REPORT

OF THE

FOURTEENTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

MARITZBURG,

1916.

JULY 3—8.

CAPE TOWN:
PUBLISHED BY THE ASSOCIATION.

1917.

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Cape Town
Townshend, Taylor and Snashall, Printers,
1917.

OFFICERS AND COUNCIL, 1915-1916.

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HIS MAJESTY THE KING.

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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.")

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S.A. Medal Fund.

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W. THOMSON, M.A., B.Sc., LL.D., F.R.S.E.

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As amended at the Fourteenth Annual Meeting at Maritzburg, 1916.*]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) Institutions, Societies, Government Departments and Public Bodies are eligible as "Institutional Members."

(*c*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), (c) Institutional Members, and (d) Temporary Members, elected for a session, hereinafter called "Associates."

(*d*) Members, Institutional Members, and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*e*) The Council shall have the power, by a two-thirds vote, to remove the name of a member of any class whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission,* their Annual Subscription.

(*c*) Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary members; and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.

(*d*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*e*) Members and Institutional Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Ten Pounds.

(*b*) Ordinary and Institutional Members shall pay, on election, an Annual Subscription of One Pound. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Five Pounds in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Session shall be Ten Shillings.

V.—MEETINGS.

The Association shall meet in Session Annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries, the General Treasurer, and the Editor of the publications of the Association, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries, General Treasurer, and the Editor of the publications of the Association shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than 20 Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such Meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries, for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Cape Town.

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* The Reception Committee should make arrangements to provide:—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Four rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography, Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology;

Political Economy; Sanitary Science; Sociology; Statistics, Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Session before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of Rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee" on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council.

II.—Duties.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution reads as follows:—

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancenent of Science.

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, 2½ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby, in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Chapter XIV. of the Association's Constitution, reading:—

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will *ipso facto* forfeit his seat on the Committee.

B. The Goold-Adams Medals.

(*a*) The Medals shall be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects; (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Matriculation Examination and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

BYE-LAWS

Under which the O.F.S. Philosophical Society was incorporated, from 1st July, 1914, with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for purposes of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Capetown, and subscriptions to be paid to the General Treasurer of the Association at Capetown, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association, to receive its Journal, and to enjoy the full privileges of membership, as soon as their subscription of £1 for the financial year 1914-15 shall have been paid.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso*, in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

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., M.I.M.M. 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. Schönland, 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.
Professor RUDOLF MARLOTH, M.A., Ph.D. KIMBERLEY, July 6, 1914.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. PRETORIA, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.
Professor LAWRENCE CRAWFORD, M.A., D.Sc., F.R.S.E. MARITZBURG, July 3, 1916.	Rev. W. Flint, D.D. Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. Prof. J. Orr, B.Sc., M.I.C.E. Sir A. Theiler, K.C.M.G., D.Sc.	Prof. W. N. Roseveare, M.A.

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.
1914. Kimberley ..	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H. Dinham-Peren.
1915. Pretoria ..	F. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
1916. Maritzburg ..	Prof. J. Orr, B.Sc., M.I.C.E.	Prof. A. Brown, P. Mesham.
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.

* 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, 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.

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.
1914. Kimberley ..	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915. Pretoria ..	H. Kynaston, M.A., F.G.S.	Dr. H. C. J. Tietz, Prof. D. F. du Toit Malherbe.
1916. Maritzburg. ..	Prof. J. A. Wilkinson, M.A. F.C.S.	Dr. H. C. J. Tietz, Prof. J. W. Bews.

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 Girouard, 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.
1914. Kimberley ..	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915. Pretoria ..	C. P. Lounsbury, B.Sc., F.E.S.	C. W. Mally, A. K. Haagner.
1916. Maritzburg. ..	I. B. Pole-Evans, M.A., B.Sc., F.L.S.	C. W. Mally, Prof. E. Warren.

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

Date and Place.	Presidents.	Secretaries.

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.

ANTHROPOLOGY, ARCHÆOLOGY, ECONOMICS, EDUCATION ETHNOLOGY, HISTORY, PSYCHOLOGY, PHILOLOGY, SOCIOLOGY, AND STATISTICS.

1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

ARCHÆOLOGY, EDUCATION, HISTORY, PSYCHOLOGY, AND PHILOLOGY.

1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.

ANTHROPOLOGY, ETHNOLOGY, ECONOMICS, SOCIOLOGY, AND STATISTICS.

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.
1914. Kimberley ..	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria ..	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.
1916. Maritzburg ..	M. S. Evans, C.M.G., F.Z.S.	Prof. R. D. Nauta, Prof. O. Waterhouse.

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.
1914. Kimberley ..	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their discovery, and their relation to other volcanic vents in South Africa.
1915. Pretoria ..	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The gold bearing conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House fly under South African conditions.
1916. Maritzburg ..	C. P. Lounsbury, B.Sc., F.E.S.	Scale Insects and their travels.
Durban. ..	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.

GENERAL MEETINGS AT MARITZBURG.

On *Monday, July* 3, at 3 p.m., the Association was officially welcomed by His Worship the Mayor of Maritzburg (Mr. P. H. Taylor, M.P.C.) and Corporation, in the Council Chamber, Provincial Council Buildings.

At 8 p.m. the Association attended a Reception by the Mayor and Mayoress of Maritzburg, in the Town Hall, when Prof. L. Crawford, M.A., D.Sc., F.R.S.E., took the chair as President, and delivered an address, for which see page 1.

The President subsequently presented the South Africa Medal and grant to Mr. T. R. Sim, F.R.H.S. For the proceedings, see page xxxii.

On *Tuesday, July* 4, at 3.30 p.m., Members of the Association were received by the Trustees and the Director of the Natal Museum, in the Museum Buildings.

At 8.15 p.m., in the Town Hall, Mr. C. P. Lounsbury, B.Sc., F.E.S., delivered a discourse on "Scale Insects and their travels," the President of the Association presiding.

On *Wednesday, July* 5, at 2.15 p.m., Members proceeded on an excursion over the railway deviation works, above the city, to Hilton Tunnel, as the guests of the Government.

On *Thursday, July* 6, at 10.30 a.m., the Fourteenth Annual General Meeting was held, in the Council Chamber, Provincial Council Buildings, for minutes of which see page xxi.

At 3.30 p.m. Members of the Association attended a garden party by the Hon. C. J. Smythe, J.P., Administrator of the Province of Natal, in the grounds of Old Government House.

On *Friday, July* 7, at 2 p.m., Members proceeded by special train on a visit to Nels Rust Farm, as guests of the Hon. J. Baynes, C.M.G., and Mrs. Baynes.

On *Saturday, July* 8, at 2 a.m., Members proceeded by train to Durban as guests of the Natal Sugar Association, and visited the Sugar Estates and Mill of the Natal Estates, Ltd., at Mount Edgecombe, and Sir J. L. Hulett & Son's Sugar Refinery at South Coast Junction. Members were entertained at breakfast by Sir Liege Hulett, and at luncheon by Sir Marshall Campbell at Mount Edgecombe, and by Sir Liege Hulett at Clairwood.

At 8 p.m., in the Town Hall, Durban, Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., delivered a discourse on "Astronomy," His Worship the Mayor of Durban (Mr. J. H. Nicolson) presiding.

After the lecture Members were received by His Worship in the Mayor's Parlour.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, MARITZBURG, 1916.

LOCAL COMMITTEE.

Chairman, Lt.-Col. J. Hyslop, D.S.O., M.B., C.M.; S. G. Campbell, M.D., C.M., Col. J. Dick, H. A. Dunat, M.D., F.R.C.P.E., M. S. Evans, C.M.G., F.Z.S., A. Hammar, C. B. Hardenberg, M.A., C. W. F. Harrison, F.R.G.S., F.R.S.S., E. Harrison, M.S.Agr., B.Sc., N.D.A., J. S. Henkel, D. Kehoe, M.R.C.V.S., J. Kirkman, M.P.C., A. McKenzie, M.D., C.M., M.R.C.S., P. Mesham, M.A., M.Sc., G. T. Plowman, C.M.G., Sir H. C. Sloley, K.C.M.G., C. H. Stott, F.G.S., M.S.A., Prof. E. Warren, D.Sc., D. C. Watt, M.D., C. Williams, B.Sc., A.R.C.S. *Local Secretary,* Prof. W. N. Roseveare, M.A.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor of Pietermaritzburg (Councillor P. H. Taylor, M.P.C.); the Hon. C. J. Smythe, J.P. (Administrator of the Province of Natal); the Hon. J. C. Dove Wilson (Judge President); Messrs. F. H. Birdsey, G. J. Macfarlane, C.M.G., Gen. Sir D. McKenzie, C.B., K.C.M.G., Prof. O. Waterhouse, M.A., Councillors D. Paton, G. B. Laffan, L. Line, W. J. O'Brien, J.P., D. Sanders, J.P., and Mrs. Theodoré Woods; D. Walker, J.P., E. W. Barns, C. Bird, C.M.G., Dr. R. A. Buntine, M.L.A., Miss Columbine, D. F. Forsyth, B.A., A. S. Hosley, Hon. Justice C. G. Jackson, F. J. Lewis, J. J. Niven, T. Orr, M.L.A., C.M.G., Rt. Rev. Bishop Roach, Rev. Dr. John Smith, Dr. Oddin Taylor, J. E. Vaughan, D. Wilson, Dr. W. J. Woods. *Hon. Secretary,* C. W. P. Douglas de Fenzi.

SECTIONAL COMMITTEES.

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

President, Prof. J. Orr, B.Sc., M.I.C.E.; *Vice-Presidents,* W. Ingham, M.I.C.E., M.I.M.E., and H. E. Wood, M.Sc., F.R.Met.S.; *Members,* G. W. Herdman, M.A., M.I.C.E., R. T. A. Innes, F.R.A.S., F.R.S.E., J. Lunt, D.Sc., F.I.C., A. H. Reid, F.R.I.B.A., F.R.San.I., Prof. W. N. Roseveare, M.A., and J. A. Vaughan. *Secretaries,* Prof. A. Brown, M.A., B.Sc., F.R.S.E. (*Recorder*), and P. Mesham, M.A., M.Sc.

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

President, Prof. J. A. Wilkinson, M.A., F.C.S.; *Vice-Presidents,* C. F. Juritz, M.A., D.Sc., F.I.C., and C. Williams, B.Sc., A.R.C.S.; *Members*, F. Flowers, F.R.A.S., F.R.G.S., E. T. Mellor, D.Sc., M.I.M.M., F.G.S., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., H. A. White, Prof. R. B. Young, M.A., D.Sc., F.G.S., F.R.S.E.; *Secretaries*, H. C. J. Tietz, M.A., Ph.D. (*Recorder*), and Prof. J. W. Bews, M.A., D.Sc.

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

President, I. B. Pole Evans, M.A., B.Sc., F.L.S.; *Vice-Presidents*, A. J. Anderson, M.A., M.B., D.P.H., M.R.C.S., and Prof. J. E. Duerden, M.Sc., Ph.D., AR.C.S.; *Members*, Prof. J. W. Bews, M.A., D.Sc., J. S. Henkel, A. Holm, Lt.-Col. J. Hyslop, D.S.O., M.B., C.M., D. Kehoe, M.R.C.V.S., C. P. Lounsbury, B.Sc., F.E.S., Prof. G. Potts, M.Sc., Ph.D., E. Holmes Smith, B.Sc., Sir A. Theiler, K.C.M.G., D.Sc., W. Watkins-Pitchford, M.D., F.R.C.S., D.P.H.; *Secretaries*, C. W. Mally, M.Sc., F.L.S., F.E.S. (*Recorder*), and Prof. E. Warren, D.Sc.

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

President, M. S. Evans, C.M.G., F.Z.S.; *Vice-Presidents*, Prof. T. M. Forsyth, M.A., D.Phil., and W. M. Macmillan, B.A., *Members*, J. E. Adamson, M.A., A. H. J. Bourne, M.A., J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E., J. A. Foote, F.G.S., F.E.I.S., J. W. Jagger, F.S.S., M.L.A., Rev. J. R. L. Kingon, M.A., F.L.S., Prof. W. A. Macfadyen, M.A., LL.D., B. M. Narbeth, B.Sc., F.C.S., F.Phys.Soc., and S. Seruya; *Hon. Secretaries*, Prof. R. D. Nauta (*Recorder*), and Prof. O. Waterhouse, M.A.

PROCEEDINGS OF THE FOURTEENTH ANNUAL GENERAL MEETING OF MEMBERS.

(Held in the Provincial Council Buildings, Maritzburg, on Thursday, July 6, 1916.)

Present: Prof. L. Crawford, M.A., D.Sc., F.R.S.E. (President), in the chair; Dr. C. Akerman, W. Alexander, Dr. A. J. Anderson, Mrs. O. W. Ball, Prof. J. W. Bews, Miss A. M. Bottomley, Miss R. Clapton, H. Clark, Miss E. Clayton, W. J. Delbridge, Mrs. M. de Villiers, I. B. Pole Evans, Rev. J. Fitz-Henry, Mrs. H. FitzSimons, Rev. Dr. W. Flint, J. Fraser, H. W. Gill, A. K. Haagner, Miss I. Hastings, C. S. Hayter, J. S. Henkel, J. Higham, Miss R. M. Hodges, R. T. A. Innes, Mrs. R. T. A. Innes, Hon. Mr. Justice C. G. Jackson, A. J. T. Janse, Dr. G. Lindsay Johnson, D. Kehoe, Rev. J. R. L. Kingon, Dr. J. R. Leech, J. Leighton, Prof. R. Leslie, Mrs. H. M. McKay, Mrs. A. W. Marchand, Rev. B. P. J. Marchand, W. B. Marshall, P. Mesham, D. T. Mitchell, B. M. Narbeth, Miss M. Narbeth, Rev. W. A. Norton, Prof. J. Orr, Mrs. J. Orr, Prof. M. Rindl, Prof. W. N. Roseveare, Prof. E. H. L. Schwarz, Rev. J. Scott, T. R. Sim, A. H. Smith, J. Stuart, Miss E. L. Teasdale, Sir A. Theiler, Rev. A. E. G. Tomes, Rev. Dr. S. R. Welch, Prof. J. A. Wilkinson, and Miss M. Wilman; J. A. Foote and Dr. C. F. Juritz (General Secretaries), and H. Tucker (Assistant General Secretary).

Minutes.—The minutes of the Thirteenth Annual General Meeting, held at Pretoria on 8th July, 1915, and printed on pp. xx to xxiv of the Report of the Pretoria Session, were confirmed, subject to the addition to the list of those present thereat, of Messrs. A. K. Haagner and D. Kehoe, Prof. M. Rindl, Mr. J. L. Soutter, and Rev. Dr. S. R. Welch.

Annual Report of Council.—The Annual Report of the Council for 1915-16, having been suspended in the Vestibule since 4th July, was taken as read and adopted, on the motion of Rev. Dr. Flint.

Report of General Treasurer and Statement of Accounts for 1915-16.—The General Treasurer's Report and the audited Financial Statements for the year ended 31st May, 1916, having been suspended in the Vestibule since 4th July, were taken as read, and adopted, on the motion of Rev. Dr. Welch.

Election of Officers for 1916-17.—The following Officers were elected for 1916-17:—

President, Prof. J. Orr, B.Sc., M.I.C.E.; Vice-Presidents, Mr. A. H. Reid, F.R.I.B.A., F.R.San.I.; Prof. W. N. Roseveare, M.A.; Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.; and Mr. H. E. Wood, M.Sc., F.R.Met.S.; General Secretaries, Dr. C. F. Juritz, M.A., F.I.C.; and Mr. J. A. Foote, F.G.S., F.E.I.S.; General Treasurer, Mr. A. Walsh.

ELECTION OF COUNCIL MEMBERS FOR 1916-17.—The following were elected Members of Council for 1916-17 (the Retiring President, Prof. L. Crawford, M.A., D.Sc., F.R.S.E., being also *ex-officio* a Member of Council for the year):—

I. CAPE PROVINCE.—(1) *Cape Peninsula*: Dr. A. J. Anderson, M.A., M.B., D.P.H., M.R.C.S.; Prof. A. Brown, M.A., B.Sc.; Rev. W. Flint, D.D.; Prof. R. Leslie, M.A., F.S.S.; and R. W. Menmuir, A.M.I.C.E. (2) *Grahamstown*: W. M. Macmillan, B.A. (3) *Kimberley*: Miss M. Wilman. (4) *King William's Town*: Mr. J. Leighton, F.R.H.S. (5) *Middelburg*: Mr. H. Cooke, B.S.A. (6) *Stellenbosch*: Prof. E. J. Goddard, B.A., D.Sc.

II. TRANSVAAL.—(1) *Johannesburg*: Mr. J. Burtt-Davy, F.L.S., F.R.G.S.; Dr. W. A. Caldecott, B.A., D.Sc., F.C.S.; Mr. P. Cazalet; Dr. H. Fielden-Briggs, M.D., L.D.S., F.C.S.; Mr. W. Ingham, M.I.C.E., M.I.M.E.; Mr. R. T. A. Innes, F.R.A.S., F.R.S.E.; and Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C. (2) *Pretoria*: Mr. I. B. Pole Evans, M.A., B.Sc., F.L.S.; Mr. F. E. Kanthack, M.I.C.E., M.I.M.E.; Prof. D. F. du T. Malherbe, M.A., Ph.D.; and Prof. H. A. Wager, A.R.C.S. (3) *Potchefstroom*: Mr. E. Holmes Smith, B.Sc.

III. ORANGE FREE STATE (including Basutoland).—Prof. T. M. Forsyth, M.A., D.Phil.; and Prof. M. Rindl, Ing.D.

IV. NATAL.—(1) *Durban*: Mr. M. S. Evans, C.M.G., F.Z.S. (2) *Pietermaritzburg*: Dr. R. A. Buntine, M.L.A., M.B., B.Ch.; and Prof. E. Warren, D.Sc.

V. RHODESIA.—(1) *Bulawayo*: Rev. S. S. Dornan, M.A., F.G.S.

VI. MOZAMBIQUE.—(1) *Lourenço Marques*: Mr. S. Seruya.

ANNUAL SESSION, 1917.—The President announced that an invitation to the Association to hold its next Annual Session at Stellenbosch had been received from the Mayor of Stellenbosch, and, on the motion of Rev. Dr. Flint, it was resolved to accept the invitation. The President further reported that the Council had resolved that it was desirable to arrange, provisionally, two years in advance for the place of meeting and the President-elect; and that Johannesburg had been recommended as the place of meeting in 1918, and Dr. C. F. Juritz as the President.

ALTERATIONS IN CONSTITUTION.—(1) *Creation of Class of "Institutional Members."*—Mr. R. T. A. Innes moved, in accordance with notice, that the Constitution be amended as follows:

II.—MEMBERSHIP.

1. Following new clause (*b*) to be inserted: Institutions, Societies, Government Departments and Public Bodies are eligible as Institutional Members.

2. Present clause (*b*) to become (*c*), and to be amended by substitution of words "(*c*) Institutional Members and (*d*)" for words "and (*c*)."

3. Present clause (*c*) to become (*d*), and to have words "Institutional Members" inserted after word "Members" in first line.
4. Present clause (*d*) to become (*e*), with substitution of words "a Member of any class" for word "anyone."

III.—Privileges of Members and Associates.

1. Following new clause (*c*) to be inserted: Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary Members; and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.
2. Present clause (*c*) to become (*d*).
3. Present clause (*d*) to become (*e*), and to have words "and Institutional Members" inserted after word "Members."

IV.—Subscriptions.

1. Clause (*b*) to be amended by insertion of words "and Institutional Members" after word "Members."

Dr. J. R. Leech seconded.

It was explained by the President that this motion was specially recommended by the Council for adoption, as its object was to make provision in the Constitution for a practice already followed. The motion was carried without discussion.

(2) *Reduction of Associates' Subscription.*—Rev. Dr. Flint moved, in accordance with notice:

That Chapter IV (*d*), relating to the subscription of Associates, be amended by the substitution of the word "ten" for the word "fifteen."

Dr. J. R. Leech seconded, and the motion, having been put to the vote, was declared carried.

(3) *Visitors' Privileges for Dependents of Members.*—Mr. R. T. A. Innes moved, in accordance with notice, that the following new Rule be added to the Constitution:—

Dependents (over 15 years of age) of Life and Ordinary Members may accompany such Members at the Annual Session as visitors, upon payment of a registration fee of 5s. each, on due notice being given by the Members concerned that they desire to avail themselves of this privilege. Such dependents shall be entitled "Visitors." These fees shall be handed over to the Local Committee at the centre at which the Session is being held.

Mr. J. Leighton seconded. The motion was put to the vote and declared lost.

(4) *Inclusion in Council, and Annual Election, of Editor of Publications of Association.*—Rev. Dr. W. Flint moved, in accordance with notice:

That Chapter VI (*b*) be amended by the substitution of the words "The General Treasurer and the Editor of the publications of the Association" for the words "and a General Treasurer."

That Chapter VI (*c*) be amended by the substitution of the words "General Treasurer and Editor of the publications of the Association" for the words "and General Treasurer."

Rev. Dr. Flint explained that his motion was designed to meet the contingency, which might at any time arise, of the Editor of the Association's Publication not being, as at present, identical with the General Secretary, Cape Town; in which event he considered it essential that the Editor should be a

Member of Council, and should be annually elected with the other Officers.

Prof. J. Orr seconded the motion, which, on being put to the vote, was declared carried.

(5) *Affiliation of Local Scientific Societies.*—Prof. W. N. Roseveare moved, in accordance with notice, the following new Rule:—

Local Scientific Associations, or similar Societies, may, on application to the Council, and with the approval of the Council, be affiliated to the Association on the following terms:—

(1) A local Society having 50 Members or less shall pay to the Association five ordinary annual subscriptions (£5); 51 to 100 Members shall pay ten ordinary subscriptions (£10); and so on for every 50 Members. In return for these subscriptions the affiliated Society shall receive the corresponding number of JOURNALS and the other rights of Ordinary Members; and shall be allowed to nominate the corresponding number of its Members to attend the Annual Session and elections of Council representatives, and to exercise thereat all the rights of Members, including the vote.

(2) The local Society shall accept Members of the Association as Members of its Society at a reduced subscription, to be approved by the Council.

The preliminary clause, establishing the principle of affiliation, was first considered and declared carried, in the following amended form:—

Philosophical and Scientific Societies, and other Associations of a kindred character may, on application to, and with the approval of the Council, affiliate with the Association on the following conditions:—

With regard to the conditions of affiliation, it was resolved, on the motion of Prof. J. A. Wilkinson, that the incoming Council be empowered to frame the conditions, with due consideration to the proposals respectively submitted by the Natal Society for the advancement of Science and Art, and the Biological Society.

CONVOCATION OF SCIENTIFIC SOCIETIES. — Mr. R. T. A. Innes intimated his intention not to proceed with the motion for the institution of a Convocation week of all Scientific and kindred Societies in South Africa, whereof he had given notice.

TIME OF YEAR FOR HOLDING ANNUAL SESSION.—A discussion on this subject was initiated by Rev. Dr. Flint, and it was resolved to request the incoming Council to take the matter into consideration.

PRINTING OF PAPERS PRIOR TO SESSION. — Mr. H. Clark moved that the incoming Council should consider the possibility of having the papers to be read at Annual Sessions printed in advance. Mr. J. Stuart seconded, suggesting that possibly *résumés* might at any rate be so printed; and after discussion, the motion was carried.

CONDUCT OF SECTIONAL MEETINGS. — Rev. J. Scott moved that the incoming Council should consider the question of the necessity for fixing the hours at which papers should be read before the various Sections. Rev. Dr. Flint moved, as an alternative, that the Council should be requested to draw up a set of instructions for the guidance of Sectional Officers in the conduct of business. This was seconded by Mr. I. B. Pole Evans; and Rev. J. Scott having withdrawn his motion, that of Rev. Dr. Flint was carried.

Application for Government Grant. — Prof. J. A. Wilkinson moved that Government be approached for a grant in aid of the Association; and that the incoming Council should be empowered to arrange details. Sir Arnold Theiler seconded the motion, and suggested that the best method of approaching the Government would be by means of a deputation. The motion was put and carried.

Votes of Thanks.—(1) On the motion of Prof. J. Orr, seconded by Prof. J. A. Wilkinson, it was unanimously resolved that the hearty thanks of the Association should be accorded to the following:—

(1) To His Worship the Mayor and Corporation for their cordial welcome and generous hospitality extended to the Association, and for travelling facilities granted.

(2) To the Hon. the Administrator of the Province of Natal and the Chairman of the Provincial Council, for their courtesy in placing the Provincial Council Buildings at the disposal of the Association during the Session, and to the former for his kind invitation to the members to a garden party at Government House.

(3) To the Local and Reception Committees, and in particular to the Local Secretary and the Town Clerk, for the excellent arrangements made for the comfort and convenience of members for the purposes of the Session.

(4) To His Worship the Mayor and the Mayoress for the most enjoyable reception given at the Town Hall.

(5) To the Trustees and Director of the Natal Museum for the most enjoyable reception given to members at that institution.

(6) To the General Manager, South African Railways, and in particular to Mr. D. Wilson, for the very interesting trip over the deviation works, afforded to members as the guests of the Government.

(7) To the Hon. Joseph Baynes, C.M.G., and Mrs. Baynes, for the kind invitation extended to members to partake of their hospitality at Nel's Rust.

(8) To the Principal of the School of Agriculture at Cedara, for his kind invitation to members to visit that institution.

(9) To the Sugar Association and to the Mayor of Durban, for the kind invitation extended to members to be their guests at Durban.

(10) To the Victoria Club, the Golf and Country Club, the Boating Club, the Bowling Club, and the Tennis Clubs, for extending the privilege of honorary membership to members during the Session.

(11) To the local Press for its kindly references to the visit of the Association, and for giving publicity to the proceedings of the Session.

(2) On the motion of Rev. Dr. Flint, it was further resolved that a hearty vote of thanks be accorded to the retiring President and the Secretaries of the Association, and to the various Sectional Presidents and Secretaries for all their efforts to make the Annual Session a success.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1916.

1. OBITUARY: During the year two more Members of the Association, *viz.*, Lieut.-Col. C. A. Madge and Mr. M. W. Duirs, both of Johannesburg, have given their lives on the battlefield. Your Council has also had to mourn the decease of Mr. H. Kynaston (President of Section B), Dr. W. Bourke, Mr. J. D. D. Mackay, Mr. J. M. Wood, the Right Rev. Bishop W. M. Cameron (Coadjutor Bishop of Capetown), Dr. C. McGowan Kitching, and the Rev. Prof. T. Walker (formerly Vice-Chancellor of the University of the Cape of Good Hope).

2. MEMBERSHIP: Notwithstanding the adverse conditions arising out of the continuance of the Great War, and the unusually heavy death-roll specified above, your Council is pleased to report that the membership as on 1st July, 1916, exceeds by 37 that on the corresponding date of last year. During the twelve months 96 new members were enrolled, and 9 have died, while 50 either resigned or have been removed from the roll owing to non-payment of subscription, or because they have gone away and their present address is unknown. In the list published on the 1st July, only those new Members have been included who have paid their first year's subscription.

The following is a comparative table of the number of Members on the Association's Roll on the two dates, showing the distribution amongst the various Provinces:—

	1915.	1916.
Cape Province	212	202
Transvaal	216	236
Orange Free State	35	30
Natal	23	51
Rhodesia..	20	20
Basutoland	3	1
Mozambique...	19	17
Swaziland	1	1
South-West Africa Protectorate	2	2
Abroad	15	17
Unknown	1	1
	547	584

The number of Life Members is now 72, eleven having been added during the year; of whom two were new members, and nine existing members of ten or more years' standing, who availed themselves of the clause recently added to Rule iv (c).

3. REPORT OF THE KIMBERLEY MEETING, 1914: The eleventh Annual Volume of the Association's Transactions, which comprises the proceedings at the Kimberley Session in 1914, was completed in ten monthly issues. The volume has since been bound uniformly with its predecessors, and consists of 484 pages; that is to say, it is equal in size to the Capetown volume of 1910. It contains 39 papers printed *in extenso*, two in abstract, and four by title only.

4. REPORT OF THE PRETORIA MEETING, 1915: The completion of this volume has been somewhat delayed by a chain of adverse circumstances. Twelve or thirteen monthly issues will be needed to complete the volume, which will probably be somewhat more bulky than that of the previous year.

5. COST OF PUBLICATIONS: On account of the restricted revenue of the Association, consequent upon the reduction of the number of Members, it was decided by the Council during the last Annual Session at Pretoria, to limit the expenditure on the printing of The Transactions of that Session to £300 nett, that is to say, exclusive of any revenue that might be derived from the sale of publications, or from outside contributions to the cost of printing. A generous contribution of £100 was subsequently made by the Witwatersrand Council of Education towards the cost of publishing the Association's Transactions, and your Council has thus been enabled to print many papers which it would otherwise have been impossible to publish. The hearty thanks of your Council were duly conveyed to the Council of Education.

6. SOUTH AFRICA MEDAL AND GRANT, 1916: The South Africa Medal Committee, comprising Prof. L. Crawford, M.A., D.Sc., F.R.S.E. (Chairman), Dr. J. Hyslop, D.S.O., M.B., C.M., R. T. A. Innes, F.R.A.S., F.R.S.E., Dr. C. F. Juritz, M.A., F.I.C., Prof. R. A. Lehfeldt, B.A., D.Sc., C. P. Lounsbury, B.Sc., F.E.S., Sir T. Muir, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E., Prof. J. Orr, B.Sc., M.I.C.E., Prof. G. Potts, M.Sc., Ph.D., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., and Sir A. Theiler, K.C.M.G., D.Sc., recommended Mr. Thomas Robertson Sim, F.R.H.S., of Maritzburg, formerly Conservator of Forests for the Colony of Natal, for the ninth award of the South Africa Medal, together with the grant of £50, which has invariably accompanied the Medal. Your Council has confirmed this recommendation.

7. GOOLD-ADAMS MEDALS, 1916: The sixth series of awards of the Medal instituted by H.E. Sir Hamilton Goold-Adams, now Governor of Queensland, in connection with the Matriculation and Senior Certificate Examinations of the University of the Cape of Good Hope, have been made on the results of the 1915 examinations. The names of the recipients are as follows:—

Mathematics: Frank Forman, Gymnasium High School, North Paarl.

Physics: Frank Forman, Gymnasium High School, North Paarl.

Chemistry: Reginald Percy Gain, South African College High School, Capetown.

Physical Science: Johannes Stephanus Marais, Boys' High School, Upper Paarl.

Botany: Judith Raubenheimer, Oranje Girls' School, Bloemfontein.

8. Research Grants: Your Council has re-nominated Rev. Dr. W. Flint, Dr. J. Lunt, Dr. R. Marloth, and Mr. A. H. Reid to represent the Association on the 1916 General Committee for Research Grants administered by the Council of the Royal Society of South Africa.

9. Presentation by Sir Thomas Muir: In addition to the complete set of the volumes of *Nature* presented by Sir Thomas Muir, Past President of the Association, to which reference was made in the last Annual Report, Sir Thomas Muir has since presented this Association with a series of the British Association's Reports from 1841 to 1889. This gift places the Association in possession of a set of those reports complete from 1841 to the present date.

10. Munitions Congress: On the initiative of the Minister of Defence, a Congress was held in Johannesburg on the 3rd November, 1915, in order to consider what steps could be taken in South Africa with a view to organising the manufacture in South Africa of articles of local consumption previously produced in the workshops of the United Kingdom, so as to relieve those workshops as much as possible of extraneous requirements, and thus enable them to devote their attention more exclusively to the production of war materials. Your Council was requested to send delegates to this Congress, and Dr. C. F. Juritz and Prof. J. Orr were accordingly delegated to attend. It is understood that the Congress appointed a Central Executive Committee with local Committees in the various centres throughout the Union.

11. Conduct of Sectional Meetings: Your Council has considered various suggestions which have been made for improving the procedure at Sectional Meetings, and resolved, as an experiment for one year, to adopt the proposal to obtain prior to the present Session a notification from Members with regard to the papers which they particularly wish to hear read.

12. Members on Active Service: Your Council has resolved that the names of Members on Active Service shall not be removed from the roll of the Association by reason of nonpayment of subscriptions resulting from absence from South Africa; and that the question of their relation to the Association shall be further considered at the close of the war.

13. The New Council: On the basis of Membership provided by Section VI (*d*) of the Constitution, the number of Members of Council assigned to the representation of the several districts for the ensuing twelve months should be distributed as follows:—

Cape Province—	
Cape Peninsula ...	5
Grahamstown ...	1
Kimberley ...	1
Kingwilliamstown ...	1
Middelburg ...	1
Stellenbosch ...	1
Transvaal—	
Witwatersrand ...	7
Pretoria ...	4
Potchefstroom ...	1
Orange Free State (with Basutoland)—	
Bloemfontein ...	2
Natal—	
Maritzburg ...	2
Durban ...	1
Rhodesia—	
Bulawayo ...	1
Mozambique—	
Lourenço Marques ...	1
	29

REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDED MAY 31ST, 1916.

In presenting the Account of Revenue and Expenditure and the Audited Balance Sheets for the year ending May 31st, 1916, I beg to report as follows:—

The amount received for current subscriptions shows an improvement on last year of £4 16s. 2d., that received for arrear subscriptions, an increase of £15 10s., together an additional revenue of £20 6s. 2d.

Owing to the great delay in printing the monthly numbers of the JOURNAL during the year, the accounts do not include any charges for the printing and circulating of the March, April and May numbers, and consequently no comparison with previous years is possible, but had it not been for the generous contribution of £100 by the Witwatersrand Council of Education towards the cost of the printing of the papers read at Pretoria, the accounts of the Society would have shown a considerable loss on the year's working.

The other expenses show a saving of about £6 on the year. The Endowment Fund has been increased by a further £70, and now stands at £1,408, which will shortly be all invested in 5 per cent. Bonds, which will increase the Interest paid over to Revenue Account by about £20 per annum.

The Medal Fund balance now stands at £1,436 0s. 11d.

A. WALSH,

June 27th, 1916. *Hon. Treasurer.*

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR YEAR ENDED 31ST MAY, 1916.

Revenue.

	£ s. d.	£ s. d.
To Assistant Secretary's Salary ...		120 0 0
,, Rent		30 0 0
,, Journal		224 18 11
,, Printing and Stationery ...		26 1 1
,, Stamps and Telegrams... ...		14 14 11
,, Sundry Charges—		
Caretaker	6 0 0	
Expenses Annual Meeting ...	18 1 0	
Medals and Engraving ...	1 9 8	
Auditor	5 5 0	
Telegraph and Reg. Addresses...	2 1 0	
Grants under Rule 9	13 8 0	
Dr. Muir's Address	1 1 0	
Sundry Charges	0 17 11	
Exchange	0 3 11	
		48 7 6
,, Depreciation on Furniture ...		2 17 2
,, Balance to Balance Sheet ...		208 11 7
		£675 11 2

Expenditure.

	£ s. d.	£ s. d.
By Balance carried forward from 1915		153 15 0
,, Subscriptions, 1915-16	375 11 2	
,, Arrear Subscriptions	96 0 0	
		471 11 2
,, Interest on Endowment Fund ...		50 5 0
		£675 11 2

BALANCE SHEET AS AT 31ST MAY, 1916.

Liabilities.

	£ s. d.	£ s. d.
Capital Account		208 11 7
Medal Fund		1,436 0 11
Endowment Fund...		1,408 0 0
Subscriptions paid in advance ...		26 0 0
		£3,078 12 6

Assets.

	£ s. d.	£ s. d.
Trustees of Medal Fund		1,436 0 11
Trustees of Endowment Fund ...		1,398 0 0
Cash—		
Standard Bank of S.A., Ltd. ...	62 17 0	
Cape Good Hope Savings Bank ...	156 0 0	
		218 17 0
Furniture	28 11 9	
Less Depreciation...	2 17 2	
		25 14 7
		£3,078 12 6

SOUTH AFRICA MEDAL FUND.

Revenue and Expenditure Account *for the year ended 31st May, 1916.*

	£ s. d.		£ s. d.	£ s. d.
To T. R. Sim, Grant for 1916..	50 0 0	By Balance 31st May, 1915	1,429 8 5	
„ Typing copies for nominations for circulation to Members of Medal Committee... ...	2 0 0	„ Interest	58 16 7	
„ Engraving Medal..	0 3 8			1,488 5 0
„ Stamps	0 0 5			
„ Balance	1,436 0 11			
	£1,488 5 0			£1,488 5 0

ENDOWMENT FUND.

For year ended 31st May, 1916.

	£ s. d.		£ s. d.
To Interest paid to General Account	50 5 0	By Balance	1,338 0 0
„ Balance	1,408 0 0	„ Interest	50 5 0
		„ Life Members' subscriptions	70 0 0
	£1,458 5 0		£1,458 5 0

ENDOWMENT FUND TRUSTEES.

For year ended 31st May, 1916.

	£ s. d.		£ s. d.	£ s. d.
To Endowment Fund Trustees..	1,408 0 0	By Investments—		
		5 % P.E. Municipal Stock ...	1,150 0 0	
		5 % Wynberg Municipal Stock..	100 0 0	
		C.G.H. Savings Bank Deposit ...	148 0 0	
		„ Balance due from General Fund...	10 0 0	
				1,408 0 0
	£1,408 0 0			£1,408 0 0

I hereby certify that I have examined the above Balance Sheet and Revenue Account with the books, vouchers, and Banker's 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).

Capetown, 15th June, 1916

NINTH 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.*)

Thomas Robertson Sim, F.R.H.S., was nominated for the award upon the following grounds:—

"1. Mr. Sim is the only authority in South Africa on the South African Ferns. The first edition of his monograph, published in 1892, having been out of print for some years, a second and enlarged edition, published by the Cambridge University Press, has been issued this year. The appearance of this important work would be suitably marked by the award for which Mr. Sim is now nominated.

"2. No one has contributed so much as Mr. Sim to our knowledge of the botany of the forests of South and South-East Africa. His comprehensive work, entitled "The Forest Flora and Forest Resources of Portuguese East Africa," was prepared and published (1909) at the expense of the Portuguese Government. His earlier work on the "Forests and Forest Flora of the Colony of the Cape of Good Hope" (1907) is, and for some years to come will be, the standard work on the subject.

"3. Owing to the retrenchment of the Natal Forest Department (of which Mr. Sim was the Chief) in 1907, Mr. Sim's opportunities for research were seriously curtailed. But in spite of the necessity which then arose of establishing a horticultural business as a means of livelihood, Mr. Sim never lost touch with the problems in which he had previously interested himself.

"4. During the last year Mr. Sim has commenced a monograph of the South African Mosses and Lichens—groups which have hitherto received a minimum of attention from South African botanists. Mr. Sim has for many years been interested in these groups, and the work he has now in hand will be a notable and much-needed addition to the botanical literature of South Africa.

"To summarise, Mr. Sim came to South Africa in 1889. He was appointed Superintendent of Plantations, Eastern Conservancy, Cape Colony, January, 1895; District Forest Officer, Kingwilliamstown, September, 1898; Conservator of Forests, Natal, September, 1902, till 1907; Member of the Technical Education Commission, Natal, 1905; Natal's Representative at the South African Products Exhibition, London, 1907; Forestal Adviser to the Portuguese Government, Mozambique Province, 1908. He was formerly, and for many years, a Fellow of the Linnean Society."

The following is a list of the most important of Mr. Sim's publications:—

The South Africa Medal.

(a) *Books*—

1. "Handbook of the Ferns of Kaffraria," 1891. (62 pages and 66 plates.)
2. "The Ferns of South Africa," 1892. (275 pages and 159 plates.)
3. "The Ferns of South Africa" (2nd edition), 1915.
4. "Sketch and check list of the Flora of Kaffraria," 1894. (92 pages and 2,449 species.)
5. "The Forests and Forest Flora of the Colony of the Cape of Good Hope," 1907. (361 pages, 160 plates, representing 312 species.)
6. "Forest Flora and Forest Resources of Portuguese East Africa," 1909. (166 pages and 100 plates, representing 158 species.)
7. "Tree-planting in Natal," Bulletin No. 7, Natal Dept. of Agr., 1905. (354 pages, 102 figs.)

(b) *Reports*—

8. Report of Conservator of Forests, Natal, 1902.
9. Report of Conservator of Forests, Natal, 1903-4.
10. Report of Conservator of Forests, Natal, 1905.

(c) *Papers*—

11. Judging Horticultural Products." *Rept. North of Scotland Horticultural Assn.*, 1887. (Awarded the Association's Jubilee Gold Medal.)
12. "Irrigation in Cape Colony," *Cape Illustrated Magazine*, 1893. (Awarded prize presented by Hon. C. J. Rhodes.)
13. "The Labour Question," *Cape Illustrated Magazine*, 1894. (Prize Essay.)
14. "Recent information concerning South African Ferns and their distribution." *Trans. S.A. Phil. Soc.*, 1906.
15. "Elementary Principles of Sylviculture." *C.G.H. Agr. Journal*, 1899.
16. "Forestal Education Necessary for South Africa." *Addresses and Papers, Brit. & S.A. Assns. for Adv. of Science*, 1905.
17. "Botanical Observations on the Forests of Eastern Pondoland." *C.G.H. Agr. Journal*, 1900.
18. "Judging Fruits, Flowers, Plants and Vegetables at Shows." *Natal Agr. Journal*, 1906.
19. "South African Horticulture," *Rept. S.A. Assn. for Adv. of Science*, 1906.
20. "South African Products Exhibition, 1907. Report on Natal Exhibits and Conditions Essential to Success." *Natal Agr. Journal*, 1907.
21. "Sisal, Mauritius Hemp, and other 'Aloe' Fibres." *Natal Agr. Journal*, 1908.
22. "Man's Influence on Climate," *Rept. S.A. Assn. for Adv. of Science*, 1908.
23. "The Flora of Portuguese East Africa." *Rept. S.A. Assn. for Adv. of Science*, 1909.
24. "Tree-planting." *Rept. Natal Farmers' Conference*, 1910.

Also many papers, mostly forestal, in *C.G.H. Agricultural Journal*, 1895-1902, and in *Natal Agricultural Journal*, 1902-1907.

After the conclusion of the Presidential Address in the Town Hall, Maritzburg, on Monday, July 3rd, 1916, the President, Prof. L. Crawford, handed the South Africa Medal and the award of £50 to Mr. Sim. In doing so, the President made the following additional statement:—

"A pleasant task is now before me to present the South Africa Medal and Grant for 1916 to Mr. Thomas Robertson Sim. This medal and grant are the outcome of a fund raised by members of the British Association in commemoration of their visit to South Africa in 1905, and this is the ninth award. On the recommendation of the South Africa Medal Committee, the Council has made the award this year to Mr. Sim.

"Mr. Sim came out to South Africa in 1889; he was appointed Superintendent of Plantations, Eastern Conservancy, Cape Colony, in 1895; District Forest Officer, Kingwilliamstown, in 1898; and Conservator of Forests, Natal, in 1902. His opportunities for research were seriously curtailed when the Natal Forest Department was retrenched in 1907. In 1908 he was Forestal Adviser to the Portuguese Government, Mozambique Province.

"Mr. Sim's work on 'Forests and Forest Flora of the Colony of the Cape of Good Hope' is the standard work on the subject. The expenses of publication of this work were defrayed by the Governments of Cape Colony, Transvaal, Orange River Colony, and Rhodesia. Another work, "The Forest Flora and Forest Resources of Portuguese East Africa," was prepared and published at the expense of the Portuguese Government.

"In these works all the plates, it may be added, were drawn by Mr. Sim himself. He is now preparing a monograph of the South African Mosses and Liverworts, groups on which he has been working for some years. These groups have received little attention so far from South African botanists, and his work will be a valuable addition to botanical literature, and especially to that of South Africa.

"The greatness of Mr. Sim's achievement is enhanced by the fact that much of his work has been done under difficulties which would have utterly discouraged most men; in the accumulation of material for his work he has displayed zeal far beyond the ordinary. It is in recognition of this most valuable research work and in good hope of further research work to come that I now on behalf of the South African Association for the Advancement of Science, hand the medal for 1916 and accompanying grant to Mr. Thomas Robertson Sim."

Mr. Sim, in thanking the President and the Association for the award, referred to the unique opportunities that had come to him in that he had served under the Governments of five separate countries, namely, the British Imperial Government, while at the Kew Botanical Gardens; the Cape Government, in its Forest Department; the Natal Government, while in charge of the Natal Forest Department; the Portuguese Government of the Province of Mozambique, as Forestal Adviser and explorer in the regions north of the Zambesi; and the Government of the Union of South Africa.

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

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

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

1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.

1914. *Kimberley.*—Prof. Rudolf Marloth, M.A., Ph.D., Capetown.

1915. *Pretoria.*—Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria.

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.

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 Society of Canada.
Papers and Proceedings of the Royal Society of Tasmania.
Proceedings of the Royal Society of Queensland.
Royal Dublin Society: Scientific Proceedings.
Proceedings of the Royal Institution of Great Britain.
Proceedings of the Royal Philosophical Society of Glasgow.
Journal of the Royal Society of Arts.
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.
Bulletins of the Indian Association for the Cultivation 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 California:
  Bulletins.
  Memoirs.

University of Virginia: Philosophical Society Bulletins.
Science Reports of the Tôhoku Imperial University.
Annals of the New York Academy of Sciences.
Proceedings of the American Academy of Arts and Sciences.
Transactions of the Connecticut Academy of Arts and Sciences.
Medelanden från K. Vetenskapsakademien Nobelinstitut.
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.
American Journal of Science.
Ohio Journal of Science.
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.
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).
South African Mueseum:
Annals.
Annual Reports.
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.
Annual Report 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 the University 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.

Union of South Africa Mines Department, Annual Reports.
Canada Department of Mines:
- Museum Bulletins.
- Memoirs of the Geological Survey.
- Reports.

Egyptian Ministry of Finance: Geological Reports.
Geological Survey of Western Australia:
- Annual Progress Reports.
- Bulletins.

Journal of Industrial and Engineering Chemistry.
Journal of Chemical Technology.
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.
Observatorio Campos Rodrigues:
- Relatorio.
- Resumo mensal.

Egyptian Ministry of Finance: Meteorological Reports.

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.

Agricultural Journal of the Union of South Africa.
Agricultural Gazette of New South Wales.

