas Works, Port Elizabeth, Cape.
1904. Auret, A. A., P.O. Box 838, Johannesburg.
1910. Ayers, Gilbert, F., Dynamite Factory, Modderfontein, Transvaal.

1913. Bachmann, Carl, Dynamite Factory, Modderfontein, Transvaal.
1906. Bailey, Sir Abe, Kt., P.O. Box 50, Johannesburg.
1902. *Baker, Herbert, F.R.I.B.A., Exploration Buildings (165-8), P.O. Box 4959, Johannesburg.

Year of Election.

1903. Balmforth, Rev. Ramsden, "Shirley," 6, Stephen Street, Capetown.

1913. Barboza, João Tamagnini de Souza, Engineer, Inhambane, Province of Mozambique.

1911. Barratt, Gaston Frederick Sharpe, Bembezaan, Queque, Southern Rhodesia.

1911. Barratt, Rowland Lorraine, Bembezaan, Queque, Southern Rhodesia.

1909. Barrett, W. H., Traffic Manager, S.A. Railways, Bloemfontein.

1905. †Basto, H. E. Alberto Celestine Ferreira Pinto, Governor of Manica and Sofala Province, Beira, Portuguese East Africa.

1909. Baumann, Gustav, Surveyor, Bloemfontein.

1911. Baxter, E. C., Customs, Bulawayo.

1903. Baxter, William, M.A., South African College School Capetown.

1902. *BEATTIE, JOHN CARRUTHERS, D.Sc., F.R.S.E. (Pres. A., 1910), Professor of Physics, South African College Capetown.

1913. Beerstecher, Leonard, P.O. Box 2888, Johannesburg.

1906. Bester, Arthur Edward, F.R.H.S., Agricultural Department, Potchefstroom, Transvaal.

1911. Bevan, Llewellyn Edward Williams, M.R.C.V.S., Department of Agriculture, Salisbury, Rhodesia.

1909. Biebuyck, M. F., P.O. Box 137, Bloemfontein.

1910. Bisset, James, M.I.C.E., M.R.San.I., Beauleigh, Kenilworth, Cape Division.

1905. Blackshaw, George N., B.Sc., F.C.S., Analytical Laboratory, Department of Agriculture, Salisbury, Rhodesia.

1904. Bleloch, W. E., P.O. Box 3692, Johannesburg.

1914. Blomefield, Mrs. Catherine, 66, Anstey's Buildings, Johannesburg.

1906. Bohle, Hermann, M.I.E.E., Corporation Professor of Electrotechnics, South African College, Capetown.

1911. Bolus, Charles Arthur, 20, Steytler's Buildings, P.O. Box 232, Johannesburg.

1905. †Bolus, Mrs. F., B.A., Sherwood, Kenilworth, near Capetown.

1913. Bonn, Adalbert L. M., C.E. (Pres. C, 1913), P.O. Box 204, Lourenco Marques.

1913. Botelho, Lieut. João Baptista, Chief Veterinary Officer, Department of Agriculture, Lourenço Marques.

1912. Bourke, Dr. W., Hanover, C.P.

1906. BOURNE, A. H. J., M.A., Principal, High Schools, Kimberley, Cape.

1913. Bracht, Oscar, P.O. Box 134, Port Elizabeth.

Year of Election.

1902. *Braine, Charles Dimond Horatio, A.M.I.C.E., Devon Pen, Holmdene, Transvaal.
1904. Brammer, Charles, Germiston, Transvaal.
1912. Brauns, H. J. C. E., M.D., Ph.D., M.A., Willowmore, C.P.
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1914. Brierly, James D., Department of Agriculture, Bloemfontein.
1910. Brill, J., Litt.D., L.H.D., Ph.Th.M., Lorothwana, 65, Park Road, Bloemfontein.
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1902. *Brooks, Edwin James Dewdney, C.E., Resident Engineer, Waterworks, Umtata, Cape.
1903. Brown, Alexander, M.A., B.Sc., Professor of Applied Mathematics, South African College, Capetown.
1914. Brown, Rev. Holman, P.O. Box 82, Bulawayo, Rhodesia.
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1912. Brümmer, Rev. Prof. N. J., M.A., B.D., Victoria College, Stellenbosch, Cape.
1907. Brune, Rev. Richard, P.O. Box 41, Kimberley, Cape.
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1902. *Buchan, James, Assistant Resident Engineer, Rhodes Buildings, Bulawayo.
1905. Burroughs, Herbert John, c/o Drawing Office, Engineer-in-Chief's Department, South African Railways, Johannesburg.

1903. Caldecott, W. A., B.A., D.Sc., F.C.S., P.O. Box 67, Johannesburg.
1914. Calder, William J., B.A., 30, Milner Street, Kimberley.
1910. Cameron, Rt. Rev. William Mouatt, M.A., D.D., Coadjutor Bishop of Capetown, 61, Burg Street, Captown.

Year of Election.

1902. *†Campbell, Allan McDowell McLeod, B.A., Resident Engineer, South African Railways, Bandolier Kop, Transvaal.

1908. Carlson, K. A., Forestry Division, Department of Agriculture, Bloemfontein.

1913. Carvalho, José J. d'A., Chief of Naval Services, P.O. Box 262, Lourenço Marques.

1910. Cattell, E. J., Chamber of Commerce, Capetown.

1903. †Cazalet, Percy, c/o Rand Mines, Ltd., The Corner House, Johannnesburg.

1906. *†Champion, Ivor Edward (address wanted).*

1913. Charters, R. H., M.I.C.E., Professor of Civil Engineering, South African School of Mines and Technology, P.O. Box 1383, Johannesburg.

1903. Clark, John, M.A., LL.D., Arderne Professor of English Language and Literature, South African College, Capetown.

1902. *Clarke, W. E. C., M.A., 777, Church Street E., Arcadia, Pretoria.

1903. Cohen, Walter P., F.R.P.S., Hon. Sec., Johannesburg Field and Naturalists' Club, P.O. Box 68, Johannesburg.

1908. Collie, J., Craigwan, 775, Schoeman Street, Arcadia, Pretoria.

1904 Collins, Ernest A. E., 66, Pritchard Street, P.O. Box 723, Johannesburg.

1914. Collins, Louis N. B., P.O. Box 723, Johannesburg.

1906. Collins, M. R., Irrigation Department, P.O. Box 399, Pretoria.

1904. Cooper, Fred W., Public Library, Port Elizabeth, Cape.

1914. Cory, George E., M.A., Professor of Chemistry and Metallurgy, Rhodes University College, Grahamstown.

1904. †Coutts, John Morton Sim, M.D., L.R.C.P., D.P.H., M.R.C.S. Britstown, C.P.

1902. *Cox, Walter Hubert, Royal Observatory, near Capetown.

1909. Crawford, David Chambers, M.A., B.Sc., B.Sc.Agr., Elsenburg, Mulder's Vlei, Cape.

1902. *Crawford, Lawrence, M.A., D.Sc., F.R.S.E. (Vice-President), Professor of Pure Mathematics, South African College, Capetown.

1903. †Cullen, William, M.I.M.M. (General Secretary, 1905-1908), Dynamite Factory, Modderfontein, Transvaal.