Department of Agriculture, New South Wales. Science Bulletins.
United States Department of Agriculture Experiment Station Record.
Journal of Agricultural Research.
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.
The Medical Journal of South Africa.
University of California: Publications in Botany.
Proceedings of the Linnean Society of New South Wales.
Missouri Botanical Gardens:
- Annual Reports.
- Annals.

Smithsonian Institution (United States National Museum):
- Contributions from the United States National Herbarium.

Bulletins of Royal Botanic Gardens, Kew.
Union of South Africa; Reports of the Director of Veterinary Research.
The Australian Zoologist.

Entomology.

Bulletin of Entomological Research.
Review of Applied Entomology.

Astronomy, Mathematics and Physics.

Royal Astronomical Society:
- Memoirs.
- Monthly Notices.

Journal of the Royal Astronomical Society of Canada.
Harvard College Astronomical Observatory:
- Circulars.
- Annals.

Union Observatory Circulars.
Observatoire Royal de Belgique; annuaire astronomique.
Bulletins of Khedivial Observatory, Helwan, Egypt.
Kodaikanal Observatory Bulletins.
Annual Reports of the Kodaikanal and Madras Observatories.
British Astronomical Association:
- Journal.
- Memoirs.

Lick Observatory Bulletins.
Astronomical Society of India:
- Journal.
- Monthly Notices.

Proceedings of the Western Australian Astronomical Society.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
Proceedings of the London Mathematical Society.
Tôhoku Mathematical Journal.
National Physical Laboratory, Middlesex:
 Collected Researches.
 Reports.
Universidad Nacional de la Plata:
 Contribucion al estudio de las Ciencias fisicas y matematicas.
Proceedings of the Physical Society of London.

Education, Political Economy and Sociology.

United Empire.
Ohio State University Bulletin.
International Institute of Agriculture, Rome: Bulletin of the Bureau of Economic and Social Intelligence.
Royal Dublin Society: Economic Proceedings.
Athenæum subject index to Periodicals.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Comitato talassografico.
 Bolletinos.
 Memorias.
The Geographical Journal.
The Geographical Review.
United States Geological Survey: Water Supply Papers.
Egyptian Ministry of Finance: Survey Department Papers.
Istituto di geografia fisica e vulcanologica della R. Universita di Catania: pubblicazioni.
United States Department of Commerce, Coast and Geodetic Survey:
 Special Publications.
 Annual Reports.

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.

Anthropology.

Journal of the African Society.

Archæology.

Bulletins of the Archæological Survey of Nubia.

PRESIDENT'S ADDRESS.

ADDRESS

BY

Professor LAWRENCE CRAWFORD,
M.A., D.Sc., F.R.S.E.

PRESIDENT.

UNIVERSITIES.

Speaking in London on May 5, 1915, Lord Rosebery said: "The war must have a particularly disastrous effect on University teaching. At the end of it all the combatants would become exhausted for an indefinite time, and those who hoped to receive from the Government some bounteous endowment or some palatial hall must adjourn those expectations indefinitely. From the chapter of national finance laid before them the day before, he saw no prospect of the Government's laying out money on such a luxury as a University for a considerable time to come. Nor did he suppose that the Government would have the time or the disposition, so long as the war lasted, to legislate in any way for their benefit. The conclusion, to his mind not wholly devoid of consolation, was that they would be thrown on their own energies for their progress and development. *Italia farà de se;* Italy must, as the old saying goes, work out her own salvation, and they in their turn, deserted necessarily by the Government, would have to work out their own salvation."

While Lord Rosebery was referring to the University of London and probably intended to suggest that a new university, well endowed, would be a luxury, his speech was taken to mean that every university was a luxury, and this view was strongly challenged. At the next meeting of the British Association for the Advancement of Science, for instance, the General Committee adopted the following resolution: "That the British Association for the Advancement of Science, believing that the higher education of the nation is of supreme importance in the present crisis of our history, trusts that His Majesty's Government will, by continuing its financial support, maintain the efficiency of teaching and research in the universities and university colleges of the United Kingdom"; and, again, shortly after, in reply to Leeds University, the King said: "His Majesty feels that the assistance of the universities is a great asset to the cause for which we are fighting, as science plays such a prominent part in modern warfare."

New universities have been founded in time of war: the University of Leyden, founded in 1575 as a reward to the inhabitants for their courageous defence against the Spaniards, and the University of Berlin, founded in 1809 when Prussia was under the heel of Napoleon, are striking examples. The Union of South Africa is not as Holland in 1575 or Prussia in 1809, and it is not a parallel case that in this year of war 1916 there have been three universities founded in South Africa, the University of South Africa, the University of Capetown, and the University of Stellenbosch. They are also not new foundations, for the second is based on the South African College, the last on the Victoria College, and the first on the present examining university with the other teaching colleges, including the School of Mines. This federal university may not prove a permanent arrangement, new universities may arise from it. The Universities of Capetown and Stellenbosch are universities such as those founded lately in England and the Scotch universities, and they are based on colleges which go back in one case for 87 years, and in the other for 39. In a recent book* on Yale University, the author writes: "There is a wide-spread feeling in America that a great university can be created anywhere in a year by adequate gifts of money. . . . . As a matter of fact, a collegiate foundation can only have its deepest effect after its character and ideals have become firmly established by a long period of corporate life. For the purpose of this study few American universities can meet the threefold tests which could be successfully applied in England to Oxford and Cambridge—influence on the nation's history, breadth of constituency and established standing in the public

*"Memorials of Eminent Yale Men," by A. P. Stokes.

mind." The speakers of the future will say how far the new universities have met these tests. The speakers of to-day agree in stating that a real forward step has been taken in getting away from an examining university such as exists at present.

That the present university has done great service to the country no one has attempted to deny; it has been to the people a constant reminder of higher education; the qualifications for its certificates and degrees have grown with the spread of higher education; and, as far as examination alone can test, it has done its best to try the knowledge acquired, and so to stimulate the teaching of higher subjects and to maintain in that teaching a good standard. The degrees of the University of the Cape of Good Hope are certainly of real value.

The craze for examinations is a product of the nineteenth century, and arose from the competitive examination systems developed between 1800 and 1850 in the Universities of Oxford and Cambridge.* That the criticisms levelled against these universities as they existed early in the nineteenth century, though certainly not all literally true, had good foundation is unquestioned, and that they did much to rouse the universities and to pave the way for the later reforms must be admitted. Later, Cardinal Newman† wrote the following: "About 50 years since, the English University (Oxford) of which I was so long a member, after a century of inactivity, at length was roused, at a time when (as I may say) it was giving no education at all to the youth committed to its keeping, to a sense of the responsibilities which its profession and its station involved." One of the criticisms at the time appeared in a review of Laplace's "Traité de Mécanique Celeste" in 1808‡: "In one of these (public institutions), where the dictates of Aristotle are still listened to as infallible decrees, and where the infancy of science is mistaken for its maturity, the mathematical sciences have never flourished; and the scholar has no means of advancing beyond the mere elements of geometry. . . . In the other seminary the dominion of prejudice is not equally strong; . . . mathematical learning is there the great object of study, but still we must object to the method in which the object is pursued. . . . The pupil must study, not to learn the spirit of geometry, . . . but to know . . . as a child knows his catechism, by heart, so as to answer readily to certain interrogations." Such attacks as this were vigorously repelled, but in one reply by Dr. Copleston§ of Oxford the following is stated about the examination tests. "It must be well known to everyone who has had experience in life, that notwithstanding this formidable array of (prescribed) books and sciences, great numbers of candidates

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* In the latter the Mathematical Tripos had existed since 1747-8.

† In the Discourse introductory to his book, "The Idea of a University," first published in 1852, under the title, "The Scope and Nature of University Education."

‡ *Edinburgh Review*, Vol. XI., p. 279.

§ "History of University Reform," by A. I. Tillyard, p. 32.

must be allowed to pass, whose attainments in both are, from various causes, very inconsiderable. Still if the system be so conducted as to encourage exertion, it would be absurd to reject those of the more moderate pretensions, who have passed through their period of residence with good conduct, and a tolerably regular attention to the prescribed duties. Nothing but extreme incapacity, extraordinary want of school education, or gross idleness at the University, will absolutely exclude a student from his degree at the regular time. Of this description some few are found every year. But even these are not finally rejected; they may appear at the following examination and, unless the same insufficiency is again observed, generally pass." With such an admission publicly made, it is obvious that the knowledge-testing was not profound.

Another writer ends an attack by saying:* "We (at Cambridge) have professors of everything, who hold their situations and do nothing. In Edinburgh the income of the professor depends upon his exertions; and, in consequence, the reputation of that university is so high that Englishmen think it necessary to finish their education by passing a year there. They learn shallow metaphysics there, and come back worse than they went, inasmuch as it is better to be empty than flatulent."

But there are stories about examining in the Scotch universities. One gives the following oral examination: "Professor, 'State the Binomial Theorem.' No reply from student. Professor, 'Is it a beast?' Student, 'No.' Professor, 'Thank you, that will do.'"

I should add here as a parenthesis that for much of the nineteenth century at the Scotch universities the percentage of students who proceeded to a degree was small; the teaching of the professors, the intimate association with men of his own age and standing and, in general, the influences of a society given to the search for knowledge were regarded as completing a university education.

The system of competitive examinations was at first a real movement of reform in the universities, but in its development the good servant has become a bad master. Endless examining bodies have sprung up, each with its certificates, and the crown of these was the University of London, of which the University of the Cape of Good Hope was a copy. It held public examinations for degrees without in any way regarding how its examinees were taught. The movement spread to Scotland, and at one time there was a proposal that there should be a common examination for degrees of the four Scotch universities, but it was negatived. Nowadays the evils of the examination system are recognised. But the change from the past to the new here has not only had difficulties arising from how to make the change, but also from opposition on the part of supporters of the old system. In the discussion in the Lower House in 1873 on the

* *Ibid.*, p. 22.

Bill for establishing the University, one of the leading members of the House said* that Nature had selected Capetown for the home of the University by her rich favours bestowed on it, and that the beauty of its scenery and the splendour and grandeur of the great mountain which overshadows it were a source of inspiration to all who regarded it. I do not know how the beauty of the scenery, etc., etc., were to be reflected through examination papers to the enormous number of students of the University, who, though taking its examinations, were never, while students, to see Capetown. But something of this idealising of the examining University seems to have always remained. In a book on South Africa in 1895,† the writer states in his preface as a qualification, "I should perhaps say that I have been able to bring information acquired during a residence of nearly two years in the Cape Colony and Natal to bear upon the treatment of this subject." A quotation from the book itself is: "In this connection it is necessary to make some mention of the Cape University. The University of the Cape of Good Hope was incorporated in 1873 and obtained its charter in 1877. It is the crown of a remarkably complete and effective system of national education; and although its teaching staff is distributed among the various colleges, there is a sufficient amount of academic work to be transacted at its headquarters at Capetown to render the University circle a distinct stimulus to the literary enterprise of the Colony." Other people have followed this in saying that the University was really a teaching University; a Vice-Chancellor has claimed that it was really a National University; one who "might be called the oldest son of the University" could see no improvement possible except by some slow process of evolution; and the Minister for Education said that the University had satisfied the needs of the people of South Africa!

In the same speech the Minister said ‡ that a change was contemplated and would be made, and now after six years the change has been made. However at first the University satisfied the needs of South Africa, the same experience has happened here as in England and New Zealand, the founding of an examining University, its initial success in the encouragement of institutions where higher education has been given, the gradual dissatisfaction with the working of the machine as higher education has developed. The examination for the certificate or the degree has ranked as practically everything in the eyes of a student, the teaching as very little; cramming has been encouraged; by many the work during the year has been looked on as merely preparation for the examination at the end, and work outside a fixed schedule has been regarded as practically useless. In this country there is a belief in education, but it is apt to show itself in the desire for certificates and examina-

* "Life and Times of Sir John Molteno," Vol. I, p. 213.
† "South Africa," by W. B. Worsfold.
‡ At Camps Bay, 1910.

tion results, so that it is a typical story which is told in a South African novel of a spectator at a football match to whom a friend points out one of the players and says most impressively, "You see that man, he's a B.A."

As far as regards the scheme which has been adopted, one federal and two single-college universities, I do not propose to say anything. There are many who say that a federal university is unworkable; there are many who consider that it answers the needs of this country, that it lifts up the small colleges to the level of the larger colleges, and that it will prove a real success. Time will solve that question, and also the question whether the South African College and the Victoria College are sufficiently developed to become universities of good name and world-wide respect. The settlement of the university question has aroused this year such controversy that it is best left alone till feelings are not so acute.

The interest shown in the university question naturally leads to an inquiry into what South Africa expects from its universities, what advantages are to accrue to South Africa, some at least in larger measure, from the new Universities? I propose to speak only on three—training in character for the youth of the country, encouragement of the study of science, furthering of research, two of which will appeal more especially to members of an Association such as ours.

A university should claim this ideal: "Every student owes to the public, in the form of superior usefulness to it, both while in the institution and afterwards, a full equivalent for its expenditure in his behalf."

Training in Character.—The American philosopher, Professor William James, says that the pithiest reply he can give to the question, "Of what use is a college training?" is "It should help you to know a good man when you see him." He points out how the narrowest trade training tells a man of good work in one line, which may suggest that in everything there is good and bad work, and he says that at college there should be obtained a general sense of what, under various disguises, superiority has always signified and may still signify. A college (or university) training ought to give its members this sense of human superiority and to light up in them a lasting preference for the better kind of man. He goes on to speak of the important function of an educated class in a democratic community like that in America. A convinced democrat himself, with the "vision of a democracy stumbling through every error till its institutions glow with justice and its customs shine with beauty," he recognises that democracy is still on its trial, and that its future depends on its capacity for choosing its leaders. Its critics say that its preferences are invariably for the inferior. In these circumstances it is the function of the "college-bred" to divine the worthier and better leaders, and to follow them and to impress the democracy with their own higher preferences. While South Africa is not exactly a democratic community as America, the same need exists here for choosing the best: the men and women trained by a University, acting by their influence and example, should induce more and more citizens to be ready to fight abuses or corruption, ready to speak, write, and vote reasonably, ready to know true men when they see them and prefer them as leaders to rabid partisans or empty quacks.

Much of this training in character will be given by the social life of the University. When a number of students come together and freely mix with one another, they learn much, new ideas, new views, and new judgments. They are in a small world of their own, and they learn, as will be of use when they take a part in the larger world, something of the qualities of force or efficiency in execution, judgment or good sense, and tact, some power in putting forward opinions which they believe to be right, while admitting freely that different opinions may be held by others as genuinely as their own. In a student community, too, a man will learn something of action, not for himself, but for his side, or his fellow-students, or his university, and there insincerity and pose will be quickly detected and pointedly condemned; there, too, he has opportunities for making congenial friendships.

This training will clearly be given best when students not only come from various parts of the country, but also are studying in various courses or preparing for various professions. In the debates on the proposal to found an Agricultural College at Pretoria early in 1910, before Union, the Colonial Secretary of the Transvaal said: "Higher education in agriculture is not an isolated thing, but part of higher education generally, and if you want to give a man the highest education in agricultural subjects he ought to be at a centre where he can exchange ideas with others, where teaching is not only given in agriculture, but in scientific subjects generally, and where higher education is fostered in all directions." An American authority, Professor Davenport, has put it in this way: "There is no such place for the farmer to study history and to learn to see himself as others see him, as where he studies history in company with those whose chief interests are not in agriculture, or in engineering, or in teaching, but rather in history itself, by which we study the true significance of world movements of all classes, and come to know things past and present in their true perspective. That is to say, every man ought to be educated in an atmosphere not especially prepared for him and his own kind, but in an atmosphere and an environment much broader than his own interests."*

So by study at a university it is hoped that while specialists in any subject are trained such may not be narrow or pedantic in their view. Too often professional or technical education means a one-sided development and may show itself by a failure to

* Quoted by Hon. Lionel Curtis in Legislative Council, Transvaal.

adopt wide views or a disinclination to look at a question from the point of view of others or in extreme cases by a tendency to judge every proposal by its effect on the men's class or caste, by indeed the phrase, "This our craft is in danger."

Encouragement of the Study of Science.—It is natural that the members of our Association will hope that the study of science will be encouraged in every way at a university. Science is not limited to the natural or physical sciences, but it is a great advantage to a student to have at some time training in one at least of these. In the experimental study of any science, a student is furnished "with a means of gaining intellectual strength and preparation for the educated man's career in life, such as it would be foolish to neglect. . . . . We all need the intellectual habits which the faithful study of science tends to foster. We are not all endowed with the same natural gifts, but —more even than original capacity—what distinguishes one man from another, and determines the greater or less success with which he shall play his part in the work of life, is the keenness and accuracy of his powers of observation, the practical ability to grasp the meaning of facts and to weigh the force of evidence. Half the weakness and perversity in the world arises from men's inability to *see* what is before their eyes, and the other half mainly from their incapacity to discern the meaning of what they see. In the business of life, in all spheres of human activity, there are multitudes who are the slaves of their eyes, the passive victims of outward impressions—who have never learned to fix their attention, who overlook half of what they see, or think they see what they do not see, or confound with what they have seen what they only imagine, or what other men tell them, with an air of confidence, that they have seen. There are multitudes who in the ever-recurring exigencies of life—when the call arises for independent judgment or rapid decision and action, from the lack of trained habits of observation and inference, because, in other words, they have a reasoning machine which has never been habituated to move smoothly and rapidly—are for all effective work weak and useless." "And just that rational gymnastic which such minds need is that which a thorough discipline in the methods of investigation, the problems, the processes of science supplies." I quote this, not from a scientist, but from a philosopher and a theologian.*

The benefit derived from the study of a science depends very much on the experimental work connected with the course, and it is here that we lag behind. Every candidate for the degree of Bachelor of Arts at the present University of the Cape of Good Hope has to take at least one one-year course in a science, but in the examination on this one-year course the practical test given by the University of the practical work, in every science but one, is of a perfunctory kind, or does not exist at all. It will be for the new Universities to improve this. A science subject is compulsory for the matriculation examination of the present Univer-

* "University Addresses," by Principal Caird, University of Glasgow.

sity, so that all the schools which teach to this stage teach at least one science. Practical work is supposed to be given, but recent comments by the University examiners in the science subjects are unsatisfactory. One examiner says: "The work handed in shows that many candidates are taught to remember a large number of formulæ as well as descriptions of experiments, which were probably not carried out by the candidates themselves"; another says, "The experimental work at such centres had apparently been neglected, and, in some cases, it was clear that the candidates had never performed any experiments themselves"; a third, "It was perfectly clear that in many cases the experiments described by the candidates had never been witnessed by them, and that the 'experimental and observational knowledge' had been derived either from text-books or from notes dictated by teachers, and then learnt quite mechanically"; while still another says, "Even in good sets of papers it is often clear that instead of the students having performed the simpler experiments for themselves, and written down an account of what they have done, the teacher has not only performed the experiment for them, but has dictated an account of it." That sort of thing brings discredit on science, and as long as schoolboys are taught in this fashion, their parents and they in turn, when they grow up, will fail to see that any benefit is derived by the study of a science. Good teachers in science will be more and more required, and it will lie with the universities to supply these. A former complaint about science teachers in schools was that they thought it only necessary to have a science degree, and that training in teaching was unnecessary, but nowadays the complaint is being reversed, and it is said that many teachers have all the pedagogic virtues but lack a decent knowledge of the subject they are to teach. Our universities will, we hope, send out to the schools teachers in science qualified in both knowledge and training; for some years now graduates have been trained as teachers under the ægis of some of the colleges, and a continuation of this work for larger numbers of graduates may be expected from the universities.

It is remarkable that an Irish member of the British Parliament, in a book lately published, has as his main suggestion for bringing out the best in the Irish character and starving out the worst, a training in science—the branch of education in which Ireland is notoriously deficient.*

A headmaster of a public school in England has declared that any extension of science in the school is impeded by the indifference, or even opposition, of the parents. But if science is to be extended, the teachers themselves must be keen in their desire for its extension; failure in that direction is certain if many teachers still retain the old idea that classical education "not only elevates above the vulgar herd, but leads not infrequently to positions of considerable emoluments." Here the devotion of the greater part of school hours to the study of

* "Ireland's Vital Hour," by Arthur Lynch, M.P.

classics does not exist, and the difficulty about first giving science at all, and then extending it, has been largely financial. But with encouragement of science at the universities and good science teaching at the schools, as students and scholars go out into professions, businesses, and trades, this difficulty will disappear in the more general appreciation of the value of science and of the teaching of science.

The universities will naturally be looked to to train men of specialised scientific knowledge. Encouragement to train these is given to a certain extent by the State, in its employment of such, and it is hoped that the Union Government will hesitate to adopt one easy method of economising in times of depression, namely, to dismiss its scientists. In the Transvaal a Geodetic Survey was being carried out; at a moment's notice all the men working on it were dismissed and the work abandoned. Money was saved at the time, but the expense of finishing this most useful work at any future time has been largely increased; a competent staff will have to be built up again, its equipment found again, and the apparatus standardised again. Under the Cape Government the Department of Marine Zoology, which had been doing valuable work, was at one time for the sake of economy practically blotted out.

Nothing will prevent this sort of economy but the far more general appreciation of the value of science I have already spoken of. Men are wanted who "have such a knowledge of science that will give them an intelligent respect for it, and an understanding of what it can do, how to make use of it, and to whom to apply when special knowledge is required,"* and these the universities should send out into all kinds of work in South Africa.

It will be an advantage to a university to have faculties of applied science. For one thing it will at present be strengthened greatly in making its influence felt in the community. The so-called "practical" men are not unknown in South Africa "what is practical to them is usually confined within the limits of personal experience, instead of being permitted to fall within the far wider limits of the experience of our race."† But the practical man must be got into touch with the university, the gulf which usually separates him from it must be bridged; he must be led to see that "there is hardly a branch of trade or commerce which does not depend, more or less directly, upon some department or other of physical science, which does not involve, for its successful pursuit, reasoning from scientific data."‡ Now at present he does see the need for training on the part of doctors and engineers, and probably admits that some pure science, even though not obviously required in practical life, is of real value to them. If a university has faculties of medicine and

* From memorandum on "The Neglect of Science," signed by 36 distinguished scientists.

† Report of the Carnegie Institution of Washington, 1915.

‡ Professor Huxley, 1887.

engineering, such a man will consider it is doing useful work and will look to it as an institution to be supported; seeing, too, more of its work, he may learn the benefits of its science teaching and its training in general for men going to take up other careers.

The future leader of applied science, too, should attend a university along with the pure scientist, not only because he should have a full training in the theory which underlies his applied science, but also because he, as I have said, requires the training in the wider atmosphere.

The student of pure science will learn much by seeing to some degree applications of the science he is studying and acquiring some interest in them; he may be prevented from becoming the "mooning pedant or pernicious crank," spoken of by our President in 1910. In any case the mingling of the pure and applied scientists will prevent any such barrier being set up between them as is referred to in scientific addresses in England, and such remarks being made here by presidents of technical institutions as that the general disregard of science in England is of course the fault of scientific men (meaning, I suppose, the pure scientists) and particularly of the Royal Society.

Furthering of Research.—A university is expected to further research. Every age is the inheritor of the intellectual wealth of preceding ages, and it is its duty to hand that on increased by its own contribution to the succeeding age. In every department the sum of human knowledge is limited, and it is an inspiration to those who are working to feel that every discovery is not only an addition to knowledge, but a sure stepping-stone to still further advance. The desire to add to human knowledge should exist right through a university, and its teachers should have ample leisure and satisfactory equipment for their private research, two conditions which have only sometimes been fulfilled at the colleges in South Africa. The new universities should at all costs avoid the danger pointed out in the "Handbook for Australia" printed for the British Association in 1914. In the section on educational policy and development in connection with their universities, there occurs the sentence, "In a new university the teaching function dominates. The teachers, especially in the faculty of arts, are overburdened with formal lecturing and class-work, and have too many subjects in charge to permit of the necessary specialisation." I must add, however, the next sentence: "Yet, in spite of these restrictions the annual output of original work is highly creditable to the Australian Universities, especially in the scientific departments, where the teachers are in less bondage to the formal lecturing system." Still, while it is necessary for the encouragement of research to build good laboratories, endow chairs well, and attract the best men possible, it must be remembered that the highest form of research is not made to order and that there is more in genius than industry and opportunity. The university which can count a Kelvin among its professors is indeed fortunate; what man, privileged to be a student under him, does not recall the vivid interest in seeing him in his class-room and his laboratory!

A connection between a university and research institutions will be of real advantage to both; the research workers would mingle with scientific workers in the departments of the university, they would be able to interest students in their work, perhaps start senior students on some definite research work, while, on the other hand, to see a research institution and know something of the work done there would be a real stimulus to the students of the university. In urging, in his Presidential Address to Section C in 1910, the establishment of a National Botanic Garden, now happily accomplished, Professor Pearson said: "The direct or indirect association of university and botanic garden is nothing new; it has endured for centuries in many European centres of learning. As an aid to education—not merely the acquisition of botanical knowledge—the botanic garden is an invaluable asset to a university, and, on the other hand, the staff of a university botanical department can contribute very effectively to the research work carried on in the botanic garden." The benefit to a university by being in any way linked to the great bacteriological research institution at Onderstepoort, under Sir Arnold Theiler, is so obvious that I need not linger over it.

It is not to be forgotten that research at a university is for the purpose of extending our knowledge, and that it cannot be measured by merely its utilitarian value. The work is worth doing if it enlarges the bounds of knowledge and discovers new truths, the university must do its best to encourage the investigator, but he must be allowed to go on his own lines.

"He who seeks for immediate practical use in the pursuit of science may be reasonably sure that he will seek in vain. Complete knowledge and complete understanding of the action of forces of nature and of the mind, is the only thing that science can aim at. The individual investigator must find his reward in the joy of new discoveries, as new discoveries of thought over resisting matter, in the æsthetic beauty which a well-ordered domain of knowledge affords, where all parts are intellectually related, where one thing evolves from another, and all show the marks of the mind's supremacy; he must find his reward in the consciousness of having contributed to the growing capital of knowledge on which depends the supremacy of man over the forces hostile to the spirit.*

It is true that many investigations of apparently the most theoretical character have led to important developments in practical science. A recently-quoted example† is interesting of how "pure science" research can result in a profit in actual money. In the routine examination of oceanic deposits on the *Challenger* Expedition, Sir John Murray detected a fragment of phosphatised limestone, and found out that it came from Christmas Island in the Indian Ocean.

* "Vorträge and Reden," by H. Helmholtz, Vol. I, p. 142

† Proceedings of the Royal Society of Edinburgh, Vol. XXXV, p. 305.

Later a company was formed to develop the island, and especially to quarry and ship the phosphate. The small fraction of the wealth of the island which went to the British Government, in the form of rents, royalties, and taxes, exceeded within fifteen years the entire cost of the *Challenger* Expedition and the publication of its results

But encouragement to research in pure science is not to be given simply because it may pay; it should be given even though there is almost certainty that it never can have a practical value, and it is a wholly unreasonable proposal even at this time that no mathematics should be investigated unless it refers to aeroplanes; even the *Educational Times** is greeted with a jeer: "It contains the usual series of out-of-the-way properties of conics, triangles, and collections of algebraical symbols and the usual neglect of aeroplanes."

Of course at a time like this if a man has the ability and the opportunity to make researches in the mathematics of aeroplanes and their application, he would be expected to do so unless he could make other investigations at least as useful and at any time money should be spent, and spent freely, on researches which have a practical application, as the Union Government is doing in connection with diseases of animals, insect pests, and so on. But that kind of research work cannot alone be expected at a university, nor is it the duty of a university to encourage only such research.

The university should provide that course of theoretical knowledge on which are based the great researches in applied science; if some of these researches can too be done at it or in connection with it, practice may be kept in touch with theory, and theory extended into practice. Students who intend to take up work in connection with manufacturers will gain some knowledge of applied research work, and will be free from the distrust so many British manufacturers are apt to have for research work and research employés. No doubt this distrust is due in a measure to the fact that they, trained in manufacture and knowing little of pure science, find it difficult to come to an adjustment with men trained in pure science and inexperienced in manufacturing processes.

The capture of industries by Germany is often quoted. It must be remembered, however, that in the famous instance of the manufacture of coal-tar dyes, two German firms spent a huge sum of money in research work before they had the processes complete; again, that before Zeiss made all the various kinds of glass of which they had practically a monopoly, as Great Britain found at the beginning of the war, they had employed experts in optics to advise them. The experiments in Germany by Professor Abbé and Dr. Schott, who continued those in England by the Rev. Vernon Harcourt and Sir George Stokes, were carried on for about three years before the glass manufactory, with the

* Now called "Mathematical Questions and Solutions."

aid of a subsidy from the Prussian Government, was set up at Jena in 1884, and it is interesting to note that in 1881 practically all the optical glass for the experiments was got from two firms, one English, the other French.

In South Africa for some time to come the number of post-graduate and research workers in the universities will be small. The real inducement to hold out to such students is a preference for appointments of good standing after their post-graduate course; if in the choice of experts for the Government scientific departments the work done in such a course is to be reckoned, a stimulus far better than the offer of scholarships or bursaries will be given. The award of scholarships for research is beset with difficulties, for any previous examination test is quite irrelevant. Nor need the complaint, voiced at times in America, that the postgraduate courses are filled with qualification-hunters instead of true seekers after knowledge be taken as very alarming; if for a post research is necessary, it is obviously good that a man should be trained for it, and trial made, if he is suitable for such work. If the heads of departments are enthusiasts themselves, they will lead on those in whom there is the real aptitude for research, though previously unknown, and your mere qualification-hunter may become a true seeker after knowledge. Research is the crown of the work of a university, and the position of a university in South Africa compared with universities in other parts of the world will largely be determined by its achievements in the higher fields of research and investigation.

To-day there is general agreement that the purposes of a University may be classed under three heads,—teaching, under which may be reckoned the influence of teacher on student and student on student, research, and influence on the community in which it does its work. For teaching to be at its best there must be the spirit of research in the members of the teaching staff. For influence on the community there must be a real co-operation between the community and the university, the university must train and help the members of the community, and they in turn must support it liberally to give it the fullest facilities for that training and help; for this influence on the community to be greatest there must be an admiration of, and pride in, the university; this must follow if, through distinction in research, it takes high rank with other universities. A university may be spoken of as a nation was spoken of by James Russell Lowell, "Outsiders can only be expected to judge a nation by the amount it has contributed to the civilization of the world; the amount, that is, that can be seen and handled. A great place in history can only be achieved by competitive examinations, nay, by a long course of them. How much new thought have we contributed to the common stock? Till that question be triumphantly answered, or needs no answer, we must continue to be simply interesting as an experiment, to be studied as a problem, and not respected as an attained result or an accomplished solution."*

In conclusion, I should like to speak on three matters which have been forced on our attention by the great war now proceeding.

The Use and Abuse of Science.—Centuries ago Francis Bacon dreamed of the time when the empire of man over man, through statecraft and force, should give place to the empire of man over nature, through morality and intelligence. For that larger empire the university professedly stands. To-day, in the midst of this great war, we seem to have gone back to the days of force, and science, by which man has triumphed so much over nature, has become not the handmaid but the tyrant of the nations. The new phenomena, the new forces found by science have always been ready for use by both the philanthropist and the criminal. Science has found chloroform as well as chlorine; it has invented wireless telegraphy to help a wrecked ship to send out a call for help, as well as the torpedo which has destroyed her. In this war it has not only improved every weapon of destruction, but it has also sharpened every engine of inhumanity. That the triumphs of the war are the triumphs of science is not in praise of science; something is wanted from science and its advancement rather to stop war than make it more hideous.

The Attitude of Distinguished Scientists.—Before the war the great position of the German universities was a frequent topic, and students in numbers went from all countries and from their own universities to German universities. When war broke out it was natural that the professors should be enthusiastically patriotic, but the extravagance of the language of many of them has proved how far they have fallen from the position and broad views cultured leaders of science and literature ought to be able to take. Professor Ostwald, visiting Sweden in October, 1914, as an "intellectual war volunteer," is reported to have said, "I say frankly that I consider that Germany, through her organised talent, has reached a higher stage of civilization than the other nations, and that the war will be the means of admitting them to a higher civilization on this basis."† Others have written in similar strains, but it is to be said that there is something of a reaction against this megalomania. A German writer‡ last year said, "We were prepared, when this war broke out, for dreadful things—unheard-of sacrifices of life, terrible misery, plague, hunger—but not for this terrifying moral degeneration," and he blamed not so much the people as its public men and its professors. On the latter class he is especially severe, and goes so far as to say that the worst aberrations of popular delusion have always been consecrated by science. This year Professor Planck,

* "My Study Windows, On a certain condescension in foreigners."
† "Before, during, and after 1914," by A. Nyström.
‡ Ernst Müller-Holm, in "*Der Englische gedanke in Deutschland.*"

of Berlin, has written admitting that the form of the letter signed in August, 1914, by 93 scholars and artists was written in the patriotic exuberance of the first weeks of war, and saying that the letter did not show the real sentiments of the signatories. He adds that he is firmly convinced that there are moral and intellectual regions which lie beyond this war of nations, and that personal respect for the citizens of an enemy State is perfectly compatible with glowing love and intense work for one's own country. This is a statement which recalls the earlier days, graphically and sympathetically described by Dr. Merz in his *History of European Thought in the Nineteenth Century*, written in the first decade of this century. "The pursuit of truth and the acquisition of knowledge for its own sake, as an ennobling and worthy occupation, has, during a large portion of our century, been the life-work of professors and students alike in the German universities. In the biographies of many of them we meet with that self-denial and elevation of spirit which is the true characteristic of every unselfish human effort. . . . Once, at least, has science, the pursuit of pure truth and knowledge, been able to raise a large portion of mankind out of the lower region of earthly existence into an ideal atmosphere. . . . We may, perhaps, have to admit with regret that this phase is passing away under the influence of the utilitarian demands of the present day; we may be forced to think that another—and, we trust, not a lower—ideal is held up before our eyes for this and the coming age. But no really unselfish effort can perish, and whatever the duty of the future may be, it will have to count among the greatest bequests of the immediate past that high and broad ideal of science which the life of the German universities has traced in clear and indestructible outlines."

It was, perhaps, the natural rebound from the praise which used to be uttered over everything German in science and the deference which used to be paid to the great claims of the Germans themselves that made many British scientists rush, when the war broke out, to explain how little Germany had done in the great pieces of research in science, and how its forte had been to carry on research when the way had been opened by others. For instance, Sir William Ramsay* wrote, "The German race has had an honourable share in the progress of science; but their influence has not been preponderating; and with some brilliant exceptions their scientific men have rather amplified in detail the work of the inventors of other nations. Such work is very useful, and is by no means to be decried; but it partakes rather of the character of that of the organ-blower, contrasted with that of the organist." This attitude is, frankly, unworthy of distinguished scientists, and it is one which has been modified by time: the stream of articles in newspapers and magazines tending to show that

* *Quarterly Review*, April, 1915.

Germany has taken but a poor place in the domain of science has now completely dried up. In every science Germany has its many honoured names, and taking only one, Pure Mathematics, the names of Cantor, Dedekind, Gauss, Grassman, Klein, Leibniz, and Weierstrass will for all time speak of original work of the highest value.

Relations of the State and Universities.—This is much too large a subject to enter on at the end of an address, but a few words may be said. Here the universities will be largely supported by funds from the State and in consequence there will be a certain amount of State control. The staffs will be regarded in some way as civil servants and some lines of activity will not be open to them. But there must not be too much control; nothing must be done to check freedom of thought or to make the views of professors conform to the views of a government. In all investigations, literary and scientific alike, honesty is more indispensable than ability, and no dissimulation through patriotic, religious, or even moral motives must be allowed in regard to the facts investigated. It is from this freedom passing from professor to student and student to community that training in individual initative is developed and character strengthened. The statement is made that there is lack of this personal will in Germany, and that the rigid State control of schools and universities has "made the minds of individuals too susceptible to current intellectual fashions, and has left them deficient in the power of independent criticism."*

These three things that I have mentioned are all deeply involved in the question of "character." It was to the effect of university training on this quality that Mr. Asquith referred at Glasgow University when he said that a university "will be judged also by the influence which it is exerting upon the imagination and the character; by the ideals which it has implanted and nourished; by the new resources of faith, tenacity, aspiration with which it has recruited and reinforced the untrained and undeveloped nature; by the degree in which it has helped to raise, to enlarge, to complete the true life of man, and by and through him the corporate life of the community."

* M. E. Sadler.

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

President of the Section—Prof. John Orr, B.Sc., M.I.C.E.

FRIDAY, JULY 7.

The President delivered the following address:—

SOURCES OF ENERGY AND ECONOMY IN FUEL.

At a time like this, when the British nation is in the throes of the greatest and most terrible war which the world has ever experienced, and we all hope never will again, I think that the proposal of the Johannesburg Section of this Association, that the work of this session should, as far as possible, have reference to problems arising out of the war, was one which must receive the heartiest support from the members of any scientific and technical body.

The Minister of Munitions has said, "This is an engineer's war, for equipment was even more needed than men," and, as Professor Unwin has said in his presidential address to the Institution of Mechanical Engineers, "We have to overcome the material resources of an enemy who had long made deliberate and, as he believed, adequate preparation."

The British nation is becoming aroused as to its mistaken policy in the past. If this war succeeds in creating a greater feeling of pride of race, and leads the British people to drop the anæmic and suicidal policy which has led to a foolish consideration of the interests of the foreigner as against their own material prosperity; if it leads to a due appreciation of the risks which have been run and the problems which have to be faced; if it creates a new national spirit and awakens the great masses from their lethargy, so that industrial advancement may be recognised as a vital necessity for its existence, and that the supremacy which in many instances has been foolishly surrendered may be permanently recovered; then this war will not have been fought in vain.

The criminal neglect of science by the British people, the boastful and culpable feeling of security, which we must admit has, in recent years, almost come to be recognised by our enemies as one of our characteristics, has, I hope, been clearly brought home to us all. Science is coming into its own; that fact has been recognised even by the British Government, and, late in the day as it is, I am sure we all welcome the steps which have already been taken, to foster and encourage British industries, and to protect them from unfair and unscrupulous competition after the war, by the appointment of the Committees, the constitution of which has been recently announced.

In July, 1915, there was set up, by an Order in Council, an

Advisory Council for the Organisation and Development of Scientific and Industrial Research, the need for which was thus expressed:—

"It appears incontrovertible that, if we are to advance or even maintain our industrial position, we must as a nation aim at such a development of scientific and industrial research as will place us in a position to expand and strengthen our industries and to compete successfully with the most highly organised of our rivals."

We, in South Africa, can lay no claim to be regarded as an industrial nation in the ordinary sense, apart from mining. But our mineral wealth is being exploited, mostly in the interests of shareholders residing in Europe, and no concerted efforts have so far been made to replace the wasting assets of the country. We take no thought of the morrow. As Professor Armstrong has recently said: "We care little, it is true for our ancestors; if possible, less for posterity; yet, there is a spirit of altruism growing up gradually which is more or less leading us to think that we must take effective steps to check the thoughtless squandering of natural resources, which has been a dominant characteristic of civilisation of late years."

One much welcome the steps initiated last month by the Council of the S.A. Institution of Engineers, which, in pursuance of a resolution recently passed by it, *viz.*, "There is a strong consensus of opinion among persons engaged both in science and industry, that a special need exists, at the present time, for means and for State assistance, in order to promote and organise scientific research, with a view especially to its applications to trade and industry," called a large and enthusiastic meeting of members of the Councils of the various scientific and technical societies, including this Association, at which the following resolution was passed unanimously:—

"The members present represent themselves as bound to combine in taking such steps as may be in their power to hasten the scientific development of the resources of South Africa, especially in view of the coming commercial and industrial competition, and the obligations of this country to do its share in providing suitably for the present and future needs of the men who are fighting its battles or who are disabled thereby, as well as the needs of their dependents, and the dependents of those who have given their lives in defending the honour of the British nation."

The following were declared to be the objects of the movement:—

1. To get in touch with the British Council of Scientific and Industrial Research, and similar Committees in other British Dominions.

2. To enlist the support and co-operation of the Government of the Union of South Africa and Rhodesia in the movement, as a step towards securing State aid.

3. To establish in South Africa a comprehensive industrial

research institution to collaborate with similar institutions which are or may be established in Great Britain and her Dominions.

4. To nominate a central committee for dealing with the subject in its various branches, with special reference to the needs of South Africa.

5. To collect, co-ordinate, and distribute information for furthering the objects in view.

The Council Members of all scientific and technical societies in the Union and Rhodesia form a general committee, and a central committee has been formed consisting of three representatives from each society. Messrs. Innes, Burtt-Davy, and myself have been appointed to represent this Association, and Mr. Innes has been elected to the Executive.

The Government of the Union has been severely criticised recently for its inaction in this important national matter. It may not be generally known, but I learn on reliable authority that at last the Government is becoming alive to the interests of this country as far as scientific and industrial research is concerned, and realises the urgent necessity of immediate action. I believe the secretariat has already been appointed to collect and co-ordinate all available information with regard to possible new industries.

It is to be hoped, however, that the Technical Societies Committee will not be dissolved, but will continue to act in a technical and advisory capacity, even if all executive authority, as it stands at present, is left to the Department of Mines and Industries.

It is exceedingly gratifying to observe in this the first real attempt to deal on a national scale with science as relating to industry in South Africa.

Apart from the war itself, there is no more important question confronting us at the moment than the industrial development of this country. As this subject is being dealt with in a paper to be read before this section, I will confine my remarks to the questions of the available sources of energy for power production and economy in fuel; since the cost of power is indissolubly related to the cost of manufacture and industrial advancement.

Considering the possible and actual sources of energy these might be classified as follows:—

Sources of energy.

The Sun's radiation	Food of animals. Fuels: Solid, liquid, and gaseous. Water above sea-level. Winds. Ocean Currents.
The earth's rotation .... Attraction of Moon and Sun	Tides
	Internal heat of the earth.
	Rock-masses at high level.
	Uncombined iron, sulphur, etc.

I have not included such sources of energy as the energy of the atom and of radium, and the truly unthinkable amount of energy accumulated in the rotating earth, all of which exist at present, as far as sources of power are concerned, as mere conceptions of the mind.

The function of man is becoming more and more, in modern industrialism, the director of a machine, and yet man, the earliest prime-mover to be put to work, is an internal combustion engine, utilising a great variety of solid and liquid fuels, having an efficiency slightly higher than the ordinary steam-engine, but inferior to the modern gas and oil engine. Such was the conclusion arrived at, after elaborate investigation and consideration of the heat value of foods, by Professors Barr and McKendrick, of Engineering and Physiology respectively, in my student days at Glasgow University. Man works at his greatest rate when lifting continuously a weight consisting of his own body, and he can then develop about ⅛ of a horse-power for 10 hours per day. Doing mechanical work, such as turning a windlass, the corresponding horse-power is less than 1-10th. Man is, and always will be, employed as a machine, and frequently, I am afraid, is treated from no other point of view, though he possesses liberty of action denied to the inanimate engine.

The world's work could not now be carried on without mechanical power. As Dugald Clerk says, "The present civilisation of the world rests upon the basis of coal and oil fuel, steam, and internal combustion motive power."

The first census of total power in the United Kingdom, taken in 1907, the latest available returns, showed that the power of industrial engines was over 10½ million h.p., or nearly 1 h.p. for every person engaged in industries, the details being shown in Table I.

TABLE I.

INDUSTRIAL POWER OF THE UNITED KINGDOM IN 1907.

	H.P.	H.P.
Steam engines—		
Reciprocating	9,118,818	
Steam turbines	530,892	
		9,649,710
Internal combustion engines		680,177
Water power		177,907
Other Power		70,681
Total capacity of engines		10,578,475
Road rollers, locomotives, etc. (public authorities)		166,897
Agriculture in 1908 (34,450 steam, gas, oil, petrol, and other engines)		213,525
Estimate—		
Railway locomotives		3,300,000
Mercantile marine		5,000,000
Royal Navy in time of war		5,000,000

The division of the total engine-power of the United Kingdom amongst different industries and different types of engines is shown graphically in Fig. 1, taken from a paper read in 1914 by E. G. Hiller before the Manchester Association of Engineers.

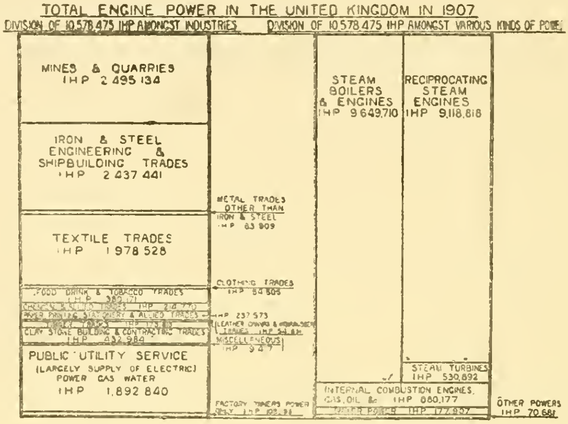


Fig. 1.

Dugald Clerk has estimated the total power of the world generated from coal alone as:—

World's Power from Coal.

	H.P.
World's factories	60,000,000
World's locomotives	19,000,000
World's ships—	
Mercantile marine	10,000,000
Warships	13,000,000
Total	102,000,000

It is a painful travesty of modern civilisation to note that the warships of the world absorb 30 per cent. more power than the peaceful commerce carriers.

Coming to South Africa, the latest returns available are those collected in 1913. Details are given in the following table for each Province and for the power requirements of gold, diamond and coal-mining, base minerals, and industries.

It will be seen that as regards steam, gas, and oil power, the requirements of the Transvaal are 80 per cent. of those of the Union. The returns from the Cape are probably not complete, as this was the first occasion on which they were made in that Province.

Solar Power.—It will be seen that practically all our available energy has its source in the sun. This fact, and a knowledge of the enormous amount of heat energy stored up in the sun, has provided one of the most fascinating problems of

TABLE II.

POWER IN SOUTH AFRICA. (Railways Excepted.) 31st December, 1913.

	Steam Engines.		Oil Engines.		Gas Engines.		Turbines and Water Wheels.		Totals. Steam, Gas and Oil.	Electric Motors using power not Generated on Property.		Compressed Air Motors, using Purchased Power.		Transport Locos, Steam, Electric, etc.	
	No.	I.H.P.	No.	I.H.P.	No.	I.H.P.	No.	I.H.P.	I.H.P.	No.	I.H.P.	No.	I.H.P.	No.	I.H.P.
TRANSVAAL.															
Gold	1,166	388,169	32	291	44	2,606	60	5 846	396,912	3,941	280,498	..	20,985	127	17,908
Diamonds	21	11,234	4	37	..	..	..	..	11,271	..	..	..	..	..	..
Coal..	202	14 717	2	16	..		..	..	14,733	..	..	..		27	3,519
Base Minerals	35	1,796	9	124	25	2 912	..		4,832	..	..	..	..	..	..
Industries	1,111	231,568	1.9	1,005	36	1,183	22	801	234,557	694	7,996	..	..	182	4 609
CAPE.															
Gold ..	2	30	..	..		..	..	..	30	..	..	..	..	..	..
Diamonds	173	31,548	75	524	6	178	..	..	32,250	..		..	..	55	1,690
Coal..	10	664	..	..	..	..	..	..	664	..	..	..	..	4	80
Base Minerals ..	23	1 833	4	348	4	465	..	..	2,646	..		..	..	20	1,075
Industries	853	29,413	401	4,265	147	4,209	38	1,176	39,063	811	5,285	..	..	105	2,504
O. F. S.															
Gold	2	42	..	..	..	..	..	..	42	..	..	..	..	..	..
Diamonds	126	15.190	17	137	8	695	..	..	16.022	..	..		..	24	757
Coal..	24	2,187	..	..	..	..	..	..	2,187	..	..	..	..	4	650
Base Minerals ..	..	..	..	..	..	..	..	..	..	..	..	..		..	..
Industries	487	8,967	111	900	47	1 632	25	779	12,278	83	559	..	..	13	287
NATAL.															
Gold	9	139	..	..	2	172	..	..	311	..	..	..	..	..	..
Diamonds	..		..	..	..	..	..	..	..	..	..	..	..	..	..
Coal	182	13,744	..	..	..	..	..	..	13,744	..	..	..	..	5	360
Base Minerals .	..	..	..	..	1	30	..	..	30	..	..	..	..	..	..
Industries	896	42,718	76	635	31	1,205	32	555	45,113	293	3,785	..	..	115	3,432
Total TRANSVAAL	2 545	647,481	176	1,472	105	6,701	82	6.647	662.305	4,635	288,494	..	20,985	336	26,036
,, CAPE	1,061	63,488	488	5,137	157	4.852	38	1,176	74,653	811	5 285	..	..	184	6,069
,, O.F.S. .. .	639	26,386	128	1,037	55	2,327	25	779	30,529	83	559	..	..	41	1,691
,, NATAL ..	1 087	56,601	76	635	31	1,407	32	555	59,198	293	3,785	..	..	120	3,792
Total for the Union of SOUTH AFRICA ..	5,332	793,959	863	8,282	351	15,287	177	9,157	826,685	5,822	298,123	..	20,985	681	37,591

science, but the alluring problem of utilising directly the sun's heat as a source of energy, and constructing a commercially successful solar motor, has so far baffled all inventors, although it has brought much grist to the mill of the patent agent.

It has been calculated that the solar energy is equivalent to 80,000 h.p. per sq. yard of the surface of the sun. If there were no absorption, Professor Fleming has calculated that the earth would receive the equivalent of 250×10^{12} h.p., but owing to atmospheric absorption, clouds, and obliquity of the rays, the actual amount absorbed at the earth's surface is only 4 per cent. to 10 per cent. of the solar heat delivered. Investigations, carried out by Professor Very, led him to conclude that the amount of solar energy received per annum at the earth's surface, on an

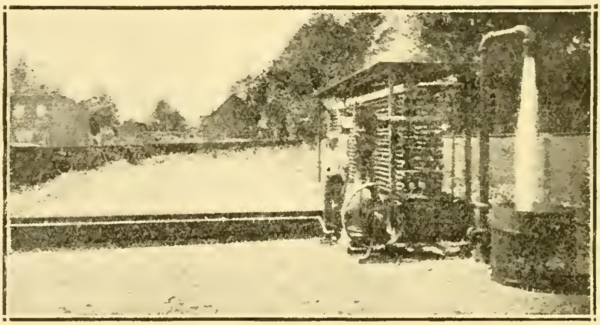


Fig. 2.—Shuman's Solar Plant. Earlier Type.

area of 100 sq. metres, was equivalent, at the places indicated, to—

	K.W. hours.
Central Europe	4 to 6 millions.
Northern United States ...	5 to 7.5 millions.
S.W. United States	10 to 15 millions.

In his Royal Institution Lectures in 1911, Professor J. J. Thomson, the well-known physicist, stated that, shining from a clear sky, the sun send to the earth, energy at the rate of 7,000 h.p. per acre. This energy would be the heat equivalent of 2½ feet thick bed of coal formed every year.

But even the most ardent advocate of the solar engine does not claim that it is practicable, except in the tropics, and even then commercially impossible unless coal is at least £3 per ton.

One of the earliest workers in this field was Captain John Ericson, who worked persistently from 1865 to 1878, and built in that time seven sun motors, the method adopted being to concentrate the sun's rays on a boiler. Eventually he succeeded in obtaining about 1 h.p. for every 100 sq. feet of absorbing surface, but finally abandoned his efforts as commercially impracticable. "The fact is," he admitted, "that, although the heat is obtained for nothing, so expensive, costly, and complex is the concentrating apparatus, that solar steam is many times more costly than steam produced by burning fuel."

Owing to the diffuse nature of the sun's rays, there is great difficulty in trapping them efficiently for practical purposes. Some of the methods, such as the one of Shuman's shown by Fig. 2, make no effort to concentrate the heat rays. Here the principle employed is that of the garden forcing-frame, in which the rays are absorbed directly, the apparatus consisting of a shallow flat box covered with two layers of window glass, to minimise loss from radiation. Coils of piping, painted black, were placed in the box, these containing the water which was converted into low-pressure steam. This experimental plant, erected at Pennsylvania in 1907, had a glass area of 1,080 sq. feet, gave a steam pressure of 15 lb., and developed 3½ h.p. Naturally a company was formed to exploit the invention, and it was stated that "if the results which are foreshadowed by the experimental plant are confirmed by more extended trials, one of the most perplexing problems will have been solved."

Efforts were afterwards directed to the system of concentrating the sun's rays on a boiler, by means of parabolic reflectors, and the first plant on a commercial scale was built by Shuman, at Philadelphia, where 32 h.p. was obtained at mid-day with an average of 14 h.p. during eight hours of the day. The experience gained from this plant was utilised in the plant erected at Meadi, near Cairo, in June, 1913. This solar engine, one of the parabolic reflectors of which is shown in Fig. 3, is used for pumping water

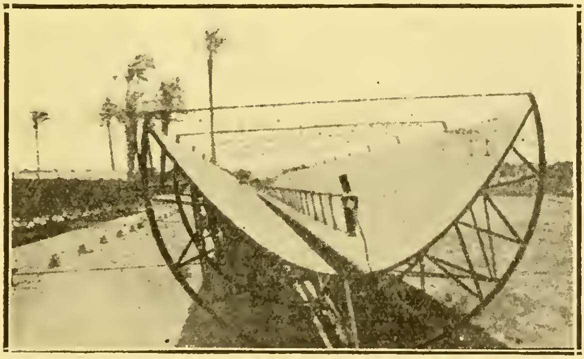


Fig. 3.—Solar Plant at Meadi, near Cairo, Egypt. One of the focussing mirrors which concentrate the sun's rays on the boilers.

for irrigation. It was visited in 1914 by Mr. Ingham, one of the Members of our Council, and a description was given by him in his presidential address to the S.A. Institution of Engineers in 1915. Parabolic reflectors are used, constructed out of ordinary window glass, silvered on the back. There are five such absorbers, each 200 feet long and 13 feet wide at the top, constructed of light structural steel, the light reflected from the mirrors being caught on the two sides of the long boilers made of thin cast-iron, which are suspended at the focus, so that every 5 sq. feet of sunlight received by the mirror is concentrated on 1 sq. foot of the boiler. Steam is generated at atmospheric pressure and utilised in a specially-designed low-pressure condensing engine. It is claimed by the inventor that high-pressure steam could be generated, but that radiation losses would be excessive. The heat absorbers, carrying the boilers, are attached to rollers and gears carried on concrete foundation-posts, and are turned slowly so as to face the sun at all times of the day, this being done automatically by means of a thermostat, which starts and stops the driving gear from the engine. Special provision is made for expansion and contraction, and the boilers are covered by a thin sheet of window glass. A wind pressure of 30 lb. per sq. foot has been allowed for.

Fig. 4.—Outline Map of Africa, showing the portion of the Sahara Desert which, according to Shuman, would have to be covered with sun heat absorbers to obtain every year a heat value equivalent to that of all the coal mined in the world in the year 1909.

The engine is capable of developing 50 h.p. and consumes 22 lbs. of steam per 1 h.p. hour. The maximum power obtained, however, has been 19.1 h.p., and in view of the fact that the plant occupies ⅞ acre this has to be compared with the 7,000 h.p., which is the power equivalent of the radiant heat received.

Mr. Ingham considers that this plant has not proved a commercial success. The essentials for such would be a reasonable first cost, and the estimated cost of the Cairo plant was £1,560, or £31 per h.p. even if 50 h.p. were obtained, or over £80 per h.p. based on the maximum power developed. There must also be an absence of high maintenance charges, and the plant must be simple in operation; these conditions it is claimed are fulfilled. The mechanical construction must also be such that the strongest winds may be resisted. Assuming that 50 h.p. could be obtained per acre, a 1,000 k.w. plant would occupy about 27 acres. But probably, apart from the high initial cost and the unweildly nature of the plant, the principal drawback is the intermittent nature of the power supply. It is not likely that a solar engine would be available for more than ⅓ of the day, or, say, 3,000 hours per annum. This disadvantage has been clearly realised by solar engine inventors, who have included, amongst other contrivances to obviate it, a combination of a windmill for use in cloudy weather, compressed air tanks, electrical storage batteries, and water pumped into a highly elevated reservoir and then used to drive a water turbine.

If engineers may be sceptical, Shuman, the inventor, is undoubtedly optimistic. Starting with the statement frequently quoted, that all the coal mined in the world is equivalent to 270,000,000 h.p. continuously throughout the year, and assuming that his Cairo plant developes 50 h.p. during a 10-hours day, and that it occupies less than 1 acre, and that it intercepts 13,270 sq.

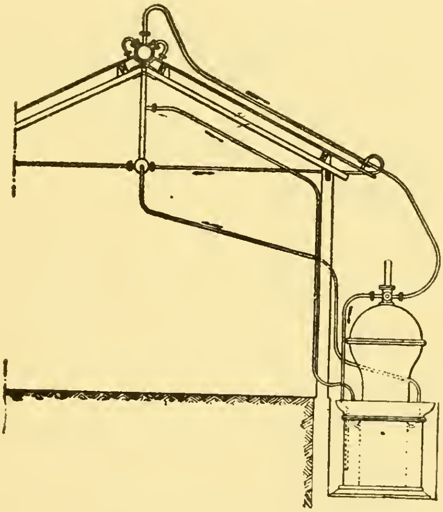


Fig. 5.—Suggestion for utilising a sun-backed roof for solar engine for heating purposes.

feet, or less than ⅓ acre of sunlight, he proceeds to unfold a wonderful scheme of power production. He calculates that it would only be necessary to cover 20,250 sq. miles, or a square of 143 miles side, of ground in the Sahara desert with sun-heat absorber units, spaced as wide apart as they are at Cairo, to give perpetually the 270 million h.p. per year to equal all the coal mined in 1909. Fig. 4 shows to scale the space occupied by this power-plant on the map of Africa.

"Surely," he says, "from this showing, the human race can see that sun-power can take care of them for all time to come." The cost of this truly American scheme he estimates at £19,700 millions sterling. "But," he continues, "this vast investment would not be made for or by the individual, but for and by the entire human race, and we can safely assume the human race to survive all the coal and oil fields by many thousands of years.

Hence its overwhelming value to posterity and its capacity for practically infinite expansion."

"One thing I feel sure of," he adds, "and that is that the human race must finally utilise direct sun-power, or revert to barbarism, and I would recommend all far-sighted engineers and inventors to work in this direction to their own profit and the eternal welfare of the human race."

A coalless world will not be so bad after all if only Mr. Shuman's advice is taken.

Other devices are shown in Figs. 5 and 6.

I am informed that the system is in use in California and other parts of America for heating purposes. There seems no reason why it should not be developed in this direction, especially in South Africa.

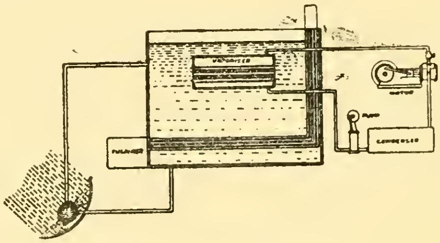


Fig. 6.—Suggestion to combine solar energy and a fuel-heated boiler for an ammonia engine.

Wind Power.—Currents of air have been employed from the earliest times as a motive power for marine propulsion; and sailing ships, at the present day, play a by no means negligible part in the carrying power of the world. But the variation of the wind in intensity and direction has militated against the general adoption of wind prime-movers. The earliest authenticated record of the erection of a windmill bears the date 1191, but there is reason to believe that it is of earlier origin. The crude construction of the earlier types have given way, under scientific engineering treatment, to the modern forms, but used as they mainly have been for corn-grinding, they could not hope to compete with modern prime-movers or electric supply giving a reliable and continuous source of power, and have consequently only survived in isolated parts, and mainly for small pumping plants, driving light farming machinery, and to a very limited extent for the generation of electricity. For such purposes, a considerable industry has been developed. It was recently stated that the production of windmills in the United States had increased fourfold during the previous ten years, and the making of windmills now constitutes, I believe, one of our few South African industries.

While the drawbacks are to a great extent similar to those for sun-power, there can be no denying the fact that a windmill is an exceedingly convenient motor. The motive fluid costs nothing, and, when it has done its work, no provision has to be made for its removal. In the smaller sizes, the machines are low in first cost; practically no attention is required in running, and maintenance costs are almost negligible. Only light foundations are required; they are easily erected, and being generally of steel construction, they are capable of withstanding heavy gales, while they will start up under light breezes. For pumping water and other purposes in which use of an intermittent character can be made they are admirably adapted, but the power obtained must always be small, as shown by Table III.

TABLE III.

Size of Mill.	Wind Velocity.		
	10 miles per hour.	15 miles per hour.	20 miles per hour.
12 feet ...	0·21 h.p.	0 58 h.p.	1·05 h.p.
16 feet ...	0·29 h.p.	0·82 h p.	1·55 h.p.

A windmill 40 feet in diameter would give about 8 h.p., but the cost would be about £50 per h.p. No windmill can be relied upon for more than one-third of the total number of hours in a year, and even then, the working hours are distributed very irregularly. Some cheap method of storing power is necessary to enable prime movers of such a fluctuating and uncertain nature to compete with energy derived from fuel.

The figures show the development of the primitive types to the present form.

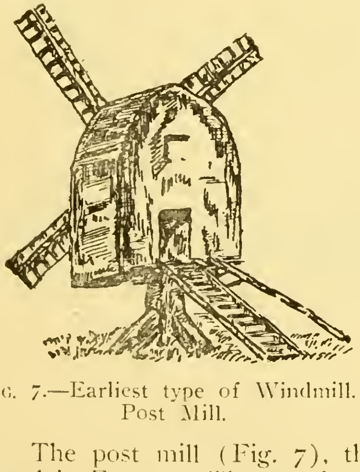


Fig. 7.—Earliest type of Windmill. Post Mill.

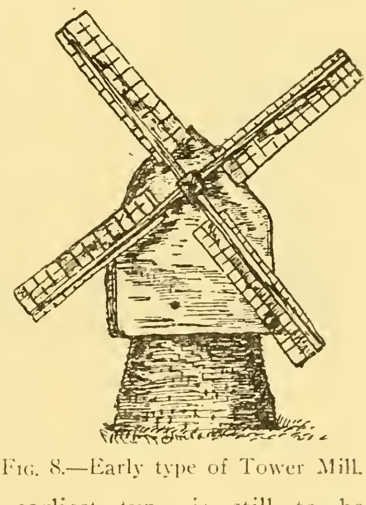


Fig. 8.—Early type of Tower Mill.

The post mill (Fig. 7), the earliest type, is still to be found in Europe. The wooden house containing the machinery has to be turned to the wind manually by means of a timber balk.

At a later date the house was supported on a masonry or wooden base (Fig. 8), and this type developed into the familiar

Fig. 9.—Modern Tower Mill.

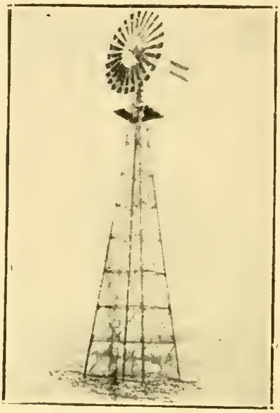


Fig. 10.—Modern Steel Windmill

tower mill (Fig. 9), to which an automatic veering mechanism was added.

The modern light steel tower windmill (Fig. 10), so familiar to the farmer and the suburban dweller, is made entirely of metal.

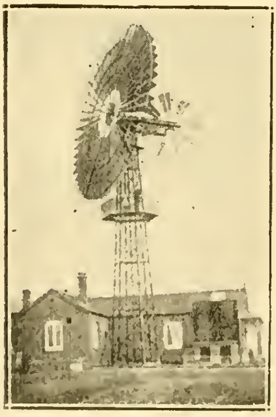


Fig. 11.—
Steel Windmill, 30ft. diam.

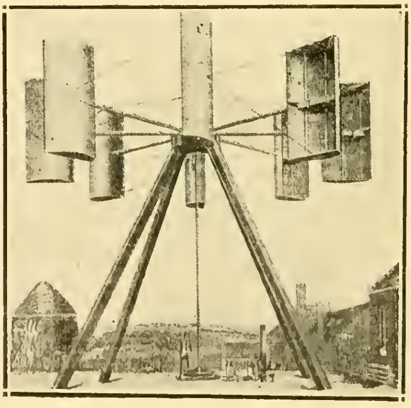


Fig. 12.—
Prof. Blyth's Windmill

Fig. 11 shows a modern windmill, 35 feet diameter employed for dynamo driving and pumping.

Much activity is still, however, being displayed in evolving new ideas. The principal objects sought after are to move the wheel automatically, so as to prevent damage in a storm, and to design the wheel so that no veering is necessary, the wheel working equally well with the wind blowing in any direction. The windmill, Fig. 12, designed by the late Professor Blyth, of the Glasgow Technical College, is worthy of notice as fulfilling both objects.

Fig. 13 shows another similar design in which the veering is assisted by two turbine wheels carrying a vane, and mounted on a horizontal axis.

Many attempts have been made to construct large-power windmills; one such is shown in Fig. 14, but is not likely ever to be erected.

Wind-power, it will therefore be seen, can never hope to be a serious rival to fuel for motive-power purposes.

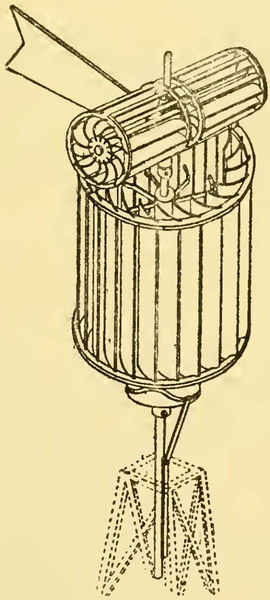


FIG. 13.—Windmill designed to work with the wind blowing in any direction.

Wave and Tidal Energy.—The utilisation of the energy of waves and tides has always had a fascination for many inventors, some of them engineers of high standing. The total mechanical power of the world is said to have been doubled during the past 20 years or so, and fears that, should this increase continue, the world's supply of fuel, now by far the principal source of power, will become exhausted, have given rise to many inventions for the utilisation of the enormous power going to waste in the tides. The majority of these proposals are exceedingly crude, and mechanically are quite impossible, although some inventors are sanguine enough to suggest that the forces of nature will be adapted and made subservient to the use of man as soon as the enhanced price of coal makes the pressure felt. The layman has observed the foolish waste of power when the many millions of tons of shipping in harbours are raised and lowered 10 to 20 feet every day, and have consequently flooded the world with many fan-

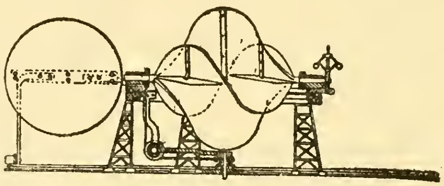


FIG. 14.—Suggested large power Windmill.

tastic schemes for the utilisation of wave and tidal power. But they forget that the work done by tides is only enormous because of its vast extent, and the time element has to be considered. To raise a vessel of 50,000 tons displacement a vertical distance of 10 feet involves an expenditure of under 85 h.p. if the time taken to do it is six hours. And then it is not fully realised that a considerable fall is necessary, unless an enormous quantity of water is available, to give a useful amount of power. For

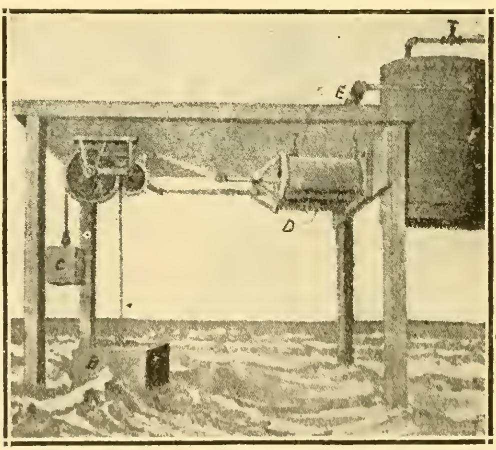


FIG., 15.—Wave and Gravity Motor.

example, a horse-power for a day of 10 hours requires about 1,200 tons of water falling from a height of 10 feet, so that to develop under this head 1,000 h.p. would require 1,200,000 tons of water, or over 40,000,000 cubic feet per day of 10 hours.

The less ambitious schemes adopt wave-motors, the power being generally utilised to compress air, though sometimes, in all innocence, electric generation has been suggested.

Fig. 15 shows one in which the alternate pull of a weighted rope, passing over a pulley, and a floating tank operates by gearing two air-compressor cylinders.

Fig. 16, taken from the *Scientific American*, shows some recent inventions which have been devised for the purpose of obtaining power from the waves. The first consists of a central square float, carrying air-compressors, the oscillation of the side-floats causing air to be delivered into the receiver shown, The advantage of this method is claimed by the inventor to be,

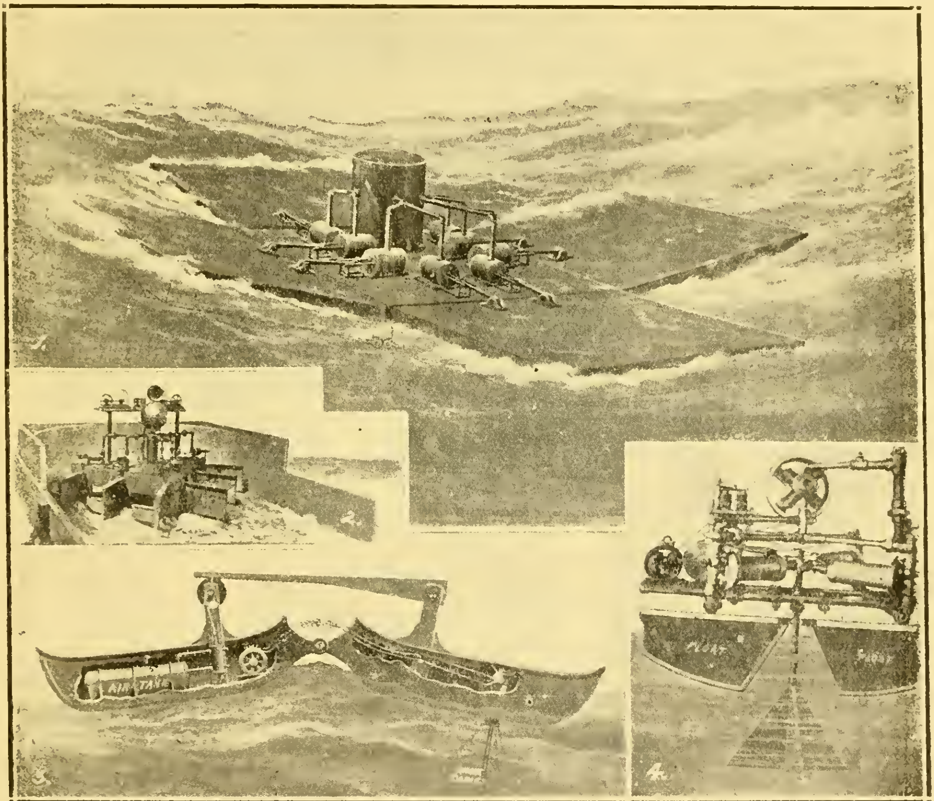


Fig. 16.—Four devices for obtaining power from waves.

that power is generated independently of the direction of the waves, because the auxiliary floats extend in four directions. The next method consists of a large floating vessel, open at one side, to the bottom of which is attached a hollow triangular piece with movable hinged vanes. The incoming waves cause these vanes to be folded against the triangular centre, and, on the return, water flows through the open back of the triangular frame and opens out the vanes, thus operating air-compressors. In the third method shown, the oscillation of two floats compresses air into a receiver, and this compressed air drives a dynamo by means of an air motor. The remaining method depends upon the greater motion of the surface water as compared with water at a greater depth, the vertical axis with attached pistons tending to remain stationary while the cylinders attached to the floats by their reciprocating motion circulate oil through a rotary engine, which in turn drives a dynamo.

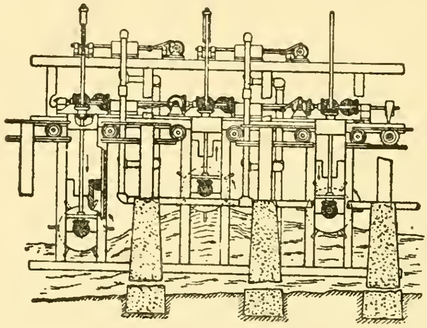


FIG. 17.—Paddle wheels propelled by the surf.

Many of the wave-motors so-called depend for their action on the horizontal travel of the water. One such surf-machine is shown in Fig. 17. Paddle-wheels, carried on floats, by their rotation due to the motion of the water to and fro, operate air-compressors.

An arrangement by which a trolley carrying a series of plates is driven by the surf up the beach, lifting meantime a weight to facilitate its return, is shown in Fig. 18.

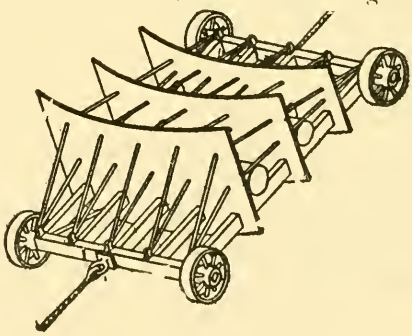


FIG. 18.—Device for obtaining power from the surf.

The next arrangement (Fig. 19) for utilising the surf has occurred to many inventors. The intention is to utilise the enormous force of the waves on a steep, rocky shore, air being compressed into cells, formed in concrete by the incoming water, the return of the compressed air being prevented by automatic valves on the delivery pipes.

It does not appear likely that much useful power is going to be gained by wave and surf motors. There is always the difficulty that floats must have an immense area in order to give power of any commercial value, while the force of the waves during a storm may wreck any machine which man can devise.

A certain amount of success has actually been attained in the utilisation of tidal energy, and some important schemes have been brought forward. The tides play an important part in modern harbour arrangements, and the familiar example of the barges floated up and down the Thames is an example of the use of tidal energy. It is a matter of great interest to note that 100 years ago the water supply of London was mainly derived from the tidal energy of the Thames. Owing to the obstruction caused by the arches of Old London Bridge, there was a fall of four feet, and this supplied the motive power of undershot water-wheels and pumps placed under some of the arches.

The usual method suggested is to impound the rising tide in a pond or reservoir, and on the ebb of the tide to utilise the

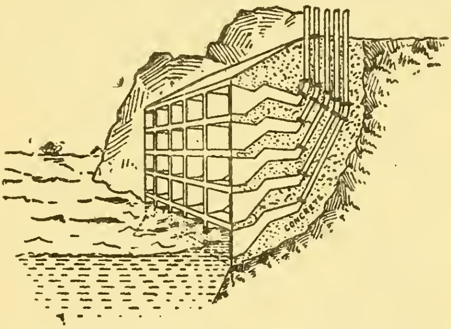


FIG. 19.—Compressing air into receivers by means of the surf.

flow to drive water-wheels or turbines. But the great obstacle to success is, that power is only available during the ebb of the tide, and even then the head for continuous output is not more than one-third the range of minimum tides, while the head of water is continually varying; the falls being low, and the ratio of maximum to minimum head being great, the conditions are very unfavourable for the efficient working of a hydraulic turbine. Further, owing to the enormous cost of masonry dams, it is necessary to take advantage of the natural configuration of a coast, to render any scheme worthy of a thought.

It is a fact not generally known that there are three tidal corn-mills working, or at any rate until recently, in England. One of these, at Walton-on-Naze, is shown in Fig 20. The ebbing tides drives an old-fashioned undershot water-wheel, under an average head of 5 feet, for a period of about five hours per day. Many proposals have been made to utilise both the flowing and ebbing tide; such a one is shown in Fig. 21. One tidal scheme at Havana is said to be successful, and to be still doing useful work. Another was actually installed at Cowes, Isle of Wight, but proved a failure. Various large schemes have been brought forward from time to time during recent years, the most important being the Chichester, Menai Straits, and Bristol schemes. The Chichester scheme was estimated to provide 8,000 h.p. at a capital expenditure of £300,000. That at the Menai Straits was to cost £542,000 and yield 14,500 h.p.; but the most ambitious proposal is that for Bristol, estimated to give

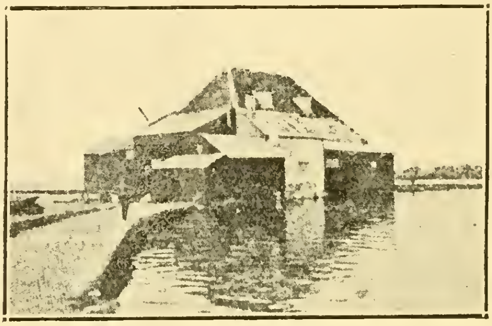


FIG. 20.—Tidal Mill at Walton-on-the-Naze.

240,000 h.p. available for the whole day at neap tides, with an additional 300,000 h.p. available for 10 hours per day at spring tides, the capital expenditure to involve the enormous sum of £9,534,000. Capital has not, so far, been forthcoming, but the inventors continue to be enthusiastic. Picturing the time when the world's power will be derived from the tides, one says: "The manufacturing city, now one of eternal smoke and vitiated atmos-

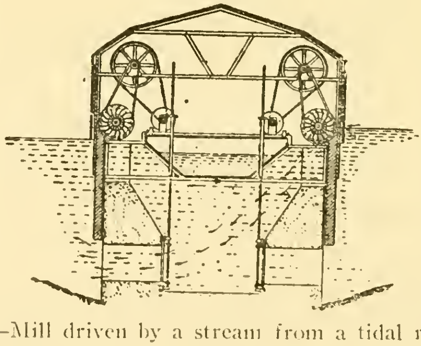


FIG. 21.—Mill driven by a stream from a tidal reservoir.

phere, will then become the city of light, health, and cleanliness." It would appear to be fairly certain that there is no field for tidal schemes as long as coal remains at its present value.

Water Power.—Flowing water was applied for the production of power over 2,000 years ago, and it is the earliest utilised motive power of which we have any records. In the early applications crude water-wheels were used, generally applied to the grinding of corn, and for many centuries these remained the only auxiliaries to animal power. Although water-wheels were gradually improved, they still remained inefficient and cumbrous machines and of comparatively low power, since they are incapable of utilising high falls. The largest water-wheel ever erected (at Laxey, Isle of Man) (shown in Fig. 22) was 72 ft. in diameter and developed 150 h.p. The introduction of steam power, towards the end of the eighteenth century, caused water power to be greatly neglected, but the development in recent years has been truly remarkable, due in the first place to the gradual improvement of the hydraulic turbine (invented about 1840), making it possible for larger and higher waterfalls to be harnessed, but mainly to the possibility of long-distance electrical transmission on an economical basis, enabling remote sources of energy to be brought

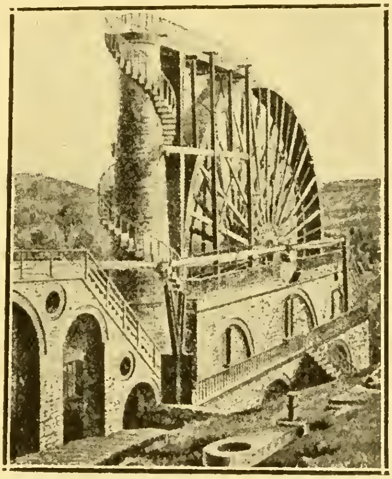


FIG. 22.—Overshot Water-wheel at Laxey, Isle of Man.

to industrial centres; but the use of electricity for chemical and metallurgical purposes has done more than anything else to focus public attention on water-power schemes—indeed, many chemical manufactures are only possible due to cheap electric power obtained hydraulically. It is estimated that the total capital invested in hydraulic power undertakings in the world is probably over £500,000,000 at the present day.

Although water power owes its origin to evaporation by the sun, hydraulic turbines receive their energy in the mechanical form without any intermediate state of transformation, as in the case of heat engines, which convert heat energy into mechanical work. Efficiencies of 80 per cent. are easily obtainable, and hydraulic turbines are now made in single units up to 20,000 h.p. Improvements now enable high heads as well as low heads to be utilised; in Worcestershire, England, there is a water turbine installation developing 40 h.p. with a fall of only 2 feet, while at Lake Tunay, Switzerland, there is a plant with an effective head of 3,018 feet, each cubic foot of water per second yielding 260 h.p. It militates against small water power schemes that the water supply is generally intermittent, so that a storage reservoir may be necessary.

As compared with water power, heat engines have the advantages of greater elasticity of site, thus obviating long-distance transmission, and although water power is available, the heavy capital cost required may render water power much more costly than steam power, in spite of extremely low running and maintenance charges, and the position is, in many instances, complicated by the cost of electrical transmission. But there is one instance in California where power is economically transmitted a distance of 232 miles, the electrical pressure being 50,000 volts. The question of the maximum economical distance of transmission for water power schemes is, of course, one which can only be solved by the consideration of many factors.

Capital cost is the main deciding factor in water power installations. The average first cost of all American water power schemes is given at £40 per h.p. developed, and it was stated in a paper read at the British Association meeting in 1912 that with water power schemes costing up to £20 per h.p. no steam plant could compete. In the admirable report on Electro-Chemical Industries, issued by the Development of Resources Committee of the South African Institute of Electrical Engineers, the following comparison between steam and water power is given:—

COST OF ELECTRICITY.

"*Steam Power Station.*—With a modern steam generating station, assuming a capacity of 5,000 K.W., and a suitable site with a plentiful supply of cooling water, the total capital cost should not exceed £15 per K.W. for plant, with a further £5 per K.W. for buildings and land. With a load factor of 0.83 per cent., the capital charges at 10 per cent. amount to 0.067 per unit. Fuel with coal at 11,000 B.T.U., costing 7s. 6d. per ton, would amount to nearly 0.15 pence per unit. Repairs, maintenance and stores about 0.06 pence; labour and management, say, 0.07 pence, so that the total cost—with the good load factor of 83 per cent.—should not exceed 0.35 pence per unit.

"*Water Power Station.*—Where suitable water power is available so that the capital cost is, say, £30 per K.W. of plant, the capital charge is (on the same basis as above) 0.1 pence per unit generated. For repairs and maintenance allow 0.04 pence, and for labour and management 0.06 pence, so that in this case the total cost should be under 0.2 pence per unit."

On these figures the cost for a horse power year would be £9.53 for steam power, and £5.45 for water power.

It is difficult to obtain reliable data as to the total amount of water power available and utilised in the world. Professor Gibson estimates the water power of the world at 200,000,000 h.p., and that the United States alone is capable of producing 35-55 million h.p. From the rainfall of the United Kingdom and the assumption that 5 per cent. could have a fall of 500 feet, it has been calculated that nearly 2 million h.p. could be obtained for 8 hours per day throughout the year. Professor Forbes has stated that the available water h.p. in Scotland alone is equal to 1,000,000 h.p.; while referring to the United Kingdom, Dugald Clerk says, "By great engineering works it might be just possible to obtain perhaps 3,000,000 h.p. from areas which could be given up for this purpose."

In a paper recently read before the Canadian Society of Civil Engineers, the following estimate of power developed by water turbines is given for Europe, United States, and Canada in 1911. (Table IV):—

TABLE IV.

	Hydraulic Power available on Turbine Shafts.		Percentage of Utilisation	Available Power per Square Mile.
	Available.	Developed.		
	H.P.	H.P.	%	H.P.
EUROPE:				
Great Britain ...	963,000	80,000	8·3	1·00
Germany ...	1,425,000	445,000	31·2	1·18
Switzerland ...	1,500,000	380,000	25·0	3·71
Spain ...	5,000,000	300,000	6·0	3·86
Italy ...	5,500,000	565,000	10·2	4·22
France ...	5,857,000	650,000	11·1	5·80
Austro-Hungary ...	6,460,000	515,000	8·0	7·34
Sweden ...	6,750,000	550,000	8·2	7·72
Norway ...	7,500,000	920,000	12·3	14·12
	40,955,000	4,405,000	10·6	5·44
NORTH AMERICA:				
United States ...	26,736,000	4,016,000	15·0	7·49
Canada ...	17,764,000	1,013,045	8·2	6·55

Since that date there has been considerable development, and the position is given for the beginning of 1915 as:—

Switzerland	about 550,000	h.p.
Norway	over 1,000,000	h.p.
United States	between 5 and 6 million	h.p.
Quebec	over 500,000	h.p.

It is generally assumed that the developed water power of the world is in the vicinity of 13,000,000 h.p.

Coming to South Africa, the only definite data available is that at the end of 1913, when the latest returns were made, power was being developed in the Union, from water wheels and turbines, to the extent of only 9,157 h.p., or less than 1.1 per cent. of the total power of the Union, railways and transport excluded. In giving evidence before the Transvaal Power Commission, Mr. A. Karlson, of the Irrigation Department, estimated the available hydraulic power in the Transvaal and Swaziland to be 250,000 h.p., and that the cost of the average of 50,000 h.p. transmitted from Kaapmuiden to Waterval Boven, a distance of 68 miles, would be £1 19s. per h.p. year. At Niagara Falls, it may be mentioned, power is being supplied at £3.6 per h.p. per annum on a capital outlay of £45 per h.p.

According to the Power Commissions report, the objects of the Victoria Falls and Transvaal Power Co., as stated in the articles of association, are of the widest character, and contemplate, amongst others, "To supply the immense existing and prospective industries of the Rand and of Rhodesia with electrical power generated from the Victoria Falls on the Zambesi River, and auxiliary steam power stations in the vicinity of Johannesburg." In 1906, the Company acquired from the African Concessions Syndicate the preferent right for 75 years to develope 250,000 K.W. (equal to 335,000 h.p.) from the Victoria Falls. The project has apparently, for the time being, been regarded as impracticable, but, in the Victoria Falls, South Africa possesses a valuable asset for the future.

The largest hydraulic power installation in South Africa is at Barberton, this being capable of developing 3,000 h.p. There are installed at the Penhalonga Mines, in Southern Rhodesia, two Pelton wheels, each capable of developing 375 h.p. under a head of 350 feet. In connection with the new water supply works for Cape Town, a hydro-electric transmission scheme is under consideration.

It is, I think, apparent to anyone who studies the subject, that water power must become of increasing importance; indeed, so much is this realised that in some countries the question of a state monopoly has arisen: its present neglect in this country is mainly due to the supply of cheap coal.

Internal Heat of the Earth.—There can be no question that an enormous amount of power is represented by the internal heat of the earth, but the problem is how to utilise it. Attempts have been made to harness hot springs, but the power represented is too diminutive. It has even been suggested that the continuous streams of molten lava which flow to the sea at Stromboli represent power going to waste. Dealing with the possibility of utilising the earth's internal heat, the Hon. Sir Charles Parsons, in his address, as President of the Engineering Section of the British Association for the Advancement of Science, discussed the feasibility of sinking a bore hole 12 miles deep, at which depth the temperature of the rock would probably be over 270° F., and down which water would be pumped to return to the earth's surface at a high temperature; but the idea was abandoned as a hopeless conception, while involving the expenditure of millions, even if it were feasible.

Recently a Johannesburg engineer propounded a scheme in which he proposed to utilise the slight difference of temperature between the surface of the sea and that at a lower depth, due to the sun's radiation, with the object of pumping salt water up-country for irrigation purposes. A paper was actually read before the leading engineering society, but as it was not published in the proceedings, the idea has been lost to the world at large.

Power Production from Fuel.—From the figures quoted from the first census of power production in 1907, it will be seen that over 91 per cent. of the total power development in the United Kingdom in that year was obtained from coal burned in boilers. The corresponding percentage for the Union of South Africa is 95.

The anxiety over the supply of this, the most important of all fuels, has led to investigations as to the available sources of supply. The appointment of a Royal Commission on Coal Supplies in 1903 gave recognition to the importance of the subject, but, although the report made it clear that in the future Great Britain would have to generate power otherwise than from coal, or depend on foreign markets, in which case price would seriously handicap her as a manufacturing nation, nothing tangible has resulted, the general feeling being one of apathy.

During the past year, Dugald Clerk selected the subject of fuel and motive power supplies as the subject of the Thomas Hawksley lecture at the Institution of Mechanical Engineers, and the question has been recently brought forward prominently by Professor Bone, of the Imperial Institute of Technology, in Royal Institution lectures and in papers contributed at the last British Association meeting, and to the Society of Chemical Industry.

It is a fact, fully recognised, that the industrial and commercial position of a country is to a great extent dependent on a cheap fuel supply. It is, therefore, of some interest to consider the coal resources of the world and their distribution. The latest estimate, that of the International Geological Congress of 1913, gives the following, losses in mining being neglected.

TABLE V.

ESTIMATE OF THE COAL RESERVES OF THE WORLD.

(In million tons.)

	Class A. Anthracitic Coals including some dry Coals.	Class B. and C. Bituminous Coals.	Class D. Sub-bituminous Coals, Brown Coals and Lignite.	Totals.
Oceania ..	659	133,481	36,270	170,410
Asia ..	407,637	760,098	111,851	1,279,586
Africa ..	11,662	45,123	1,054	57,839
America ..	22,542	2,271,080	2,811,906	5,105,528
Europe ..	54,346	693,162	36,682	784,190

Expressed in percentages we have:—

COAL RESERVES OF THE WORLD.	Per cent.
America	69
Asia	17.3
Europe	10.6
Oceania	2.4
Africa	0.8

and taking a more detailed sub-division we get:—

COAL RESERVES OF THE WORLD.	Percentage of total.
United States	51.8
Canada	16.4
China	13.5
Germany	5.7
Great Britain	2.6
Siberia	2.4
Australia	2.2
Russia	0.8
South Africa	0.8
Other Countries	3.8
	100.0

From the same source the coal resources of Africa are given as follows:—

TABLE VI.

Coal Resources of Africa.

(In million tons.)

	Actual Reserve. (In million tons). Class of Coal.			Probable Reserve. (In million tons). Class of Coal.			Total.
	A	B & C	D	A	B & C	D	
Belgian Congo	..	..	..	..	B 90	900	990
Southern Nigeria	..	..	80	..	..	..	80
Rhodesia ..	2	B 306 C 37	74	..	B 119 C 31	..	509
South Africa:							
Transvaal ..	..	..	..	..	B 28,800 C 7,200		
Natal ..	..	..	..	4,700	B 4,600		
Zululand ..	..	..	..	6,000			
Orange Free State, Cape					..		
Swaziland	..	..	..	960	B 2,880 C 960		
				11,660	44,540	..	56,200
Total Estimate for Africa	2	343	54	11,660	44 780	900	57,839

Large unestimated reserves remain in Southern Nigeria, a moderate amount in Nyasaland, and small reserves in Madagascar, East African Protectorate, Sudan, and Abyssinia.

Referring to the estimate of coal reserves, Professor Bone says: "It is, therefore, not difficult to foresee where, in the not far-distant future, when Europe's coal supplies approach exhaustion, the world's chief centre of manufacturing industry will be located.

"The relative insignificance of Great Britain's coal reserves is a fact of which our commercial and ruling classes seem to be profoundly ignorant, otherwise effective measures would have been taken long ago to check the criminal wastefulness of all classes of the community using coal.

"It must be our business," he continues, "not only to make these facts universally known, but to insist on the Government taking immediate effective action in the direction of establishing some systematic supervision and control of fuel consumption in all large industrial areas, and of furthering scientific investigations on a large scale upon the better utilisation of coal."

The output of coal for the world is given for 1913 as 1,363,878,110 tons. In 1903 it was only 800,000,000 tons, so that it is increasing at a somewhat alarming rate. The figures for the three principal industrial countries, which supply over 80 per cent. of the total coal, is given in Table VII.*

TABLE VII.

Coal Production of the United States, Great Britain, and Germany.—Quinquennial Averages 1900 *to* 1914.—*Millions of tons per annum.*

	United States.	Great Britain.	Germany.
1900-4	288.2	226.8	112.5
1905-9	400.5	256.0	139.8
1910-14	519.2	269.9	168.7
Approximate percentage rate of increase (compound interest)	6.0	2.0	4.0

A painful feature of coal-mining is the fact that much of the coal is left underground and wasted. This amount was stated by the Royal Commission on Coal Supplies to be 25 per cent.

And the case is even worse in South Africa, where the seams are thick, and where the higher grade part only is mined. Professor Bone says: "The question of checking this wastage is one of supreme national importance. Much of the coal now left in the mine ought to be brought up and converted at the pithead into useful forms of energy and products for public purposes. Some people put it forward as an argument in favour of the nationalisation of mines, and most of us will, I suppose, agree that the nation should possess and exercise some power of control or supervision in such a matter."