1903. Currie, O. J., M.B., M.R.C.S., Claremont, near Capetown.

1913. Da Silva, Colonel Pedro Luiz de Bellegarde, Surveyor-General of Mozambique, P.O. Box 288, Lourenço Marques.

1905. Dale, Hubert, P.O. Box 632, Johannesburg.

1903. Dalrymple, Hon. W., P.O. Box 2927, Johannesburg.

Year of Election.

1913. Damant, E. L., P.O. Box 1176, Johannesburg.
1913. Daniel John, Armley House, 30, Plein Street, Johannesburg.
1910. Davenport, William John, P.O. Box 1049, Johannesburg.
1903. Davies, J. Hubert, M.I.E.E., M.I.Mech.E., A.M.I.C.E., P.O. Box 1386, Johannesburg.
1903. Davis, Frederick H., B.Sc., M.I.E.E., P.O. Box 1934, Johannesburg.
1903. †Davy, Joseph Burtt, F.L.S., F.R.G.S., Burttholm, Vereeniging, Transvaal.
1914. De Kock, Dr. S. M., P.O. Box 321, Bloemfontein.
1913. Delbridge, Wm. J., A.R.I.B.A., P.O. Box 120, Capetown.
1913. Dinham-Peren, A. E. H., De Beers Consolidated Mines, Ltd., Kimberley.
1904. Dobson, Professor J. H., P.O. Box 1176, Johannesburg.
1903. Dodds, William John, M.D., D.Sc., Glencoila, Bellahouston, Glasgow, Scotland.
1909. Dodt, J. J., National Museum, Bloemfontein.
1911. Dornan, Rev. Samuel S., M.A., F.G.S., P.O. Box 510, Bulawayo.
1913. Drake, John Bernard, M.A., 82, Fourth Street, Boksburg North, Transvaal.
1914. Drake, Wilfred, B.Sc., 55, Robinson Street, Beaconsfield, Kimberley.
1908. Drège, Isaac Louis, P.O. Box 148, Port Elizabeth, Cape.
1914. Dreyer, P., Civil Commissioner, Civil Commissioner's Office, Kimberley.
1906. Druce, P. M., M.A., The College, Potchefstroom, Transvaal.
1902. *Drury, Edward Guy Dru, M.D., B.S., D.P.H., Grahamstown, Cape.
1913. Du Toit, Professor A. E., Transvaal University College, Pretoria.
1906. Duerden, James E., M.Sc., Ph.D., A.R.C.S., Professor of Zoology, Rhodes University College, Grahamstown, Cape.
1913. Duirs, M. W., P.O. Box 1176, Johannesburg.
1910. Duncan, A., P.O. Box 1214, Johannesburg.
1904. Duncan, Patrick, C.M.G., Sauer's Buildings, Johannesburg.
1909. Dunkerton, E. B., c/o Messrs. Lennon, Ltd., West Street, P.O. Box 266, Durban, Natal.
1910. Dunn, William J., 48, Corrie Street, Jeppestown, Johannesburg.
1911. †Duthie, George, M.A., F.R.S.E. (Pres. D. 1911), Director of Education, Salisbury, Rhodesia.
1912. Dwyer, E. W., B.A., Forest Department, Port Elizabeth.

Year of Election.

1904. Eaton, William Arthur, 74, St. George's Street, Capetown.

1909. Edwards, Charles J., c/o Messrs. Heynes Mathew & Co., P.O. Box 242, Capetown.

1914. Edwards, Miss, St. Michael's Home, Bloemfontein.

1914. Elsdon-Dew, William, M.I.E.E., F.Am.I.E.E., P.O. Box 4563, Johannesburg.

1910. †Engelenburg, Dr. F. V., Editor, *De Volksstem*, Pretoria.

1910. Erskine, J. K., F.C.S., Willowdene, near Johannesburg.

1905. Evans, Iltyd Buller Pole, M.A., B.Sc., F.L.S., Chief of the Division of Plant Pathology, Department of Agriculture, P.O. Box 1294, Pretoria.

1905. Evans, Maurice Smethurst, Hillcrest, Berea, Durban, Natal.

1905. EVANS, SAMUEL (Vice-President), 79, Nuggett Street, Johannesburg.

1914. Eveleigh, Rev. William, 28, Gladstone Avenue, Kimberley.

1914. Ewing, Sydney E. J., M.I.E.E., M.S.A.I.E.E., P.O. Box 3, Brakpan, Transvaal.

1906. EYLES, FREDERICK, F.L.S., M.L.C., (Pres. C., 1911), Umsasa Farm, P.O. Mazoe, Rhodesia.

1914. Falck, D. G. A., 100, Zastron Street, Bloemfontein.

1905. Farrar, Edward, P.O. Box 1242, Jahonnesburg.

1904. Farrar, Sir George, Bart., P.O. Box 305, Johannesburg.

1914. Farrow, Frederick D., M.Sc., Rhodes University College, Grahamstown.

1905. Feetham, Richard, Sauer's Buildings, c/o Loveday and Market Streets, Johannesburg.

1904. Ferguson, E. W., P.O. Box 1066, Johannesburg.

1913. Fischer, Christian Ludwig, B.A., Maritzburg College School, Pietermaritzburg, Natal.

1913. FitzHenry, Rev. J., Bedford, C.P.

1912. FitzSimons, F. W., F.Z.S., FR.M.S. (Pres. C. 1912), Director, Port Elizabeth Museum, Port Elizabeth.

1902. *Flack, Rev. Francis Walter, M.A., The Rectory, Uitenhage, Cape.

1902. Flanagan, Henry George, F.L.S., Prospect Farm, Komgha, Cape.

1902. *FLINT, Rev. WILLIAM, D.D. (Pres. D, 1910), Wolmunster Park, Rosebank, near Capetown.

1902. *FLOWERS, FRANK, C.E., F.R.G.S., F.R.A.S., P.O. Box 1878, Johannesburg.

1909. Fogarty, Rev. N. W., Director, Government Industrial School, Maseru, Basutoland.

Year of Election.

1907. Foote, J. A., F.G.S., F.E.I.S. (Pres. D, 1913), Government School, Troyeville, Transvaal.
1913. Foote, Mrs. J. A., 12, Beelaerts Street, Troyeville, Johannesburg.
1913. Foote, Miss N., 12, Beelaerts Street, Troyeville, Johannesburg.
1914. Ford, Thurston J., Secretary, De Beers Benefit Society, Kimberley.
1914. Forsyth, Thomas M., M.A., D.Phil., Professor of Philosophy, Grey University College, Bloemfontein.
1914. Forsyth, Mrs. T. M., 77, King Edward Road, Bloemfontein.
1905. Frames, P. R., P.O. Box 148, Johannesburg.
1906. †Frankenstein, Miss Adelia, B.A., 9, Knight Street, Kimberley, Cape.
1902. Fremantle, Henry Eardley Stephen, M.A., F.S.S., M.L.A., Bedwell Cottage, Rosebank, Cape.
1913. Frew, John, P.O. Box 1, Johannesburg.
1904. Friel, Dr. Alfred R., P.O. Box 4299, Johannesburg.
1912. Friel, R., M.A., M.D., P.O. Box 144, Potchefstroom, Transvaal.
1914. Frood, Dr. T. M., Rand Club, Johannesburg.
1902. *Fuhr, Harry A., A.M.I.C.E., Public Works Department, Kingwilliamstown, Cape.
1913. Fuller, Right Rev. John Latimer, M.A., Bishop of Lebombo, P.O. Box 120, Lourenço Marques.
1904. Fuller, W. H., Chairman, Public Library, East London, Cape.