In the paper already referred to, Mr. Hiller gives the following diagram (Fig. 23), showing the annual output and the

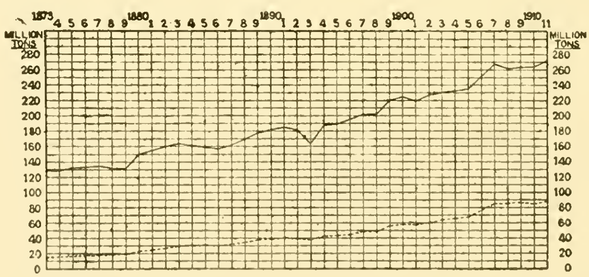


FIG. 23.—Full line shows annual output of coal in the United Kingdom. Dotted line shows annual export of coal from the United Kingdom.

amount exported, which in 1913 was 34 per cent. of the gross output. This question of export is one which is seriously exer-

* *J.S.C.I.*, April 15, 1916

cising the minds of all critical thinkers. Professor Armstrong (J.S.C.I., Feb. 19, 1916) says:—

"The primary political issue in connection with coal to be considered some day in the not distant future, though not yet I imagine, will be that of the ownership of our national fuel supplies. We should be prepared and prepare to deal with this grave problem in an absolutely philosophic and scientific manner, without tinge of political feeling; it will be a thorny one to attack, but it is inevitable that it should be attacked.

"One of the greatest questions to be discussed to an issue in the near future will be the extent to which such raw materials as coal should be allowed to leave a country which is undoubtedly a home of industrialism."

At any rate, there would appear to be a growing desire in certain quarters for the re-imposition of the coal export tax in Great Britain. One scientist advocates that the proceeds from such a tax should be ear-marked for investigations upon coal and fuel economy, and in loans in aid of improved methods of using fuel. It is a well known fact that the taxation of coal is already in force in Westphalia, the amount raised being expended partly for the benefit of the workers, but mainly for the education of the miners and officials engaged in the industry, several Schools of Mines being maintained in this way.

Coming to South Africa, the coal output for the Union during the past five years is shown in Table VIII (1 ton, 2,000 lbs.), the figures for 1915 having been kindly supplied in advance by the Government Mining Engineer. It will be seen that the Transvaal provides about 63 per cent. of the total coal sold, and that the price is also the lowest in the Union. As compared with the total world's reserves, as already seen, South Africa is very poor in coal.

It is evident that, to conserve our coal resources, there are two courses open to us, *viz.*:—

(1) To adopt every possible means of increasing the efficiency when coal is used and heat converted into work, so that a smaller amount may suffice to do the world's work.

(2) To utilise to the utmost natural sources of energy, such as water power, which is a permanent source of energy, and not a wasting asset like coal; to utilise other fuels; and to endeavour to obtain substitutes, the supply of which could be continued when the world's coal reserves are exhausted.

It is unfortunately impossible, for thermodynamic reasons, to convert more than a fraction of the heat energy of coal into mechanical work, and an actual engine has not more than 60 per cent. of the efficiency of an ideal one, due to inevitable losses.

The greater amount of coal used for power production is consumed in boilers, and in these the amount of heat lost may be as much as 50 per cent. Recently-published (*Engineering*,

TABLE VIII.

The Union of South Africa.

COAL, COKE AND TAR, MINING AND OUTPUT.

YEAR 1915.	Mining.			Coal Sold.			Coke Produced		Tar Produced.	
	Tons Mined.	Tons of waste sorted out of tons of Coal mined.	Per centage of waste sorted to tons mined.	Tons.	Value at Pit mouth. £	Value per ton. s. d.	Tons.	Value £	Gallons.	Value. £
Transvaal ..	6,004,566	719,946	11.99	5,202,805	1,145,060	4—4.82	24	31	26,050	881
Cape ..	59,207	12,351	20.86	46,850	26,591	11—4.22	—	—	—	—
Orange Free State	839,132	28,622	3.41	727,553	188,364	5—2.14	—	—	—	—
Natal ..	3,150,964	831,022	26.37	2,304,116	782,464	6 - 9.50	7,255	12,849	—	—
Union of S.A. 1915	10,053,869	1,591,941	—	8,281,324	2,142,479	—	7,279	12,880	26,050	881
,, ,, 1914	10,220,018	1,588,314	—	8,477,923	2,258,896	—	6,493	12,377	2,225	124
,, ,, 1913	10,732,653	1,827,348	—	8,801,216	2,240,458	—	9,345	15,862	43,293	1,433
,, ,, 1912	10,059,037	1,920,647	—	8,117,078	1,999,378	—	7,960	11,980	25,895	806
,, ,, 1911	9,931,327	2,263,854	—	7,594,944	1,935,153	—	5,541	7,544	41,352	1,411

April, 1916) results of 100 tests made on boilers of the Lancashire type, supplying power to factories and various industrial concerns in England, showed that the mean thermal efficiency obtained was 62.03 per cent., and, assuming the high average indicated thermal efficiency of 15 per cent. for the engine, this would give a plant efficiency of 9.3 per cent., that is, less than 10 per cent. of the heat of the coal is converted into work. It is, however, possible at the present day, in an up-to-date boiler of the water-tube type, supplied with auxiliaries such as mechanical stokers, economisers, superheaters, mechanical draught, automatic dampers, and such scientific guides as automatic CO_2 recorders to transfer 80 per cent. of the heat of the coal to the steam. And then the introduction of the compound engine, the steam turbine made in single units up to nearly 35,000 h.p., and more recently the Uniflow engine, has raised the indi-

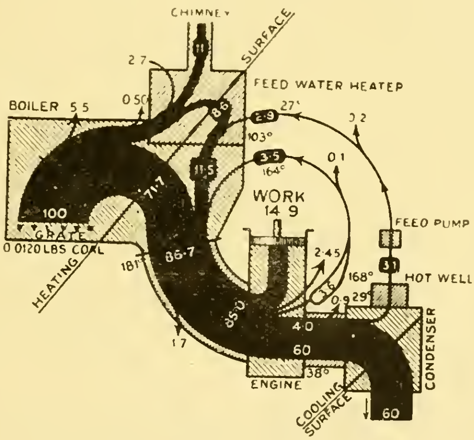


FIG. 24.—Heat Energy Stream for Compound Condensing Engine.

cated thermal efficiency to 23 per cent. The diagram, Fig. 24, taken from Professor Dalby's book on "Steam Power," gives an indication of the heat losses in a compound steam-engine boiler plant.

From the figures of coal production quoted, it will be realised that a saving of even 10 per cent. in boiler efficiency represents an enormous quantity of coal; on the basis of 120,000,000 tons of coal used for power production in Great Britain a saving greater than the total coal mined in South Africa.

In giving evidence before the Royal Commissions on Coal Supplies, Dr. Beilby (now Sir George Beilby), who was President of the Chemical Section during the visit of the British Association to South Africa, calculated that, taking the total home consumption of coal in Great Britain in that year (1903) as 168 million tons, there was a possible saving of 60 per cent. to be obtained by more scientific utilisation. Details are given in Table IX.

TABLE IX.

	Consumption in Million tons.	Percentage.	Possible Saving.	How Saved.
Railways ..	14	8.4	7	Electric Traction
Steamers ..	8	4.7	..	..
Factories ..	45	26.8	30	Gas generators and generators
Mines ..	12	7.2	7	Gas engines and recovery ovens.
Blast Furnaces ..	18	10.7	3	
Iron and Steel ..	12	7.1	3	Gas generators and coke.
Other Metals ..	2	1.2	..	..
Brickworks, Potteries, Glass & Chemical Works ..	6	3.6	2	Gas generators.
Gas Works ..	15	8.9	..	..
Domestic purposes ..	36	21 4	8	Gas cooking, heating, briquettes and coke.
	168	100.0	60	

Were such economies to be accomplished, Dugald Clerk calculates that the estimated coal life of Great Britain would be increased from 500 to 676 years.

The following diagram, Fig. 25, also taken from Hiller's paper, shows the position at the date of the Commission and in 1911, eight years later; allowing for the increase of population and of power requirements, the hopes expressed have not been realised.

There can be no question that one of the most potent factors in fuel economy has been the centralisation of power rendered possible by electrical transmission. The Power Companies Commission of the Transvaal investigated in 1909-10 the question of the establishment of large power companies and the probable effects in industrial and other directions. The Commission endorsed the recognised advantages—amongst others, the saving in capital costs in equipment, the saving in working costs both as regards fuel and in maintenance and attendance following the use of large units, and the greater simplicity and convenience in the application of power. Tests made on twelve mines of the Rand Mines-Eckstein group showed that the average cost with the then existing steam plants was .018d. per unit, whereas it has been possible to purchase power at .525d. per unit.

It is evident that the Transvaal Coal Owners' Association did not view with any satisfaction the conservation of the finest asset which any country in the world can possess. It called for the remedial attention of the Government "to the securing of the greatest possible consumption of coal," and even suggested to the Power Commission as a remedy for the decrease in the coal trade, which they feared would result, that coal should be so cheapened by the reduction of railway rates that mining companies might be induced to retain their inefficient steam plants, instead of purchasing power, and maintain the existing consumption of fuel. The Commission, however, considered that "it would be unwise and unreasonable in the best interests of the country that the gold-mining industry should be

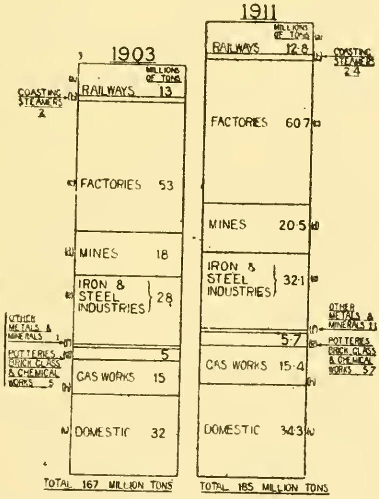


FIG. 25.—Approximate sub-divisions showing the uses to which the coal consumed in the United Kingdom was applied in 1903 and 1911.

artificially deterred from reaping the economic benefits from improved scientific methods."

The report further states that "the Coal Owners' Association offered strenuous opposition to the proposal to establish a hydraulic power station on the Crocodile River," but the Commission wisely declared that no question of coal output should "influence the decision whether such available water power should be utilised to the best advantage."

Perhaps it is not fully realised outside the Rand how enormous are the undertakings of the Victoria Falls and Transvaal Power Co. and the Rand Mines Power Supply Co. The following table (X), gives a list of the power generators at the various stations, together with the voltage and the lengths of the transmission lines.—

TABLE X.

Victoria Falls and Transvaal Power Co. and Rand Mines Power Supply Co.

POWER EQUIPMENT OF STATIONS.

Station.	No. of Sets.	Capacity in K.W. of each set.	H.P. of each set.
Brakpan ..	2 turbo-generators ..	3,000	4,000
	2 ,, ,, ..	12,500	16,750
Total ..	4 ,, ,, ..	31,000	41,500
Simmer Pan ..	6 ,, ,, ..	3,000	4,000
	2 ,, ,, ..	11,000	14,250
Total .	8 ,, ,, ..	40,000	53,500
Rosherville ..	5 ,, ,, .	10,000	13,400
	6 turbo-compressors ..	(= 3,000)	4,000
	3 ,, ,, ..	(= 6,000)	8,000
Total ..	14 turbo-generators and compressors	86,000	115,000
Vereeniging ..	2 turbo-generators ..	10,000	13,400
	2 ,, ,, ..	12,000	16,100
Total ..	4 ,, ,, .	44,000	59,500
Grand Total	30 sets	201,000	269,000

Transmission Lines.

68 miles of 80,000 volt overhead lines.
57 ,, 40,000 ,, ,, ,,
37 ,, 20,000 ,, ,, ,,
37 ,, 10,000 ,, ,, ,,
48 ,, 20,000 ,, underground cables.

(Total length = 247 miles.)

Table XI, taken from the Government Mining Engineer's Report, shows the number of units of electricity disposed of in the Union during 1915. It will be observed that the Transvaal is responsible for 92 per cent. of the total.

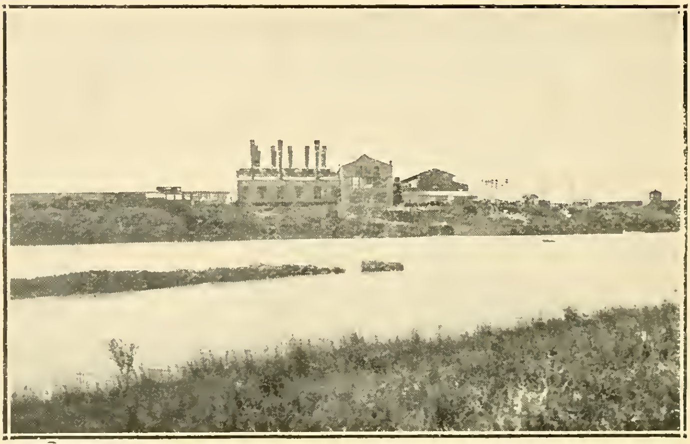


Fig. 26.—Vereeniging Power Station of the Victoria Falls and Transvaal Power Co. Capacity 44,000 K.W.

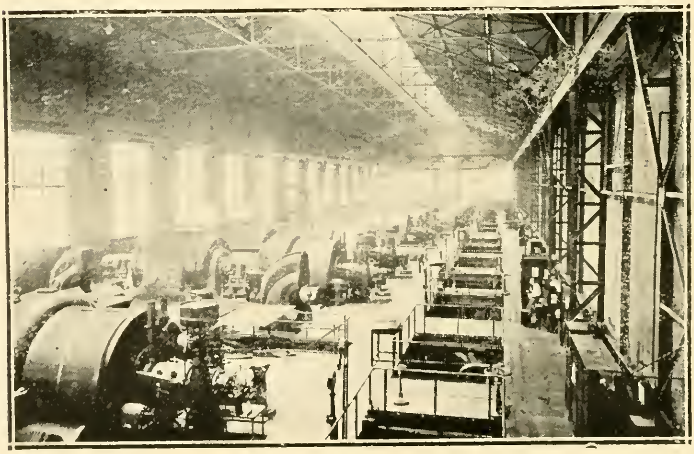


Fig 27.—Interior of Rosherville Power Station. Capacity, 86,000 K.W.

Power Generation on the Rand by the Victoria Falls and Transvaal Power Co.

TABLE XI.

Electrical Machinery.

The following table shows the total units disposed of during the year by the Power Stations of corporations and municipalities, and by public supply companies. The units used for mining purposes, out of the totals shewn in the table, amount to 533,546,468 electrical and 147,928,535 compressed air units. The outputs of the power stations on the Mines are not included in the table.

	Total Units Disposed of during 1915.					
	Direct Current.		Alternating Current.		Total.	
	Lighting and Power.	Tramways.	Lighting and Power.	Tramways.*	Direct.	Alternating.
Transvaal ..	14,111,509	8,708,757	706,854,903	357,261	22,820,266	707,212,164†
Cape	11,160,744	6,196,199	22,047,891	378,932	17,356,943	22,426,823
O F S.	599,186	..	1,827,078	6,985	599,186	1,834,063
Natal	4,099,090	3,987,668	12,047,005	..	8,086,758	12,047,005
Total for 19.5 ..	29,970,529	18,892,624	742,776,877	743,178*	48,863,153	743,520,055
			Total for 1914 ..		46,168,510	603,286,880‡
			Total for 1913 ..		42,490,911	555,181,027§

* Converted to direct current.
† Includes 147,928,535 units of compressed air.
‡ ,, 121,014,096 ,, ,, ,, ,,
§ ,, 123,081,136 ,, ,, ,, ,,

Fig. 26 shows the latest station to be erected, adjacent to a colliery, on the banks of the Vaal River at Vereeniging, 35 miles from Johannesburg, and having a capacity of 59,000 h.p. The next photograph, Fig. 27, shows the interior of the Rosherville Power Station, where the enormous total of 115,000 h.p. is generated. Under that roof, power is developed equivalent to that of nearly 2½ millions men working 12 hours a day, the total capacity of all the stations being equal to the power of about 5½ million men working on 12-hour shifts. It would, however, be quite impossible in practice even for this great army of men to accomplish the work done by the turbines. There is shown by the next photograph, Fig. 28, one of the turbo-generators, occupying a floor space of about 50 feet x 15 feet, and giving 10,000 k.w., or 13,400 h.p. Fig. 29 shows the interior of the Robinson Central Air-Compressor Sub-Station, containing five electrically-driven air compressors, having a total of 20,000 h.p. The Rand possesses by far the most important system of compressed air distribution in the world, nearly 70,000 h.p. being distributed through mains 20 miles long to mines having a distance apart of 14 miles.

One of the immediate effects of the initiation of this huge power scheme was that, the boiler plant being suitably arranged, it is possible to utilise fine or "duff" coal, which forms 20 per cent. to 30 per cent. of the mine output, and which had hitherto been considered a waste product and been placed on the dump and burned. Originally obtainable at about 6d. per ton, it now costs about 2s. 6d. at the colliery, but the S.A. Railways, being conducted on so-called business principles, increase this price by over 200 per cent., so that the average cost at the power stations is about 8s. per ton.

It is painful to think of the many thousands of tons of this valuable fuel still being destroyed, especially in Natal. A few years ago I visited the majority of the Natal collieries, and was so impressed by this terrible waste that on my return I wrote an article, entitled "The Waste of Coal," which was published in the *S.A. Mining Journal*. But the waste still goes on!

Readers of technical journals are fully acquainted with the efforts which are now being made to arouse public opinion on the necessity of fuel economy. Attention is specially directed to the carbonisation of coal in gas works and coke ovens, with a view to the recovery of the valuable bye-products, tar and ammonia, from which can be obtained that valuable fertilizer, ammonium sulphate, and the efficient utilisation of the gases produced in coke ovens. It is stated that not more than 20 per cent. of the total coal consumed in Great Britain is so used that the bye-products may be recovered. Efforts are being directed towards the low temperature carbonisation of coal; it produces less gas and a more friable coke (coalite), but the yield of volatile products is increased. Professor Armstrong urges that the suggested coal-tax should be utilised "in developing suitable methods of coking coal so as to conserve, as far as possible, all valuable products, and at the same time produce fuel for public use."

He goes so far as to ask "whether drastic action should not be taken to put an end to much of the waste in burning raw coal, at all events in the case of that burnt by domestic users," and suggests a law "forbidding the use of raw coal for domestic purposes—such enactment to come into force at latest ten years hence."

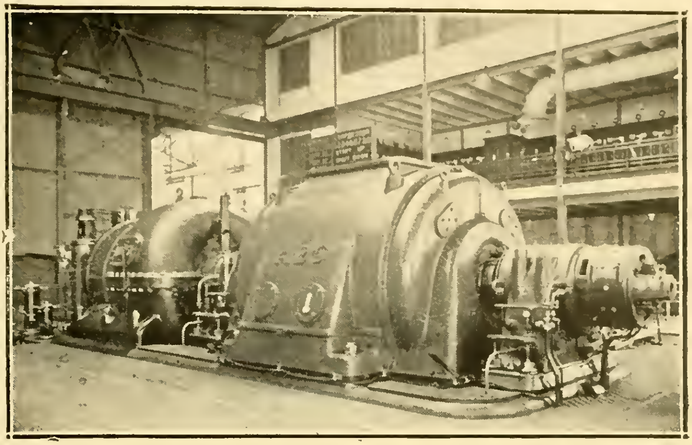


Fig. 28.—One of the five 10,000 K.W. Turbo-Generators at the Rosherville Power Station.

Fig. 29.—Interior of Robinson Central Air-Compressor Sub-Station. Capacity, 20,000 H.P.

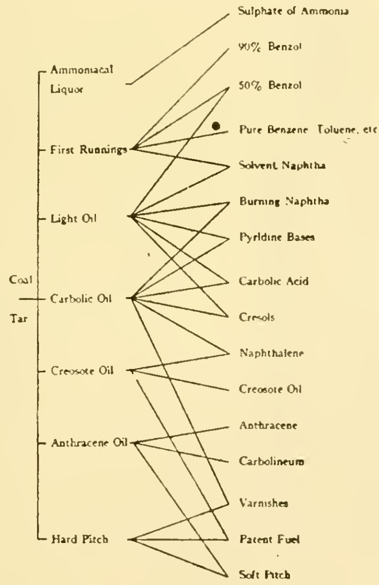
How important coal-tar products are at the present day is shown by Table XII, which represents diagrammatically the derivatives of coal-tar. This is a subject which I hope will continue to be emphasised in the chemical section. Too long has the British people been content to leave the manufacture of coal-tar products to the Germans, and it is only now, when the supply has been cut off, that the true position is generally realised.

The question of fuel economy was taken by the British Association at the Manchester meeting last year. A committee was formed under the chairmanship of Professor Bone, and five sub-committees have now been formed, as under:—

TABLE XII.

First Products from Coal Tar

(*Lunge*)



1. *Chemical and Statistical* (including the chemical nature of coal and the character of the principal British coal seams). Chairman: Dr. J. T. Dunn, of Newcastle-on-Tyne.
2. *Carbonisation* (including gas works, coking ovens, low temperature distillation, and the utilisation of products derived therefrom). Chairman: Mr. T. Y. Greener, of Beamish, Co. Durham.
3. *Power and Steam Raising* (including experiments of public power schemes). Chairman: Mr. Chas. Merz, of London.

4. *Metallurgical (Iron and Steel) and Ceramic Industries.* Chairman: Dr. J. E. Stead, F.R.S., of Middlesborough.
5. *Domestic Smoke Prevention* (including problems relative to domestic heating). Chairman: Mr. E. D. Simon, of Manchester.

It is a question worthy of consideration whether this Association should not offer its co-operation in such important matters.

A company has laid down, in Natal, works now nearing completion, for producing ammonia from coal with the object of making ammonium sulphate. But no provision is made for the

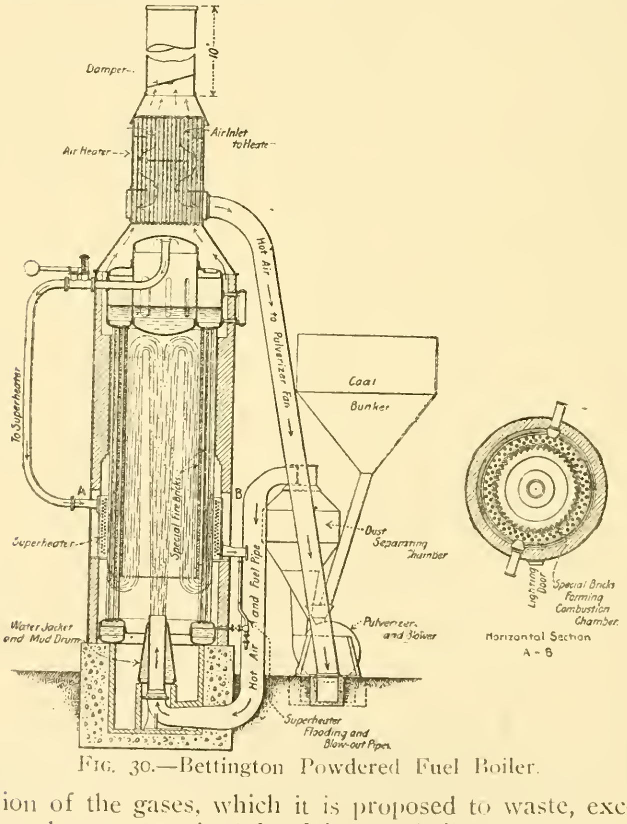


FIG. 30.—Bettington Powdered Fuel Boiler.

utilisation of the gases, which it is proposed to waste, except in so far as they are required for firing the boilers for the auxiliary machinery, and may be available for doubtful new industries. Surely internal combustion engines to utilise all waste gases, and to drive electric generators for use in such electro-chemical industries as the manufacture of calcium carbide, cyanamide and its derivatives, might reasonably have been expected to form part of such a scheme. The object of the works is to produce ammonium sulphate, of which the world's production in 1914 was 1,365,700 tons. But in the newer process nitrogen, obtained from liquefied air, may be directly combined with hydrogen under the influence of a catalyst, and 120,000 tons are said to have been produced by this method in 1914; with the extensions in progress, the yield will be brought up to 300,000 tons per annum. Tar is not contemplated as one of the products at the Natal works, because the object is the maximum production of ammonium sulphate, and the coal is said to be anthracitic; but why waste a national asset in the way proposed, by allowing thousands of horse-power to be ruthlessly destroyed?

Powdered Fuel Firing.—This is an ideal system for the efficient combustion of coal. It is in use for firing the cement kilns at Pretoria and Ventersburg Road cement works, and is becoming common in metallurgical works generally. It is the system adopted in the Bettington boiler (the principle of which is shown in Fig. 30), which has been installed at various works and mines in South Africa. It has the great advantage, from the fuel economy point of view, that it can utilise coal of a very poor quality, and from the power station point of view that steam may be got up in 20 minutes. Tests made by me, assisted by the students of the S.A. School of Mines and Technology, through the courtesy of Prof. Dobson, M.Sc., M.Eng., the General Manager, on two boilers of approximately 3,000 h.p. each, one a marine type Babcock & Wilcox, as used by the Victoria Falls and Transvaal Power Co., and the other a Bettington boiler, both at the power station of Johannesburg Municipality, gave the following results:—

TABLE XIII.

RESULTS OF TESTS MADE ON THE ROBESON-BETTINGTON BOILER AND THE BABCOCK AND WILCOX MARINE TYPE BOILER.

ITEM.	Bettington Tests.	Babcock & Wilcox Tests.
Date of test	26.6.1913	27.6.1913
Duration of test	9.8 hours.	10 hours
Guage pressure	173.7 lbs. per sq. in.	161.9 lbs per sq. in.
Feed temperature	65.5° F.	64 7° F.
Steam temperature	510.3° F.	546° F
Water evaporated per hour .	31 561 lbs.	29,370 lbs.
Coal consumed per hour. (No allowance made carbon value of ashes) ..	4,477 lbs.	4,183 lbs.
Lbs. of water evaporated per 1 lb. coal (as fired)	7.050 lbs.	7.014 lbs
Gross calorific value of coal as received	11 50	11.80
Net calorific value of coal as received	11.10	11.42
Heat transmitted to feed by boiler per 1 lb dry coal	1,240 B. Th. U.	1,208 B. Th. U.
Evaporative equivalent from and at 2 2° F (as fired)	9.049	9.140
Evaporative equivalent from and at 212° F. (dry)	9.464	9·868
Efficiency on gross calorific value .	78 6	77 4
Percentage auxiliary power ..	3.8	1.0
Net efficiency on gross calorific value	*75.6*	*76 6*
Efficiency on net calorific value ..	81.4	80.0
Net efficiency on net calorific value ..	*78 3*	*79.1*

Factors, such as installation, running and maintenance costs, have to be taken into consideration, and, probably due to the fact that cheap coal can be burned in mechanical stokers, the powdered fuel system, apart from the Bettington boiler, does not appear to be making much progress. But it is used in the United States for locomotive firing, and a trial of the system in South Africa is worthy of consideration.

Considerable progress has been made in the utilisation of other solid fuels. For example, enormous quantities of *peat* are available as fuel. In Europe the peat area is esimated at 140 million acres, in the United Kingdom 2 million acres, Canada 30 million acres, while Ireland has peat equivalent to 2,500 million tons of coal. It may be burned directly after air drying, converted into peat charcoal, briquetted by a new process after semi-carbonisation, and its use in gas producers has now passed the experimental stage; it may be used successfully in suction gas producers or in pressure producers with ammonia recovery. Unfortunately, peat generally occurs in inaccessible districts, but, all the same, it is beginning to take an important part in fuel economy.

Lignite, or brown coal, is principally converted into briquettes; sometimes it is distilled merely for the tar products, but I have seen it used in gas producers in Germany for the working of gas engines, and this is a use which is rapidly extending.

Wood was undoubtedly the first substance used as a fuel, and is still the only fuel in many parts. In the form of charcoal it is probably the main fuel for suction gas producers in South Africa, especially in Rhodesia, at the present day, but improvements in gas producer practice are such that wood waste and sawdust are now being directly utilised. In view of the depletion of the world's forests and the increasing price of wood for industrial purposes, it seems a pity to use it as a fuel, except in the waste form. It has been urged that where a tree is cut down, three should be planted, and we must welcome the assurance of the Minister of Agriculture, at the close of last session, that the afforestation of South Africa has his cordial support, and that tree-planting will be carried out with Government funds. From the fuel and power production point of view, however, it would be impossible for firewood to supply our needs in a "coal-less age."

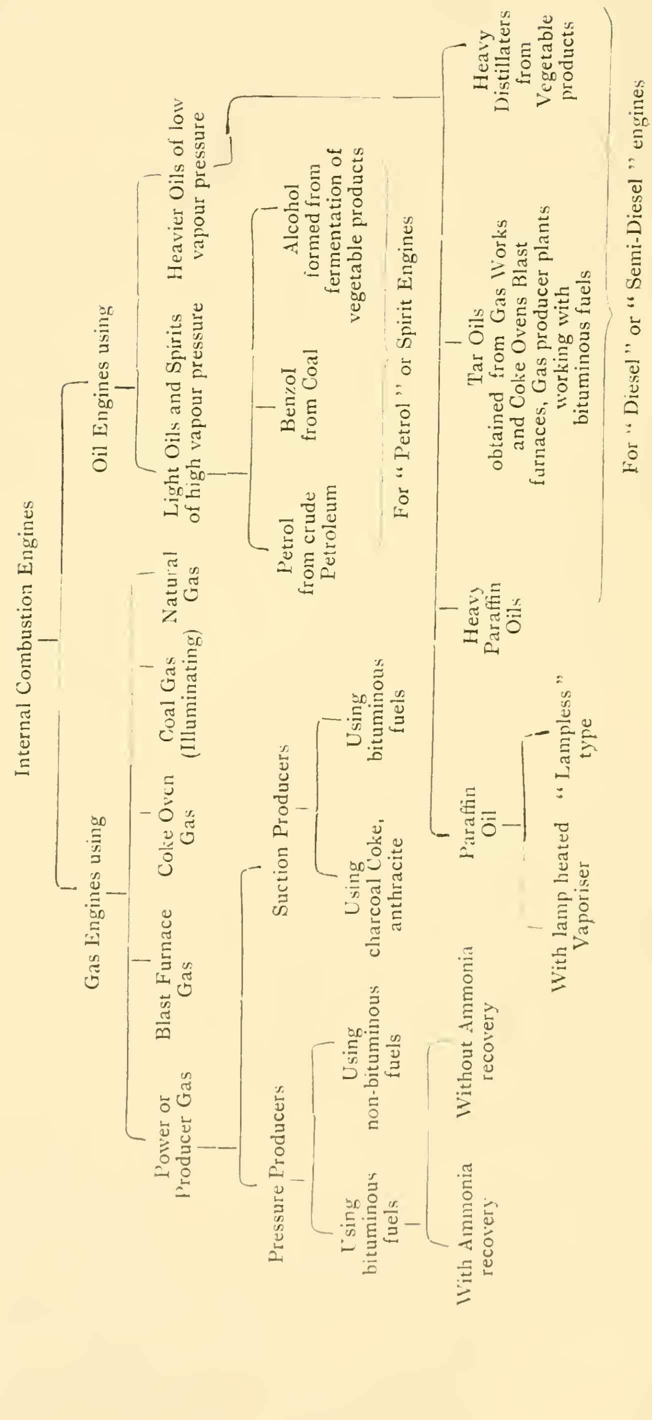
Liquid Fuel has been in use for many years for locomotives and in the mercantile marine, more particularly in oil-carrying steamers. The obvious advantages, not the least important of which are the higher calorific value and greater density, which combined make 1 lb. of fuel oil the equivalent of 1.7 lbs. of coal, thus increasing the range; the absence of smoke; and the facility with which it may be transported and transferred to ships, have caused the British Government to adopt it almost exclusively for steam raising in warships. In this case it is entirely a question of efficiency. There can be no doubt that the wonderful naval results achieved have been in large measure due to the use of liquid fuel and steam turbines.

Gaseous Fuel plays a most important part in many industrial operations, which indeed in many cases could not be conducted without it, and it renders available as a fuel millions of tons of inferior coal which might otherwise be discarded. Natural gas has been used since 1821 in the United States, which in 1914 produced 592,000 millions cubic feet, or 13,200,000 tons, this being 96 per cent. of the world's output, and having a value of £19,336,000.

Since means have existed for its direct utilisation in the gas engine, the use of gas as a fuel for boilers has greatly diminished, and would only appear to be justified when steam for industrial purposes is required; the introduction of the "surface combustion" method of burning gas in a boiler has enabled thermal efficiencies of over 92 per cent. to be obtained, and the method is now being introduced on a commercial scale. But even with this high boiler efficiency, and using blast furnace gas, the overall efficiency could not equal that of the gas engine supplied from a gas producer, on account of the higher thermal efficiency of the internal combustion engine.

In earlier days the gas from coke ovens was wasted or, at least, used for firing boilers with no attempts at recovery of tar and other bye-products; now it is urged that the economic utilisation of coke oven gas is a matter of national importance. Coke oven gas is a rich gas, perfectly suitable for use in gas engines, and I have seen on the Continent a gas engine power plant of 20,000 k.w. working successfully with this hitherto wasted fuel.

Internal Combustion Engines.—The advent of the internal combustion engine has changed the whole complexion of power production. There is now available a great variety of fuels, and these and the various types of prime movers may be classified as follows:—


Internal Combustion Engines
Gas Engines using
Oil Engines using
Power or Producer Gas
Blast Furnace Gas
Coke Oven Gas
Coal Gas (Illuminating)
Natural Gas
Light Oils and Spirits of high vapour pressure
Heavier Oils of low vapour pressure
Pressure Producers
Suction Producers
Using bituminous fuels
Using non-bituminous fuels
Using charcoal Coke, anthracite
Using bituminous fuels
With Ammonia recovery
Without Ammonia recovery
Petrol from crude Petroleum
Benzol from Coal
Alcohol formed from fermentation of vegetable products
For " Petrol " or Spirit Engines
Paraffin Oil
Heavy Paraffin Oils
Tar Oils obtained from Gas Works and Coke Ovens Blast furnaces, Gas producer plants working with bituminous fuels
Heavy Distillaters from Vegetable products
With lamp heated Vaporiser
" Lampless " type
For " Diesel " or " Semi-Diesel " engines

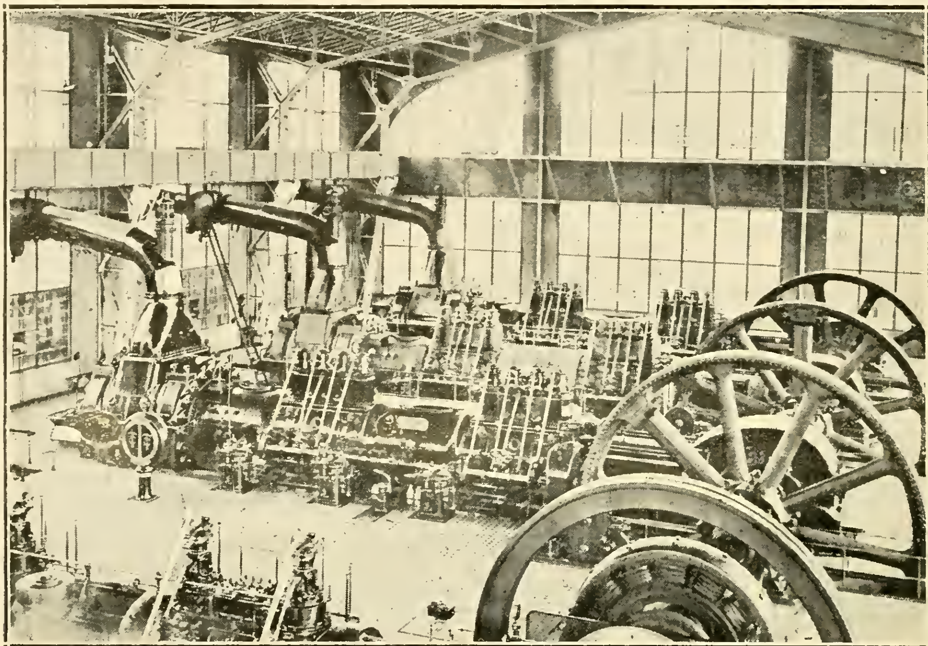


Fig. 33.—Engines of several thousands of horse power using blast-furnace gas.

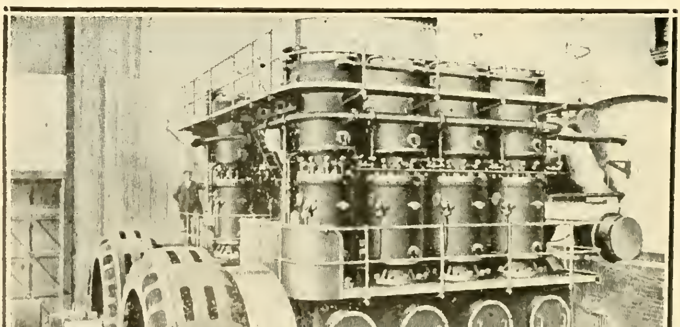


Fig. 34.—Two Gas-engines of 1,000 H.P. each, used for town-lighting and Power.

The development since 1850 and present position with regard to the various heat engines is seen in Fig. 31, taken from Mr. Hiller's paper referred to. The diverging line indicates the increase and decrease in use.

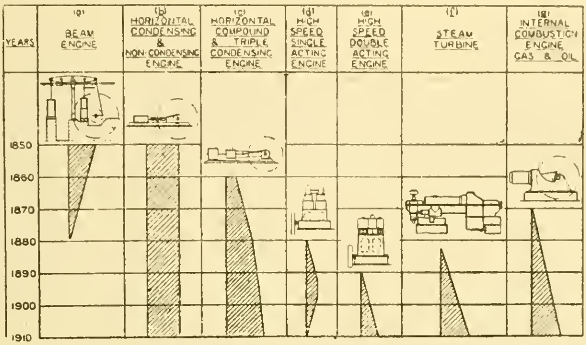


FIG. 31.—Illustrating the alteration of types of new engines installed for power production on land in the United Kingdom.

It is impossible here to trace the development of the gas engine, but the figures show:—

(1) Otto's engine of 1876 of about 6 h.p. (Fig. 32).
(2) Engines of several thousands of h.p. using blast furnace gas.
(3) Two engines of 1,000 h.p. each for the power and lighting supply of the town of Accrington (Fig. 34).

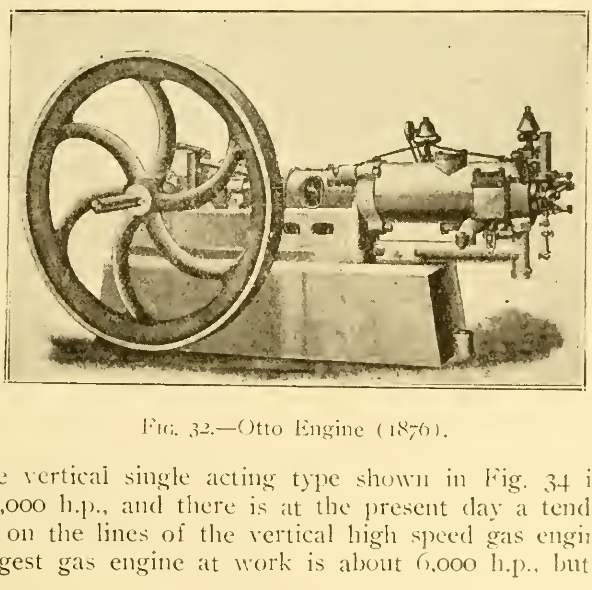


FIG. 32.—Otto Engine (1876).

The vertical single acting type shown in Fig. 34 is made up to 3,000 h.p., and there is at the present day a tendency to develop on the lines of the vertical high speed gas engine type. The largest gas engine at work is about 6,000 h.p., but this is by no means the limit of power, since it is possible to develop 2,000 h.p. in one cylinder.

The *Paraffin* Engine was placed on the market on a commercial scale in 1888. It has the drawback, as compared with the petrol motor, of requiring a vaporiser to gasify the oil, involving a delay of 15 to 20 minutes in starting up, but it still remains an exceedingly useful motor for small powers.

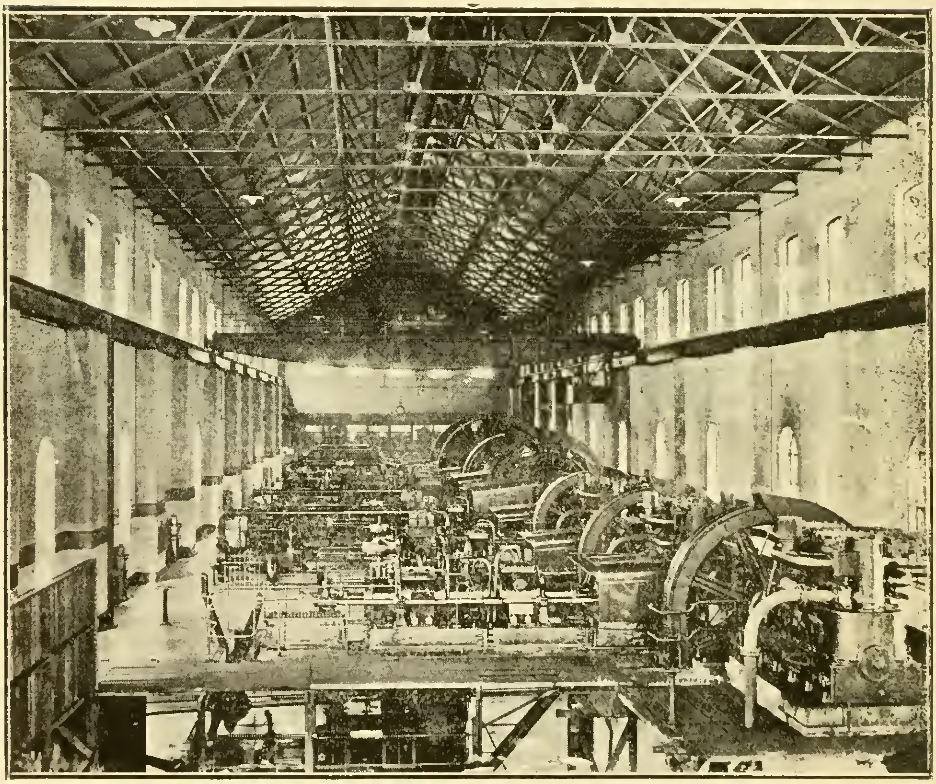


FIG. 35.—Gas-engine Power Station at Beardmore's Naval Construction Works, Dalmuir, Scotland. Gas-engines of same type as installed by Johannesburg Municipality.

Previous to the invention of the power gas producer, by Dowson, successfully applied in 1881, the gas engine was dependent upon town's gas, and was making little progress. The production of a cheap gas of low calorific value, in a practically automatic apparatus, having a thermal efficiency higher than the best boiler using coal, for use in a gas engine having a thermal efficiency at least 10 per cent. higher than that of the best steam engine, was bound in time to make its influence felt in spite of the opposition of prejudiced steam engineers.

The unfortunate failure of the gas engine power-plant at Johannesburg has served to create a prejudice against this type of prime mover in South Africa. But that failure is generally recognised by engineers to have been due to causes unconnected with the gas engine itself. In Fig. 35 is shewn the central power station at Beardmore's great naval works, where gas engines, worked from bituminous producer gas, aggregating over 20,000 h.p., have been at work continuously and successfully for many years.

Mond, in 1893, succeeded in obtaining a tar free gas, suitable for gas engines, from bituminous coal. Dowson's producer was confined to the use of non-bituminous fuel, so the introduction

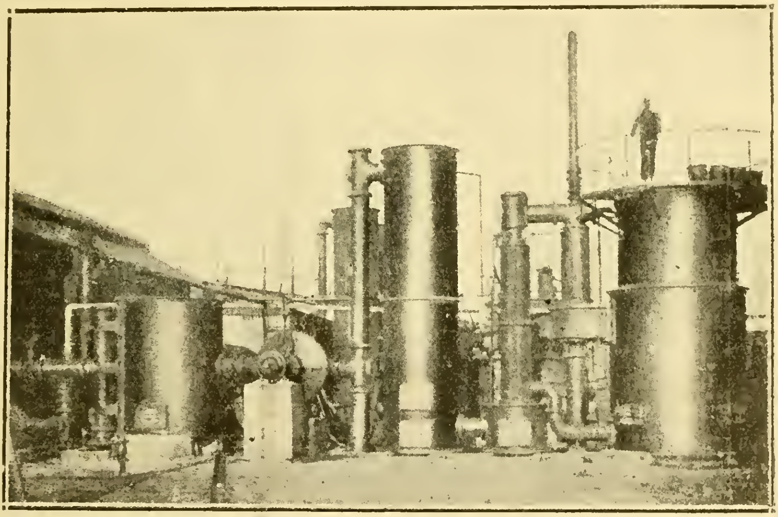


Fig. 36.—Bituminous suction gas plant of 575 B.H.P., at Machavie Gold Mines, Transvaal.

of the Mond system has greatly increased the scope of the gas engine. A large central Mond producer plant was installed at Dudley Port, near Wolverhampton, in 1901, with the object of distributing gas under pressure over an area of 140 square miles for power and heating purposes, it being estimated that the bye-products would practically pay for the coal. The original hopes, however, have not been quite realised; during a visit to this plant a few years ago I was informed by one of the directors that the extraordinary development of the suction gas producer had introduced serious competition with the gas transmission scheme.

Suction Gas Plants.—Referring to the suction gas engine, one writer says: "No more important invention from the point of view of the production of power in small and moderate-sized plants has been made, and the simplicity of working, the compactness of the plant, and the wonderful economy of this system, as compared with the extreme waste of fuel entailed in nearly all the small-type steam engines (which suction gas engines are qualified more practically to replace), account for the rapid advance made in the use of such plants in recent years."

The suction-producer may have an efficiency of over 85 per cent., and a h.p. for an hour may be obtained for the expenditure of .8 to 1 lb. of coal. Ever since the commercial introduction of the suction gas producer using anthracite, coke or charcoal, in 1903, efforts continued to be made with a view to the utilisation of bituminous fuels. Dowson succeeded in 1908. The use of bituminous fuel now presents no difficulties to the makers of suction-gas plants, and several such are now at work in South Africa.

Fig. 36 shows a plant of nearly 600 b.h.p., installed at the Machavie Gold Mines, using bituminous coal, having a calorific value of 10,900 b.th.u per lb. and containing 60.7 per cent. fixed carbon, the consumption on full load being 1.146 lb. per b.h.p. hour.

Diesel Engine.—An event of great importance in internal combustion engineering was the introduction of the Diesel engine first experimented in 1892, but not publicly exhibited until 1898. It is now made in single units up to 6,000 h.p., and even that is by no means the limit to its power.

The result of tests show that 2,000 h.p. can be developed in one cylinder. This opens prospects of Diesel engines of 20,000 h.p. It is anticipated that 3,000 h.p. per cylinder can be realised.

Fig. 37 shows a Diesel engine of 120 b.h.p. of the four cycle type supplied to Aliwal North Municipality, while a 4,000 h.p. two-cycle Diesel engine at work in Harland and Woolf's shipyards at Belfast is shewn in Fig. 38.

Its application to the propulsion of ships and the wonderful progress made in this direction has been one of the most important developments of modern engineering. The Diesel engine now provides the propelling force for ships of over 9,000 tons displacement, and the multiple-cylinder high-speed vertical type, built in units up to 3,000 h.p., with 400 h.p. developed in each cylinder, has made the modern submarine possible. Unfortunately, the supply of suitable fuel has not kept pace with the wonderful development of the oil engine, and there exists at the present day considerable anxiety on that account.

The world's yield of crude petroleum was, in 1914, about 57,000,000 tons. But since this oil, apart from that distilled from shale in Scotland, has to supply the world with petrol, illuminating oils and lubricants, less than half is available for fuel oil, or for use in Diesel engines. Heavy petroleum oil has

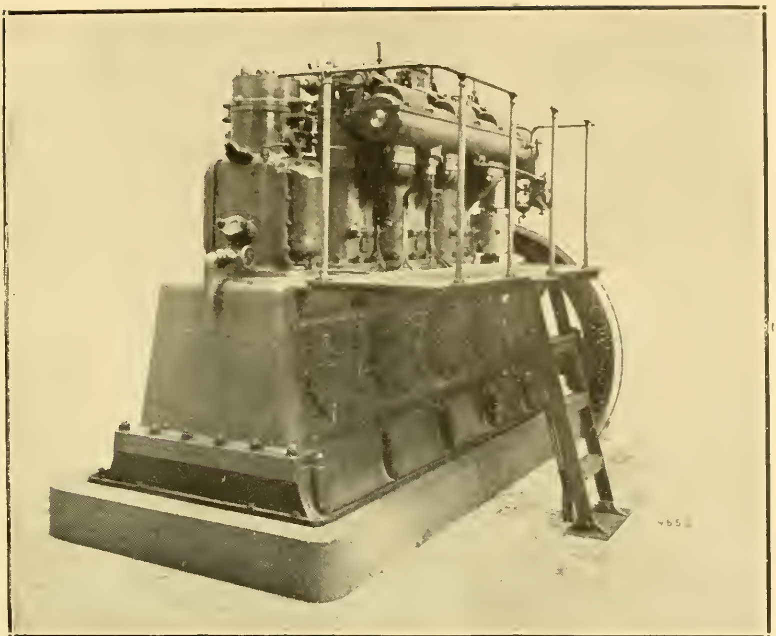


Fig. 37.—Four-cycle Diesel Engine of 120 B.H.P. installed by the Municipality of Aliwal North.

Fig. 38.—Two-cycle Diesel Engine of 4,000 B.H.P., installed at the Shipbuilding Works of Harland & Wolff, Belfast.

been the main fuel in the past, but now all difficulties in the way of utilising tar oils have been overcome. Unfortunately, the price of tar has been increased through its extensive use for spraying roads. At a recent meeting (February, 1916) of the Diesel Engine Users' Association, it was stated that of the 850,000 h.p. developed in Germany by Diesel engines, 150,000 h.p. was produced from tar or tar oils. Remembering, also, how essential tar is for chemical manufactures, it will be recognised how important it is that the deplorable waste of coal should be stopped.

Arrangements have recently been made for the storage of fuel oil at the principal South African ports, the price being in the neighbourhood of £6 10s. per ton. At the present time, this high cost of oil renders the use of the Diesel engine prac-

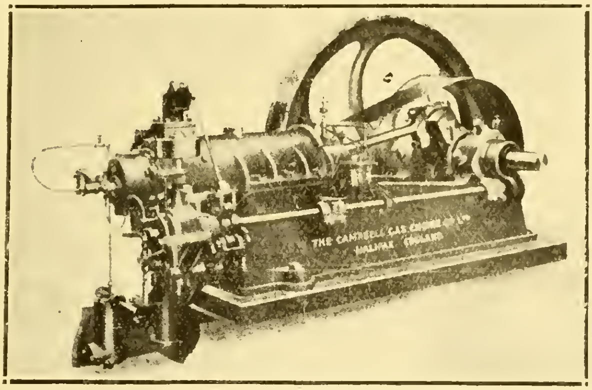


FIG. 39.—High Compression or "Semi-Diesel" Oil Engine of 35 B.H.P. for Crude or Residual Oils.

tically prohibitive up-country, except as a stand-bye; it is in regular use at coast towns, where coal is expensive, and at a few places to which the cost of railway transport is not too high. A source of locally-made tar-oils would be a matter of great importance. Within the past few years a cheaper engine, known as the Semi-Diesel or "Bulb" engine, an example of which is shown in Fig. 39, has been devised for burning heavy oils; it is practically a high compression paraffin engine, with compression of air alone on the Diesel principle to about 275 lbs. pressure.

The best consumptions may be taken as approximately:

Diesel engine with heavy petroleum oils: .4 to .45 lbs. per b.h.p. per hour.

Diesel engine with tar oils: .43 to .47 lbs. per b.h.p. per hour.

Semi-Diesel engine with heavy petroleum oils: about .5lb. per b.h.p. per hour.

It must not, however, be imagined that the Diesel engine is entirely dependent upon petroleum and tar oils. Animal and vegetable oils may be used directly in Diesel motors. Experiments have been carried out on a great variety of fuels, including petrol, paraffin, ordinary crude petroleum, the residuum from crude petroleum distillation, palm and nut oils, castor oil, fish oil, alcohol, coal gas and producer gas. Special attention has frequently been directed to African Ground Nuts as a source of Diesel motor fuel. I am also assured on reliable authority that there are immense deposits of suitable oil shale in the Wakkerstroom district. The question is a most important one. No work having more far-reaching effects could be undertaken by the newly-formed Scientific and Industrial Research Committee than an investigation into the possibilities of motor fuels from South African resources.

The figures for indicated thermal efficiency given by Dugald Clerk, who is recognised as the greatest authority on internal combustion engines at the present day, shown in Table XIV, are of considerable interest.

TABLE XIV.

Industrial Thermal Efficiency of Steam and Internal Combustion Engines.

	Indicated efficiency. Per cent.
Steam.	
Boulton and Watt, condensing low pressure (about 1820)	3.8
Cornish engine (about 1850)	9.0
Triple expansion (about 1910)	17.0
Parson's turbine (about 1914)	23.0
Internal Combustion.	
Lenoir (about 1860)	4.0
Compression—Constant volume (1876) ..	16.0
(Two or four stroke) (1906)	35.0
Compression—Constant Pressure (Diesel) (1910)	40.0

Fig. 40 gives a graphic representation of the heat consumption per B.H.P. hour of various prime movers.

Efforts have been made to utilise the waste heat from steam and internal combustion engines, and a great deal more will probably be done in the future, especially in connection with the internal combustion engine. Exhaust steam might be applied to a greater extent for heating purposes; its application in the exhaust steam turbine, introduced about 15 years ago, is extending in cases where it is applicable. Very little has been done to utilise the high temperature exhaust gases from internal combustion engines; but waste heat boilers are already in use, and a more extended adoption of combined steam and internal combustion plants may be looked for in the future.

Several large firms are known to be at work on the gas turbine; at present it is merely in the experimental stage, but although there are difficulties to be overcome, it would be folly to imagine that they are insuperable.

The selection of a prime mover depends, in addition to efficiency, upon other factors; but, in the end, the tendency must be towards the adoption of the most efficient engine. The internal combustion engine has now established its claim to reliability as well as efficiency, and that it will continue to make progress in the future, even at a greater rate than it has in the past, there cannot be the shadow of a doubt.

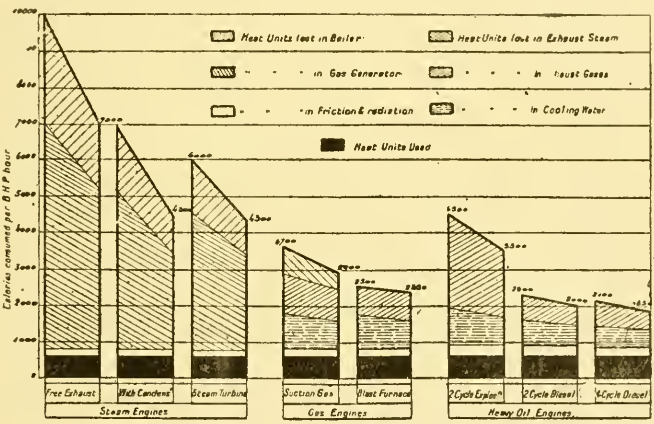


FIG. 40.—Comparative diagrams of Heat Consumptions, per B.H.P. per hour, of various types of Heat Prime Movers.

Petrol and Petrol Substitutes.—The gradual increase in the price of petrol, more accentuated recently, has served to alarm the motoring public. The petrol supply is obtained by the distillation of crude petroleum, and Fig. 41 shows that the increase, for example, in the British imports, has far outstripped the production of crude oil. It is admitted that the annual output is excessive as compared with probable available supplies, and the demand is likely to continue at an increasing ratio. Apart from the more extended use of the motor-car as a means of locomotion and pleasure, recent years have seen an extraordinary development in the application of the petrol motor to motor traction, to agriculture and to the general purposes of a commercial community. And everyone must realise how indispensable the spirit engine has become in modern warfare. Without it the aeroplane and the air ship are impossible, and the magnificent mechanical transport of the Allies, which has been one of the most satisfactory features of the present war, has, in the main, been due to the petrol engine.

The world's supply of crude oil, which, as already stated, was 57,000,000 tons in 1914, has only increased at the rate of 6 per cent. for the three previous years. The amount of petrol obtainable from crude petroleum does not exceed 10 per cent., so that in 1914 the total yield was not much over 1,700 million gallons. America absorbed 1,200 million gallons of this, and Great Britain, which in 1910 imported 55 million gallons, took 120 million gallons.

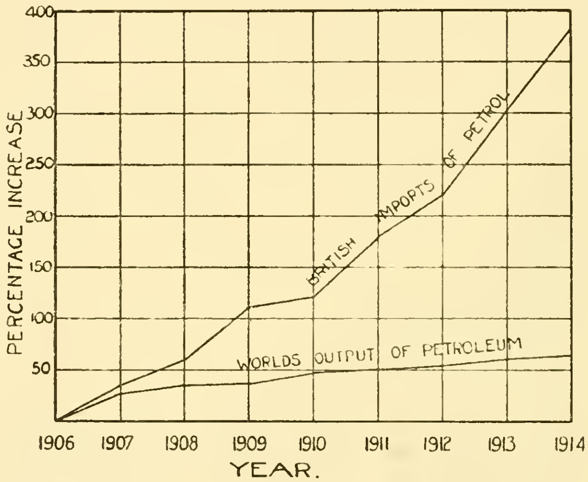


FIG. 41.—Diagram showing production of crude oil and import of petrol into the United Kingdom.

A motor spirit is one sufficiently volatile to form an explosive mixture at ordinary atmospheric temperature. Petrol, which is distilled from petroleum at a temperature below 250°F., and has a specific gravity below .75, has admirably met this condition, but as the supply decreases, there is a gradual tendency to carry the distillation further and increase the specific gravity so as to increase the yield, producing a less volatile spirit, and decreasing the facility of starting of the motor. Efforts are further being made to increase the yield of motor spirit by cracking heavier distillates of petroleum into more volatile fluids, and by the destructive distillation of coal and shale.

Benzol, the most generally used petrol substitute, is obtained from the light oils obtained by coal tar distillation, and extracted from the gases and vapours given off from recovery coke ovens. It has a lower calorific value than petrol, but, since its specific gravity is greater (.886), its calorific value per gallon is greater, and greater power is obtained for equal consumption. In 1914, nine million gallons of benzol were used in spirit motors—a very small fraction of the world's petrol requirements. There are several reasons why benzol cannot to any extent take the place of petrol, and apart from this, it suffers from the great economic disadvantage that it is the product of a wasting asset—coal.

For a considerable number of years many have endeavoured to utilise alcohol, which is derived from the fermentation of vegetable products, but there are two main considerations with regard to its use:

(1) The flash point is too high (65° F.) to enable it to form an explosive mixture, so that the addition of some ingredient to lower the flash point is necessary in order that the motor may start easily, especially in cold weather.

(2) Alcohol, being an intoxicant, is subject to excise regulations, to avoid which some denaturant or unpalatable substance must be added to it to make it undrinkable. If the denaturant at the same time is such that the flash point is reduced, and the calorific value increased, both requirements would be simultaneously met, and there would be a considerable advantage.

The importance of alcohol as a motor fuel is such that at the Imperial Motor Transport Conference, held in July, 1913, the following resolution was unanimously passed:—

"Having regard to the high price of petrol, the limited quantities of petrol, coal and oil shales available, and the obvious fact that all these sources of hydrocarbons are in process of depletion, it is advisable that attention be given to the construction of motors for alcohol fuel, and that concurrently action should be taken with the view to the ultimate creation of an adequate supply of this fuel, obtainable at sufficiently low price."

An important series of tests were carried out by the United States Government in 1912, and the results of over 2,000 comparative tests are contained in a report by the Bureau of Mines. Ordinary methylated spirit—having the composition Ethyl Alcohol 100 parts, Methyl Alcohol 10 parts, and ½ part of benzine—was used in low speed single cylinder engines. One of the important results arrived at was that explosive mixtures of alcohol vapour and air could be compressed in an engine cylinder to a much higher pressure, without pre-ignition, than explosive mixtures of petrol and air; with alcohol the compression could safely attain to 180 to 200 lbs. as compared with the safe compression of 70-90 lbs. in the case of petrol.

Another important point is that alcohol requires little more than half the amount of air necessary in the case of petrol for complete combustion, with corresponding less heat wasted in heating, and, further, more complete combustion is obtained than in the case of petrol, so that for equal compression ratio alcohol gives a slightly higher thermal efficiency. It is a well-known fact that an increase in the compression ratio in an internal combustion engine gives increased thermal efficiency. The calorific value of alcohol being only about 3/5 that of petrol, it follows that for equal efficiency the consumption of alcohol must be correspondingly higher to give the same power. But, by increasing the compression in the case of alcohol to an extent impossible with petrol, the thermal efficiency may be so increased that the consumption becomes practically equal, that is, the product of the calorific value and the thermal efficiency becomes about the same. In the United States tests, an indicated thermal efficiencyof 26 per cent. was obtained with petrol, with

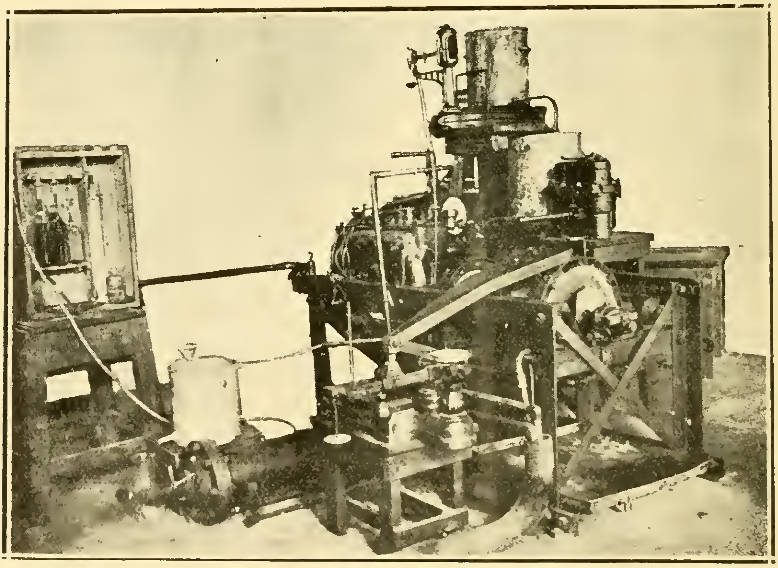


Fig. 42.—Arrangement of petrol engine for testing alcohol fuel.

compression pressure of 70 lbs., as compared with 39 per cent. for alcohol, with a compression pressure of 180 lbs. To accomplish this result would, however, involve an engine designed for high compression; it would be unsafe to subject an ordinary petrol motor to such high compressions, which would naturally increase the explosion pressures.

About two years ago a Johannesburg resident succeeded in producing a petrol substitute, having alcohol as the base, which appears to meet the requirements of a motor fuel. On the suggestion of the Government Mining Engineer, I carried out, a year ago, a series of complete efficiency tests with this fuel, being associated in the investigation with Mr. Vaughan, the Chief

Inspector of Machinery. The composition of this fuel, as given in the patent specification, is as follows:—

Ethyl Alcohol (C_2H_5OH)	86 per cent.
Sulphuric Ether	10 ,,
Methyl Alcohol (CH_3OH)	2 ,,
Benzol	2 ,,

Comparative tests were made on a 15 h.p. petrol motor with this alcohol fuel, and a standard brand of petrol, under exactly the same conditions, the only difference being that a larger jet was used in the case of the alcohol fuel, owing to the greater consumption necessary to yield equal power; no structural alterations were made to the motor.

Fig. 42 shows a photograph of the testing plant. The relative properties of the fuels are given in Table XV:—

TABLE XV.

	Petrol. (Pegasus Motor Spirit)	Alcohol Fuel.
Specific gravity at 60° F.	.716	.812
Calorific value determined by direct experiment (higher value)	20,280 B. Th. U.	12,033 B. Th. U.
Ultimate analysis—		
Carbon	84.10 %	48.71 %
Hydrogen	14.74 %	11.93 %
Oxygen	—	39.36 (by diff.)
Distillation	30°- 60° ...... 10 %	35°-60° .... 1 %
	60°- 70° ...... 12 %	60°-65° .... 7 %
	70°- 80° ...... 12 %	65°-70° .... 15 %
	80°- 90° ...... 18 %	70°-72° .... 17 %
	90°-100° ...... 17 %	72°-76° .... 58 %
	100°-110° ...... 6 %	Residue .... 2 %
	110°-130° ...... 15 %	
	130°-140° ...... 5 %	
Theoretical amount of air required for complete combustion of 1lb. of fuel (by calculation from analysis)	14.992lbs.	8.086lbs.
Weight of (water) steam produced by complete combustion of 1lb. of fuel (by calculation from analysis)	1.3266lbs.	1.0737lbs.

Table XVI. gives the results of the various tests, details of which will be found in the appendix.

TABLE XVI.

PARTICULARS OF TESTS.

Test No.		1.	2	3.	4.	5.	6.	7.	8.
Date of Test	1915.	June 27.	July 1.	July 4.	July 4.	July 5	July 5	July 9.	July 9.
Duration of Test	..	6 hours.	6 hours.	2 hours	2 hours	2 hours.	2 hours	2 hours.	2 hours.
Fuel used		Pegasus Motor Spirit.	Ethol.	Pegasus Motor Spirit.	Pegasus Motor Spirit.	Pegasus Motor Spirit.	Ethol.	Ethol.	Pegasus Motor Spirit.
Jet No. used in Carburetter		95	125	100	90	95	125	125	95
Barometer Inches of Mercury	..	24·68	24·54	24·45	24·43	24·51	24·48	24·67	24·64
Compression Ratio	..	3·69	3·69	3·69	3·69	3·69	3·69	4·76	4·76
Mean Temperature of Air in Engine Room °F. ..	..	56.98	60·05	59·07	64·36	52·4	65·06	53·5	54·6
,, ,, ,, at Carburetter °F. ..	..	62·5	68·9	64·5	72·5	60·3	69·7	61·5	63·25
,, ,, ,, Water leaving Jackets °F. ..	..	130·5	131·5	170·0	169·9	170·9	174·2	169·5	168·9
,, ,, ,, Exhaust Cases leaving Engine °F.	..	884·0	834·1	786·2	879·3	885·0	907·8	917·6	907·7
,, Analysis of Cases:—									
Carbon Dioxide	%	11·37	12·52	8·23	10·76	11·5	12·825	12·63	12·00
Carbon Monoxide	%	2·77	1·44	7·93	2·66	2·36	1·10	·47	2·37
Oxygen	%	1·53	1·40	26	2·64	·96	1·975	2·90	1·32
Nitrogen (by difference) .. .	%	84·33	84·64	81·24	83·94	85·18	84·10	84·00	84·31
Weight of Exhaust Cases per lb. of Fuel. lbs. ..	..	16·312	9·712	13·912	17·115	16·415	9·858	10·405	15·81
Mean No of Revolutions per minute	..	1285·18	1310·71	1308·6	1307·75	1305·04	1312·21	1316·04	1314·96
Brake Horse Power	..	12·235	12·478	12·458	12·45	12·424	12·492	12·529	12·518
Consumption of Fuel per hour lbs.	..	11·421	18·924	15·602	12·223	11·133	16·789	16·547	11·07
,, ,, ,, ,, ,, Gals.	..	1·595	2·33	2·18	1·707	1·555	2·068	2·038	1·546
,, ,, ,, ,, B.H.P per hour lbs. ..		·933	1·517	1·252	·982	·896	1·314	1·321	·884
,, ,, ,, ,, ,, ,, ,, Gals. ..	..	·13	·187	·175	·136	·125	·1655	·163	·12
Calorific value of Fuel (Lower). B. Th. U. ..	..	18,985	10,975	18,985	18,985	18,985	10,975	10,975	18,985
Thermal Efficiency (Brake)	%	14·36	15·29	10·71	13·65	14·96	17·254	17·56	15·16

It is worthy of note that with the alcohol fuel no trouble whatever was experienced in starting up with the engine either hot or cold, that the deposit in the cylinders and on the pistons and plugs was considerably less than with petrol, and that, in addition, the exhaust was colourless and odourless.

Among the advantages claimed for alcohol as a fuel may be mentioned: its greater safety—due to its higher flash point and low degree of volatility, and the fact that it mixes in all proportions with water, so that burning alcohol may therefore, unlike petrol, be extinguished by water; it is safer because a greater proportion of vapour in air is required to form an explosive mixture, and further, the density of the vapour being less than half that of petrol, there is not the same tendency for the vapour to accumulate.

The explosive range of alcohol air mixtures is greater than in the case of petrol, and this gives greater flexibility in running. But one drawback to the replacement of petrol by an alcohol fuel, in an ordinary motor-car without increased compression, would be that the total mileage capacity would be reduced on account of the greater bulk of fuel required for equal power.

Probably the main objection urged against the use of alcohol fuels is the fear of corrosion due to the formation of acids. But, as one writer puts it, this is probably a case of "lack of confidence springing from inexperience." It is known that the incomplete combustion of an alcohol leads to the formation of an aldehyde, which in turn forms an acid—acetic acid in the case of Ethyl Alcohol, and formic acid in the case of Methyl Alcohol, or wood spirit. Chemical tests of the condensate from the exhaust gases showed a slight trace of acetic acid, but as the vapourising temperature of this acid is 246° F., and the temperature of the exhaust is about 900° F., any acid formed would pass off with the exhaust gas, and the velocity of efflux would cause its ejection before any chemical action could take place.

All published statements, with regard to corrosion, when alcohol is used as a motor fuel, have reference to methylated spirit; that is, Ethyl Alcohol made poisonous or repulsive by the addition of 10 per cent. of crude methyl alcohol or wood spirit—made by the destructive distillation of wood and condensation of the vapours—and small amounts of other obnoxious substances. Methyl alcohol is much more liable to form an acid than ethyl alcohol, and the immunity from acid in this case is probably due to the small amount (2 per cent.) used in this fuel. Any corrosive effect which could take place due to the presence of acids would be in the cold exhaust pipe and silencer after shutting down. The risk of corrosion can best be determined by practical running tests extending over a considerable period. This, I understand, has been done in the case of this petrol substitute, many thousands of miles having been run without any evidence of corrosion.

There are many other petrol substitutes, the majority containing a fairly large percentage of benzol. The Germans are reported to be using a mixture consisting of 80 per cent. alcohol, 20 per cent. benzol, with the addition of 200 gms. of napthalene per gallon. Among other substitutes there are:—

Benzol-Spirit: (*a*) 95 per cent. methylated spirit, 70 parts; benzol, 30 parts.

(*b*) 90 per cent., or ordinary methylated spirit 50 parts; commercial acetone, 20 parts; benzol, 30 parts.

Petrol-Spirit: (*a*) 95 *per cent. methylated spirit*, 70 *parts;* petroleum spirit, 30 parts.

(*b*) 90 per cent. methylated spirit, 50 parts; commercial acetone, 20 parts; petroleum spirit, 30 parts.

Acetone-Spirit: (*a*) 95 per cent. methylated spirit, 70 parts; commercial acetone, 30 parts.

(*b*) 90 per cent. methylated spirit, 50 parts; commercial acetone, 50 parts.

Spirit-Ether: (*a*) 95 per cent. methylated spirit, 90 parts; sulphuric ether, 10 parts.

(*b*) 95 per cent. methylated spirit, 90 parts; sulphuric ether, 10 parts; napthalene, 1 part.

I understand that the motor fuel, known as "Natalite," has a composition similar to the fuel tested, but contains 40 per cent. of sulphuric ether. This should give a very volatile fuel, increasing the facility of starting, but the cost must be considerably added to seeing that it requires about 1.6 gallon of alcohol to produce 1 gallon of ether.

To my mind there is only one consideration which can weigh as regards the general adoption of alcohol as a motor fuel, and that is the cost of manufacture. This is a question which should be investigated by the Industry and Research Committee just formed. The main supplies of industrial alcohol have in the past been derived from the potato and the beetroot. But enormous quantities are made from maize and from molasses. Mr. Burtt-Davy informs me that he knows of one town in America where there are 18 distilleries making industrial alcohol from maize. Maize is said to produce 90 gallons of 94 per cent. alcohol per ton of 2,000 lbs., and the corresponding yield from molasses is said to be 80 gallons. The yield of molasses is stated to be about ⅓ the yield of sugar, and to amount to about 40,000 tons per annum in Natal. And the American tests proved that pure alcohol is not necessary for a motor fuel; it was found that with alcohol from 84 per cent. to 94 per cent. purity, the consumption of pure alcohol was about the same, The use of alcohol as a motor fuel and its manufacture from maize would give a wonderful filip to the agricultural interests of this country, and, at the same time, serve the higher interests of fuel economy. As one writer has said:

"It is at present the only medium through which man is able to convert the heat energy of the sun into work in a sufficiently reasonable time, and in sufficient quantities to justify the term 'fuel' to the product. . . . It is the only fuel which can be manufactured in large quantities without recourse to existing fuel substances, and this possibility is of the utmost importance in countries devoid of any large quantity of natural oils suitable for internal combustion engines. It affords the only weapon of defence against increasing cost of imported fuel. . . . At some distantly future date, when our coal measures are nearing exhaustion, it may become the fuel on which the nation is primarily dependent."

Notwithstanding the advanced state of civilisation at the present day, many problems have still to be solved. In improved methods of the production of power there is much work for the engineer of the future, and in connection with fuel his labours must be closely associated with those of the chemical technologist. Who knows that posterity may not smile at the crude method of obtaining power in the twentieth century by excavating a carbonaceous substance from the bowels of the earth!

I will conclude with a quotation from an introductory lecture delivered to his students at University College, London, a few years ago by Professor Fleming:

"While we are no doubt a long way yet from an energy famine, the world has arrived at a stage in which we cannot afford to treat our available resources at all wastefully. Hence the engineer is more than ever the arbiter of the world's destinies. The fate of the population, and, indeed, of civilisation itself, depends a great deal more on the engineer than it does on most of our statesman and politicians with their quack or doubtful remedies for human ills. Hence there is a wide field for useful work in all branches of engineering, provided we bring to its prosecution initiative, originality, and a high scientific training."

APPENDIX.

Tests of Alcohol Motor Fuel.

Object of the Tests: The object of these tests was to determine, under ordinary petrol conditions, the relative consumptions per brake horse-power per hour of petrol and a new fuel having alcohol as its base, and to ascertain its possibilities as a substitute for petrol as a motor fuel.

Engine used in Tests: It was decided to carry out the tests on an ordinary motor-car engine, isolating it from the car so that the various observations might be more readily made. This engine was of the ordinary four-cylinder vertical Otto cycle type, as built for motor-car work, with the cylinders cast in pairs. The cylinder diameters were 3½ inches, and the stroke 4¼ inches. The valves were arranged in side pockets, and the magneto, carburettor, and exhaust pipe were arranged on the same side. The ordinary type of water circulation was fitted, the cooling fan being disconnected during the tests. The valve timing and ignition remained the same throughout all tests. This was a very inefficient engine, but as the tests were mainly comparative from the point of view of fuel, this was not considered of very great moment, especially as the engine was thoroughly overhauled before the series of tests was made and carefully inspected before beginning a new test to ensure that it was in good running condition.

Arrangements for Tests: In order to ensure greater accuracy in carrying out the tests, and to enable the results obtained to be checked, arrangements for complete thermal efficiency tests were made so that heat balances could be constructed. The engine was mounted on a rigid testing stand, and the crank shaft connected by means of a universal joint to the shaft of the water-cooled brake wheel, which was carried on ball bearings, so as to eliminate friction. The brake arm rested, through a knife edge, on the platform of a small sensitive balance, and the load was kept perfectly constant during the period of each test by means of an adjusting screw operated by hand. Water passed from the town mains through the jackets, and the calorimeter which absorbed the heat in the exhaust gases. All thermometers and other measuring instruments used were carefully calibrated before the tests. The temperature of the exhaust was measured by means of an electric thermo-couple, specially arranged and calibrated for the tests. The analysis of the exhaust gases were effected by means of the Orsat apparatus, sometimes in duplicate, and also by means of continuous samples capable of being examined more closely in the laboratory for other constituents.

In order to maintain the best mechanical operating conditions of the engine, it was decided to secure the services of experts in the "tuning up" and running of petrol motors, and the works manager of a local garage and an expert motor mechanic were selected for this purpose.

Particulars of Fuel Used: The chemical and physical properties of the fuels used have already been given. The calorific valves were determined by means of the Mahler Bomb calorimeter.

Duration of Tests: In testing internal combustion engines it is generally recognised that a test lasting 1 hour is sufficient to obtain reliable data owing to the uniformity of the conditions and the rapidity with which these are reached. Only in the case of a gas-engine producer plant is it regarded as desirable to run 6 hours. In the recent important tests carried out by the United States Government on petrol and alcoholic fuels the duration of each test was from 15 to 30 minutes. It was, however, decided to run each of the first two tests for a period of 6 hours, partly as a test of reliability under a continuous heavy load, and partly with the object of examining the pistons, cylinders, plugs and valves for deposit, etc., after the test. The remaining tests lasted two hours each.

Load on Brake: The engine was found to be capable of exerting with petrol a maximum brake horse-power of about 15 for short periods. To leave a slight margin over a 6 hours' run it was decided to run it at a load corresponding to about 12½ b.h.p. at 1,300 revolutions per minute, the load being maintained constant, and the speed of the engine regulated by hand control.

Carburettors: The engine on receipt was fitted with a Claudel-Hobson carburettor, so this type was retained. No structural alterations of any kind was made to the carburettor during the whole of the tests, but various sizes of jets were used both for petrol and the alcohol fuel. The use of a variable jet would have been advantageous with regard to mixture adjustment, but it was considered desirable to adhere to the standard jets, selecting the one for use which gave the best running results. This "tuning up" was left entirely in the hands of the motor experts, and the test was not proceeded with until they were satisfied from their practical experience that the best was being got out of the engine.

Starting: Starting from cold with ordinary denatured alcohol has always been a difficult problem, and one of the objections to its use, involving starting on petrol or running on a mixture of alcohol and benzol. In the tests under consideration no trouble was experienced on any occasion in starting up with the alcohol fuel, with the engine either hot or cold, due, no doubt, to the presence in the fuel of sulphuric ether as a carburant. When cold, as is usual in practically all motor-car engines using petrol, it was necessary to partly reduce the air supply.

Tests Conducted: The following are the particulars, observed and calculated, of the various tests conducted. See Table XVI.)

Test No. 1.—The duration of this test was 6 hours, with petrol fuel and a 95 jet in the carburettor. A temperature of

130° F. in the jackets was aimed at, the mean for the test being 130.5° F. The brake horse-power developed was 12.235, the petrol consumption .13 gallon, per b.h.p. per hour, and the brake thermal efficiency 14.36 per cent. It is to be noted that in all the tests the brake thermal efficiency is based on the lower calorific value; that is, the total calorific value, minus the latent heat carried away by steam formed from the hydrogen in the fuel, the result being the heat available for conversion into work.

Test No. 2.—This test was carried out with alcohol fuel under the same conditions as test No. 1, the only change being the substitution of a 125 jet for the 95 jet used with petrol. The brake horse-power was 12.478, the consumption .187 gallons per b.h.p. hour, and the brake thermal efficiency 15.29 per cent., the calorific value (lower) being 10,975 B.Th.U., as compared with 18,985 B.Th.U. for petrol, as shewn in Table XVI. The valves at the ends of the test were remarkably clean, and required practically no regrinding for the next test.

Tests Nos. 3 and 4.—As compared with the published performances of petrol motors, the consumption in Test No. 1 appeared to be high, so tests Nos. 3 and 4 were made specially to endeavour, by improved conditions, to reduce the petrol consumption. In test No. 3 a 100 jet was used, and all the air supply possible given, the regulating plug being withdrawn. The percentage of CO in the gas analysis shows that the air supply was inadequate, resulting in increased petrol consumption and reduced thermal efficiency. Test No. 4 was run under the same conditions as test No. 3, but with a 90 jet. This ensured a greater excess of air than in test No. 1, but the percentage of CO_2 showed a diminution, as compared with test No. 1, and the CO remained high, although over 2½ per cent. of oxygen was found in the exhaust gases. It was consequently decided, in any further test with petrol, to use a 95 pet for the given load.

In any comparison these tests should be eliminated, but they are given to show how, if the mixture is not correct, the fuel consumption may be greatly increased, and the thermal efficiency reduced, although the power developed is greater, and the running of the engine perfectly satisfactorily from a mechanical point of view.

Tests Nos. 5 and 6 were run under, as nearly as possible, local conditions as regard temperature of water in the jackets. Tests were made, by experimental runs, with various types of motor-cars, British and American, and it was ascertained that the average temperature in the jackets, allowing 22° F. difference between summer and winter mean atmospheric temperatures, averaged 171° F. This temperature was aimed at, but owing to the variation of pressure in town mains, it was difficult to maintain the jackets exactly at this temperature. The results show increased efficiency, the increase being greater, however, in the case of the alcohol fuel than in the case of petrol. The results of very numerous tests carried out, under the auspices of the United States Bureau of Mines, gave no conclusive results as to the effects of varying jacket temperature upon the thermal efficiency of internal combustion engines. The direct effects of varying jacket water temperature upon heat losses in the engine are complicated by such other variables as the lubrication, the fit of the piston and valves, carburettor adjustment, etc. The improvement in consumption in tests Nos. 5 and 6 over tests Nos. 1 and 2 may be due to the more perfect combustion shown, but it is admitted that high jacket temperatures are very favourable to perfect combustion in the case of alcohol.

Tests Nos. 7 and 8.—The compression ratio of the engine 3.69 is considerably lower than is usual with motor-car engines, especially of British make, and this was increased in these tests to 4.76. The compression space may be reduced by (*a*) displacing the pistons relatively to the cylinders, by lowering the cylinders on the bed plates, by inserting packing pieces at the large ends of the connecting rods if they are of the marine type, or by fitting longer connecting rods; or (*b*) by adding plates to the top of the pistons. The latter method was adopted as the only one possible, but the increased weight of metal may by heat interchanges largely neutralise the increase of thermal efficiency, which ordinarily accompanies an increase in the compression pressure. A slight improvement was obtained both in the petrol and alcohol fuel consumption, as shown in Table XVI. It was impossible to carry the compression ratio further owing to the volume of the valve pockets. In any case, increase of compression beyond a certain limit might involve risk, so that to obtain the full advantage of high compression a specially-designed engine would be essential.

Formation of Deposit in Cylinders.—At the end of each of the 6 hour runs in tests Nos. 2 and 3, the engine was opened up and carefully examined for deposit formed. All deposit was thoroughly removed and analysed.

The results were as follows:—

Deposit from Cylinder, Plugs, and Piston Heads.

Petrol Fuel, Test No. 1:

Weight: 16.15 grams.
Ash: 27.06 per cent.

Alcohol Fuel, Test No. 2:

Weight: 6.2 grams.
Ash: 20.48 per cent.

The balance in each case was carbonaceous matter. The ash contained ferruginous matter, and included the dust drawn in with the air. The same lubricating oil was used in all the tests, the amount used in each 6 hours' test being about 5½ pints.

Nature of Exhaust.—Since the exhaust gases in the case of the alcohol fuel contain 11.8 per cent. of steam as compared with 8.3 per cent. in the case of petrol when the minimum or theoretical amount of air is used, on starting up with the alcohol fuel, the exhaust appeared more clouded, especially if the air approaches saturation, due to the considerable length of cold exhaust pipe used in the tests. On the engine and exhause pipe becoming warmed up, however, this entirely disappears, and the markedly clear exhaust was specially noticeable during the tests. This is borne out by other tests. The report of the United States tests referred to contains the following:—

"In regard to general cleanliness, such as absence of smoke and disagreeable odours, alcohol has many advantages over gasoline or kerosene as a fuel. The exhaust from an alcohol engine is never clouded with a black or greyish smoke as is the exhaust of a gasoline or kerosene engine when the combustion of the fuel is incomplete, and it is seldom, if ever, clouded with a bluish smoke when a cylinder oil of too low a fire test is used, or an excessive quantity thereof is supplied, as so often happens with a gasoline engine. The odours of denatured alcohol and the exhaust gases from an alcohol engine are also not likely to be as obnoxious as the odour of gasoline and its products of combustion."

The exhaust gases collected as a continuous sample over a considerable period showed merely traces of free hydrogen and hydro-carbons.

Corrosion.—Owing to the numerous statements which have been made locally with regard to the possible unsuitability of alcohol fuel for power purposes, due to the formation of acids leading to corrosion, special attention was directed to this question.

Various chemical tests were carried out. From the exhaust pipe, near the cylinders, gas was withdrawn and passed through a worm condenser so as to collect a sample of condensed steam for examination. The result was to show a very slight acidity equivalent to 0.02 per cent. of acetic acid. Taking the mean weight of exhaust gases formed during the tests with the alcohol fuel as 9.99 lbs. per lb. of fuel, the weight of acetic acid vapour detected would thus equal only 0.00215 per cent. of the weight of the exhaust gases.

No trace of sulphuric acid was found in the water obtained by condensing the steam in the exhaust. The lubricating oil from the crank chamber was also tested and found to be neutral.

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

President of the Section.—Professor J. A. Wilkinson, M.A., F.C.S.

TUESDAY, JULY 4.

The President delivered the following address:—

The choice of a subject for a sectional address is normally fraught with some difficulty, but this year your Council specifically requested contributions from its members dealing with (1) the organisation of the Union for the fuller development of its industries and resources, and (2) the necessity for research work with a view to the establishment of new industries and the development of those already existing. On glancing at the list of papers to be submitted to this Section, it was evident that none of the authors had attemped to deal with either of these subjects, and hence I felt that the path of duty compelled their treatment in some degree. It will therefore be my endeavour in this address to attempt to deal from that point of view with the matters with which I am mostly concerned, namely, the necessity, the organisation, and the development of chemical industry and research, using these terms in their widest sense.

South Africa is a country which has hitherto existed, and still does at the present moment exist, on its rich stock of raw materials. Its exports, in addition to the raw products of agriculture, are chiefly metals, crude and unrefined, and diamonds uncut. Their extent and relation to other exports are easily read in Figures 1 and 2 derived from the official data published by the Union Government. It is there seen that the chief chemical industry is the preparation of raw gold bullion from the quartzitic ore of the Transvaal. This is carried out in three operations—the first being fine pulverisation by mechanical means; the second, amalgamation with mercury; and the third, solution of the unamalgamated gold still remaining by means of sodium cyanide solution followed by reprecipitation with excess of zinc shavings and final treatment of the metal, so as to get rid of as much of the base metal present as possible before pouring into commercial bars. The major portion of the plant necessary for these operations consists of iron and steel, and the raw materials for their manufacture exist in comparative abundance in the Transvaal. A thorough and scientifically complete investigation of these has not yet been undertaken, but in the interests of the country at large and not merely of the metal industry this should, I venture to state, be one of the first, since iron is the most important necessity for industrial progress of every kind. The normal value of the iron and steel imports into this country annually is almost one million pounds, and with an expanding population this must rapidly increase, as there is, practically speaking, no industry, operation, or even trade, for which it is not necessary in some form or another. One small manufactory is working at Vereeniging, but this is not engaged in the production of cast iron from the raw ore and its subsequent conversion into steel of known and definite composition; and further, what is being done is not, as

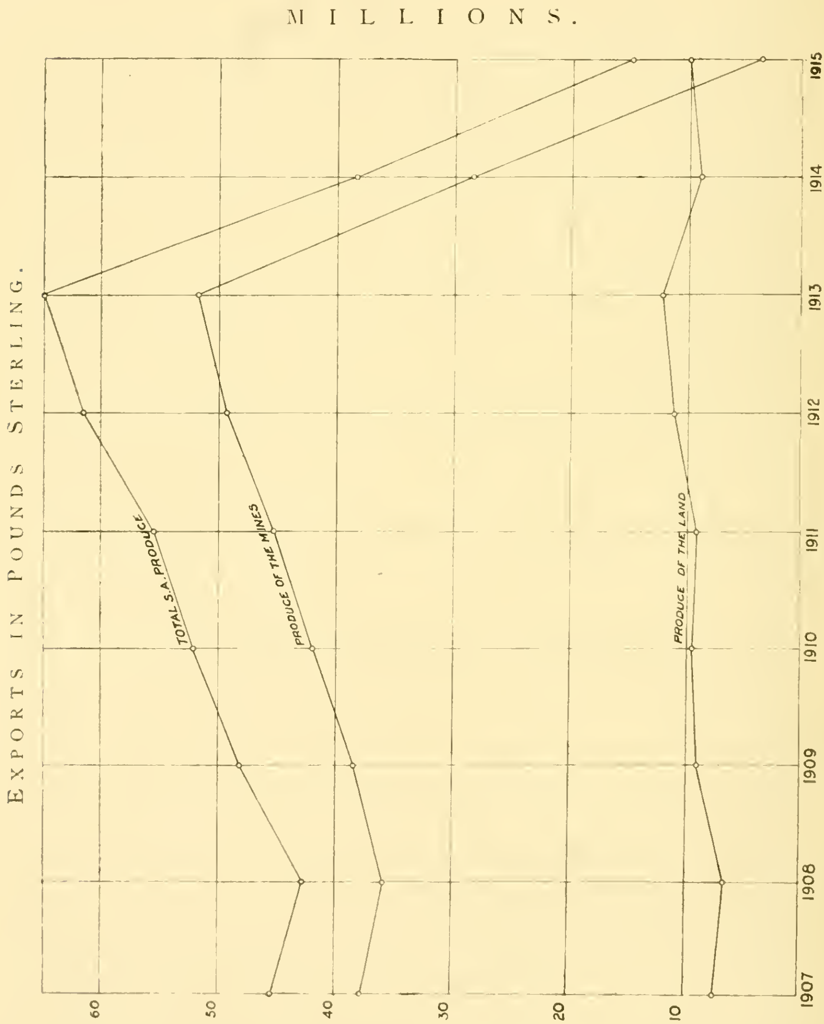


Fig. 1.

far as I am aware, under strict chemical control, by which means alone can proper and definite results be achieved.

The function of the chemist in the control of matter and its energy content is imperfectly, if at all, understood, even in industries such as this, where one might at least expect that the

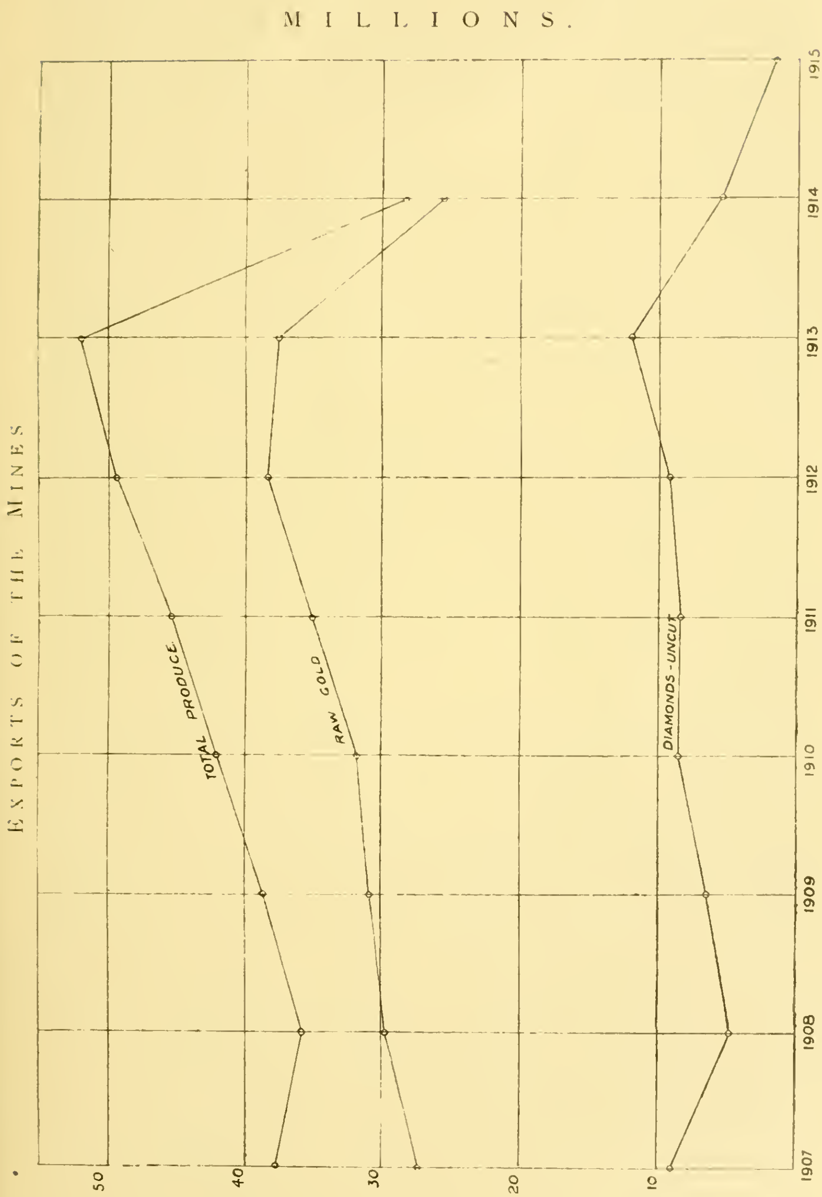

MILLIONS.
EXPORTS OF THE MINES
50
40
30
20
10
1907
1908
1909
1910
1911
1912
1913
1914
1915
TOTAL PRODUCE
RAW GOLD
DIAMONDS-UNCUT

Fig. 2

methods which have been successful, and hence adopted in their entirety in other countries, would be followed here. This state of affairs is, however, too common an occurrence in this country, and even in England, the popular opinion being that the duties of the chemist and the pharmacist are identically the same.