1907. Gairdner, Dr. J. Francis R., 754, Church Street, Arcadia, Pretoria.
1903. Galpin, Ernest Edward, F.L.S., c/o National Bank of South Africa, Ltd., Queenstown, Cape.
1913. Garbutt, Henry William, F.R.A.I., J.P., P.O. Box 181, Bulawayo, Rhodesia.
1902. *Gasson, William, F.C.S., Dutoitspan Road, Kimberley, Cape.
1904. Gellatly, John T. B., M.I.C.E., P.O. Box 37, Bethulie, Orange Free State.
1911. Gibbs, Alfred Ernest, P.O. Box 85, Johannesburg.
1913. Gibson, F. W., P.O. Box 1231, Johannesburg.
1912. Gibson, Harry, J.P., F.S.A.A., P.O. Box 1653, 85, St. George's Street, Capetown.
1902. *Gilchrist, John Dow Fisher, M.A., D.Sc., Ph.D., F.L.S., (General Secretary, 1903-1908), Professor of Zoology, South African College, Capetown.
1903. Gilchrist, W., M.S.A., Mariendahl, Mulder's Vlei, Cape.

Year of Election.

1902. *Gillespie, John, A.M.I.C.E., Railway Construction, by Clanwilliam, C.P.
1910. Ginsberg, Franz, M.P.C., P.O. Box 3, Kingwilliamstown, Cape.
1912. Goddard, Ernest James, B.A., D.Sc., Professor of Zoology, Victoria College, Stellenbosch, Cape.
1913. Goddard, Mrs. E. J., Stellenbosch, C.P.
1902. †Godfrey, Robert, M.A., Pirie Mission Station, Kingwilliamstown, Cape.
1911. Goetz, Rev. E., S.J., M.A., F.R.A.S. (Pres. A, 1911), The Observatory, Bulawayo.
1904. Goffe, Edward, Rand Club, Johannesburg.
1913. Gomez, José Vaz Monteiro, B.Eng., Assistant Electrical Engineer of Ports and Railways, P.O. Box 252, Lourenço Marques.
1914. Goodman, Simon L., F.I.O., P.O. Box 5802, Johannesburg.
1904. Gorges, Edmond Howard Lacam, M.V.O., Secretary for the Interior, Pretoria.
1913. Graça, Capt. Alberto C. de F., Sub-Chefe de Estado Major, Quartel General, Lourenço Marques.
1908. Grant, Charles C., M.A., Education Department, Bloemfontein.
1914. Grant, William F., B.Sc., South African College High School, Capetown.
1907. Gray, Charles Joseph, Mines Department, P.O. Box 401, Pretoria.
1907. Gray, James, F.I.C., P.O. Box 5254, Johannesburg.
1906. Grimmer, Irvine Rowell, Assistant General Manager, De Beers Consolidated Mines, Ltd., Kimberley, C.P.
1912. Gubbins, John Gaspard, B.A., Ottos Hoop, Transvaal.
1913. Gundry, Philip G., B.Sc., Ph.D., A.R.C.S., Professor of Physics, Transvaal University College, Pretoria.
1911. Guradze, Dr. Franz, Vice-Consul for Germany, German Consulate, Capetown.
1905. †Gutsche, Phillipp, M.D., Villa Torrita, Kingwilliamstown, Cape.
1903. Gyde, Charles J., Public Works Department, Capetown.

1904. Haagner, Alwyn K., F.Z.S., Zoological Gardens, Pretoria.
1904. †Haarhoff, Daniel Johannes, J.P., Market Street, Kimberley, Cape.
1902. * **HAHN, PAUL DANIEL,** M.A., Ph.D., (PRESIDENT, 1911, Pres. A, 1903), Jamison Professor of Chemistry and Metallurgy, South African College, Capetown.
1904. Hall, Arthur Lewis, B.A., F.G.S., Geological Survey, P.O. Box 401, Pretoria.
1907. Hall, Carl, A.M.I.C.E., F.G.S., 28, Club Arcade, Durban, Natal

Year of Election.

1910. Halm, Jacob K. E., Ph.D., F.R.S.E., Royal Observatory, Cape.
1907. Hammer, A., 441, Burger Street, Pietermaritzburg, Natal.
1902. *Hancock, H., A.M.I.C.E., P.O. Box 192, Klerksdorp, Transvaal.
1903. †Hancock, Strangman, M.Amer.I.M.E., Kennel Holt, Cranbrook, Kent, England.
1904. Harries, W. M., P.O. Pox 2189, Johannesburg.
1905. Harris, Lionel, M.E., B.Sc., 113, Sivewright Avenue, Doornfontein, P.O. Box 1311, Johannesburg.
1914. Harrison, Frederick, 4, Elsmere Street, Kimberley.
1914. Harvey, Sidney F., P.O. Box 1386, Johannesburg.
1905. Hatchard, John George, F.R.A.S., 3, Harvey Road, Bloemfontein.
1907. Henderson, Rev. James, M.A., Lovedale, Cape.
1914. Henderson, Miss J., c/o Dr. J. B. H. Ruthven, P.O. Box 6253, Johannesburg.
1902. *Henkel, John Spurgeon, Conservator of Forests, Knysna, Cape.
1904. Herdman, G. W., M.A., M.I.C.E., Public Works Department, Pretoria.
1912. Heugh, George William, P.O. Box 1611, Johannesburg.
1911. Hewetson, W. M., M.B., D.P.H., J.P., Wankie, Southern Rhodesia.
1909. Hewitt, John, B.A., Director of the Albany Museum, Grahamstown, Cape.
1905. Heymann, Alexander, M.Ph., M.Ch., M.A., P.O. Box 3427, Johannesburg.
1909. Heymans, Dr. G. M. A., 702, Church Street, Arcadia, Pretoria.
1905. Hintrager, Dr. O. R., Windhuk, German South-West Africa.
1912. Hohmann, E., M.D., Western Road, Port Elizabeth.
1914. Holdsworth, W. J., P.O. Box 1737, Johannesburg.
1913. Holgate, V. G., P.O. Box 1176, Johannesburg.
1905. Holm, Alexander, Department of Agriculture, P.O. Box 434, Pretoria.
1905. Honnold, W. L., P.O. Box 2269, Johannesburg.
1902. *Horne, William James, A.M.I.E.E., Education Department, Pretoria.
1905. Hosking, Charles, Town Engineer's Office, P.O. Box 106, Krugersdorp, Transvaal.
1902. *Hough, Sydney Samuel, M.A., F.R.S., Astronomer Royal, Royal Observatory, near Capetown.
1914. Howitt, A. Gordon, B.Sc., Civil Service Club, Capetown.
1910. Hughes, George Robert, Under-Secretary for Lands, Pretoria.

Year of Election.

1905. †Humphrey, William Alvara, B.A., Ph.D., F.G.S., P.O. Box 401, Pretoria.
1912. Hunt, Donald Rolfe, Sub-Native Commissioner, Secocoeni land, *via* Lydenburg, Transvaal.
1911. Hurtzig, G., Gwelo, Rhodesia.
1904. **HYSLOP, JAMES**, D.S.O., M.B., C.M. (PRESIDENT, 1907), Government Asylum, Pietermaritzburg, Natal.
1913. Hutcheon, James, M.A., F.R.G.S., Rosedale, South African College School, Capetown.