The second process mentioned involves the use of mercury, which must necessarily be imported at present. The case, however, is otherwise as far as sodium cyanide and zinc are concerned, the imports of which amount to half a million sterling, and both of which can be manufactured here. The former can be obtained indirectly from atmospheric nitrogen through cyanamide, which would find great use as an artificial manure, and thus stimulate agricultural progress. In point of fact, the Rand may be said to be primarily responsible for this great and growing industry, since it was the search for a new method of preparing cyanide that first discovered the reaction. Zinc blende is also found native, and the winning of the metal offers no great difficulty.

The mining of gold ore or other mineral deposits would be, practically speaking, impossible without the use of explosives, and to meet this necessity three large explosive factories have been established in the country, all of which are entirely dependent for their raw materials on other countries. The value of these imports in 1913, the last completely normal pre-war period, was as follows: Sulphur, £78,386; nitrates, £235,984; glycerine, £563,014; or a total of £877,384, iron pyrites not being given. Of these, no large deposits of sulphur or pure pyrites are known to exist in South Africa, but nitric acid and its salts can now be prepared in any quantity from the nitrogen present in the atmosphere, and glycerine is a bye-product in the manufacture of soap, factories for which have recently been erected here.

The production of the oils for the latter purpose would necessitate the provision of artificial fertilisers, an industry of prime importance for the progress of every branch of agriculture. Happily the problem of the transference of atmospheric nitrogen to the requirements of the soil, first stated by Sir William Crookes in his classic address to the British Association at Bristol in 1896, has now been solved in various ways, two of which have been indicated above, and which would therefore serve, if established, a double function. Unfortunately deposits of potassium salts or mineral phosphates of any large extent and degree of purity, have not hitherto been discovered here; but in this respect South Africa is in no worse case than most other countries, and hence this problem is by no means insoluble. The manufacture of superphosphate, however, could and should be undertaken, the value imported in 1913 being £95,273, and of raw phosphates only £1,705. It should also be mentioned in this connection that over 13½ million pounds of basic slag, a bye-product of the steel industry, were imported in 1914—another valid argument for the creation of the latter. With regard to potassium salts there are no deposits of easy chemical access outside the celebrated Stassfurt beds, but there are sources within this country, which could be realised if the necessity arose. At the present moment strenuous research is being made in the United States of North America with regard to the treatment of similar sources of potash in order to meet their own requirements, and, should these experiments prove successful, the application of similar methods in this country may yet prove of great value.

Returning again to the consideration of the exports of the country, we find that copper ore and matte, tin ore, lead ore, and raw asbestos, along with coal and diamonds, form the remainder. It is, indeed, a sad reflection that we must needs export these raw materials, as such, without making even the slightest attempt to extract their valuable contents or work them up in any manner whatsoever, but rather in addition pay freightage on admixed dross. A pitiable confession of failure in very truth, since the paths are easy and rendered still more so by the value of the prospect! If the Chinaman and the Malay are capable enough to win the tin from its ore, why should we hesitate?

Further, we require these metals in some degree even at present, since we imported in 1913 the following amounts:—

Copper: Bar, ingot, and rod	£8,158	
,, Plate and sheet	4,767	
		£12,925
Tin: Bar, block, and ingot		£12,797
Total		£25,722

If these figures constitute a subject for serious study, the case is even more surprising, when the imports necessary for the prosecution of the country's work are considered. The following table gives a list of the articles (and their value for the year 1913), produced by chemical industry which could be manufactured in this country. In this are included only such substances as can be prepared from materials which are available here, either in their raw state or those which can be grown on the soil:

I. *Coal Products.*	£
Ammonium Sulphate	4,707
Ammonia for ice making	4,811
Ammonium Carbonate	928
Carbonic Acid Gas	1,827
Calcium Carbide	46,715
Creosote	801
Pitch	913
Tar	26,765
Disinfectants and Germicides	43,272
Printers' Ink (?)	10,802
	£141,541

II. *Silica and Clay Products.*

Building Bricks	1,086
Fire Bricks	4,181
Fire Clay	702
Pipes and Piping	8 678
Earthenware	153,266
Glass	269,880
Beads (of glass?)	20,319
	£458,112

III. *Limes, Cements, etc.*

Lime	1,818
Bleaching Powder	2,316
Cement	125 616
Magnesium Sulphate...	2,104

IV. *Starch and Sugar Products.*

Glucose	12,997
Molasses and Treacle	799
Golden Syrup	135,440
Vinegar	10,188
Alcohol	(?)
Confectionery (?)	261,788

V. *Oils, Fats, and Waxes.*

Castor Oil	19,778
Colza and Rape Oil	2,375
Cotton Seed Oil	34,819
Linseed Oil	43,405
Lard	48,317
Beeswax	543
Margarine	26,643
Soap	94,287
Candles	9,221

VI. *Cellulose.*

Paper (cheaper grades)	340,541

VII. *Condensed Milk* 464,886

VIII. *Paints.*

Ochre	6,670
Water Paints and Distemper	14,090

IX. *Various.*

Medicinal Preparations (Spirituous)	22,331
Medicinal Preparations (non-Spirituous)	101,609
Ale, Beer and Stout	40,742
Aerated Waters	14,066
Matches	3,786
Tartaric Acid	5,639
Cream of Tartar	8,059
Baking Powder	46,761

It will be obvious to any chemist, that this list is by means as exhaustive as could be made, and that many common substances have been omitted. As an example of the latter, perhaps the absence of all sodium compounds, more particularly cyanide, every molecule of which is imported—in 1913 to the extent of £395,639—may form a subject for criticism. But it is a well-known fact that within the borders of the Union no large economic supply of the raw material, common salt, of sufficient purity has hitherto been discovered. In British East Africa, however, there is a large deposit, Lake Magadi, of pure soda which constitutes, as far as is at present known, one of the most remarkable natural phenomena in existence. On the other hand, it may be objected that many of the materials quoted are at present being manufactured here, in which case South Africa is unable to meet even her own requirements. In addition to this, however, the chemist does not hesitate to assert and maintain, as he can prove, that the articles manufactured in this country do not, as a general rule, attain the same level of perfection as those to which importation has accustomed him, the chief, and generally speaking, the sole reason being an utter lack of chemical control. "Bricks are made from clay, and clay is clay," is the article of faith upon which a manufacture is founded; the geographical survey of the bed furnishes a basis for a usual estimation of profits, the mixing, moulding, mining and transport machines are provided by the engineer salesman, untrained and uneducated labourers are drilled into daily routine operations and the work begins, with the only result possible, the usual muddle through somehow, or trust to luck kind. A few analyses of the virgin clay may have been done at first, but physical and chemical control of every phase of the operation, from the clay pit to the sales product, is either unknown and unvalued or ignored and despised.

A successful industry must be founded upon and controlled by true scientific knowledge, and the transformations of matter form the province of the chemist, whether it be the manufacture of the food on which we live, the bricks, lime, and cement, with which we build our homes, the medicines to cure our infirmities, the paper and ink to disseminate and preserve our ideas, or the explosives we use as weapons of destruction.

And if we are to build an edifice consecrated to the future progress of our race in this country, where, owing to our native population, self-preservation itself demands efficiency and leadership means excellence, it is our bounden duty that the advancement of science shall permeate the mass and be understanded of the common people. Our workmen, too, must drink of the fountain, so that even routine operations may reflect scientific skill, and the atmosphere of science our dominance.

The realisation of our hopes is the mission of our youth, and our assistance in the provision of the fullest means for its achievement must be forthcoming in bounteous plenty.

The rule of thumb artisan, who is merely waiting for the whistle to blow, must give place to the workman trained to direct his energy with innate and acquired skill, and more especially with some knowledge of the physical and chemical properties of the materials he employs. Conservatism, worship of tradition, ignorance of the discoveries of modern science and failure to apply them are grievous sins in workmen, and heinous crimes in those who control and direct industry, and the country which allows these weeds, not merely to exist, but oft-times to flourish, is doomed to an early grave in the fellowship of nations.

South Africa has been endowed beyond measure with rich stores of useful minerals, and whilst these are being exploited, she is dependent entirely on others to supply her most elementary wants. Thoughtless criticism might saddle me with lack of a due sense of proportion in that the economics of these possible industries have been left wholly out of consideration. In this regard I maintain that the duty of a country is to its own people and the primary necessity is to furnish, as far as it can do so, its own immediate requirements. South Africa is not nearly at present as self-contained as is possible, and hence the necessity for the establishment of chemical industry in our midst is, in every sense, a vital one. Private enterprise has to some extent made a beginning, as illustrated by the success of the soap and cement factories established within the last few years, but the coal industry is still confined to the utilisation of the raw material accompanied with the waste and loss of its most valuable bye-products. I am well aware of the fact, that recently an ammonium sulphate industry has been started in this province, but in this case also bye-products of considerable value will be lost.

There are two points of view which make this particular industry of supreme importance—firstly, the defence of the country; and secondly, conservation of its natural resources. Phenol, benzene and toluene are three of the most important distillates obtained from coal tar, and apart from their own use as motor fuels, when treated with nitric acid, these substances yield on the one hand the highest explosives at present known, and on the other hand the mother substances for the preparation of dyes, drugs, and perfumes. Much has been heard since the commencement of the war on this latter subject, owing to the fact that the textile industries of Great Britain were so absolutely dependent on Germany for these products, that, for a short time, their position was extremely critical. This subject is, to the chemist, certainly one of the most attractive within his vision, but it would be superfluous to deal with it here, because I am of the opinion, that the day is yet distant when its institution can be profitably discussed in South Africa. On the other hand, if war and the creed of a spurious superman are to continue their existence, the manufacture of explosives from our own resources is a necessity, neglecting for the moment their use in mining, engineering and agriculture. These, however, are not the only substances which would justify the inception of a tar distillation industry in this country, as a perusal of the short list given will readily show.

The second point of view put forward is, that conservation of natural resources should constitute one of the primary functions of Government, and as, according to the statistics of the world's coal resources collected recently by the International Geological Congress, the quantity of coal we possess is but four-fifths of one per cent. of the total amount known to exist in the world, this statement should require no advocacy on my part with respect to a substance so rich and fertile in its already known potentialities.

Parenthetically, I may remark here that the subject of national conservation is one which has not yet been taken up by this Association, but its close and intimate connection with development should make it a matter for serious consideration even now. In the United States of North Amercia, which is one of the portions of the earth most richly endowed by nature, much preliminary work has been done upon this subject, and the publications of the Government Commission, as also the addresses and papers of some of its foremost scientific workers, are worthy of careful study. South Africa is still a young country, but in the evolution and development of its heritage it must seek to take advantage of the experiences of this nature, which other countries can show.

The late Lord Beaconsfield once said that the prosperity of a country could be gauged by the extent of its chemical industry, a statement which was received by his contemporaries with scorn and derision. The years which have elapsed since then have proved, as is often the case, that his words were not the accident of an impulsive verbosity, but the reasoned verdict of a deliberative mind. The realisation of this dictum has been most profoundly shown by the stupendous progress in chemical industry made by Germany during the last forty years, more especially in the domain of organic chemistry.

It may appeal to some to state here, that their great chemical factories, each with a capital of from one to two million pounds, paid dividends out of profits varying from 14 per cent. to 30 per cent. in 1913, and as a specific example may be quoted, the firm of F. Bäyer and Co., of Elberfeld, which on a capital of £1,800,000 made a net profit of £838,092, figures which remind one of a rich Transvaal Gold Mine. Lesser concerns show proportionate results.

From the point of view of the present conflict, these factories, with their vast chemical equipment and organisation, are among the greatest national assets of their country, and it is by no means beside the mark to state, that without her chemical industries Germany would never have been able to continue the struggle.

If we leave out of consideration the exploitation of her metalliferous minerals, which will in the not far distant future be but memories, South Africa may be considered as a country where chemical industry is, practically speaking, non-existent. Hence, to prepare the nation for the future prosperity we should so earnestly desire to see attained, the obligation rests upon this generation to develop, at the earliest possible moment, those chemical industries, in the first place, needful for its own existence, and only when this has been achieved, to attempt an expansion beyond its borders.

The second portion of my theme relates to the organisation of chemical industry and the part which research should play therein. So much has been written upon this subject, since the war began, that it requires some amount of courage to add to the already voluminous literature bearing upon it, and, in venturing to do so, I cannot hope to do more than give a brief survey, one which, however, will relate more especially to the conditions as they exist in this country.

Reference has already been made to the enormous progress which Germany has made in this direction, but, unfortunately, it has required a war of the present dimensions to pierce the armour-plated conservatism of the governing classes in England, and, even yet, is is a matter of grave doubt, whether much impression has been made. The force of precedent and example within the Empire in all its affairs is so dangerous, that, in many respects, it should be classified as a disease and treated accordingly. But this is a phase of mentality, which so far has been outside the vision of those to whom we have entrusted our destinies. It should, however, in this respect be noted that the agitation for the endowment of scientific education and research on the one hand, and the scientific development and control of industry on the other, is a theme upon which the leaders of science and contemporary thought have never wearied to dilate since Germany first began to rival her competitors, and then leave them behind in the race for industrial supremacy. Patent laws and other legislative expedients of a like artificial nature are but momentary impedimenta in the path of modern scientific industry, and soon melt away like the proverbial dew. It will suffice to mention the comparison between the great anticipations and their realisation, when a few years ago Mr. Lloyd George attempted by such legislation to transfer in some degree German chemical industry to Great Britain. Tariffs may protect the birth throes of industries, whose sponsors are fully conversant with modern methods of their exploitation and utilise this knowledge to the fullest extent in their control, but otherwise they provide an illustration of a futile and impotent waste of energy, such as any scientific man would most rigorously condemn.

By way of preface it would, perhaps, at this stage be of interest to take a few illustrations of the manner in which some of these industries have risen to their present state of flourishing activity, and, although the story is an oft-repeated tale, constant reiteration does not yet seem to have brought home the lessons it teaches. I shall first refer to the synthetic preparation of of indigo. This example is at the present moment the most fitting one which, I think, could be chosen, since it bears the closest possible resemblance and analogy to an industry upon which much of the prosperity of this particular Province is directly dependent, namely, the tannin industry.

The synthesis of indigo was first accomplished by Nencki in 1876, but it was not until Bäyer and his pupils had five or six years later thoroughly investigated and proved its constitution, that simple methods for its synthesis became available. The next step, namely, the translation of the laboratory methods thus discovered into commercially economic processes, proved a source of extreme difficulty, in which success was only achieved after nearly one million pounds had been spent on innumerable and laborious experiments, and at the end of seventeen years' work, artificial indigo prepared from the napthalene of coal tar being first put on the market in 1897. If anything can excite our admiration, surely this example of one of the finest industrial achievements known to science should do so. The result of this vast amount of labour and expenditure, which, it is needless to say, would not have been incurred had the consequences not been clearly and precisely foreseen, is shown in the following table given by Professor P. F. Frankland in an exhaustive paper on the Chemical Industries of Germany last year:—

INDIGO.

	British East Indies.		*Germany.*	
	cwts.	Value of Exports.	Imports.	Exports.
1896	188,337	£3,569,670	£1,036,000	£319,550
1899	135,187	1,980,319	415,450	392,250
1902	89,750	1,234,837	184,350	923,100
1905	49,252	556,405	60,100	1,286,050
1908	32,490	424,849	44,100	1,932,750
1911	16,939	225,000	22,300	2,091,500
1913/4		60 to 70,000		

In 1895-96 the acreage under cultivation was approximately 1,400,000 acres, and on December 31st, 1915, the *Indian Trade Journal* (Calcutta) published an estimate that the total area in 1915 was 314,300 acres, as compared with 148,400 acres in 1914, this increase being due to the high prices ruling on account of the war and the cessation of the German industry. The total yield was estimated at 39,000 cwt., as against 25,200 cwt., the revised estimate for 1914-15, and the average output per acre 14 lb., as against 19 lb. in the preceding year. The price of indigo (100 per cent.) in 1897 was sixteen shillings per kilo, and in 1913 seven shillings.

The success of the synthetic industry, as had been also foreseen, would probably not stop here, and the following quotation from Professor Frankland will show this:—

By varying the ingredients in the indigo synthesis, many very valuable dyes related to indigo have been obtained. Thus the chlorine and bromine substituted indigos are manufactured as ciba blue, brilliant indigo, and bromo-indigo. Again with sulphur instead of oxygen, thio-indigo-red and thio-indigo-scarlet. Moreover, by using the anthracene grouping in the indigo synthesis, a number of the most important colours have been obtained, *e.g.*, Indanthrenes of extraordinary fastness to light; Alizarin indigo; Algol colours (Robert E. Schmidt), in all varieties of colour and of the greatest fastness to light."

The knowledge of what was being done in Germany prior to the advent of the marketing of synthetic indigo was not unknown to the Indian planters, but they were sceptical of the results, many believing that it was an impossibility to prepare the substance from coal tar, with the result that, practically speaking, they took no steps whatever to improve either the yield per acre or the quality of their finished product. Having thus lulled themselves to sleep, their awakening in 1897, when synthetic indigo was placed on the market at a price much below that demanded for the natural substance, was somewhat of a bolt from the blue. Owing to the stress of the competition, which they at last realised would take place, they attempted some improvements; but, as seen above, they were somewhat belated. It is difficult to predict with any degree of accuracy whether the natural product would have been entirely ousted had there been no war, because tradition is hard to kill, and there are still dyers who prefer to use the natural dye. On the other hand, there can be no doubt that the production of the latter would have been insignificant in comparison with that of the synthetic material, as happened in the previously well-known and analogous case of the dye alizarin, formerly extracted from madder root. The indigo fields would have shared the same fate as those of the madder.

The tannin industry in this Province is in a similar position to that in which the indigo industry found itself about 1880-82. The master synthesis of tannin was effected in 1913 by Professor Emil Fischer and Dr. Karl Freudenberg in Berlin. How this has been accomplished will be dealt with fully in a separate paper before this Section. The formula of tannin is now known with a great degree of certainty, and the researches are still being continued. The next step is the commercial utilisation of this knowledge, which means the synthetic production of artificial tannin on a commercial scale from raw materials found in Germany. This, as stated above, in the case of indigo took seventeen years' work and one million pounds in money.

The value of the tannin bark industry to Natal is approximately three hundred thousand pounds per annum, as shown in the Annual Statements of the Trade and Shipping of the Union (1912 *et seq.*), namely:—

I.—*Amounts Exported in Pounds.*

	1912.	1913.	1914.	1915.
To the United Kingdom ...	62,007,314	99,203,808	92,276,338	
,, Germany .	32,523,378	30,745,850	25,904,174	
,, Australia .	16,072,668	8,871,278	7,156,368	
,, Other countries	7,604,239	6,896,802	4,879,946	
Total . . .	118,207,599	145,717,738	130,216,826	89,639,564

II.—*Value of the above in £ sterling.*

To the United Kingdom	145,304	208,192	200,772	
,, Germany	83,240	68,318	60,735	
,, Australia	35,890	17,845	13,872	
,, Other countries	18,576	15,974	11,020	
Total	283,010	309,329	286,399	195,184

The problem, which confronts the industry in this province, is therefore how, whilst there is still time, to protect it against any conception, which might possibly arise from the presence on the market of an artificial substitute. The answer to this may be put in the form of a question. If, during the years 1880-1896 the indigo planters of India had invested one million pounds in the scientific investigation and development of their industry, would they have for one moment feared to have faced competition at the end of that period? This would have meant an expenditure to the extent of between fifty and sixty thousand pounds per annum for seventeen years invested so as to obtain results, which would not only have made the future secure, but at the same time would also have increased the output annually during the period of its outlay. In point of fact, it would in all probability have placed vegetable indigo beyond competition. Moreover, just as India was compelled to export the indigo which she grew, so also must Natal at present export her tannin bark, until the chemical industry of leather manufacture be established here, in which case the leather would be required to stand the strain of the competitive market. In passing, it may be noted here that of the twenty-five large classes into which Germany officially divides material connected with chemical industry, one of the divisions is "tanning extracts" and another "dyes and dye material."

In both these industries, the production of indigo and tannin, the problems are so very similar, that the lesson of the former should be the incentive for the latter in the superlative degree. It is ofttimes the wail of the profitmonger that the industry will not "stand the expense," and in annual balance-sheets we look in vain for the record of "investments" in the future of the industry itself. The work of the botanist and chemist are the corner stones, upon which these organisations must not only be built up initially, but also must be conducted throughout. Each must have had the highest training possible, must be thoroughly skilled in his work, thoroughly conversant with all that has been done, and must be selected for the work on these grounds and no other. They must be provided, as far as they can be, without stint or question with all that they deem necessary for the prosecution of their investigations, and results will follow. The days of rule of thumb experience, the legacy of a former generation, are as dead as the dodo, and he who still clings to them, will be left behind his more enlightened contemporaries as the cab-horse is outdistanced by the aeroplane. The weigh scales and the magnifying glass may have been excellent tools for our great grandfathers, but we desire the microbalance and the ultra-microscope. If in pain, we do not despise the veronal which the chemist has provided for our ease, but as yet we scorn his aid in the prosecution of our industries.

Chemical industry requires a complex organisation beginning with the chemist, and ending with the patent agent and advertising salesman, sometimes also the machinery for running to earth patent thefts and fraudulent imitations. Its board of control should be self-contained, and consist of representatives of each of the main branches, whose qualification should be that they have specially studied their own sphere of the work, and been at the same time highly trained therein. Industrial success at the present day demands this, and illustrations of the efficiency and success thereby produced are easily obtained. The number and kind of men required will, of course, vary considerably with the particular industry, and in each case requires the exercise of much careful thought before commencing operations.

But at the outset the chemist is the most important factor in chemical industry, because it is in the first degree upon his work that the operations depend. This may seem to some a self-evident truth, but, as a chemist, I can give the assurance that it is unfortunately otherwise in most instances in this country with, of course, results which are easily foretold; in fact, this is one of the main reasons, why our chemical products are not up to the standard of imported goods. Given the chemist and the problem of the industry to be undertaken, the next procedure is its complete investigation, in other words, to ascertain as much as possible of what is already known, for which access to a good technological and scientific library is required, and then to carry out, after complete analyses of the raw materials have been made, such tests on a small scale as will give some clue to the difficulties to be encountered on the large scale, for which purpose the establishment of a properly equipped laboratory is indispensable. If these meet with success, and the industry is undertaken, the laboratory can be utilised to aid the engineer in selecting the best materials of construction, until such time as it is necessary for controlling the daily routine. At the same time, it should serve as an instrument of research with a view to improving methods of daily control, methods of manufacture, and also the discovery of new methods or processes. Whether any or all of the functions be efficiently performed depends on the equipment and staff of the laboratory, but more especially on the man, who is the head. Routine operations soon become to a certain extent standardised, and can be carried out efficiently by well-trained assistants, but research work of the beneficial kind can only be effectively performed by the head of the laboratory in touch with every phase of the manufacturing process, or by chemists specially appointed for this purpose working independently. The value of the work done will manifest itself in the smooth working of the process of manufacture and the sales of the finished product, when compared under commercial conditions with its competitors. It will also be of great assistance to the engineer in the control of his supplies, especially fuel. It is difficult, if not impossible, to assess the value of such a laboratory in pounds, shillings and pence, but on the other hand in a few instances, where they have been installed in this country, they have rendered invaluable assistance and made for efficiency.

It is not my intention here to enter upon the other phases of the organisation, as they are in most respects common to all industries, and hence are well known. The sad aspect of the special cases with which we are concerned here is, that it has hitherto been considered sufficient for these industries to employ business men and engineers alone, all excellent in their own lines, but quite unfitted to govern an industry, whose fundamental basis is a chemical process. This, in fact, is one of the chief reasons why England lost her supremacy and was outstripped by Germany, and the appreciation of this fact at the present moment by the Americans is manifesting itself in a keen endeavour to take the lead.

Another reason is, that Germany has appreciated to the full the value of scientific research and education, and it is necessary for us to realise this in like measure, if we are to utilise efficiently the abundance of raw material found in this country. We have seen above in the case of one industry the vast sums of money they were willing to spend to effect its capture, and this was strictly in keeping with their general policy, both on the part of the State and the individual. That the Empire is beginning at last to appreciate this is shown by the steps being taken in England, Canada, and Australia. Little has, as yet, been done in England compared with what we should expect, but this may be partly accounted for by the war. The Canadians, at the instigation of Lord Shaughnessy, have made a beginning in the establishment of the Canadian Research Bureau at Montreal, thus seconding the excellent work, which has been accomplished in recent years by their Mines Department. The proximity of the United States will doubtless assist in making for efficiency, as the work of the scientific departments attached to their Bureaus of Agriculture, Geology, Mines, Commerce, Standards, etc., is too well known to need description. The Australian Government has endowed a similar institution, the Commonwealth Institute of Science and Industry, to the extent of half a million pounds as a beginning, the object in both cases being the development of the natural resources for the benefit of the country in the first, and of the Empire in the second place. So far as I am aware, in this country nothing has yet been done in this direction, other than the meeting of the scientific societies of the Rand, held recently in Johannesburg, which laid stress on this matter, and formed a Committee to further the project.

No opportunity like the present has ever before presented itself, and the cessation of the war will witness the still fiercer struggle of industrial competition, for which we must gird on our armour. At present we are, as I have shown, exporting our raw materials and importing the articles manufactured from them, hence our first and foremost need is to attempt to make ourselves independent of others, as far as our own wants are concerned. For this purpose research is necessary, and, in my opinion, the prime mover must be the State, since its proper execution demands, if performed efficiently, an organisation which is beyond the scope of the individual. It would take too long to enter fully, as the subject most rightly merits, into all the details of its requirements, and I shall therefore content myself with a brief summary of the most essential considerations and necessities. In the first place, however, I desire to explode a popular fallacy, that there are two kinds of research, which have been miscalled pure and applied research. They correspond to the undignified and unworthy divisions into which even science itself has been classified. If research be undertaken, as it is, to thrust back the boundaries of the unknown, and to widen the areas of existing knowledge, then, no matter if the purpose for the moment be, in a sense, the abstract, such as the proof or establishment of a law, principle, or hypothesis, or the concrete, such as we find exemplified in the successful development of the contact method of manufacturing sulphuric acid, as a result of the commercial preparation of indigo, it is somewhat of an anachronism to draw a sharp line of division. More especially is the practice to be condemned, since in the popular mind research of the former kind is supposed to have no utility whatever, whereas without it the latter would be absolutely impossible, and hence in any scheme which may be put forward it must claim the part, to which it is justly entitled. The steps, which are necessary in this country for this work, are as follows:

1. PRELIMINARY:
   (*a*) A complete census of existing laboratories and workers.
   (*b*) A complete census of facilities for the education of scientific workers of all kinds and classes.
   (*c*) A complete census of all manufactures, their location, methods, raw materials and output.
   (*d*) A complete census of all known existing raw materials of this country, which might be put to use for manufacturing or other purposes.
   (*e*) The collection of information from, and reciprocity with, organisations having similar objects throughout the Empire, and in Allied or friendly States.

2. STANDARDISATION:
   (*a*) Of scientific instruments of all kinds, whether used in laboratories or works.
   (*b*) And scientific control of apparatus and materials required in research.

3. INITIATION: The appointment of a Central Council which shall—
   (*a*) Receive and suggest problems for research;
   (*b*) By the organisation of manufactures of the same or similar products, ascertain what is necessary for their progress;
   (*c*) Keep in close touch with all the Universities and Scientific Societies in the country.

4. ASSISTANCE:
   (*a*) By endowments to laboratories and workers.
   (*b*) By the collection, publication, and dissemination of information.
   (*c*) By the establishment and endowment of libraries.
   (*d*) By the advancement of scientific education in schools, colleges, and universities.
   (*e*) By increasing the equipment, etc., of existing laboratories, and the establishment of new ones.
   (*f*) By the provision of laboratories for carrying out suggested industrial processes on a small commercial scale with the sanction and approval of the Central Council.

5. CO-ORDINATION:
   (*a*) By annual reports from all laboratories.
   (*b*) By bringing all workers in the same branch together.
   (*c*) By the dissemination of information respecting similar work being done elsewhere.
   (*d*) By annual Congresses of all Scientific Societies.
   (*e*) By annual Congresses of manufacturers and trade interests.

If research should show, that new industries can be established in this country with advantage, of which I cannot entertain the slightest doubt, it will be possible by legislation, if necessary, to assist their inception by the establishment of Industrial Banks, which would advance funds for the purpose of financing them in their early stages, provided that the methods to be employed had been sanctioned by a competent authority as mentioned above. In addition to this, protection could be given for a time at least by patent laws, which, if unsuitable, could be amended, but this is a shield upon which too much reliance should not be placed.

What is really necessary is a complete union of every interest concerned, and no link in the chain must be wanting, but it must be clearly recognised that the first necessity, the absolute prime mover of modern industrial progress at the present day is science and scientific research. What science has achieved in the past must be used as a tool to delve into her still unknown secrets, and the country that ignores the call must soon be reckoned amongst the least of the nations.

Much preliminary work will be necessary, before it will be possible to move in the right direction, but this organisation should be undertaken without delay. With the means of communication and the officials employed in every corner of the country, the Government could undertake this work in a manner, that lies outside the reach of any other body, and this could be carried on concurrently with the preliminary arrangements for conducting experiments on its raw materials with a view to the encouragement of local industries. In progressive civilised countries, which are comparable with this in point of age. Governments have deemed it a necessity, and spent large sums in maintaining laboratories of all kinds and publishing information freely for the use of its citizens and the advancement of science. The value of research is happily not unknown here, and we all gladly pay tribute to the great work accomplished by Sir Arnold Theiler and his associates, and at the same time to the Government, which has made it possible. Our desire is for more and yet more, in order that we may supply our fundamental necessities, at least, in some measure. Day by day our natural resources are being exhausted and our stock of raw materials is disappearing. In the meantime but little, if any, attempt is being made to develop industrial activity.

At its base lies the work of the chemist and the physicist, too little known and still less appreciated, even by those of whom some slight knowledge might be expected. The work of the former is still associated with that of the pharmacist, and that of the latter is unknown. The general diffusion of scientific knowledge may bring enlightenment to the people in the course of time, but in those, who desire to develop and control progress, we insist upon the knowledge and capacity that will command success. Some painful examples of this colossal ignorance have made themselves manifest recently, both here and in England, but it will suffice to emphasise that without their assistance true progress is an utter impossibility.

History has shown, that wars in the past have proved a stimulus to industry. There is no valid reason to believe, that the present one will prove an exception to that rule, and hence the urgent necessity for the immediate organisation of all our resources, even were that not desirable on other more fundamental grounds. Co-operation is the key, and science, education, commerce and manufacture must form one organic whole, each contributing its share to the common stock, their united effort for the common weal.

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

President of the Section: I. B. Pole Evans, M.A., B.Sc., F.L.S.

WEDNESDAY, JULY 5.

The President delivered the following address:—

The subject which I have chosen for my address is—

A Sketch of the Rise, Growth, and Development of Mycology in South Africa.

But before doing so, I would first ask to be permitted to pay my personal tribute to the venerable and celebrated botanist of this Province, whose loss we have sustained since this Association last met.

John Medley Wood passed away on August 26th, 1915, while still employed as Director of the Natal Herbarium. Not only did he make a name for himself in connection with the phanerogamic flora of Natal, but as I hope to show to-day, he is almost solely responsible for our present knowledge of the fungi of Natal.

Working for the most part under exceptional difficulties, with little encouragement from either the State or the general public, he is an example to many of us as to what can be accomplished by individual effort and energy. Often had he quite pathetically told me that he hoped that he might never become too infirm to work. The end came as he wished. On the evening prior to his death he had been busy with a description of *Cotyledon orbiculata* for Vol. 7 of his "Natal Plants." He was then in his 88th year. To those of you of this Province who have followed his career and have taken more or less interest in his work, it must be some source of satisfaction to know that the foundations which he has laid are being built on, and a laboratory specially equipped for the investigation of phytopathological problems is already established at the Natal Herbarium, Durban.

South African mycology falls naturally into three periods: The pre-Darwinian period, which embraces collections of fungi made by the early travellers and botanists. This we may regard as the rise of South African mycology.

The post-Darwinian period, in which the labours of MacOwan and Medley Wood added largely to our knowledge of the fungus flora of the country, and which may be looked upon as the growth of the science.

The present epoch, dating from the time (1905) at which mycology was first officially recognised as a distinct branch of research.

It is not generally known that "the father of the science of mycology" came from South Africa. I refer to Persoon. Persoon was born at the Cape of Good Hope in 1755. At this time fungi were practically unknown from this country. Although Persoon left the Cape at an early age, went to Germany, and afterwards settled in Paris, it is rather interesting to find that some of the earliest references to Cape fungi are in his "Synopsis Methodica Fungorum," published in 1801.

Persoon's (**67** and **68**) "Observations Mycologicæ," published in 1795, his "Synopsis Methodica Fungorum," and his "Mycologia Europæa," will ever remain as masterpieces in the annals of mycology. His herbarium is now preserved at Leyden.

The earliest mention of South African fungi are, of course, to such fragmentary specimens as were sporadically collected from time to time by travellers and botanists who visited the country, and who naturally sent back to Europe those unusual forms of growth which attracted most attention.

Amongst the pioneer collectors of South African fungi must be included Thunberg, Zeyher, Burke, Drege, Harvey, Wahlberg, Queinzius, and Boivin.

All these workers were busy before the latter half of the nineteenth century, at a time when mycology was anything but an organised science. In fact, the appearance of Persoon's work mentioned above is generally regarded as the beginning of a new era in mycology.

Just as these early fungi were collected perhaps more as objects of curiosity than as material for systematic research, so we find that the first records refer to isolated and odd specimens.

A few examples will suffice. Thus it is interesting to note that these plants did not escape the attention of Thunberg, "the father of Cape Botany," during his brief stay in the country, for one of the earliest references to Cape fungi relates to *Podaxon carcinomalis* (Linn.) Fr., the fungus so commonly seen on antheaps throughout South Africa just after soaking rains. This plant was first collected by Thunberg and described by Linnæus as *Lycoperdon carcinomale* in 1781.

Persoon (**67**) in 1801 referred the specimen to the genus *Scleroderma*, and named it *S. carcinomale*, while Fries a few years later placed it in the genus *Podaxon*, where it has since remained.

The fungus is usually from about 7 to 12 inches in length, and is remarkable in that the stem is continued right up to the apex of the plant, and forms an axis for the gleba. The peridium is cylindrical; when ripe it dehisces at the base, and an inky mass of spores escapes.

Whether the fungus is actually cultivated by white ants we do not yet know. There are about 18 species of *Podaxon* known, and all are found in the warmer regions of the world.

In 1829 we find Rudolphi (**76**) describing the parasite (*Æcidium resinicolum* *Ru* Wint.), which produces such remarkable galls on Raphnia angulata, and which is so common about Lion's Head at Capetown. A good illustration of this fungus is given in Marloth's "Flora," Vol. I, Plate 3, Fig. B.

Some eleven years later Prof. Gustav Kunze (**47**), in a short note in "Flora," described *Secotium Queinzii*, which was collected by *Queinzius* in sandy places at the Cape in 1839, and shortly afterwards by Zeyher at Uitenhage.

The genus *Secotium* was founded on this specimen. The plant is about 3 to 4 inches in height; the peridium 2 to 3 inches in diameter, while the stem is firm and runs right into the interior of the peridium.

About 20 species are known; the majority come from Australia and New Zealand. Several are found in Africa, North America and Europe.

So much for the early fragments of South African mycology.

The first detailed and systematic account of South African fungi appeared in 1843, entitled "Fungi collected by Zeyher in Uitenhage."

This paper was published by Miles Joseph Berkeley (**1**), the British mycologist, in Hooker's *London Journal of Botany*. The specimens recorded amounted to 31 species, of which 13 were described as new. The majority belonged to the Hymenomycetes, and included such types as could be more readily preserved.

Berkeley, in the introduction to his paper, remarked on the extraordinary paucity of certain genera which even in those days were regarded as cosmopolitan; included amongst these were the Polypori, of which only five were mentioned. One of them, *Polyporus sanguineus* Fr., is of exceptional interest to me, because it is recorded "on decayed stems of *Aloe africana*, Uitenhage." I refer to it here because I have received specimens of this same fungus on a variety of species of aloe from many localities in South Africa, and I have reason to believe that the fungus is truly parasitic upon this host.

Berkeley, even at this time, was regarded an one of the foremost mycologists of the day, and through the influence of Sir William Hooker, had at his disposal most, if not all, of the exotic fungi that passed through Kew.

It is not surprising, therefore, to find Berkeley's name associated with many of the mycological treasures discovered at the Cape by the botanical collectors of his time.

Most of Zeyher's fungi are now preserved in the Herbarium at Kew.

Thus, shortly after this Berkeley (**2**), in the same journal, in a paper entitled "On Two Hymenomycetous Fungi belonging to the Lycoperdaceous Group," described *Polyplocium inquinans*, which was collected on the banks of the Orange River by Burke and Zeyher, and also discussed briefly the fungus *Secotium Queinzii* Kunze, which has already been referred to above.

This fungus *Polyplocium inquinans* deserves a few notes in passing. So far as I am aware, it has never been collected since Zeyher visited the Orange River. The plant is only known from Zeyher's single specimen, which is now preserved at Kew. The plant is about 6 to 7 inches in height. The peridium is volviform, and 4 to 5 inches in diameter. Stem stout and farctate. It is found growing on the ground, and in the words of Berkeley, "fœdissime inquinans."

Several authorities are inclined to think that *Polyplocium* is identical with the closely related genus *Gyrophragmium* Montagne specimens of which are recorded from Northern Africa. This point will probably remain undecided until further specimens are obtained.

In the following year (1844) we again find Berkeley (**3**) describing in Hooker's *London Journal of Botany* South African fungi of exceptional interest, viz.:—

Broomeia congregata, collected in the Albany district of the Cape by Backhouse and *Cantharellus capensis*, one of Harvey's treasures.

Broomeia congregata is only known from South Africa. It has been recorded from South-West Africa, the Cape, and the Transvaal. The plant is nearly always found in close association with *Acacia* trees. Around Pretoria it occurs chiefly under *Acacia horrida*. It reminds one of a cluster of Geasters spring from a common stroma. There are usually from 50 to 100 individuals in the cluster. Before the outer peridium bursts, the plant is of a beautiful smooth white colour, slightly hemispherical, and from 3 to 4 inches in diameter. After the outer peridium breaks away each individual takes on a buff or tawny colour, while the mouth is conspicuous by a dark circular area. The plants emit a strong, though somewhat pleasant, smell of benzaldehyde, and their presence in the bush can frequently be detected from the odour emitted. A second species, *Broomeia ellipsospora* v. Hohn., has recently been described from South Africa.

The year 1843 saw another celebrated mycologist interesting himself in Cape fungi, for Montagne (**63**) published a description of *Homostegia amphimelæna*, which is parasitic on *Colpoon compressum*.

Two years later (1845) another distinguished French mycologist, Joseph Henri Leveille (**48**) in his "Champignons Exotiques," described *Dothiorella congesta* (Lev.) Sacc., which had been collected by Drege on *Podocarpus* at the Cape.

In 1847 a second systematic account of South African fungi was published. This was by the French mycologist, Montagne (**64**), who dealt with the specimens collected by Drege. Montagne records 41 specimens belonging to the genera *Agaricus, Schizophyllum, Polyporus, Trametes, Hexagonia, Favolus, Dædalea, Glæoporus, Cymatoderma, Thelephora, Stereum, Corticium, Exidia, Hypoxylon, Mycenastrum, Bovista, Podaxon,* *Perichaena, Stilbum* and *Ustilago*. Most of Drege's specimens are now preserved in the Herbarium Delessert at Geneva.

Another comprehensive addition to the mycology of the country was made the following year (1848) by Elias Fries (**32**), the Swedish mycologist, who is universally regarded as the greatest mycologist of his time. Fries in 1848 published his "Fungi Natalensis" in Stockholm. These fungi were collected by the Swedish naturalist and hunter, J. A. Wahlberg, in Natal, during 1839-40. Fries described 40 fungi from Natal, included in the genera *Pleurotus, Panus, Schizophyllum, Lenzites, Polyporus, Trametes, Hexagonia, Favolus, Theleporus, Guepinia, Cladoderris, Stereum, Corticeum, Hirneola, Tremella, Geaster, Lycoperdon*, and *Lanopila*.

This paper also recorded five fungi which were collected by Zeyher at Uitenhage. These were sent by Prof. Gustav Kuntze to Fries, and were referred by the latter to the genera *Amanita, Lepiota* and *Mycena*.

This brings us to the close of the first period of South African mycology, and for over 20 years little that was fresh or of any note appeared in literature dealing with this aspect of the flora of the country.

The second period, which we may regard as the growth of the science of mycology in South Africa, coincides very closely with that period which is generally looked upon as the dawn of modern mycology, and is attributed to the extraordinary stimulus in this branch of research, resulting from the publication of De Bary's classical work, "Morphologie und Physiologie der Pilze" in 1866.

Peter MacOwan arrived at the Cape a few years after the publication of Darwin's "Origin of Species," and his fungi from the "Boschberg," near Somerset East, soon became famous and much coveted. One of the first papers dealing with these fungi appeared in 1875 in the German publication, "Flora," by Felix von Thuemen (**87**), a mycologist of considerable repute. Five subsequent papers by the same author, entitled "Fungi Austro-Africani," were published by 1878. These dealt with 127 species collected by MacOwan chiefly in the locality mentioned above.

After a lapse of over 30 years, Miles Joseph Berkeley (**5**) in 1876 again identified himself with two remarkable and essentially South African fungi, viz.: *Kalchbrennera Tuckii* Berk. and *MacOwanites agaricinus* Kalch. These two plants had been sent by MacOwan to Kalchbrenner, the Hungarian mycologist, who in turn had forwarded a figure of *Kalchbrennera* and a section of *MacOwanites*, together with the discoverer's notes to Berkeley.

Kalchbrenner, in the same year, 1876, published an account and description of these two fungi in "Hedwiigia."

Kalchbrennera Tuckii Berk. belongs to the group of fungi commonly known as Phalloids. It is usually found growing in sandy soil, and is from 4 to 6 inches in height. The receptacle is hemispherical, and is divided into 10 to 15 bright scarlet nailshaped processes. Like other members of this group, it has a very offensive smell, and decays very rapidly.

The genus is only known from Africa, and chiefly from the southern portion.

A variety of *K. Tuckii*, var. *clathroides*, P. Henn., was described in 1895 by Hennings from Togoland, while a second variety, which was sent to me by Dr. Schonland and Miss Alice Pegler, has recently been defined by myself as *Kalchbrenna Tuckii* (Kalchbr. and MacOwan) Berk., var. *microcephala*.

MacOwanites agaricinus Kalchbr. is a monotypic genus peculiar to South Africa, and so far as I am aware has not been collected by anyone except MacOwan, whose name it commemorates. It is a small umbrella-shaped plant, about 2 inches high. The hemispherical peridium is from 1 to 2 inches in diameter, and of a dirty brown colour. The plant has a strong odour like that of garlic.

In 1879 Natal fungi again figured in mycological literature. For this John Medley Wood and Mordecai Cubit Cooke were responsible; the former collecting in Natal, the latter publishing and editing cryptogamic literature in England. Both these veterans have only passed away since this Association met last year. Cooke was in his 90th year, while Medley Wood was 88.

The paper, which was entitled "Natal Fungi," contained descriptions of 12 new species and 36 determinations of specimens, which Medley Wood had sent to Kew.

In the following year (1880) Kalchbrenner and Cooke (**45**), in a paper entitled "South African Fungi," described 108 new species from material collected by MacOwan at Somerset East and Medley Wood in Natal; while in the same year Kalchbrenner (**44**) began a series of articles headed "Fungi MacOwani," which dealt with specimens submitted by the two collectors above. The first paper recorded 75 species of Agarics, of which 19 were described as new. In the second paper 64 species of Hymenomycetes were enumerated, of which 14 were new species.

The third paper recorded 75 species, mostly belonging to the genera *Polyporus, Trametes, Merulius, Hydnum, Irpex, Cladoderris, Thelephora, Stereum* and *Corticium*. Eleven new species were described.

The fourth article enumerated 60 species, and included the genera *Cyphella, Stigmatolemma, Guepina, Clavaria Hirneola, Tremella, Exidia, Phallus, Kalchbrennera, Anthurus, MacOwanites, Cyathus, Podaxon, Geaster, Bovista, Lycoperdon, Scleroderma* and *Phellorina*.

The fifth paper recorded 48 species belonging to the *Discomycetes* and *Pyrenomycetes*.

Two years later (1882) Cooke (**16**), under "Exotic Fungi," Natal, published an account of 49 new species, belonging chiefly to the Ascomycetes and Uredineæ, from a collection of about 200 specimens obtained by Medley Wood at Inanda, Natal. Cooke continued to describe odd specimens of Natal fungi during the years 1883 to 1889, the details of which may be found by consulting the bibliography quoted at the end of this address. Two of these fungi, however, deserve mention here, viz., *Schulzeria umkowaani* Cke. and Mass., a delicious mushroom commonly known by the natives as "Umkowaan." This plant is unique amongst the fungi of its class, in that about two-thirds of the long stem is embedded in the ground.

The other fungus, which was first named *Campbellia africana* Cke. and Mass.—a member of the *Polyporaceæ*—is now referred to the genus *Rodwaya* Syd., as the former generic name had already been applied to a phanerogamic plant belonging to the *Scrophulariaceæ*.

Only two species of *Rodwaya* are known at the present time, viz., *R. infundibuliformis*, from Australia, and *R. africana*, from the Botanic Gardens, Durban.

I must not overlook a short but admirable paper which appeared at this time (1883) by George Murray (**66**) on *Broomeia congregata*. Murray accurately described the mode of growth of this interesting fungus, and drew attention to the presence of the outer peridium, which had not been remarked upon by previous mycologists. I have personally been able to verify Murray's observations and conclusions from my own study of living specimens in the neighbourhood of Pretoria.

MacOwan (**54**) at this time (1883) also published a short note on *Broomeia congregata*, in reply to Murray's article. MacOwan confirms Murray's view about the outer peridium, and points out that if Kalchbrenner and himself had been able to carry out their original plan of publishing a full account of the fungi collected by himself at the Cape, there never would have been any doubt about the presence of an outer peridium.

Soon after this (1884) we find a microscopic fungus in Natal attracting not only the attention of the mere botanical collector, but causing panic and ruin amongst a considerable portion of the community. I refer to *Hemileia vastatrix* Berk. and Br., the causal organism of "leaf disease" in coffee, which broke out in Lower Umzimkulu in 1884. In a very short time it had practically destroyed a promising and flourishing industry.

The history of this disease is of interest. It appeared in Ceylon in 1871, and by 1879 had ruined the industry. It was observed in Natal in 1884, in German East Africa in 1894, in British East Africa in 1904.

Hemileia vastatrix is found on the indigenous coffees of Tropical Africa, and it now seems highly probable that the disease from Africa was introduced into Ceylon.

In 1884, George Winter, the German mycologist, published in "Hedwigia" some notes on Rabenhorst's Century XXXI and XXXII of European and extra European fungi, and mentioned those of interest which had been received from MacOwan at the Cape. The new species recorded included *Didymella maculiformis* Wint. on *Protea grandiflora*; *Auerswaldia disciformis*

Wint. on *Myrica* sp., and *Periconia velutina* Wint. on *Brabejum stellatifolium.*

The next year, in a paper "Exotische Pilze II.," Winter (**95**) described 13 new species collected by MacOwan at Somerset East and Table Mountain, Capetown. These belonged to the Ascomycetes and Fungi Imperfecti. The paper also included one new species, *Melampsora puccinioides*, from Medley Wood, Natal.

During the next fifteen years numerous mycologists referred to specimens from South Africa, chiefly in monographs on various genera which were being compiled from the rich collections of material stored in the great herbaria at Kew, Berlin, Paris, and elsewhere. Most of these authors are quoted in the Bibliography appended to this address, and I will not bore you with the individual mycologists and the details of their studies, but will only briefly mention those items of passing interest and more general importance.

P. A. Saccardo (**77**) in 1886 described *Tripospora Cookei* from the Cape. The genus is peculiar to South Africa, and is monotypic. The fungus is parasitic on leaves of *Podocarpus elongatus* and *P. Thunbergii*, and is fairly common wherever the trees occur.

Paul Hennings of Berlin was also an important contributor to our knowledge of South African fungi towards the close of this period. In 1891 he described from the Berlin Botanical Museum specimens which had been collected by Bachman in Pondoland, while in 1895 he communicated the results of his examination of a small collection of fungi which was made by Schlechter in the Transvaal during the years 1893 and 1894. Five new species were recorded. Of special interest amongst this collection is the fungus described as *Sclerotium Paspali* P. Henn., which was collected by Schlechter in Natal. This fungus is now known as *Claviceps paspali* Stevens and Hall, and has suddenly appeared in epidemic form during the past two years throughout South Africa. In fact, I am doubtful whether a single patch of paspalum could be found within the Union that was not infected with this fungus. There is reason to believe that this infected grass is sometimes injurious to stock, and definite feeding experiments have already been carried out by Sir Arnold Theiler, but so far the results obtained have been inconclusive.

Hennings (**36**) in 1898 gave an account of another collection of fungi made by Schlechter during 1896-1898 in the western portion of the Cape, chiefly from the vicinity of Clanwilliam, Van Rhynsdorp, and Piquetberg. Fifteen fungi were recorded, of which nine were described as new species. In this same year Medley Wood (**99**) published a list of Natal fungi. This is the first enumeration of South African fungi that was published in the country. This collection has now been revised by Miss Bottomley, and will be the subject of a paper in this section.

P. Sydow, of Berlin, now began a series of papers on South African fungi. In 1899 he dealt with collections made by Schlechter and Medley Wood. The latter's collection was described under "Fungi Natalenses." Some 41 fungi were determined. Amongst these the new genus *Woodiella* was described, and it was a fitting and happy compliment to the botanist, whose active days for collecting were now past.

Woodiella natalensis Sacc. and Syd., belongs to the *Discomycetes*, and occurs on leaves of *Pavetta obovata*, near Durban.

The Development of Mycology in South Africa.

In the year 1905 the Transvaal Government made special provision for the investigation of plant diseases by the establishment of a post of Mycologist in the Department of Agriculture. To this I had the honour of being appointed.

Up to this time no attempt had been made to study the life-history and development of fungi in the country; they had simply been collected, and in most cases sent to Europe for determination and classification.

Three mycological herbaria were in existence, two of which MacOwan was practically responsible for: one at the Government Herbarium, Capetown, and the other at the Albany Museum, Grahamstown. The majority of specimens in both these herbaria were collected by MacOwan, and the greater portion of them belonged to the Hymenomycetes.

The third herbarium was in Natal, at Durban, and was made by Medley Wood.

The number of fungi recorded from South Africa up to this time (1905) amounted to 765 species.

There was no mycological herbarium in the Transvaal in those days, and with the exception of a few fungi which had been collected by Schlechter on his botanical tours through the country, practically nothing was known of its fungus flora.

In view of our complete ignorance of the life-histories of the fungi on cultivated crops in the country, it was therefore deemed highly important that attention should also be paid to the fungi prevalent on the indigenous plants, and with this end in view a mycological herbarium was begun in Pretoria in connection with the work.

With the advent of Union in 1911 a Division of Plant Pathology and Mycology was established in the Department of Agriculture, for the purpose of investigating and controlling plant diseases throughout the Union.

Largely owing to the loyal co-operation and assistance of my colleagues, Dr. Ethel Doidge, Dr. P. A. van der Bijl, Miss Bottomley, B.A., and Mr. P. J. Pienaar, a Herbarium, consisting of over 4,400 species of South African fungi has been formed. Amongst the many enthusiastic collectors who have also assisted very materially in this work, I must mention Miss Alice Pegler, A.L.S., of Kentani, who has probably made a more exhaustive collection of the flora of her district than has yet been attempted in any other part of South Africa.

A paper dealing with these collections, and entitled "An Enumeration of the Fungi collected at Kentani, in the Cape Province, by Miss Alice Pegler, from 1911-1914, with Descriptions of some New Species," has been prepared by myself and Miss Bottomley, and has now been in the hands of the press for over a year.

Messrs. T. R. and J. M. Sim, both of this city, have also been responsible during the past few years for forwarding us many interesting fungi from Natal.

We have thus accumulated sufficient data not only to enable us to generalise on the fungus flora of South Africa, but in many cases there is now present in the Herbarium at Pretoria adequate material to provide for detailed systematic work.

Dr. Doidge, of whom this city may justly be proud, has already monographed the *Erysiphaceæ* and *Perisporiaceæ*.

Dr. Van der Bijl, who is in charge of the Natal Herbarium and Phyto-Pathological Laboratory, is paying particular attention to the *Polyporaceæ*, a group of fungi, many of which are very destructive to our forest trees and timbers.

Incidentally, I have been working up the *Uredineæ* or rust fungi, which are extremely prevalent and destructive in all classes of vegetation in South Africa. So much for the systematic side of our subject.

We will now turn our attention to the economic aspect of mycology, or that phase of the subject which appeals more directly to the general public, and I shall endeavour to show why mycology deserves recognition as an important branch of research, confining myself to a few South African examples which have directly come under my notice during the past ten years.

The ignorance of the subject and the vague notions that people have about fungi are, I think, due chiefly to the fact that most of them are microscopic, and consequently cannot easily be conceived by those unfamiliar with the life of the unseen world.

Fungi affect our staple crops, especially those upon which our very existence depends. They inhabit and attack the pasturage upon which our stock subsist. They destroy our forest trees and ruin our timber. On the other hand, we know that they prepare the soil for plant growth, and with bacteria play a most important part in the preparation of humus. They undoubtedly control and are often the means of saving the country from ruin and devastation by insect pests. They have important commensal relationships with many of the higher plants, and thus have far-reaching effects upon their distribution.

Whenever the topic of plant diseases comes under discussion, it frequently happens that the grower is inclined to take a very pessimistic view of the situation in South Africa, and imagine that the country is unique in possessing an abnormal share of diseases. When we come to compare South Africa in this respect with other countries, we find that such is not the case. In fact, South Africa at present compares most favourably with any other country in the world whose agricultural resources are of any importance.

As far as I am aware, there is not a single fungus disease of any importance that attacks our crops that is not equally prevalent on similar crops in other parts of the world.

On the other hand, there are present in Europe and America many serious fungus pests that have not yet been detected in this country. I will only mention a few of these:—

Amongst the cereal crops, there is the fungus *Sclerospora graminicola*, a serious pest in millets, etc., and Stewart's bacterial disease of sweet corn is also absent. There are several important sugar-cane diseases, such as root rot, caused by *Marasmius plicatus*, stem-end rot, due to *Gnomonia iliau*, and blight, due to *Peronospora*, which we do not know of in South Africa.

Crown gall of lucerne, due to *Urophlyctis alfalfæ*, and wart disease of potato, caused *Synchytrium endobioticum*, both destructive parasites in Europe, are not yet known here.

The Texas root rot of cotton, caused by *Ozonium omnivorum*, which is prevalent in the United States, has not troubled us in South Africa.

No cases of *Plowrightia mortosa* or *Sclerotinia cinera* (Bon.) Schroet. have been recorded in our stone fruit trees.

Pear blight, due to *Bacillus amylovorus*, which also attacks apple, quince, plum and apricot, is not known in South Africa.

No single species of *Peridermium* or *Gymnosporangium*, both serious pests of the forest and orchard, have ever been detected in South Africa.

Side by side with these fact it should be remembered that the development of the agricultural resources of this country is as yet in its infancy, and year by year a greater variety of crops and a more expanding area are being put under cultivation. This, coupled with the advance of civilisation, involving increased facilities for communication with the different parts of the world, will render our crops more liable to risk of infection.

Furthermore, as soon as intensive cultivation is practised in South Africa, it is only reasonable to expect that some of our endemic fungi will assert themselves.

In all these cases it is clearly in the interests of the nation that it should have at its disposal an Institution where officers are thoroughly acquainted with the fungus flora of the country, who have a competent knowledge of the diseases prevalent in other parts of the world, and who are able to tackle the problems that arise on the spot.

In comparing South Africa in relation to plant diseases with other countries, I have purposely omitted, so far, any mention of the bacterial diseases of plants present here, simply because phyto-bacteriology is becoming a subject of such vast importance that even at present it may be looked upon as a science of its own, as is evident from the large output of literature dealing with this branch of research.

At some future date I hope that this whole question of plant bacteriology may be dealt with by Dr. Doidge, who has already made a special study of the subject, and who will be able to handle it far more skilfully than it would be possible for me to do.

At this meeting Dr. Doidge will bring to your notice two bacterial diseases which, so far as we at present know, seem to be peculiar to South Africa. There is the bacterial spot of citrus, caused by *Bacillus citrimaculans* Doidge, and which appears to be confined to the Cape Province.

There is also the bacterial blight of pear blossom, prevalent in the Cape and other parts of South Africa.

To me it seems more than probable that when the research work that has been done on these diseases is more generally known, these troubles may be recognised in other parts of the world. As an illustration, I might quote a rather important citrus disease which was first detected and described by myself from this Province in 1909, and was referred to as "black rot" of Natal citrus fruit. The causal organism was determined and described as *Diplodia natalensis* Pole Evans. At that time it was unknown in any other part of the world. Since then the same disease has been found in Florida, Cuba, and Porto Rico, where it not only causes a decay of citrus fruit, but produces a gumming of citrus trees, and to which Pomelo are most susceptible. It has also been shown to be the cause of gummosis in peach trees in Florida.

One serious bacterial disease, that due to *Bacillus mangiferæ* Doidge, which causes a rot of the mango fruit, must, however, in the light of our present knowledge, be looked upon as peculiar to South Africa. This parasite has practically ruined one of South Africa's promising fruit industries.

I will now select a few of the more important economic problems in mycology which have received attention during the past ten years.

The Cereal Rusts.

Up to 1905 little was known about the rusts present on cereals in South Africa. For years past crops of wheat, barley, and oats had been ruined by this pest. In fact, in some localities, the cultivation of these crops had been abandoned on account of rust.

This problem is one to which I have devoted some attention, and from observations extending over a period of five years we now know that—

A. Wheat is attacked by two distinct rust fungi:
  1. The Black Rust, *Puccinia graminis* Pers.; and
  2. The Brown Rust, *Puccinia triticina* Eriks.

B. Oats are attacked by—
  1. The Black Rust, *Puccinia graminis* Pers.
  2. The Yellow Rust, *Puccinia Lolii* Nielsen.

C. Rye is affected by two distinct rusts—
  1. The Black Rust, *Puccinia graminis* Pers.
  2. The Brown Rust, *Puccinia dispersa* Eriks.

D. Barley is attacked by—
  1. The Black Rust, *Puccinia Graminis* Pers.

E. Maize is subject to two rusts—
  1. The Brown Rust, *Puccinia maydis* Bereng.
  2. The Red Rust, *Puccinia Sorghi* Schw.

Two very common and widespread rusts, *Puccinia glumarum* and *Puccinia simplex,* the former occurring on wheat, barley, and rye; the latter, on barley, have not, so far as I am aware, been detected yet on these cereals in South Africa. The explanation for this cannot yet be given. It seems hardly possible to believe that if they did occur here they could have escaped observation.

Only the uredo and teleuto forms of *P. graminis, P. triticina, P. Lolii,* and *P. dispersa* are known in South Africa. In Europe the æcidial stage of *P. graminis* is on *Berberis vulgaris;* of *P. Lolii* Nielsen it is on *Rhamnus catharticus.*

In South Africa it does not seem that the æcidial host is necessary or is ever secured in the case of these species. In endeavouring to account for the sudden outbreaks of disease, I am firmly of opinion that over-wintering uredospores cannot be held entirely responsible. The fate and subsequent history of the teleutospores in this country still await elucidation.

In the case of one of the maize rusts (*P. maydis*) we have a more complete picture of events, although one of the spore forms—the spermatia—still remains a mystery. Indeed, *Puccinia maydis* is the only heterœcious rust at present known in South Africa.

I succeeded in 1911 in establishing the fact that æcidiospores from *Oxalis corniculata* readily infected maize and produced the rust *Puccinia maydis;* while teleutospores of *Puccinia maydis,* when sown on *Oxalis corniculata,* brought forth typical æcidia in eight to ten days.

These experiments were repeated for several years with the same result, except that during the season 1913 inoculated plants of *Oxalis* produced practically nothing else but spermagonia with their attendant spermatia. This remarkable phenomenon would, I think, more than repay following up, and would perhaps furnish a clue as to the exact nature and purpose of these most puzzling bodies.

The case of *Puccinia Sorghi* is even more interesting, partly because its complete life-cycle is still unknown, and partly because of its rather remarkable distribution. So far as I am aware, it seems to be confined to Natal. This naturally suggests an association with a local æcidial host, and opens up another interesting field for research.

The result of all this work has brought out clearly the fact that the more and the longer susceptible varieties are grown, the more susceptible do they become to rust attack. As far as one is able to judge, it seems that the host plant under South African conditions becomes less and less able to withstand the attacks of the parasite, and the problem is one that is now engaging the attention of the plant-breeder.

The matter of breeding wheat, barley, and oats for rust-resistance, milling qualities and so on, is now in the hands of Mr. J. H. Neethling, Botanist at the Elsenberg School of Agriculture, and from what I have seen of the work in hand I am confident that, if he is given the necessary support and assistance, Mr. Neethling will accomplish for South Africa what men like Biffen, Howard, Farrar, and Carleton have done for Britain, India, Australia, and the United States.

Locust Fungus.

As an illustration of the importance of studying the life-history and development of the fungi with which we are concerned, I cannot do better than quote the now historical case of the locust fungus.

Soon after my arrival in the country in 1905, amongst other things which I was asked to do was that of preparing supplies of locust fungus for distribution. In fact, large stocks of material for the cultivation of the fungus were already on hand. Fortunately, I know nothing about the fungus or its previous history, and it seemed advisable to learn what information I could about it first-hand before we embarked on an elaborate and extensive production of fungus.

Locust swarms were plentiful at this time, and not only were they the means of bringing the subject of "locust fungus" again prominently in the public mind, but they also afforded a unique opportunity of investigating it rather thoroughly.

Without going into details, I may say that locust fungus had been cultivated for years in Cape Colony and Natal, and distributed amongst the farmers as the causal organism of locust disease. Apparently no steps whatever were taken to follow up the life-history of the fungus or prove satisfactorily that the cultivated article was identical with that causing locust disease.

We now know that the locusts died from attacks of the fungus *Empusa Grylli* Fres., which is widely distributed throughout South Africa, and when suitable climatic conditions prevail is responsible for destroying large numbers of various members of the locust and grasshopper family. This fungus has not yet been successfully grown in artificial media, but requires living tissue for its growth and development. The original cultivators of the "locust fungus," instead of producing *Empusa Grylli*, the casual organism of locust disease, cultivated a species of *Mucor*, under the impression that it was the responsible parasite. In short, as they were only amateurs in the field of mycology, they failed to discriminate the *Empusa* growth from that of *Mucor*. My experiments with these *Mucor* cultures left no shadow of doubt as to their innocuous nature in so far as locusts were concerned, and this conclusion has been fully borne out by other investigators in those countries to whom "locust fungus" tubes were sent.

The "dry-rot" disease, or mildew of maize, a trouble that is particularly prevalent in Natal, has received considerable attention from Dr. Van der Bijl. The investigation was undertaken for two reasons. In the first place, the disease causes a serious loss in the crop, and secondly, farmers complained of heavy mortality amongst stock fed on such mouldy cobs. In nearly all cases symptoms of intoxication and paralysis were described. While the conclusions arrived at by Dr. Van der Bijl (**91**) are such that the fungus cannot be regarded as poisonous to stock, they open up and invite further inquiry as to the cause of such mortality in these areas.* Indeed, the whole subject of fungus-infected grass and fodder, and its effect upon stock, is one that would more than repay thorough investigation. Over and over again cases have been brought to my notice in which animals have died after having fed on certain fodder and forage, which on examination was found to be infected with various fungi.

Feeding tests subsequently made on such infected food have invariably led to negative results. It, however seems fairly clear that there must be something in these mysterious cases of poisoning that we have not been able to fathom.

The numerous fungus pests of the potato, tomato, and citrus crops, have been very carefully worked out by Dr. Doidge, and a whole series of valuable and popular articles has been published which has done much to stimulate public interest in these matters.

In conclusion, I must refer to the prominence that mycology and phyto-pathology is now taking in the curriculum of studies at the Schools of Agriculture and in the syllabus of the Cape of Good Hope University, in comparison to what it did a few years ago.

I must also remind you of the recent establishment and equipment of a second phyto-pathological laboratory in the Union viz., at Durban, for the special investigation of mycological problems connected with tropical and sub-tropical crops.

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* Since this address was delivered, I have been informed by the Director of Veterinary Research that paralysis has been produced in stock fed recently on mouldy cobs at the Veterinary Research Laboratory at Pietermaritzburg.—I. B. P. E.

These factors alone must convince you that the State is alive to the importance of the subject, that the development of mycology has grown apace, and is tending slowly but surely towards the advancement of Science.

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88. (1875) Mycotheca universalis Cent. Bayreuth. 1-3.
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90. (1847) Memoire sur les Ustilagines.—*Ann. sc. nat.* 3 *ser.* 7, 12.

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91. (1916) A Study on the "Dry-rot" disease of Maize.—Dept. of Agric., Union of S. Africa. *Science Bull.*, No. 7, pp. 1-60.

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92. (1884) Repertorium Rabenhorstii Fungi europæi et extra-europæi Cent. XXXI-XXXII.—*Hedwigia* 23, 164.
93. (1884) Exotische Pilze.—*Flora* 68, 259.
94. (1884) Uber die Gattung Corylia.—*Ber. Deutsch. Bot. Ges.* 2, 120.
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96. (1885) Rabenhorstii Fungi europæi et extraeuropæi Cent. XXXIII. and XXXIV.—*Hedwigia*, 24, 255.
97. (1887) Ditto. Cent. XXXV and XXXVI.— *Hedwigia*. 26, 26.

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98. (1884) Hemileia vestatrix.—Report Natal Bot. Gardens, p. 7.
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100. (1903) Coffee leaf disease.—*Agric. Journ. and Mining Record Natal*, 6, 30.

RESEARCH GRANTS.—The Royal Society of South Africa announces that the sum of £50 has been awarded to Mr. J. S. v. d. Lingen, Capetown, for continuation of work on X Rays and Radiology generally.

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

President of the Section: Maurice S. Evans, C.M.G., F.Z.S.

THURSDAY, JULY 6.

The President delivered the following address:—

A Survey of the Past and Present Relations of the European and Bantu Races in Natal and Surrounding Territories.

Had time permitted, I would have liked to make this short review of the relations of the two principal races which inhabit South Africa one which would have also embraced the other races of the sub-continent.

For we must remember that we have, in addition to the outstanding racial question, which I briefly discuss, three other sub-problems, each one of which would be sufficiently important in any country less problem-ridden than South Africa. There is the question of Dutch and English, which absorbs far too much time and attention both in the country and Parliament; the Asiatic question, which, fortunately, is now limited to those already in the country; and the coloured question. In Natal this last is of comparatively small moment, but I have been travelling lately in the West and North-West portions of the Cape Province, and I find that it is there a very serious matter indeed. I earnestly wish that someone competent would study the life conditions and prospects of these coloured people, for it is a question only second in importance to that of Black and White, with which I now deal.

In my title I speak of the past of the Bantu and European peoples, but I want to limit my reference to the past to some 40 or 45 years ago, when I first landed in Natal. From the first I was charmed with the country, and took the greatest interest in all phases of life it presented, and, perhaps, as something specially new and strange, particularly in the life, manners, and customs of the Bantu people. With men who knew the people intimately I went into the native reserves of Natal, staying at trading posts, mission stations, and at the kraals of the natives. Not long afterwards I had opportunities to visit Zululand, Basutoland, Griqualand East, and some of the more remote parts of the Transvaal. Everywhere I observed the life of the people, and my memory still pictures the scenes visited and the people I met, and from memory and notes then made I think I can reconstruct a fairly accurate picture of the social conditions of that time in the area of which I speak.

The native reserves of Natal were in number and extent what they are now, and the native people lived on these reserves and also on the farms of Europeans. But also, scattered throughout the Colony at that time, were large areas of Crown lands, unfenced and in a state of Nature, and the natives were at liberty to squat wherever they pleased on these Crown lands, paying no rent—wood, water, grazing, and tillage, all free. The native reserves proper were not crowded, there was plenty of virgin soil of fair quality, and in good seasons the crops raised exceeded the food requirements of the people. In the Umlazi Reserve, for instance, there were several stores kept by Europeans, who traded annually thousands of bags of mealies from the natives. On the farms little fencing had been done: one could ride straight across country to a distant peak without being stopped by barbed wire or gates. The crops of the white farmer were limited to small areas near the homestead, and his livestock was of the same class as that of his native tenants, and often they grazed together. The native tenant was at liberty to make his garden wherever he chose, and as one plot became exhausted, could pick another from a huge unoccupied area. The rents charged by the farmer were low, and could easily be met by the tenants from the sale of some fowls or goats, or at most an ox or two. The labour demanded by the farmer on the farm was not excessive, and with the exception of herding was mostly seasonal, and left the tenants much leisure and liberty. At this time there was not a yard of railway running into the interior of South-East Africa, but there was a very considerable trade between Durban, Maritzburg, and the Overberg territories, and most of the farmers were transport riders, this activity being the principal source of income to many. The drivers and leaders of the farmer-transport-rider were taken from his native tenantry, and as the wages for a capable driver were even then fairly high, this was a source of considerable profit to the native tenants. The condition of the natives living on Crown lands was much like that of those in the reserves. As stated before, they paid no rent, but were at liberty to live where they liked, and do much as they liked. Travelling over the Crown lands or in the reserves, one was struck by the neat appearance of the kraals. The huts were well built in the traditional Zulu style, the thatch closely bound down, often having well-made mats to screen the doorway, the cattle kraal fence or wall was secure and unbroken, and everything about the place tidy and well kept. At every kraal one expected to find, and actually did find, herds of sleek fat cattle, free from ticks or disease, and milk and amasi were in abundance. The gardens then, as now, were cultivated in slovenly fashion, the use of the plough was beginning to be understood, but most of the land was still hoed by the women. Bad seasons happened as they do now, but new and virgin fields yielded better crops under untoward conditions than the exhausted fields of the present, and shortage in grain could always be supplemented by animal food products. As I said, the plough was beginning to take the place of the pick, and blankets were in general use, but at home the native did not wear clothing. The old men would sit in the sun with their blankets wrapped round them; the young men wore little but the mutya, and the clothing of the girls consisted almost entirely of beads. An imported fabric of muslin-like texture, called in the trade "tonga salempore," was beginning to be worn in graceful folds weighted with rows of beads, but I distinctly remember walking one hot day from the Inanda, *via* Verulam, to Durban, and in this long distance noted that I did not meet any girls wearing anything beyond the beads. The costume of the children was then, as it is to-day, what Adam and Eve wore before the Fall.

In addition to the native labour required by the white man on the farms and roads, there was a demand in the towns. It was a general complaint that the native was so well off at his kraal that he did not turn out to satisfy even the limited demand, and this was certainly the case at times, and it led to the first importation of Indian coolies in the sixties. But things went easily in those days; there was no rush to get rich quickly, and generally speaking the native turned up a little late, and the white man grumbled but was satisfied.

The natives still strongly adhered to their tribal system and ancient customs. So long as the native turned out to work in what he considered reasonable numbers in reasonable time, the white man did not bother with what went on in the reserves, and there is no doubt but that witchcraft and smelling-out still continued, and in some cases there was still an attempt at a military system. The native conserved the old social customs and lived generally much as he did before the white man came.

In Zululand, Basutoland, Pondoland, and Swaziland, the natives still had their paramount chiefs and were independent. A few missionaries and traders lived in these countries, but I remember when a trading trip to Swaziland took months, and was regarded as an adventure only to be entered upon with fasting and prayer. Outwardly the life of these independent peoples was that of their fathers, but the subtle pressure of the white man had effected two great changes. No longer was war between the tribes possible, and the loss of life due to this cause had stopped, and with it the internal killings, which had to a certain extent kept down the numbers of the people before the white man came.

Taking a wide survey of the Bantu people at this time, it may be said that the influence of the white man had been in their favour. The few articles of European make he had introduced, the plough and the blanket, had made for additional comfort and security, the introduction of the wagon and the use of the ox for draft purposes, had lessened the danger of famine. Native customs, sanctions, and controls still kept the people moral and healthy, and the prevention of war and killing customs had reduced the death-rate. It was an idyllic time for the Bantu: they had got such advantages of civilisation as suited their condition, and as yet the drawbacks had not appeared. It was a common saying among the whites that the natives were the happiest people upon earth, and when one saw the neat brown kraals in such beautiful surroundings, the contented old men sitting in the sun, the splendidly-framed young men and maidens going to dance and festivity, the happy round children, one felt inclined to endorse it.

I should say, though, that even then there was one dark spot in race relations. Nearly every small store in the country sold rum to the natives, and this illicit traffic was the cause of local drunkenness and crime.

I need not say much of the white man of those days. There was plenty of land and plenty of food for all. Overberg the vast herds of game still provided a living for the class of white man who had never been trained to work, and when the game was thinned, transport riding was still possible. Although these callings did not demand strenuous continuous work, they did call for periods of exertion and for special aptitudes, and there was no reason why those following them should degenerate. While hunting and kurveying remained possible the poor white was not a problem. He came later.

And so things remained on the whole till 1886.

It is true that during this time the Zulu power was broken, but the life conditions of the people under the separate chiefs remained much the same as before in that country. In the districts settled by whites, better cattle, sheep, and horses were gradually introduced, fencing and cultivation were extended, but there was still plenty of room for the natives to live their old life on the farms. The locations were gradually filling up, and the Crown lands were surveyed and taken up by whites, but still on the whole the position was not materially altered.

In 1886 came the great discovery which was to alter the whole social and economic position in South Africa for both white and black. This is now 30 years ago, and to-day we are in a position to judge of the difference. The life of the ordinary native has been changed, both directly and indirectly by this event. The farms on which, up till this time, he could live his ancestral life, are no longer natural spaces undefined and unaltered by man's action. Fences extend all over the country, open grass land has been covered with plantations, the white man's crops run continuously for miles, the livestock, which used to graze with that of the native, must be kept apart and carefully guarded from contamination, and the cattle of the native, if he has any, must be fenced off in the most sterile portion of the farm. The rent demanded by the landowner has increased enormously; and instead of simply asking from his tenant a few weeks' work in the year, the native is now bound by contract to work continuously for months or years, and if he wants to earn higher wages at a distance, must get permission to do so. The population of the reserves has increased, and although to the eye of the European there is still plenty of room for the people, the native considers he is overcrowded. And so he is with his present methods of cultivation, which, on the whole, have not improved in the past 40 years. He still tills the same garden until it refuses to respond, and then looks for a fresh piece, and still scratches the surface, giving nothing back to the exhausted earth. Lately I went through the Umlaas Reserve, and in my mind's eye contrasted it with what I had seen 40 years before. The kraals were now without plan and untidy, the herds of sleek cattle had gone, and in their place were a few rusty goats. The people were clothed, but mainly in dirty rags. The gardens were full of weeds, and many abandoned plots could be seen. I was told that the women no longer worked in the fields and took a pride in their crops; they expected the men to find money to buy the food they used to grow. The men worked in Durban, and came home at intervals, many returning each week-end, and their wages were largely spent on food. With but little to do in the shape of home duties, this left the women idle, and idleness had begotten the usual crop. This was in a reserve which in the old times grew a considerable surplus of food. It is a picture that is more or less typical of many of the reserves, and to my mind the contrast is a sad one. The Crown lands referred to before have now all been taken up by Europeans, and if the native remains he remains as the tenant of the white man on terms imposed by him. A native headman residing on these lands, on which his fathers had lived before him, generally got his first notice of the change of ownership from the European who had purchased them. His love for his kraal site often prompted him to remain, and his status was thus transformed from that of an independent herdsman and cultivator, to that of tenant and farm labourer.

Contemporaneously, however, with these restrictions on the land came the great opportunity of earning afforded by the Witwatersrand discovery. I need not dwell on this. We know that there are about 300,000 natives continuously working on this area in mine, store, household, and many miscellaneous callings, and earning on an average, say, 60s. a month. This it is which has saved the economic situation for the native, and this enormous amount of money circulating through them, and diverted in large part into the pockets of the Europeans, has been of tremendous economic advantage to the whites also. With the economic benefit to the native there have come other advantages. On the mines he has been taught to work, to be punctual, and also learned to understand certain skilled processes; and when he has served in good European homes, he has learned other virtues, and seen what home life at its best may be. But there is another side. He has learned that the white man will descend to the lowest depths for money; he has seen him gratify his animal passions in bestial fashion; he has been used as a pawn in thieving and breaking the law in any way in which gain could be got. The balance, on the whole, seems on the side of evil. And while he is learning good and evil, he is leaving behind him all the salutary influences that controlled his fathers and kept them from acting contrary to the laws which the wisdom of their ancestors placed upon them.

Since the great Witwatersrand discovery and all that followed it came to break up the old native life, two disasters swept the country which had a more immediate influence upon the Bantu. These were the two waves of cattle disease—first the rinderpest, and then the East Coast fever. The economics of this last-named visitation have been investigated and recorded in our transactions by the Rev. J. R. L. Kingon, and I would refer my hearers to his account of the changes this disaster effected in the life of the people.* Remember that before the time the cattle were swept away, the land on which the natives could graze was becoming more and more restricted, particularly on the farms, and the native had been finding greater and greater difficulty in obtaining sufficient land for them and their increase. When the visitation came, the farmer, who had been feeling the cattle of the native a restraint on his opportunities, took advantage of the position to further curtail grazing rights. The native regarded his cattle as his bank, and with his bank broken and no opportunity of getting another bank site, it is no wonder that he feels he might as well spend his earnings as he has nothing in which to invest them. I am told by those living on farms and among the natives in the country that this is the position to-day, and that the money earned by work is often spent in worthless trash. Unfortunately this is a tendency that is likely to grow with indulgence. It may be seen in actual operation; the man who heretofore would have saved and gradually gathered together a herd of cattle, now first spends what he earns, and then borrows for further spending, until the occasional practice becomes a habit. I do not think it is an exaggeration to say that the events of the last two or three decades have transformed an economically free people, with quite considerable assets, into a community of debtors.

This question of the indebtedness of the natives is a very serious one. Go where one will, coast or uplands, Natal proper or Zululand, and it will be found that the natives working on farm and plantation are no longer free men. The employer will tell you that what was an occasional practice has now become an universal custom, and that it impossible to get labour unless a cash advance is made. Sometimes this advance is to buy something required by the native, but often simply to transfer his indebtedness. This will vary in amount, but often it is very large in proportion to the wages he will receive; and the borrower may mort-

* Rept. S.A. Assoc. for Advancement of Science, Pretoria, 1915, 213-226.

gage his future for years, and under the contract agree to accept a very much lower wage than he could obtain elsewhere. Naturally under such conditions as time goes on the worker loses heart, and by and by spends his thought and energy in devising how he can best evade his obligations, or at best only doing his work in a half-hearted way. I know farmers who say that half their time is taken up in negotiating with natives in regard to terms of tenancy and loans. The native will promise anything when he wants money, but when he has to work it out at a rate of wages far lower than he could get if he was free to move, it is not surprising that he becomes a confirmed shirker.

Could any labour conditions be less likely to lead to satisfactory economic results? The wonder is that relations are not more strained than they are, but they are bad enough, and the tension on this account is probably increasing.

During this time there has been a great increase in the number of natives who can be called "educated." I have spoken of the education they have been unconsciously receiving by their contact with white men, by learning to work, by the influence upon them of the aspects of civilisation, good and bad, they saw at the centres to which they went. In addition to this there has been a great demand for conventional education; reading and writing, and what follows them in the school curriculum. In church and school, in kraals and in kitchens, they have met together and laboriously pored over the written word. They have gone further, and have been encouraged by the missionaries and indirectly by Government to soar higher, and many have passed the higher examinations which have proved a stumbling block to some white students. I have spoken of the general education they get by work. Another word must be said here. By actually doing the manual work in mine and workshop, by watching and helping the white man at the skilled work, they have learned as much about the technique as those employing them, and if allowed to do so, could with a little training actually supplant the skilled man.

Here the colour bar is drawn, and the skilled white man is protected by law from the competition of the man who would be able and willing to do his work at one quarter his wage. I feel certain that if the present legal protection was removed and public opinion could be ignored or defied, the organisers and executive of the great gold mining industry could find black men who could fill the places of the majority of the white men in the mines at vastly lower wages. Whether this will at any time be tried or not I cannot say, but the position as it stands is an artificial and strained one. On the one side a sufficient capacity to do the work at this lower cost, which naturally appeals to the management, and on the other hand protection to those who may be doing the work in a somewhat better and safer way, but who demand and receive a remuneration so much higher than what the work could be done for in an open labour market.

This education of head and hand and character, carrying with it a new outlook on life and sweeping away the old controls and restraints is being carried from the centres of industry to the remotest kraals in South Africa.

The old controls and restraints mentioned had been evolved by the people themselves, and were understood and obeyed by them. The education they are now receiving, using the term in its broadest sense, does not necessarily carry with it any guide to conduct nor impose any restraints on misconduct. The only influences which can be said to take the place of the old controls are the teaching and examples of the missionaries, and these do not affect a large proportion of those who are to-day feeling the stir of the new conditions. Of great value this missionary teaching undoubtedly is to many, as inculcating a high standard of morals, and providing a guide to life. In old times when the converts remained in their homes close to the mission station many examples could be shown of men and women who consistently followed the teaching they had accepted. To-day while still young, the mission native leaves his home and all these salutary influences, and goes into the midst of temptation, and it is little wonder that he so often falls a victim and becomes a byeword and a scoffing.

With education comes unrest, the old life no longer satisfies, a discontent, divine or otherwise, takes the place of the old satisfaction with things as they are. Then when knowledge increases and capacity grows there comes a hunger to satisfy this by adequate effort and to take a higher position and play a more important part in the world and reap its higher rewards. When a whole race is being roused to such ambitions and yet denied a proper field in which to find scope for increasing knowledge and capacity, the position is a dangerous one for the State.

I cannot call to mind any people having had to face such a tremendous change of life and outlook in such a short period. The great gold discovery of the Witwatersrand has also had its effects on the white man. Wealth among the white population of South Africa has increased enormously during the last 30 years. The gold production has revolutionised the manner of life for thousands, and the standard of living has risen greatly all over the country during that time. It has come gradually, and we have become accustomed to the change, but let anyone who knew the life of town and country in the early eighties compare the mode of living of people then and now, and he must be struck with the difference. Every large town in South Africa shows in dwellings, food, clothing, entertainments, luxuries and pleasures of all kinds a far greater expenditure than was current before the gold period. I have been travelling over a large part of the Union during the past eighteen months, and have been struck by the evidence of wealth everywhere, even in many country districts ordinarily considered backwards. The South African citizen, whether artisan, commercial, or professional man, or one deriving his income from the soil, has a much higher standard of living than of old. But this is not the whole story. Concurrently with this there has been a falling back. A section of the community, originally farmers, have been unable to keep pace with the changing times and have deteriorated. Accustomed to regard manual labour as Kaffir's work, and untrained to any skilled calling, they gradually lost their place in the community. For a time the hunting of game and then transport riding gave them employment, but these failed, and they have gradually drifted to the towns. Here again they had no satisfactory place, but the peculiar social conditions of South Africa enabled them to make a living in ways that are full of danger to the community. Along the Witwatersrand they are the illicit liquor selleers, and worse, on the Basuto border they engage in unlawful traffic, and in many dorps they subsist by exploiting the native in many ways. Their presence in due both directly and indirectly to the fact that they have been able to escape work, and the penalties due to not working, by living upon the native, to the demoralisation and deterioration of both white and black.

Forty years ago the whole of the manual labour of the country was done by natives. At that time there were those who thought they saw reason to hope that in time the white man might take the place of the native labourer. The four decades have not brought this any nearer. Excepting for certain doubtful experiments of the nature of relief work, all the manual labour is still the prerogative of the black man, and in this field the white man shows no inclination to challenge his supremacy. This monopoly carries with it certain advantages of discipline and training which in other countries fit those who go through this apprenticeship for the higher posts. We see one effect of this condition in the class of poor whites, what effect it may ultimately have on the rest of the community we have yet to learn.

I would now like to summarise the position of the races to-day as compared with what it was 45 years ago.

1. The independent native States have been broken up, or are, as in the case of Basutoland and Swaziland, under the government of the white man.
2. The wars and customs which kept down the native population are no longer possible, and the people are increasing steadily in numbers.
3. Cultivation of the land is still backward, the lands are being worked out, and more and more the natives are dependent on wages earned.
4. Reserves are overcrowded according to native ideas, and further production is curtailed for reasons already given.
5. On farms the natives are being more and more restricted, and from being peasant farmers and pastoralists, are becoming day labourers.

6. The hoarding of other days for the purchase of cattle is being superseded by extravagance, and indebtedness is universal.
7. Education, including higher education and some industrial efficiency, is increasing rapidly.
8. Concurrently with the education in good, there is an education in evil going on, and morals and manners are deteriorating.
9. The sanctions and controls of ancient days are losing their force, and excepting in the case of those under the guidance of the missionaries, nothing is taking the place of these salutary restraints.
10. The immense increase of wealth in South Africa, due to the discovery of the Witwatersrand gold field, has mainly been secured by the white man. The wages of the native have risen considerably, but his wants have increased, the demands upon him are heavier, and with the loss of his cattle he is poorer than before.
11. Both by law and custom the efficient native is prevented from rising and obtaining the remuneration he could otherwise earn.
12. In large part due to the presence of the native a considerable number of the whites have deteriorated and are now living on the exploitation of the native and pandering to his passions.

This summary, and I do not think it exaggerated, surely shows the tremendous change that has and is still taking place with accelerated speed, and the profound influence the changed circumstances are having on South African society. The outlook for the native people is one demanding the most careful attention, and there are points of contact between the races which show signs of strain which should be seriously considered and kept in view by people and Government if some sudden racial movement is not to take the country by surprise and lead to tragic happenings.

Under representative institutions the needs and desires of the electors have first call upon Government attention, and neither Parliament nor the Executive may take up questions, however important, which have no present interest for the constituencies. It is of little use to expect Parliament as Parliament, or Government as Government, to take thought on this question, however much individual members of Parliament or Government may recognise its paramount importance, and however much they may individually desire to do so. We must also recognise that a body such as Parliament is, by its very constitution, unfitted for the calm, impartial, scientific study which is necessary to enable us to arrive at sound conclusions on such an extraordinarily complex social problem as the one before us.

To a certain extent, apart from, and certainly in addition to, our other racial problems we have to face this one of Black and White. What our aim should be may be stated in terms I have used in other writings.

I have put it as a statement:

To so act in our relations with the natives, and so guide them that they may have all reasonable opportunity for developing their race life along the best lines, taking account of their physical, mental, and moral improvement; not necessarily following the line of evolution of the white man, but the one their race genius suggests. And that we, while so acting, shall also have an opportunity of development, and be not subject as a race to deteriorating tendencies which may be present in our race environment.

I also put it as a question:

Is it possible for a white race whose race aspiration is the utmost economic development of the country in which they live, and every effective member of which is filled with a desire to acquire and advance, to live with a black one, to whom the aspirations and efforts of the white do not appeal, and yet so adjust the life of each that both shall be content with the position, and the black have all reasonable opportunities for such development as is possible to him?

Further thought and experience have not enabled me to put the problem more clearly.

I do not propose to attempt to place before you at this time any suggestions for a "solution" of the complicated and changing social phenomena of which I have given an outline. Probably there is no "solution" as the term is ordinarily used, and I must be careful not to cross the border line into politics. I am speaking to the members of an Association for the Advancement of Science, whose object is the increase of natural knowledge, whose field of investigation is that of all natural phenomena, and whose methods are scientific. And by scientific, I understand that on any given subject, including the grouping of humanity in societies, they first carefully collect all the data bearing upon it, and then endeavour to find the laws governing the phenomena they are studying.

By the increase of knowledge and by its application to the needs of humanity it is hoped to increase the welfare of mankind.

This brings our subject well within the purview of this Association; it is a question which calls for scientific treatment; for investigation, for careful generalisation, for application to welfare of mankind.

What are we who from our environment have such a deep interest in this problem, and who from an intellectual standpoint should find a fascination in it, doing to study it in a scientific spirit? I am afraid it must be said that apparently we do not realise its importance.

For we want as a preliminary and basis not general views on the "Native Question," such as we see in the Press, but accurate investigation into special phases of the history and life of the people, and into the relations and interactions of the races in the many different conditions of our civilisation in which they come into contact. From time to time monographs do appear in our Proceedings, and most valuable many of these are, but more are wanted, especially *on the economic side*, and certainly more co-ordination among those who are undertaking these studies. In addition to private study, and the encouragement of associations, it may be suggested that special courses be prepared suitable for schools, such as the history and folklore of native tribes, and instruction in the proper treatment of natives. Also that much more attention be given to Ethnology and comparative Sociology, with special reference to South Africa, by examining bodies and the Universities.

We must remember also that however much individuals or associations may study the subject, the practical application of the knowledge gained under our system of Government lies in the hands of the electors, and unless the knowledge obtained by specialists can be made available to these our rulers, unless they are persuaded that action thereon is, in the national interest, study will end as study, and be of little practical value.

The first step then is to study the whole question of race relations in a scientific spirit.

The next is to convey to the public the broad results which have been attained by that study, and the third (which may be regarded as contemporaneous with the second), is to collect and co-ordinate all the knowledge acquired in such a form that it is possible to frame a policy thereon, and place it before Parliament and Government in such a manner that attention must be given to it.

Here I trench upon politics, but before I conclude, I must repeat what I have often said, and again advocate a course which is to my mind a step with possibilities for much good.

There should be established by law a Council of Europeans, whose duty and status should be clearly defined by statute. This duty should be to study the whole question of race relations and interactions. They would collect and co-ordinate the mass of loose information now in the Union, would keep in touch with the points at which the races came into contact, and note the effects thereof, and advise Government with regard to possible legislation and improvements in administration. An authority would thus be established to which Parliament and Government could look for accurate information. Also under legal sanction this authority should have the power to direct the attention of Government to dangers ahead and suggest remedies therefor with a force which must command attention. It may then be hoped that legislation and administration will be on scientific lines; on an accurate knowledge of the facts and reasonable and logical deductions from those facts.

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

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

MONDAY, JULY 3.

1. The metric system of weights and measures and the decimalisation of the coinage: R. T. A. INNES, F.R.A.S., F.R.S.E.
2. Daylight saving: R. T. A. INNES, F.R.A.S., F.R.S.E.

TUESDAY, JULY 4.

3. Note on equilateral triangles, inscribed in ellipses, and regular tetrahedra in ellipsoids: Prof. W. N. ROSEVEARE, M.A.
4. A class of alternants with trigonometrical elements: Sir T. MUIR, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E.
5. Fire-resisting building construction: W. J. DELBRIDGE, A.R.I.B.A.
6. The modification of South African rainfall: J. M. SIM.