1913. Imperial Government of German South-West Africa, Windhuk, German South-West Africa.
1913. Ingham, William, M.I.C.E., M.I.M.E., Chief Engineer's Office, Rand Water Board, P.O. Box 1703, Johannesburg.
1907. Innes, Hon. Justice Sir James Rose-, K.C.M.G., B.A., LL.B., High Court of Appeal, Capetown.
1902. *INNES, ROBERT THORBURN AYTON, F.R.A.S., F.R.S.E. (GENERAL SECRETARY, 1909-1912), Union Observatory, Johannesburg.
1905. Innes, Mrs. R. T. A., Union Observatory, Johannesburg.
1908. Institute of Government Land Surveyors, Cape of Good Hope Savings Bank Buildings, Capetown.
1904. Irvine, Dr. L. G., P.O. Box 320, Johannesburg.

1914. Jacot, Edouard, B.A., Lecturer in Physics, South African College, Capetown.
1904. Jagger, J. W., F.S.S., M.L.A., P.O. Box 258, Capetown.
1903. Jameson, Rt. Hon. Sir Leander Starr, Bart., C.B., M.D., L.R.C.S., L.S.A., c/o British South Africa Co., 2, London Wall Buildings, London, E.C., England.
1911. Jarvis, E. M., Jelf Estate, Umtali, Rhodesia.
1910. Jeffrey, John, Standard Bank, P.O. Box 57, Capetown.
1903. Jennings, Hennen, 2221, Massachusetts Avenue, Washington, U.S.A.
1913. Jensen, Axel Emil, 36, Maddison Square, Jeppestown, Johannesburg.
1903. Jeppe, J., P.O. Box 311, Johannesburg.
1912. Johnson, Miss Alta, New Street, Wellington, C.P.
1903. Johnson, Edward H., P.O. Box 134, East Rand, Johannesburg.
1912. Johnson, George Lindsay, M.A., M.D., 5 and 6, Castle Mansions, Eloff Street, Johannesburg.
1909. JOHNSON, W., L.R.C.P., L.R.C.S. (Vice-President), 3, Link Road, Bloemfontein.
1914. Johnson, W. S., M.A., Professor of English, Grey University College, Bloemfontein.

Year of Election.

1911. Jones, Ernest Hope, Control and Audit Office, Pretoria.
1913. Jordaan, David J. M., Principal, Normal Training Centre, Normal College, Heidelberg, Transvaal.
1911. Joubert, M. J., B.Sc.Agr., Department of Agriculture, Bloemfontein.
1905. Junod, Rev. Henri A., P.O. Box 21, Lourenço Marques.
1903. JURITZ, CHARLES FREDERICK, M.A., D.Sc., F.I.C. (GENERAL SECRETARY, 1910-1914, Pres. B, 1909), Government Analyst, Government Chemical Laboratory, Department of the Interior, Capetown.
1912. Juritz, Walter Daniel Christian, B.A., A.M.I.E.E., Villa Marina, Beach Road, Sea Point, Capetown.

1907. KANTHACK, FRANCIS EDGAR, M.I.C.E., M.I.M.E., Director of Irrigation, P.O. Box 444, Pretoria.
1902. Kaufmann, Siegmund, M.D., Middelburg, C.P.
1912. Kehoe, D., M.R.C.V.S., P.O. Box 593, Pretoria.
1903. Kent, Professor Thomas Parkes, M.A., South African College, Capetown.
1914. Kelly, Rev. A. D., M.A., Cathedral Cottage, Bloemfontein.
1905. King, Austin, Director of Mines, Macequeçe, Portuguese East Africa.
1904. King, R. P. H., P.O. Box 365, Johannesburg.
1914. Kingon, Rev. John Robert Lewis, M.A., F.L.S., Somerville, Inxu Drift, *via* Maclear, East Griqualand.
1913. Kipping, Vernon, 316, Minnaar Street, Pretoria.
1913. Kirkland, John Wilkinson, M.Am.I.E.E., President, S.A.I.E.E., P.O. Box 1905, Johannesburg.
1907. Kirkman, John, Esperanza, Natal.
1906. Kirkman, Hon. Thomas, Croftlands, Esperanza, Natal.
1904. Kisch, C. H. M., P.O. Box 668, Johannesburg.
1905. Kitching, Charles McGowan, B.A., M.D., B.S., 6, Hof Street, Capetown.
1902. *†Knapp, Arthur D., Chikondi Estate, Neno Post Office, British Central Africa.
1902. Kolbe, Rev. Frederick Charles, B.A., D.D., St. Mary's Presbytery, Capetown.
1903. Kotze, Robert W. N., B.A., P.O. Box 1132, New Law Courts, Johannesburg.
1903. Kynaston, H., M.A., F.G.S., P.O. Box 401, Pretoria.

1911. Lake, Henry Lawrence, Government School, Dynamite Factory, Modderfontein, Transvaal.
1913. Landau, Nathan, P.O. Box 1382, Johannesburg.
1914. Lange, Hon. Justice Johannes H., LL.B., Judge's Chambers, Kimberley.
1913. Lansley, William G., P.O. Box 1485, corner Main and Donelly Streets, Kenilworth, Johannesburg.

Year of Election.

1903. Laschinger, E. J., B.A., P.O. Box 149, Johannesburg.
1903. Lavenstein, L. H., P.O. Box 4480, Johannesburg.
1911. Lawn, James Gunson, A.R.S.M., M.I.M.E., F.G.S., Johannesburg Consolidated Investment Co., Ltd., P.O. Box 231, Johannesburg.
1910. Leask, Tom., Jun., P.O. Box 3, Klerksdorp, Transvaal.
1904. Leech, Dr. John Richard, "Greystones," Sir Lowry's Pass, C.P.
1904. Leeds, R. Q., P.O. Box 928, Johannesburg.
1903. Legat, C. E., P.O. Box 434, Pretoria.
1907. Lehfeldt, Robert A., B.A., D.Sc. (General Treasurer, 1909-1910), Professor of Physics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1908. Leighton, James, F.R.H.S., P.O. Box 86, Kingwilliamstown, Cape.
1908. Leiter, Miss Susan B., M.A., Huguenot College, Wellington, Cape.
1914. Leith, Miss A. M., B.A., Eunice High School, Bloemfontein.
1902. *Lenz, Otto, P.O. Box 92, Johannesburg.
1903. Leslie, T. N., C.E., F.G.S., P.O. Box 23, Vereeniging, Transvaal.
1908. Leviseur, M., Bloemfontein.
1903. Lewis, Leon, P.O. Box 617, Johannesburg.
1905. Lewis Mrs. Helen R., P.O. Box 617, Johannesburg.
1910. Littlewood, E. T., M.A., B.Sc., Boys' High School, Wynberg, Cape.
1903. Logeman, William H., M.A., Professor of Physics, Grey University College, Bloemfontein.
1902. *Logeman, Professor William Sybrand, L.H.C., B.A., South African College, Capetown.
1903. Lorentz, Henri, P.O., Box 55, Johannesburg.
1903. Loubser, M. M., Port Elizabeth, Cape.
1902. Lounsbury, Charles Pugsley, B.Sc., F.E.S., Chief of the Division of Entomology, Department of Agriculture, Pretoria.
1905. Lucas, J. C., P.O. Box 537, Johannesburg.
1902. *Lunt, Joseph, D.Sc., F.I.C., Royal Observatory, near Capetown.
1914. Lyle, James, M.A., Grey College School, Bloemfontein.
1902. *Lynch, Major F. S., J.P., Kimberley Waterworks Co., Ltd., Kimberley, Cape.

1908. Maasdorp, Hon. Justice Sir Andries F., 40, Elizabeth Street, Bloemfontein.
1905. McArthur, Duncan Campbell, M.R.C.S., L.R.C.P., District Surgeon, Clanwilliam, C.P.

Year of Election.

1905. McCallum, William, P.O. Box 4889, Johannesburg.
1909. Macdonald, G., M.A., Normal Training College, Bloemfontein.
1902. *McEwen, T. S., A.M.I.C.E., South African Railways, Capetown.
1908. Macfadyen, William Allison, M.A., LL.D., Professor of Philosophy, Transvaal University College, Pretoria.
1909. McFeggans, Alexander, Umtata, Cape.
1910. McGaw, James, P.O. Box 4280, Johannesburg.
1914. McGregor, Rev. Andrew Murray, M.A., B.D., Blommestein, Three Anchor Bay, Capetown.
1910. Macgregor J. C., Government Secretary, Bechuanaland Protectorate, Mafeking, C.P.
1912. Macintosh, William, "Jutland," Park Drive, Port Elizabeth.
1913. Mackay, James Dalziel Dougall, Standard Bank of S.A., Ltd., P.O. Box 40, Capetown
1904. McKenzie, Archibald, M.D., C.M., M.R.C.S., Glen Lyon, Berea, Durban, Natal.
1903. Mackinlay, Andrew Grieve, C.E., M.S.I., District Engineer, South African Railways, Ladysmith, Natal.
1905. McLaren, W. A., P.O. Box 1209, Johannesburg.
1914. Macmillan, William M., B.A., West Hill, Grahamstown.
1902. *Macmuldrow, W. G. P., P.O. Box 95, Salisbury, Rhodesia.
1913. Macpherson, H. W., P.O. Box 4252, Johannesburg.
1908. Macrae, H. J., P.O. Box 817, Johannesburg.
1905. Madge, Captain Charles A., P.O. Box 4303, Johannesburg.
1914. Maitland, A. Gibb, Government Geologist of Western Australia, Bon Accord, 3, Ventnor Terrace, Perth, South Australia.
1910. Malan, Hon. François Stephanus, B.A., LL.B., M.L.A., P.O. Box 450, Pretoria.
1912. †Malherbe, D. F. du Toit, M.A., Ph.D., Professor of Chemistry, Transvaal University College, Pretoria.
1914. Malherbe, D. F., B.A., Ph.D., Professor of Modern Languages, P.O. Box 424, Bloemfontein.
1904. Malherbe, H.L., P.O. Box 208, Pretoria.
1902. Mally, Charles William, M.Sc., Division of Entomology, Department of Agriculture, Capetown.
1909. Marchand, Rev. Bernard P. J., B.A., Clairvaux, Rondebosch, Cape.
1914. Mardall, W. H., Johannesburg Consolidated Investment Co., Johannesburg.
1904. Marks, Samuel, Hatherley Buildings, P.O. Box 379, Pretoria.
1914. Marloth, Mrs. Marion M., Ellerborn, 7, Park Road, Capetown.

Year of Election.

1902. *MARLOTH, Professor RUDOLF, M.A., Ph.D. (PRESIDENT, Pres. B, 1903), P.O. Box 359, Capetown.
1907. Marriott, William Edward, Benvie, P.O. York, Natal.
1904. Marshall, W. S., P.O. Box 3055, Johannesburg.
1905. Martini, J. D., P.O. Box 34, Beira, Portuguese East Africa.
1913. Martins, P. van der Merwe, B.A., Education Department, Volksrust, Transvaal.
1912. Mathew, George Porter, M.A., M.D., B.S., L.R.C.P., F.R.C.S., 45, Western Road, Port Elizabeth.
1911. Maufe, Herbert Brantwood, B.A., F.G.S., P.O. Box 168, Bulawayo.
1913. Maury, Carlotta J., Ph.D., Hugnenot College, Wellington, Cape.
1902. Melle, G. J. McCarthy, M.B., C.M., Robertson, Cape.
1903. Mellor, Edward T., D.Sc., F.G.S., Geological Survey Office, P.O. Box 401, Pretoria.
1902. *Menmuir, R. W., A.M.I.C.E., National Mutual Buildings, Church Square, Capetown.
1914. Mesham, Paul, M.Sc., Natal University College, Pietermaritzburg, Natal.
1902.*† **METCALFE, Sir CHARLES**, Bart., M.I.C.E. (PRESIDENT, 1904 Pres. C, 1903), 21, Pall Mall, London, S.W., England.
1905. Miller, Allister M., The Swaziland Corporation, Ltd., Mbabane, Swaziland.
1911. Miolée, Willem Frederik, Consul for the Netherlands, P.O. Box 362, Bulawayo.
1910. Moffat, Henry Alford, B.A., F.R.C.S., L.R.C.P., Norwich Union Buildings, St. George's Street, Capetown.
1912. Moll, Dr. A. M., Kerk and Eloff Streets, Johannesburg.
1904. Molyneux, A. J. C., F.G.S., F.R.C.S., (Pres. B, 1911), P.O. Box 526, Bulawayo, Rhodesia.
1903. Morice, Advocate George T., B.A., K.C., P.O. Box 1275, Pretoria.
1912. Mortimer, Dr. W., M.R.C.S., Potchefstroom, Transvaal.
1902. ***MUIR, THOMAS**, C.M.G., M.A., LL.D., F.R.S., F.R.S.E., (PRESIDENT, 1910), Education Department, Capetown.
1913. Munro, James, P.O. Box 19, Lourenço Marques.
1904. Murray, George Alfred Everett, M.D., F.R.C.S., L.R.C.P., P.O. Box 105, Johannesburg.
1913. Murray, Myles T., M.Sc., P.O. Box 1176, Johannesburg.
1911. Musselwhite, Rev. E. W. H., B.A., Zonnebloem College, Capetown.

1910. Nauta, Prof. Renicus D., South African College, Capetown.
1905. Neilson, A. M., Manager, Safco Fertilizers Co., Umbilo, Natal.
1914. Newhall, Percy M., B.Sc., P.O. Box 485, Johannesburg.

Year of Election.

1913. Nicholas, Samuel J., P.O. Box 829, Johannesburg.
1902. *Nicholson, Colonel George Taylor, M.I.C.E., Resident Engineer Docks, Capetown.
1904. Nixon, Edward John, M.R.C.S., L.R.C.P., P.O. Box 57, Heidelberg, Transvaal.
1910. Noaks, E., M.A., "The Croft," Morgenrood Road, Wynberg, Cape.
1902. Nobbs, Eric Arthur, Ph.D., B.Sc., F.R.H.S., Director of Agriculture, Salisbury, Rhodesia.
1913. Nicol, John, M.R.C.V.S., Government Veterinary Surgeon, Kingwilliamstown.

1905. †Oats, Francis, F.G.S., Director, De Beers Consolidated Mines, Ltd., Kimberley, Cape Province.
1908. O'Connor, James, Railway Hotel and Stores, Ashton, Cape.
1907. Ogg, Alexander, M.A., B.Sc., Ph.D., (Pres. A) Professor of Physics and Applied Mathematics, Rhodes University College, Grahamstown, Cape.
1904. O'Reilly, James Paul, P.O. Box 53, Johannesburg.
1914. Orford, Rev. Canon Horace W., M.A., Ficksburg, Orange Free State.
1906. Orpen, Joseph Millerd, Mon Asile, 43, St. Mark's Road, East London.
1902. *Orr, John, B.Sc., M.I.C.E., Professor of Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1913. Orr, Mrs. J. c/o Professor Orr, P.O. Box 1176, Johannesburg.
1904. Osborn, Philip B., P.O. Box 1242, Johannesburg.

1905. †Paisley, William, M.B., B.Ch., P.O. Box 127, Queenstown, Cape.
1908. Palmer, W. Jarvis, B.Sc.A., P.O. Box 2567, Johannesburg
1905. Papenfus, H. B., K.C., P.O. Box 5155, Johannesburg.
1903. Park, Sir Maitland H., Kt., M.A., LL.D., 1 Montrose Avenue, Orangezicht, Capetown.
1914. Parry, John, P.O. Box 220, Kimberley.
1912. Paterson, Mrs. T. V., Redhouse, near Port Elizabeth.
1902. *†Pattrick, C. B., A.M.I.C.E., 6 Cottesloe, Auckland Park, Johannesburg.
1903. Payne, Albert E., A.R.S.M., P.O. Box 15, Langlaagte, Transvaal.
1913. Pearson, Henry Harold Welch, M.A., Sc.D., F.L.S. (Pres. C, 1910), Bolus Professor of Botany, South African College, Capetown.
1913. Pepulim, Dr. D., P.O. Box 704, Lourenço Marques.
1913. Perez, Manoel A. Jr., Chief Assistant, Observatorio Campos Rodriguez, Lourenço Marques.

Year of Election.

1907. Péringuey, Louis, D.Sc., F.E.S., F.Z.S., Director South African Museum, Capetown.
1910. †Perold, Abraham I., B.A., Ph.D., Principal, Government School of Agriculture, Elsenburg, Mulder's Vlei, Cape.
1912. Perrins, George Richard, "Grange," 106, Cape Road, Port Elizabeth.
1905. Petersen Carl Olief, P.O. Box 4938, Johannesburg.
1904. PETTMAN, Rev. CHARLES, Wesleyan Parsonage, Chapel Street, Kimberley, Cape Province.
1912. Pickstone, Harry Ernest Victor, Lekkerwijn, Groot Drakenstein, Cape Province.
1903. Pim, Howard, B.A., F.C.A. (GENERAL TREASURER, 1906-1907), P.O. Box 1331, Johannesburg.
1914. Pooley, John, F.S.A.A., F.R.C.I., P.O. Box 189, Kimberley.
1905. Pott, Mrs. R., P.O. Box 413, Pretoria.
1905. POTTS, GEORGE, M.Sc., Ph.D., (Pres. C), Professor of Botany, Grey University College, Bloemfontein.
1902. *Price, Sir Thomas R., K.C.M.G., P.O. Box 1038, Johannesburg.
1913. Provay, Giuseppe, Chief Electrical Engineer of Harbours and Railways, P.O. Box 1479, Lourenço Marques.
1910. Purcell, William Frederick, M.A., Ph.D., C.M.Z.S., Bergvliet, Diep River, Cape Division.
1906. PYM, FRANK ARTHUR OAKLEY, Public Museum, P.O. Box 51, Kingwilliamstown, Cape.

1902. Quinan, Kenneth B., Chemist and Engineer, Cape Explosive Works, Somerset West, Cape.
1903. Quinn, J. W., J.P., M.L.A., P.O. Box 1454, Johannesburg.

1903. Rattray, George, M.A., D.Sc., F.R.G.S., Selborne College, East London, Cape.
1906. Reid, Alexander William, M.D., C.M., Medical Officer of Health, Kimberley, Cape.
1902. *REID, ARTHUR HENRY, F.R.I.B.A., F.R.San.I., P.O. Box 120, Capetown.
1909. Reid, F. Murray, Morija, Basutoland.
1914. Reid, Walter, F.R.I.B.A., P.O. Box 746, Johannesburg.
1902. ***REUNERT, THEODORE**, M.I.C.E., M.I.M.E., (PRESIDENT, 1905), P.O. Box 92, Johannesburg.
1905. Reunert, Mrs. Theodore, P.O. Box 92, Johannesburg.
1907. Reuter, Rev. Fritz L., Medigen, P.O. Duivel's Kloof, *via* Pietermaritzburg, Natal.
1903. †Reyersbach, Louis J., c/o Messrs. Wernher, Beit & Co., 1, London Wall Buildings, London, E.C.
1913. Reyneke, Andries Adriaan Louw, B.A., Wilgenhof, Stellenbosch, Cape Province.
1913. Reyneke Rev. Jacobus C., De Pastorie, Cradock.

Year of Election.

1904. Richardson, Sidney William Franklin, M.B., B.S., B.Sc., L.R.C.P., F.R.C.S., 2, Wale Street, Capetown.
1909. Rindl, Max, Ing.D., Professor of Chemistry, Grey University College, Bloemfontein.
1903. Ritchie, William, M.A., (Pres. D), Professor of Latin and Classical Philosophy, South African College, Capetown.
1903. Robb, A. Moir, M.A., Normal College, Pretoria.
1902. ***ROBERTS, ALEXANDER WILLIAM**, D.Sc., F.R.A.S., F.R.S.E. (Pres. A 1908; PRESIDENT, 1913), Lovedale, Cape Province.
1914. Roberts, John Lloyd, P.O. Box 577, Kimberley.
1913. Roberts, Rev. Noel, The Vicarage, Pietersburg, N. Transvaal.
1914. Roberts, Thomas S., P.O. Box 572, Kimberley.
1909. Robertson, C.C., M.F., c/o Forest Department, Pretoria.
1906. Robertson, John, P.O. Box 138, Bloemfontein.
1903. Robson, T. Conyers, Salisbury Buildings, Von Brandis Square, Johannesburg.
1902. Rogers, Arthur William, M.A., Sc.D., F.G.S. (Pres. B 1910), South African Museum, Capetown.
1902. *Rose, James Wilmot Andreas, M.I.C.E., Patrys Vlei Farm, Stellenbosch.
1905. †Rose, John George, F.C.S., Government Chemical Laboratory, Capetown.
1913. Rosenthal, R., P.O. Box 1537, Johannesburg.
1912. Roseveare, W.N., M.A., Professor of Mathematics, Natal University College, Pietermaritzburg.
1914. Ross, John, P.O. Box 636, Kimberley.
1903. Rouliot, G., 37 bis, Rue de Villejust, Paris, France.
1902. *Runciman, William, M.L.A., Simonstown, Cape.

1903. Saner, C. B., A.I.M.E., P.O. Box 53, Krugersdorp, Transvaal.
1913. Santa Barbara, Juvenal Elvas, Postmaster-General of Mozambique, General Post Office, Lourenco Marques.
1902. *Scaife, Thomas Earle, M.I.C.E., P.O. Box 23, Irrigation Department, Capetown.
1904. Schlesinger, Dr. J., P.O. Box 1829, Johannesburg.
1902. *Schönland, Selmar, M.A., Ph.D., F.L.S., C.M.Z.S., (Pres. C., 1908). Professor of Botany, Rhodes University College, Grahamstown, Cape.
1913. School of Agriculture, Cedara, Natal.
1913. School of Agriculture and Experimental Farm, Glen, Orange Free State.
1913. School of Agriculture and Experimental Station, Grootfontein, Middelburg, Cape Province.

Year of Election.

1913. School of Agriculture, Elsenburg, Mulder's Vlei, Cape Province.

1913. School of Agriculture and Experimental Farm, Potchefstroom, Transvaal.

1914. Schreiner, Hon. Senator William Philip, M.A., M.L., South African Chambers, Capetown.

1903. Schumacher, R. W., P.O. Box 149, Johannesburg.

1902. SCHWARZ, ERNEST H. L., A.R.C.S., F.G.S., (Pres. B. and C., 1908), Professor of Geology, Rhodes University College, Grahamstown, Cape

1905. Sellar, John Nicol, M.L.A., P.O. Box 3102, Johannesburg.

1912. Seruya, Salomon, Vice-Consul for Portugal, P.O. Box 5633, Johannesburg.

1912. Shand, Samuel James, Ph.D., D.Sc. Professor of Geology, Victoria College, Stellenbosch, Cape.

1903. Shanks, Robert, 10, Graf Street Johannesburg.

1902. *Shores, J. W., C.M.G., M.I.C.E., Rutland, Scottsville, Pietermaritzburg, Natal.

1911. Simons, Stefanus Johannes Biesman, B.A., Leiden House, Census Street, Capetown.

1909. Sloley, Sir Herbert, K.C.M.G., Resident Commissioner, Maseru, Basutoland.

1914. Smail, William M., M.A., Professor of Latin, Rhodes University College, Grahamstown.

1902. *Smartt, Hon. Sir Thomas William, K.C.M.G., L.R.C.S.I., L.K.Q.C.P.I. M.L.A. Glen Bân, Stellenbosch, Cape.

1906. Smith, Frank Braybrooke Secretary for Agriculture, Union Buildings, Pretoria.

1912. Smith, George William, A.M.I.C.E., 11, Constitution Hill, Port Elizabeth.

1903. Smith, James, M.A., Normal College, Capetown.

1906. Smuts C., P.O. Box 1088, Johannesburg.

1905. Smuts, Hon. Jan C., B.A., LL.B., Minister of Finance, P.O. Box 1081, Pretoria.

1914. Smyth, Right Rev. Bishop William E. M.A., M.B., c/o English Church House, 61, Burg Street, Capetown.

1903. Solly, Mrs. Julia F., Knor Hoek, Sir Lowry's Pass, Cape.

1903. Solomon, Hon. Justice Sir W. H., High Court of Appeal, Capetown.

1908. Somerville, A. J., M.A., College House, Graaff-Reinet, Cape.

1910. †Soutter, John Lyall, Arcadia, Pretoria.

1911. Speck, Frederick, Temple Court, Eloff St Johannesburg.

1913. Spencer, George Ross, L.D.S., Public Library Buildings, Kingwilliamstown.

1906. †Spencer, Dr. Henry Alexander, M.R.C.S., L.R.C.P., Middelburg, Transvaal.

Year of Election.

1905. Sperryn, Arthur James, J.P., P.O. Box 1, Ermelo, Transvaal.
1903. Spilhaus, William, c/o Messrs. W. Spilhaus & Co., Strand Street, Capetown.
1913. Stafford, Miss Susan, M.A., Huguenot College, Wellington, Cape Province.
1910. Stainthorpe, Thomas William, A.M.I.C.E., P.O. Box 399, Pretoria.
1905. Stallard, C. F., K.C., P.O. Box 5156, Johannesburg.
1905. STANLEY, GEORGE HARDY, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., (Pres. B), Professor of Metallurgy and Assaying, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1905. Starkey, Samuel, Assistant General Manager's Office, System C, South African Railways, Johannesburg.
1904. STEAD, ARTHUR, B.Sc., F.C.S., School of Agriculture, Grootfontein, Middelburg, Cape Province.
1912. Stead, William Godly Stockdale, P.O. Box 307, Port Elizabeth.
1908. Steedman, Miss E. C., M.A., Gando Farm, Gwelo, Southern Rhodesia.
1913. Stephen, Alexander, M.A., P.O. Box 51, Volksrust, Transvaal.
1903. Stevens, J. D., P.O. Box 1782, Johannesburg.
1909. Stewart, G. A., City Engineer, Bloemfontein.
1905. Strollreither, G. D., M.E., P.O. Box 1156, Johannesburg.
1905. Stoneman, Miss Bertha, D.Sc., Huguenot College, Wellington, Cape Province.
1902. *Stott, Clement H., F.G.S., M.S.A., P.O. Box 7, Pietermaritzburg, Natal.
1904. Struben, A. M. A., A.M.I.C.E., P.O. Box 1228, Pretoria.
1906. Stuart, James, Native Affairs Department, Pietermaritzburg, Natal.
1906. Stucke, W. H., P.O. Box 2271, Johannesburg.
1907. Sutton, Hon. Sir George Morris, K.C.M.G., Fair Fell, Howick, Natal.
1904. Syfret, S. B., B.A., M.B., B.C., Main Road, Mowbray, near Capetown.

1905. †Tannahill, Thomas Findlay, M.D., C.M., D.P.H., Queenstown, Cape.
1913. Tasker, Percival S., A.M.I.C.E., P.O. Box 204, Lourenço Marques.
1909. Teasdale, Miss Emma L., Government School, Maraisburg, Transvaal.
1913. Teixeira, Lieut. Augusto D'Almeida, Observatorio Campos Rodrigues, Lourenço Marques.

Year of Election.

1906. Tennant, Sydney Dennison, P.O. Box 132, Ermelo, Transvaal.
1904. ***THEILER, Sir ARNOLD**, K.C.M.G., D.Sc., (PRESIDENT, 1912), Director of Veterinary Research, P.O. Box 593, Pretoria.
1903. Thomas, Walwyn, B.C., M.B., B.A., 2, Greenham Villas, Annandale Street, Capetown.
1902. *Thompson, William Wardlaw, F.Z.S., Kimberley Cottage, Kalk Bay, Cape.
1913. Thomson, Samuel C. A., P.O. Box 228, Johannesburg.
1902. Thomson, William, M.A., B.Sc., LL.D., F.R.S.E., University Offices, Queen Victoria Street, Capetown.
1903. Thorne, Sir William, Kt., Capetown.
1910. Thornton, Russel William, Principal, Government School of Agriculture, Grootfontein, Middelburg, Cape.
1903. Teitz, Heinrich C. J., M.A., Ph.D., Buona Vista, Burham Road, Observatory Road, near Capetown.
1908. Tooke, W. Hammond (Pres. F 1908), P.O. Box 30, Grahamstown, Cape.
1902. *Townsend, Stephen Frank, C.E., Rhodesia Railways, Ltd., Bulawayo, Rhodesia.
1910. Traill, David, M.A., M.B., Ch.M., B.Sc., Railway Medical Officer, Beaufort West, Cape.
1910. Trollip, W. L., Office of the Hon. the Administrator of the Cape Province, Capetown.
1906. Troup, James Macdonald, M.B., Ch.B., L.S.A., 230, Esselen Street, Sunnyside, Pretoria.
1903. Tucker, William Kidger, C.M.G., P.O. Box 9, Johannesburg.
1902. *Tudhope, Alfred Dryden, M.I.C.E., Office of the Assistant General Manager of Railways, Capetown.
1906. TYERS, F. G., M.A., The College, P.O. Box 93, Potchefstroom, Transvaal.

1912. Van der Lingen, Jan Stephanus, B.A., P.O. Box 59, Kroonstad, Orange Free State.
1909. Van der Merwe, C. P., Division of Entomology, Department of Agriculture, Pretoria.
1910. VAN DER RIET, BERTHAULT DE ST. JEAN, M.A., Ph.D., (Pres. B, 1912), Professor of Chemistry, Victoria College, Stellenbosch, Cape.
1904. Van der Sterr, W. C., P.O. Box 1066, Johannesburg.
1913. Van Riel, Miss Johanna M., Huguenot College, Wellington, Cape Province.
1903. Vaughan, J. A., P.O. Box 1132, Johannesburg.
1913. Von Hafe, João Henrique (Pres. A, 1913), Director of Railways, Lourenço Marques.

Year of Election.

1903. Von Lindequist, His Excellency Baron, Kurfurtendomm, 225, II Berlin, W., Germany.

1903. Von Oppell, Otto Karl Adolf, Department of Lands, Pretoria.

1912. Wager, Horace Athelstan, A.R.C.S., Professor of Botany and Zoology, Transvaal University College, Pretoria.

1913. Wahl, R. Owen, Grootfontein School of Agriculture, Middelburg, Cape Province.

1912. Walker, James, M.R.C.V.S., P.O. Box 593, Pretoria.

1902. Walker, Rev. Thomas, M.A., LL.D., Litt.D., Professor of Mental and Moral Philosophy, Victoria College, Stellenbosch, Cape.

1902. *Waller, A. H., A.M.I.C.E., F.R.Met.Soc., Assistant Engineer, Beira and Mashonaland Railways, Beira.

1902. *Walsh, Albert (General Treasurer, 1910-14), P.O. Box 39, Capetown.

1913. Walsh, Lionel Henry, Brackley, Kenilworth, Cape.

1914. Wark, Rev. David, M.A., The Manse, Woodley Street, Kimberley.

1907. Warren, Ernest, D.Sc., Professor of Zoology, Natal University College, Pietermaritzburg, Natal.

1906. Watermeyer, Frederick Stephanus, P.O. Box 973, Pretoria.

1902. *Watkins, Arnold Hirst, M.D., M.R.C.S., M.L.A., (Pres. D, 1906), Ingle Nook, Kimberley.

1906. Watkins-Pitchford, Wilfred, M.D., F.R.C.S., D.P.H., Government Laboratories, Johannesburg.

1914. Watson, Thomas H., M.S.A.I.E.E., P.O. Box 1719, Capetown.

1906. Watt, Dugald Campbell, M.D., 131, Pietermaritzburg St., Pietermaritzburg, Natal.

1912. Way, William Archer, M.A. (Pres. D, 1912), Grey Institute, Port Elizabeth.

1914. Webb, George A., A.I.E.E., M.S.A.I.M.E., M.S.A.I.E.E., M.S.A., P.O. Box 3136, Johannesburg.

1902. *Webb, H. H., M.I.M.M., 8, Old Jewry, London, E.C.

1911. Welch, Rev. Sidney Read, B.A., D.D., Ph.D., St. Mary's, Bouquet Street, Capetown.

1903. Wessels, Hon. Justice Sir J. W., B.A., LL.B., Pretoria.

1902. White, Miss Francis M., Trescoe, Cornwall Place, Wynberg, near Capetown.

1902. *White, Franklin, M.I.M.M., P.O. Box 617, Sydney, New South Wales.

1910. White, H. A., Roodepoort Central Deep, P.O. Box 114, Roodepoort, Transvaal.

1902. White, Miss Henrietta Mary, B.A., Trescoe, Cornwall Place, Wynberg, near Capetown.

Year of Election.

1905. White, Maurice, M.A., Education Department, Volksrust, Transvaal.
1902. *White-Cooper, William, M.A., F.R.I.B.A., P.O. Box 11, Cradock, Cape Province.
1905. Whitton, James Reid, Principal, Normal College, Capetown.
1909. Whitworth, Walter S., Koffyfontein Diamond Mine, Orange Free State.
1910. Wiener, Ludwig, F.R.G.S., Riebeek Street, P.O. Box 365, Capetown.
1904. Wilhelm, A. R. A., M.B., C.M., Barkly East, Cape.
1904. Wilkinson, J. A., M.A., F.C.S., Professor of Chemistry, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1910. Wille, Friedrich Adolf, M.D., Ch.B., D.P.H., 11, Derby Road, Bertrams, Johannesburg.
1912. Willet, J. A., Laurence Street, Port Elizabeth.
1912. Willey, E. A., L.D.S., Potchefstroom, Transvaal.
1902. *WILLIAMS, ALPHEUS FULLER, B.Sc., (Vice-President), Mining Engineer, De Beers Consolidated Mines, Ltd., Kimberley, Cape.
1912. Williams, Cornelius, B.Sc., A.R.C.S., Government School of Agriculture, Cedara, Natal.
1902. Williams, Prof. D., B.Sc., Rhodes University College, Grahamstown, Cape.
1902. ***WILLIAMS, GARDNER F.**, M.A., LL.D. (PRESIDENT, 1906), 2201, R. Street, N.W. Washington, D.C., U.S.A.
1903. WILMAN, MISS M., McGregor Memorial Museum, Kimberley, Cape.
1903. †Wilson, Arthur Marius, M.D., B.S., L.R.C.P., M.R.C.S., Jesmond House, Hof Street, Capetown.
1909. Wilson, Alfred William, P.O. Box 24, Langlaagte, Transvaal.
1909. Windram, James Thomas, P.O. Box 3547, Johannesburg.
1913. Winscom, Miss L. E., c/o Mrs. Kempe, Schmidt Street, Observatory, Johannesburg.
1912. Winter, Rev. Johannes August, Onverwacht, P. O. Sekukuni, District Lydenburg, Transvaal.
1903. †Winterton, Albert Wyle, F.C.S., Lemoenfontein, near Beaufort West, Cape.
1906. WOOD, H. E., M.Sc., F.R.Met.S. (GENERAL SECRETARY 1913-1914), Union Observatory, Johannesburg.
1905. †Wood, James, M.A. P.O. Box 2, Kingwilliamstown, Cape.
1903. Wood, John, P.O. Box 363, East London, Cape.
1907. Wood, John Medley, D.Sc., Botanic Gardens, Durban, Natal.

Year of Election.

1904. Young, Professor Robert B., M.A., D.Sc., F.R.S.E., F.G.S., (Pres. B, 1913), P.O. Box 1176, Johannesburg.

1910. Young, T., M.A., Boys' High School, Sea Point, Cape.

1911. Zealley, Arthur E. V., A.R.C.S., F.G.S., Bulawayo

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