WEDNESDAY, JULY 5.

7. Trades schools as aids to industry: Prof. J. ORR, B.Sc., M.I.C.E.

FRIDAY, JULY 7.

8. Address by Prof. J. ORR, B.Sc., M.I.C.E., President of the Section.

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

TUESDAY, JULY 4.

1. Address by Prof. J. A. WILKINSON, M.A., F.C.S., President of the Section.
2. A note on the thermal conductivity of the rocks of the Witwatersrand: Prof. R. A. LEHFELDT, B.A., D.Sc.
3. The medicinal springs of South Africa: Prof. M. M. RINDL, Ing.D.
4. The wheat soils of the Alexandria Division, Cape Province: C. F. JURITZ, M.A., D.Sc., F.I.C.

WEDNESDAY JULY 5.

5. Standards and standard methods in the analysis of foods and drugs: J. S. JAMIESON, F.I.C., F.C.S.
6. On a unique occurrence of molybdenum in Natal: A. L. DU TOIT, B.A., D.Sc., F.G.S.
7. Experiments with sugar beet in South Africa: C. F. JURITZ, M.A., D.Sc., F.I.C.
8. Fischer's synthesis of tanning substances and depsides: Prof. J. A. WILKINSON, M.A., F.C.S.

FRIDAY, JULY 7.

9. Examination of the bark and seed oil of *Trichilia emetica*: J. S. JAMIESON, F.I.C., F.C.S.
10. Some factors influencing the solubility of phosphoric oxide in mixed fertilisers containing superphosphates: E. V. FLACK.

Section C.—Bacteriology, Botany, Zoology, Agriculture, Forestry, Physiology, Hygiene, and Sanitary Science.

TUESDAY, JULY 4.

1. Wattle growing: its effect on the wattle insect problem: C. B. Hardenberg, M.A.
2. Note on the occurrence of a pedal nose in the males of trap-door spiders: J. Hewitt, B.A.
3. Forest progress in the Drakensberg: J. S. Henkel.
4. Tree-planting competitions in Natal: J. S. Henkel.
5. The Cedara plantation: J. S. Henkel.
6. Humus, humogen, and its accessory plant-food substances: A. Stead. B.Sc., F.C.S.
7. The farming industry in Natal: Rev. J. Scott.
8. Some observations on the occurrence of bulbillae on the subterranean or aerial organs of plants: Prof. R. Marloth, M.A., Ph.D.
9. Progress of the Natal sugar industry: W. P. Tucker.
10. Note on *Polyporus lucidus* Leyss., and its effect on the wood of the willow: P. A. van der Byl, M.A., D.Sc., F.L.S
11. Note on the feeding habits of a ladybird larva: C. W. Mally, M.Sc., F.E.S., F.L.S.
12. Bird life in the midlands of Natal: J. King.

WEDNESDAY JULY 5.

13. Address by I. B. Pole Evans, M.A., B.Sc., F.L.S., President of the Section.
14. On certain remarkable resemblances between the formation of images and colour-vision in man and certain vertebrate animals: G. Lindsay Johnson, M.A., M.D.
15. An account of the chief types of vegetation in South Africa; with notes on the plant succession: Prof. J. W. Bews, M.A., D.Sc.
16. A preliminary account of some breeding experiments with foxgloves: Prof. E. Warren, D.Sc.
17. A bacterial blight of pear blossom: Miss E. M. Doidge, M.A., D.Sc., F.L.S.
18. The black wattle industry: T. R. Sim, F.R.H.S.
19. A short note on bryophyta of South Africa: T. R. Sim, F.R.H.S.
20. Commercial afforestation in South Africa: T. R. Sim, F.R.H.S.
21. The association of game with tsetse fly disease in domestic animals in Zululand: D. T. Mitchell, M.R.C.V.S.
22. Cotton growing in South Africa: W. H. Scherffius.
23. Game and game protection in Zululand: F. Vaughan Kirby, F.Z.S.
24. Our native birds; their value to man: F. W. Fitzsimons, F.Z.S., F.R.M.S.
25. A bacterial spot of citrus: Miss E. M. Doidge, M.A., D.Sc., F.L.S.
26. Citrus canker: Miss E. M. Doidge, M.A., D.Sc., F.L.S.

FRIDAY, JULY 7.

27. Bilharziasis: or, some risks of river bathing: F. G. Cawston, B.A., M.B., B.C., M.R.C.S., L.R.C.P.
28. Members of the genus *Aloe* in South Africa: I. B. Pole Evans, M.A., B.Sc., F.L.S.
29. An account of the Natal fungi collected by the late J. Medley Wood: Miss A. M. Bottomley, B.A.
30. On the selection and breeding of desirable strains of beneficial insects: C. W. Mally, M.Sc., F.E.S., F.L.S.
31. A convenient type of hydrocyanic acid gas generator for the destruction of the mealy bug, *Pseudococcus capensis*, Brain: C. W. Mally, M.Sc., F.E.S., F.L.S.

32. Finely powdered mercuric chloride ($HgCl_2$) for the destruction of the Argentine ant, *Pseudomyrex humilis* Mayr: C. W. Mally, M.Sc., F.E.S., F.L.S.
33. Note on the eversion of the ptilinum during the emergence of the House fly, *Musca domestica* Linn.: C. W. Mally, M.Sc., F.E.S., F.L.S.
34. The respiratory organs of dragon-fly larvae, S. G. Rich, M.A., B.Sc.,
35. Variations in *Agaratum conyzoides*, Family Compositae: S. G. Rich, M.A., B.Sc.
36. Notes on some of the trees and shrubs of the Melsetter District of Rhodesia: C. F. M. Swynnerton, F.L.S.
37. Note on the occurrence of trapdoor caterpillars at Alicedale: F. Cruden.

Section D.—Anthropology, Ethnology, Education, History, Mental Science, Philology, Political Economy, Sociology, and Statistics.

TUESDAY, JULY 4.

1. Paper money, and the gold exchange standard at the Cape: Prof. R. Leslie, M.A.
2. Some notes on Rhodesian native poisons: Rev. S. S. Dornan, M.A., F.G.S.
3. Some financial features of the Canadian education system: Rev. W. Flint, D.D.
4. Place names of the Tsolo district: Rev. J. R. L. Kingon, M.A., F.L.S.

WEDNESDAY JULY 5.

5. Eulogies (iziBongo) of the Zulu Kings: J. Stuart.
6. Bantu place names in Africa: Rev. W. A. Norton, B.A., B.Litt.
7. More Europeans, and how: J. Kirkman, M.P.C.
8. Vocational training: R. T. A. Innes, F.R.A.S., F.R.S.E.
9. Simplified spelling: R. T. A. Innes, F.R.A.S., F.R.S.E.
10. Africa and skin colour: J. T. Gibson.
11. Insurance against litigation: J. R. Leech, M.D., C.M.

THURSDAY, JULY 6.

12. Address by M. S. Evans, C.M.G., F.Z.S., President of the Section.

FRIDAY, JULY 7.

13. Native Education: Rev. J. R. L. Kingon, M.A., F.L.S.
14. A plea for the scientific investigation of race differences as a basis for social legislation, in connection with the South African races: S. G. Campbell, M.D., C.M.
15. An irrigation settlement: Rev. B. P. J. Marchand, B.A.
16. A preliminary study of the comparative mentality of European and native school pupils; with special reference to the theory of arrested mental development in the Native: C. T. Loram, M.A., LL.B., Ph.D.
17. Rock paintings of the Northern Transvaal: Rev. N. Roberts.
18. A summary of Bantu methods of divination: Rev. N. Roberts.
19. The relation of production to consumption: P. J. du Toit.
20. A Scholastic view of Time: Rev. S. R. Welch, B.A., D.D., Ph.D.
21. The entrenchment of industry: Hon. C. G. Smith.
22. The religion of the Zulu: Rev. A. T. Bryant.
23. An intestinal beetle of the Bantu, as a possible origin of the sacred scarab cult of ancient Egypt: Rev. A. T. Bryant.
24. Native superstition in its relation to crime: Hon. Justice C. G. Jackson.

A

THE RELATION OF PRODUCTION TO CONSUMPTION.

By Pieter Johannes du Toit.

It seems superfluous to say that man eats food before he produces any; in other words, that he is a consumer before he is a producer: that the need to consume renders it necessary to produce. Yet increase of production in relation to agriculture, without regard to consumption, is a favourite theme with many, as if, in the first place, production has no reference to consumption, and, in the second place, *cost* of production does not enter into consideration at all. And when we speak here of consumption, which amounts in practice to demand for the article produced, it matters not whether the consumer is in the country in which the production takes place or in some other country, so long as he is one who demands the particular article. For the purposes of production in South Africa, therefore, both the consumer in the country and the consumer beyond the shores or boundaries thereof come under notice. So that anyone who advocates only increase of production assumes that the demand is there; and not only does he assume such a demand, but he also neglects to give attention to the important question of the *cost* of production.

It is evident that if there is no one who has the need or the wish to consume a certain article, that article will not be or will cease to be produced; and, further, if one person produces what it takes ten to consume, then, if one of the ten also becomes a producer, and both produce more than the one produced before, there must be an over-supply and a fall in price. The same would apply if there were such a disturbance between production and consumption of the same article or articles in a country, or in several countries having the same external market. On the other hand, there may be an under-supply and a consequent rise in prices. In this event production would be very profitable, and the tendency would be towards an adjustment in favour of the consumer by the latter being induced to become a producer.

Taking the illustration already used, although a fall in price may result when, instead of one producing for ten, two produce for nine, it may be that the price realised is yet considered by the two sufficient to encourage them to pursue their course. But, again, it is evident that if the process of substituting production for consumption be extended illimitably, a point will be reached at which production becomes unprofitable. In this case the cost of production will be considered by the producer to be too high in comparison with the price realised. Too high cost of production may also arise from physical disadvantages, from inadequate transport facilities, from want of education or of suitable education, from inadequate security, from isolation, from bad government, and, indeed, a large number of causes. Hence, when advocating increased production, the cost thereof enters as a prime factor.

The relation between production and consumption is scientific—that is, it is based on certain definite principles, among which we need mention, for our purposes, only (*a*) the means to buy, and (*b*) a fair payment for the article bought. Production and consumption are so interwoven in their incidence that any act, by legislation or otherwise, that seriously disturbs the one must inevitably seriously affect the other. Over great length of time a certain adjustment has taken place between the two; there may be flaws and obstacles—distribution to be improved, markets to be regulated, cultural methods to be bettered, transport to be facilitated, co-operation to be organised, and so on—but, broadly, that adjustment has a scientific basis, namely, a certain quantity produced in order to supply at a certain price the same quantity demanded at a certain price. And whatever development or change takes place industrially—whether by production of raw material or by utilisation of raw material, or as the result of immigration, or as the consequence of war—that adjustment commences automatically and immediately. We may be able to improve the condition of the consumer or the producer, or of both, but only enlargement of consuming power, as well as producing power, can bring about constant development and progress; and this can proceed in South Africa along any or all of three avenues, namely, (1) natural increase of population, (2) increase of, or new, demand beyond our borders, and (3) stimulation of the wants of our large native population. Before I proceed to enlarge on these avenues, let me invite attention to our external trade in agricultural products during the last five years. Of the leading articles South Africa exported:—

Article.	Year.	Quantity. Lbs.	Value. £
Wool	1911	132,207,829	3,899,828
	1912	161,974,684	4,780,594
	1913	176,971,865	5,719,288
	1914	133,847,012	4,228,630
	1915	170,003,173	5,380,031
Mohair	1911	21,066,825	917,874
	1912	23,479,729	967,286
	1913	17,355,882	876,255
	1914	18,865,743	834,202
	1915	16,304,378	687,635
Hides	1911	13,211,734	370,548
	1912	20,428,461	670,887
	1913	21,279,840	794,937
	1914	14,773,065	544,050
	1915	15,304,911	575,945

Article.	Year.	Quantity.	Value.
		Lbs.	£
Skins	1911	31,536,507	840,979
	1912	37,241,136	1,020,127
	1913	41,351,091	1,215,547
	1914	38,294,917	1,023,443
	1915	45,547,242	1,099,849
Ostrich Feathers	1911	826,992	2,253,140
	1912	999,704	2,609,638
	1913	1,023,307	2,953,587
	1914	735,325	1,342,717
	1915	948,945	743,772
		Muids.	
Mealies	1911	1,016,443	402,680
	1912	832,742	443,492
	1913	114,723	65,169
	1914	1,100,156	438,455
	1915	1,493,826	631,646
		Packages.	
Fruit, Fresh	1911	234,208	45,487
	1912	296,963	54,668
	1913	232,959	51,858
	1914	475,308	94,245
	1915	240,269	63,967
		Lbs.	
Wattle Bark	1911	111,205,265	289,557
	1912	118,219,023	283,060
	1913	145,717,738	309,328
	1914	130,216,826	286,399
	1915	89,661,464	195,244

Shortage of shipping accommodation accounted for the decrease in the exportation of fresh fruit and of wattle bark. This disability did not apply to the other products; moreover, as regards fruit, the 1915 season was an unfavourable one. The ostrich feather trade, as is well known, is in the throes of depression; while the increase in the skin export trade has to be attributed to a very severe drought.

The best export year was 1913, when the value of these products totalled £11,985,969. The value for 1915 was £9,378,089. It will be seen that, with the exception of maize, the year 1915 was not as successful as an earlier one so far as exports were concerned. Imports of agricultural products, however, exclusive of spirits and fruit (chiefly dried) show a very appreciable decline in 1915 as compared with any year in the preceding four. This decline, at pre-war values, can be put down at the sum of £516,000. The import figures for the five years 1911 to 1915 are as follows:—

Article.	Year.	Quantity. Lbs.	Value. £
Butter and Butter Substitutes	1911	5,948,335	250,244
	1912	6,632,671	318,530
	1913	5,882,522	255,622
	1914	5,692,061	250,213
	1915	4,121,587	187,790
Cheese	1911	4,949,356	143,640
	1912	5,165,715	158,787
	1913	5,586,244	167,440
	1914	5,223,283	157,405
	1915	3,966,269	155,466
Jams and Jellies	1911	2,330,537	41,546
	1912	1,788,457	33,994
	1913	2,213,601	40,824
	1914	1,352,365	26,354
	1915	876,272	18,957
		Muids.	
Wheat and Flour	1911	1,810,315	1,147,386
	1912	1,271,367	895,729
	1913	2,244,224	1,803,127
	1914	1,637,797	1,373,519
	1915	1,252,129	1,444,500
Eggs	1911	15,386,944	57,297
	1912	18,355,299	69,753
	1913	21,263,252	77,560
	1914	——	59,314
	1915	525,351	19,233
Fruit, Fresh and Dried, including Nuts, etc.	1911	——	124,217
	1912	——	150,863
	1913	——	174,418
	1914	——	111,924
	1915	——	122,956
		Lbs.	
Meat, Fresh, Frozen, and Preserved (all kinds)	1911	21,934,828	481,157
	1912	21,319,429	474,134
	1913	21,953,416	532,228
	1914	10,426,638	382,336
	1915	7,407,332	355,176

Article.	Year.	Quantity.	Value.
		Lbs.	£
Milk, Condensed	1911	22,407,913	405,280
	1912	20,948,352	424,447
	1913	22,667,633	464,886
	1914	20,954,884	434,979
	1915	19,262,765	410,435
		Gallons.	
Wine and Spirits	1911	922,634	438,121
	1912	931,883	447,399
	1913	890,272	419,842
	1914	765,544	370,147
	1915	856,642	422,622
		Lbs.	
Sugar	1911	72,964,741	464,941
	1912	38,770,753	257,328
	1913	58,454,849	343,172
	1914	47,033,568	270,192
	1915	16,856,883	115,247
Golden Syrup, Molasses, etc.	1911	12,424,218	118,755
	1912	14,633,362	138,408
	1913	14,458,562	136,736
	1914	6,546,899	65,262
	1915	4,155,426	49,329
Food and Drink—Total	1911	——	6,336,262
	1912	——	6,359,404
	1913	——	7,584,290
	1914	——	5,975,953
	1915	——	6,113,337
Tobacco	1911	1,370,937	188,606
	1912	1,326,280	176,240
	1913	1,514,960	190,005
	1914	1,326,182	166,286
	1915	813,243	109,026

As already pointed out, South Africa exported, in 1915, less of its principal agricultural products than it did in 1913, to the value of £2,607,880. On the other hand, new exports (beef and eggs chiefly) amounted to about £114,000, while there was an increase in the exportation of minor products to the extent of about £200,000. These two amounts, together with the saving in imports of £516,000 already mentioned, have to be deducted from the adverse balance of £2,607,880 on exports of major products, leaving a net balance against 1915 of, say, £1,777,000; and this is nearly equal to the loss (£2,209,815) caused by the slump in the ostrich feather market. Therefore, even if this slump had not occurred, the year 1915 would not have shown much progress as compared with 1913. For the purposes of this comparison the European war may be left out of account. It is true that there were shipping difficulties in the later year, but these very difficulties reduced our imports of agricultural products as well as our exports, while at the same time new exports became possible. My object in presenting these figures is to indicate the slow growth of our farming industries in recent years. I also endeavoured to show, in the paper which I read before this Association last year,* that our greatest advancement in agriculture took place when our internal and external markets were enlarged—that is to say, when demand, and particularly internal demand, increased. As soon as demand extended supply responded.

To revert now to the avenues along which constant progress must be attained: Firstly, natural increase of population. The area cultivated is limited by the number of producers and by the means at their disposal; and the number of producers is limited by the number of consumers and the amount received from the latter for the commodities produced. If the consumers are few, the producers must be few; and if the consumers pay low prices the producers will also be few. So long as distribution is unduly in favour of the consumer, so long will production be impeded; and it is useless calling for greater production so long as the producer considers that he does not receive a fair return for his labour. Also, if the cost of production be high, the producers will be few. If distances from and to the market are great and transport is dear, the cost of production will be high; and it is futile to cry out for settlement on the land if it is more profitable not to settle on it; or against the least gifted taking to farming when the most gifted can obtain better value for his labour elsewhere. We must recognise the need for demand when we talk about supply. We must recognise that this is a land of distances. We must recognise cost of production and all that this implies—education, roads, railways, irrigation, security, and every other act of Government—when we speak of increasing production. Production automatically and naturally increases when the cost thereof decreases or prices for the articles produced rise. The cost can be decreased by various Governmental acts, as I have indicated; and prices rise when demand increases. The cost of agricultural products may be cheapened to the consumer by lessening the cost of production and of distribution; but if it is cheapened to the consumer, without reducing that cost, then it will be at the expense of the producer, and the latter, receiving a smaller profit, will have less to produce with; and conceivably a point may be reached at which he will cease altogether to produce.

For some commodities, however, there is a demand beyond our shores, in addition to the demand within our borders. And

* Rept. S.A. Assn. for Adv. of Sc.: Pretoria (1915), 145-155.

now I come to the second avenue along which constant development may proceed. Probably, because this demand exists, therefore so much attention has been given in this country to—or rather, should I say, so much has been spoken of—increasing production. Demand—that is, markets—should be sought and developed wherever situated. Every new demand met means a new supply produced; and every production is at a profit or it will cease. But encouragement of sale in another country is discouragement of consumption in one's own country; and it is preferable that the necessary consumers be in one's own country—(*a*) because consumers of certain articles are suppliers of other articles, or are otherwise useful in occupations or professions; (*b*) because the cost of distribution between producer and consumer is reduced when the distance between them is lessened; and (*c*) because population enriches and strengthens the State.

The third avenue I have mentioned is our native population, which, at the census-taking of 1911, numbered 4,075,042. To a great extent they are already producers either on their own account or for others. Their educational and social advancement must have, as a concomitant, increase of production by themselves as well as by Europeans to meet the greater demand which must ensue from such advancement. So far, however, as their consumption of agricultural produce is concerned, progress of the native races can only change the demand, but cannot increase it (except in proportion to the increase of native population), since they have already sufficient food. They may consume more meat and less milk, more vegetables and less maize, and follow the Europeans' example of indulging in what are termed luxuries. But their demand for manufactures rises with civilisation, and, therefore, in the industrial development of the country both as consumers and as producers they are a valuable asset. In other words, increasing the natives' wants is equivalent to increasing the population to the extent that their greater demand represents. Thus, if the wants of the native population of 4,075,042 were increased by one-fourth, the increase would be equivalent to the addition of 1,018,760 natives to that number; and if the consumption of three natives were regarded as equal to that of one European, that addition would be equal, for consuming purposes, to an increase of Europeans, engaged on the same labour, of 339,587. Such an addition to our European population would be regarded, economically, as a great gain to the State. Such an increase in the natives' wants would have a similar value, provided that socially, morally, and in other ways the Europeans did not permit themselves to suffer by the advancement of the natives.

I have said that production and consumption bear a scientific relation to one another. This relation is based on self-preservation, but affected in the intermediate stages by a host of political, social, industrial and physical influences labyrinthine in their ramifications. It embodies the whole history of a country, which again includes the distribution of its population and the industries which they have established. So complex is this relation that only its main features appear; so minute and numerous the causes at work, that in the end we seldom see more than the effects. To begin where civilisation in South Africa had its starting-point, the production of wheat is linked up with the ships that called at Table Bay and traded between the Netherlands and the East Indies; of fruit, with seasonal conditions and the discovery of diamonds, and even the ravages of phylloxera in the vineyards; of wine, with the native problem; of lucerne, with the domestication of the ostrich; of inland cultivation, with the Great Trek; of sugar, with the Anglo-Boer War of 1899-1902, that made the last Customs Convention practicable; and so on. And who can form an estimate of the influence which British occupation, the Settlement of 1820, the subjugation of the native tribes, the Great Trek, the Anglo-Boer War, the discovery of diamonds and gold, have had on the production of agricultural products in this country? These events have left on the character of the people permanent, indelible effects; cast the future of the country for a considerable period; dictated the distribution and the industries of the people, and established the present relation between our production and our consumption. These events have created many great problems and, agriculturally, none so great as this: how to bring producer and consumer closer together; how to span the distances which separate this sparse population. A scattered population entails heavy expenditure in administration, high cost of production, and high cost of living. And while we proceed to harness our energies to the unfolding of this problem, let us do so in the light of the influences that have produced it.

DAYLIGHT SAVING.—It has recently been resolved by the Council of the Association: "That in view of the considerable advantages to be gained by a fuller use of daylight, the Association requests the Government to take into consideration the desirability of advancing the time of the Union one hour for six months of the year, from September 30th till March 31st."

FISCHER'S SYNTHESIS OF DEPSIDES AND TANNING SUBSTANCES.

By Prof. J. A. Wilkinson, M.A., F.C.S.

The work carried out by Professor Emil Fischer and his pupils on the polypeptides, which has contributed so largely to the extension of our knowledge of the proteins and their derivatives, is well known, and led indirectly to the work outlined here, culminating in the synthesis of a substance which possesses practically all the properties of tannic acid, and the preparation of a large number of others, strictly allied both in properties and composition. Whilst engaged on the synthesis of polypeptides of tyrosin, he desired to prepare a chloride of chloracetyl tyrosin in order to obtain glycyl tyrosyl glycin. On treating with phosphorus trichloride, it was found, that the free phenol groups present in the molecule caused trouble, and hence he conceived the idea of fixing them, in the meanwhile, by means of a group, which could afterwards be removed easily, and the original phenol group restored. For this purpose the methyl ester of chlor-carbonic acid, $Cl.COOCH_3$, was used, the hydrogen of the phenolic hydroxyl being replaced by the methyl carbonato group $—COOCH_3$. The methyl carbonato-compounds thus produced were then treated with phosphorus chloride, yielding the methyl carbonato-chlorides, which on subsequent treatment with sodium hydroxide reintroduced the original phenol group. The success of this procedure in the case mentioned led to its trial with the phenol carboxylic acids, the results of which are detailed in a series of brilliant papers, entitled "The Methyl Carbonato Derivatives of Phenol Carboxylic Acids, and their use for synthetic operations," the first of which appeared in 1908. In these it was shown, that the chlorides of these acids were unobtainable by the ordinary methods of preparing acid chlorides, owing to the fact that the phosphorus chlorides attack both the hydroxyl and carboxyl groups, and yield products of variable composition, as had been shown previously by R. Anschutz. The reactions which take place may be exemplified thus:—

Starting with para-hydroxy-benzoic acid—

$$(a)\ C_6H_4 \begin{cases} OH & 1. \\ COOH & 4. \end{cases}$$

By the action of $Cl.COOCH_3$ —

$$(b)\ C_6H_4 \begin{cases} O.COOCH_3 & 1. \\ COOH. & 4. \end{cases}$$

By the action of PCl_5 —

$$(c)\ C_6H_4 \begin{cases} O.COOCH_3 & 1. \\ COCl & 4. \end{cases}$$

Which combines with glycin ester, forming

$$(d)\ C_6H_4 \begin{array}{l} \diagup O.COOCH_3 \\ \diagdown CO.\ NH.\ CH_2.\ COOC_2H_5 \end{array}$$

which, with dilute alkali and subsequently acid, yields—

$$(e)\ C_6H_4 \begin{array}{l} \diagup OH \\ \diagdown CO.\ NH.\ CH_2.\ COOH \end{array}$$

Para-hydroxy-hippuric acid.

Similarly, in the case of the phenol-carboxylic acids themselves, union takes place between the OH and COOH groups; thus—

$$C_6H_4 \begin{array}{ll} \diagup O.\ COOCH_3 & 1. \\ \diagdown COCl & 4. \end{array} \quad \text{with} \quad C_6H_4 \begin{array}{ll} \diagup ONa & 1. \\ \diagdown COONa & 4. \end{array}$$

yields

$$C_6H_4 \begin{array}{ll} \diagup O.COOCH_3 & 1. \\ \diagdown CO.\ O.\ C_6H_4.\ COONa & 4. \end{array}$$

which, with alkali and then acid, as above, yields

$$C_6H_4 \begin{array}{ll} \diagup OH & 1. \\ \diagdown CO.\ O.\ C_6H_4.\ COOH & 4. \end{array}$$

This is the simplest type of a new series of substances which have been named by Fischer the depsides, from the Greek word *δεψειν* to tan, since many of these substances possess properties similar to the tanning materials in common use. From this substance and p.-hydroxy-benzoic acid is obtained in a similar manner—

$$C_6H_4 \begin{array}{l} \diagup OH \\ \diagdown CO.O.\ C_6H_4\ CO.O.C_6H_4\ COOH \end{array}$$

and so on. According to the number of phenol carboxylic acids coupled together, we distinguish between di-, tri-, tetra-, depsides, just as in the case of the polysaccharides and polypeptides. Up to 1913, Professor Fischer had prepared, in a state of purity, 28 di-depsides, 2 tri- and 2 tetra-depsides.

These substances are by no means new, a few of the simpler ones having been prepared formerly. H. Schiff and others prepared from gallic acid, by means of silver nitrate or arsenic acid, and then phosphorus oxychloride, a substance to which the name digallic acid was given, and formula $C_{14}H_{10}O_9$, supposed to be identical with tannic acid, a statement found in text-books even to-day, but which in the light of Fischer's work cannot be maintained. This investigation was extended later to a whole series of other phenol carboxylic acids, but unfortunately most of the substances he obtained were amorphous, and hence have been criticised, especially with respect to uniformity of composition. It is worthy of note, however, that these researches gave rise to the commercial preparation of artificial tanning materials. Further, Klepl, in 1883, by heating para-hydroxy-benzoic acid, obtained both the above substances, but this simple method is inapplicable in other cases.

In addition to the depsides, which are pronounced acids, the phenol carboxylic acids can also form neutral anhydrides.

The introduction of the methyl carbonato group, by use of the methyl ester of chlor-carbonic acid, is not difficult to effect in the case of the meta- and para-hydroxy-benzoic acids, and this is found to be general, if the phenol groups are in these positions with respect to the carboxyl group. At the same time, the number of hydroxyl groups present makes but little difference. The hydroxyl groups in proto-catechuic and gallic acids are completely converted with slightly more than the theoretical quantity of methyl-chlor carbonate. But the case is quite different, if the hydroxyl group stands in the ortho position to the carboxyl group. The replacement sometimes succeeds, if excess of the chlor-carbonic ester be used in aqueous alkaline solution—*e.g.*, with orsellinic and pyrogallol carboxylic acids—but examples of this are rare. The general method used in this case was first employed by F. Hofmann for the preparation of ortho-ethyl-carbonato-benzoic acid by the action of ethyl chlor carbonate on a mixture of salicylic acid and di-methyl aniline in an indifferent solvent—*e.g.*, benzene. Professor Fischer used this method to convert the two hydroxyl groups in gentisinic and β-resorcylic acids into methyl carbonato groups, from which the chlorides were afterwards prepared (*Ber.*, 1909, 215). More difficulty was experienced with the phloroglucin carboxylic acids, but this was overcome by using large excess of methyl chlor-carbonate and di-methyl aniline, and afterwards treating with bicarbonate in acetone solution.

If the carboxyl group is not united directly to the benzene ring, *e.g.*, ortho coumaric acid, no difficulty is experienced, and the reaction proceeds well in aqueous alkaline solution.

By these methods a large number of the phenol carboxylic acids have been completely converted into the corresponding methyl carbonato compounds. Partial replacement may also occur, this being chiefly dependent on the active mass of the reagents used, but in these cases also it has been found that the para-compound is the one most generally formed, and next the meta derivative.

The complete reconversion of the methyl carbonato group to the phenol group is easily carried out by using excess of cold aqueous alkali, and more slowly with normal ammonia solution; but in the latter case the group splits off, not as carbonate, but as urethane $NH_2.COOCH_3$. Neutral alkali carbonate acts even more slowly, whilst bicarbonate is apparently indifferent, and hence is useful for dissolving out the acids. Partial removal also takes place with smaller quantities of alkali, the para groups being first attacked. By this means the mono-methyl carbonato compounds can be prepared from the di methyl carbonato compounds.

The chlorides of these methyl carbonato carboxylic acids are prepared by the action of PCl_5 either by gentle heat or shaking the acid with PCl_5 and dry chloroform. Generally speaking, they crystallise well, and show the reactions of acid chlorides, such as benzoyl chloride. By replacement of the methyl carbonato group with the original phenol group, the acid chlorides themselves are obtained. The latter have been obtained directly by H. Meyer, but the products he obtained do not crystallise, remaining as oils, and cannot be compared in importance with those obtained as above by Fischer's method. Further, the chlorides of the completely methylated or acylated phenol carboxylic acids have been known for a long time, and are stable enough to serve for synthetic purposes, but the removal of the methyl or acyl groups afterwards is difficult.

These methyl carbonato acid chlorides have been used for the following syntheses:—

1. With alcohol they form esters, which on subsequent saponification with alkali, are changed to the esters of the free phenol carboxylic acids. This reaction is of especial importance in the case of the polybasic alcohols of the sugar class, as will be exemplified later.
2. With the amino acid esters in aqueous alkaline solution, they couple themselves directly, as shown in the case of para hydroxy hippuric acid, given above. By this means the isomeric ortho-salicyl-uric acid has also been prepared.
3. In the presence of aluminium chloride direct union with benzene takes place as shown in the synthesis of para oxy benzo-phenone: thus—

$$C_6H_4\begin{cases} O.COOCH_3 \\ COCl \end{cases} + C_6H_6 = C_6H_4\begin{cases} O.COOCH_3 \\ CO.C_6H_5 \end{cases} + HCl$$

saponification removing the methyl carbonato group. It is noteworthy here that pyrogallol carboxylic acid yields 2.3.4. trihydroxy-benzophenon identical with alizarin yellow A, whose formula $CO\ [C_6H_2\ (OH)_3]_2$ is now conclusively established.
4. The free phenol carboxylic acids also react directly with the chloride forming di-depsides, as already shown, and similarly for tri- and tetra-depsides.

In the case of the di- and tri-hydroxy benzoic acids, containing two and three hydroxy groups, isomeric methyl carbonato depsides result, as also complicated derivatives, which are difficult to separate and purify. So far one case only has been fully worked out, the coupling of di-methyl carbonato orsellinic acid chloride with orsellinic acid necessary for the synthesis of lecanoric acid.

Digallic, di-protocatechuic acids, as well as a large number of other di-depsides, have been prepared by this method, and their constitution thus clearly established. Many of these substances, as has been already mentioned, show the reactions of the tannins in greater or lesser degree.

On the subject of these chlorides, Professor Fischer further remarks that their applicability for synthetic purposes is by no means exhausted, and that they will yet prove of great service in cases where benzoyl chloride has hitherto been found of service, and where the phenol groups may be easily restored by gentle saponification. He further recommends the use of the chloride of methyl carbonato ferulic acid as suitable for the synthesis of curcumin, which has not yet been worked out.

The reconversion of the methyl carbonato group to phenolic hydroxyl is possible by using cold dilute alkali or aqueous ammonia at 20° C, the reaction being generally completed in half to three-quarters of an hour, with normal or semi-normal solutions. If alkali be used, sufficient is added to neutralise the carboxyl group, and then two molecules NaOH for each methyl carbonato group. If the weaker ammonia be employed, a large excess is required.

The di-depsides hitherto investigated are crystalline substances, difficultly soluble in cold water, but soluble in bicarbonate solution, acid in reaction, and melt with decomposition. Like the simple phenol carboxylic acids, they give colourations with ferric chloride. They react with diazo methane, forming completely methylated compounds, which crystallise extremely well, and melt at a lower temperature than the depsides without decomposition. Owing to these properties they have been useful for the purposes of identification.

The first paper directly concerned with tannin appeared in the *Berichte* in 1912, and was entitled "Tannin, and the Synthesis of Similar Substances." It begins with an historical introduction discussing briefly the various researches published up to that time. These had not resulted in the establishment of a definite composition or formula for tannin which would defy criticism or investigation, but certain facts had been ascertained which Professor Fischer thought it necessary to confirm or reject as a result of his own investigations.

Under the generic name of tannin, a large number of vegetable substances from different sources have been included, which have been classified at various times in various ways, according to the point of view chosen. The experiments undertaken in this case were limited to the tannin of gall apples and some substances which belong to the same type. The first experiments carried out by Fischer and Freudenberg had for their object the question whether the glucose, first observed by Strecker in 1852-4, was in reality a component of the tannin molecule or merely an accidental adulteration. For this purpose they used as raw materials:—

(*a*) Acidum tannicum leviss. puriss. (Merck's purest preparation); (*b*) ditto (Kahlbaum), both of which they subjected to purification by special methods devised for this purpose. Briefly these consisted in (*a*) extraction with ether, which gave a yield of 60 per cent.; (*b*) extraction with ethyl acetate gave a yield of 60 per cent.; (*c*) preparation of the potassium salt and subsequent acidification with $N.H_2SO_4Aq$.

The object was to get a preparation as pure as it was possible to get. The purified tannin so prepared was so hygroscopic that great care had to be taken to exclude the moisture of the atmosphere when weighing. On analysis the following numbers were obtained:—

	I.	II.	III.	IV.	V.
Carbon, per cent.	53·3	53·7	53·62	53·16	52·59
Hydrogen, per cent. . . .	3·25	3·3	3·39	3·4	3·24

I. Merck's tannin purified by method *b*.
II. Kahlbaum's ditto.
III. Kahlbaum's tannin purified by method *c*.
IV. Kahlbaum's tannin, not purified, but dissolved out with water.
V. Merck's tannin purified by method *a*.

The optical rotatory power was also determined, and gave for three different preparations of I the values

$[\alpha]_D^{20} = +67.65^\circ\ (\pm 2^\circ)$ Aqueous solutions.
$+70.09^\circ\ (\pm 1^\circ)$
$+18.43^\circ\ (\pm 3^\circ)$ Alcoholic solution.

for two different preparations of III the values

$[\alpha]_D^{20}$ $+70.77^\circ\ (\pm 2^\circ)$ Aqueous solutions.
$+68.48^\circ\ (\pm 2^\circ)$
and for V $+58.23^\circ\ (\pm 2^\circ)$.

Theoretically—

Digallic Acid contains.	C. 52.16 %	H. 3.13 %
Pentagalloyl glucose.	C. 52.33 %	H. 3.43 %
Pentadigalloyl glucose	C. 53.63 %	H. 3.08 %

These analyses did not lead to any definite conclusion. The acidity was next tested and found to be one-tenth that of gallic acid.

Hydrolysis was then undertaken with dilute sulphuric acid in order to separate the sugar, which was very carefully estimated by several methods, from the acid portion of the molecule. Examination and analysis of the osazone proved conclusively that dextrose was present and the acid gallic acid. If the hydrolysis were not completed, in addition to the gallic acid and glucose, a dark coloured substance remained, which was called the tannin residue. As a final check, artificial mixtures of gallic acid and dextrose were also made and similarly treated. The acid used was 5 per cent. H_2SO_4Aq, but in one case, Strecker's method, using 11 per cent. H_2SO_4Aq, and heating for 24 hours at 400° was employed. The results obtained are shown in the following table:—

Material.	Duration of Hydrolysis.	Gallic Acid, dried.	Tannin Residue.	% Glucose.				Total.
				Polar.	Fehl.	Grav.	Average.	
Tannic Acid	5	...	...	...	...	0 5	0·5	...
Tannic Acid—Kahlbaum ...	20	...	...	...	...	1·1	1·1	...
,, ,, ...	24	80 2	13	1·3	2 2	2·5	2·0	95·2
,, , ...	45	90·4	3·9	4·6	3·8	4·7	4·4	98·7
,, ,, ...	60	88·7	1·5	5·8	6·9	7·6	6·8	97·0
,, ,, ...	72	93·7	1·5	7·3	7·5	9·0	7·9	103·1
,, ,, ...	87	90·9	...	5 0	6·4	7·9	6·4	97·3
Tannic Acid—Merck ...	8	...	...	...	...	2·6	2·6	...
,, ,, ...	24	87·2	...	...	...	4·9	4·9	...
,, ,, ...	72	94	1	5·3	7·4	8·3	7·0	102
Tannic Acid—Merck, purified by method *a* ...	8	...	...	3	4	...	3·5	...
Tannic Acid—Merck, purified by method *b* ...	18	72 7	22·2	...	...	3·2	3·2	98 1
,, ,, ,,	72	93·6	...	5·9	6·0	8·4	6·8	100·4
Tannic Acid—Kahlbaum, purified by method *b* ...	24	81 2	18	3·1	3·1	3·3	3·2	102·4
Tannic Acid—Kahlbaum, purified by method *c* ...	51	92·1	3·8	7·5	6·8	7·6	7·3	103·2
Tannic Acid—Kahlbaum, purified by Strecker's method	24	94·3	...	4·6	6·8	7·3	6·2	100·5
Mixtures—								
95·2% water free gallic acid 4·8% glucose ...	24	90·2	...	...	...	3·7	3·7	93·9
91·8% water free gallic acid 8·2% glucose ...	30	86 8	1·3	4·0	3·8	5·1	4·3	92·4
86·6% water free gallic acid 13·4% glucose ...	30	85 0	...	7·8	9 1	10·3	9·1	94·1

These experiments lead to the conclusion that in the purest tannin investigated 1 mol glucose is combined with about 10 mols gallic acid, and no other phenol carboxylic acid is present. In order to elucidate its structure still further, an attempt was made to isolate intermediate products, but this was found to be impossible owing to their properties, in consequence of which the synthetic method was adopted. No free carboxyl being present, as the above experiments showed, the method of combination of the glucose with the gallic acid was indicated as being in the form of an ester, and these conditions are satisfied if tannin be considered as a compound formed by the union of 1 mol glucose with 5 mols digallic acid, similar to pentacetyl glucose. Digallic acid, $C_6H_2(OH)_3CO.OC_6H_2(OH)_2COOH$, is a didepside, which was synthetically prepared in a pure condition, first by Fischer in the manner indicated above, but as it is extremely difficult to work with, an attempt was first made with gallic acid in order to obtain pentagalloyl glucose $C_6H_7O_6[OC.C_6H_2(OH)_3]_5$, and test its properties.

The methods hitherto used for the complete acylation of glucose were found to be unavailable for the preparation of penta galloyl glucose, and a new method had to be worked out. This was done, and consisted in bringing together the glucose and the chloride of the acid dissolved in dry chloroform, together with quinoline. In this manner penta trimethyl-carbonato galloyl glucose (mol. wt. 1810.5) $C_{71}H_{62}O_{56}$ or, $C_6H_7O_6[OC.C_6H_2(OCOOCH_3)_3]_5$ was obtained as a granular colourless amorphous powder sintering about 90° $[\alpha]_D^{20} + 34.34°$ ($\pm 0.4°$). By careful saponification with excess alkali, in aqueous acetone solution at ordinary temperature, this yielded pentagalloyl glucose $C_{41}H_{32}O_{26}$ (Mol. wt. 940.26), as a yellow amorphous powder, softening about 150°, and beginning to decompose at 160° $[\alpha]_D^{20} + 31°$ to 35°.

This substance shows a startling similarity to tannin, the chief differences being the optical rotation and the amount of gallic acid obtained on hydrolysis with sulphuric acid. It possesses a strong astringent, and bitter, but not acid, taste. It is soluble in most of the organic solvents, gives coloration with ferric chloride (inks) and is precipitated by the same reagents. Analysis gave—

Carbon, per cent...	52.49	Hydrogen	3.79
	52.41		3.67
Theoretically ...	52.33		3.43

The benzoylation of glucose was also carried out, and in this case two stereoisomers were obtained, which could be separated by crystallisation, according as α or β glucose was used, but in the case of the corresponding galloyl compounds, owing to their amorphous nature, this was impossible. From analogy and other considerations Professor Fischer does not consider that the pentagalloyl glucose is a single uniform substance, but probably a mixture of isomers.

In spite of this, he states that with its preparation the chapter of the principal synthesis seems to be concluded, though not yet fully completed owing to the fact that tannin itself has not yet been synthesised. A large number of other experiments have been carried out, some dealing with other commercial tannins, which were purified and hydrolysed as above, others being attempts at synthesis along the above lines, but these have not yielded the results expected. Nor has anything occurred which has yielded such strong evidence of the structure of the tannin molecule as the synthesis of penta galloyl glucose.

Other pentacylated glucoses have also been prepared, namely, with para hydroxy benzoic, salicylic, and pyrogallol carboxylic acids, also probably mixtures of the α and β stereo-isomers.

The bearing of the above syntheses on the chemical processes occurring in plants is of extreme interest, as showing that the polyvalent alcohols can be utilised by the plant in the esterification of acids, the free acids themselves being found only in a few species, and the significance of this is of the utmost importance to vegetable physiology as the sugar derivatives found so widely distributed have not hitherto been regarded in this light.

The compounds of high molecular weight and known constitution prepared in the course of these researches are also of great interest from a theoretical point of view.

The above résumé has been prepared from the various papers by Fischer and his pupils published in the *Berichte der Deutschen Chemische Gesellschaft*. For other work dependence has been placed upon abstracts.

Decimalisation of Weights, Measures and Coinage.—The Council of the Association recently adopted the following resolutions:—(1) That the metric system of weights and measures be legalised at as early a date as possible, for permissive use until the end of the war, and that its use become compulsory and exclusive after such time as may be found practicable; (2) That the Government of the Union of South Africa should co-operate with the other self-governing Dominions with regard to the decimalisation of coinage; (3) That copies of the foregoing resolutions be sent to (*a*) His Excellency the Governor-General, (*b*) the Prime Minister, (*c*) the Minister of Trade and Industries, (*d*) the daily Press, (*e*) the Decimal Association, Finsbury Court, London, E.C., and that they be published in the Association's Journal.

DAYLIGHT SAVING.

By Robert Thorburn Ayton Innes, F.R.A.S., F.R.S.E.

This year has seen the adoption of the device called Daylight Saving by Great Britain and several other European nations. During the summer months all clocks are advanced one hour.

The title "Daylight Saving" is a misnomer, as daylight cannot be saved. A more correct designation would be "Daylight Using," or, better still, "An Earlier Hours Regulation."

Theoretically our clock-times depend upon the place of the sun in the daylight sky, and this was also the case practically until railways and the electric telegraph came into general use. To-day there is no necessary connection between the clock-hours and the diurnal motion of the sun. The hours shown by the clock may be conventional, and, by the adoption of zone or standard times, are so.

There is a little historical interest in this, because it shows a slight inconvenience caused by the logic of astronomers.

In some old book—the exact reference is unnecessary—the author complains that he had to be at work at two in the morning, which at first sight seems to be rather early. But when we remember that the hours were counted from sunrise, the apparent hardship disappears. Some centuries ago the progress of astronomy and of watch-making led to the day being considered to commence at midnight, especally as in that age no one would be about at that time, and it was therefore a convenient hour by which to commence the new day.

Then the fixing by statute of certain hours during which certain trades might be plied undoubtedly gave rise to the use of late hours in town—a use or abuse which the invention of gas and other artificial illumination made easy.

Having made my protest against the loose English of "Daylight Saving," I will keep to that term to avoid the charge of pedantry.

Daylight Saving is peculiarly a town device—it is not wanted in the country, because the country folks always use the daylight. But we are becoming a a town-living people. In nearly every country in the world which is populated by the white races, the country-side population decays, slowly when compared with itself, rapidly when compared with the growth of towns. Hence we must not be surprised that little should be said about daylight so far as it regards country folk.

Near the equator, where there are no seasons, there could not, of course, be a Summer Daylight Saving Regulation. There the sun rises and sets at practically the same time all the year round. Nor could daylight be saved in summer-time in the more northern parts of Europe (such as Scotland north of Dundee), because daylight persists to a late hour or even all night long.

But if at the equator, and even to latitudes 30° north and south, the logic of "Daylight Saving" is weak, there is something to be said for an alteration in our hours of rising and going to bed. The fashionable tendency in towns has been for well-to-do people to rise and go to bed later and later, and this reacts on all town classes. If rich people want entertainment after 11 p.m., and even up to midnight or later, the working people will cater for them. The evil of such late hours is obvious, yet how is it to be combated? Legislators have evidently considered that a direct appeal would be useless, or at least difficult to make effective, so they have, in accordance with tradition, taken the line of least resistance, the line we see adopted on the stage by wives who are aggrieved at their husbands' late hours—they advance the clock—and by this harmless if theatrical deception attain their object.

If this device is unscientific it is, after all, not very objectionable, because, as said earlier, our clock hours are now little more than conventional. It would have been better to have relied on the moral fibre of townspeople, and have asked them to rise an hour earlier in summer time and to have adopted generally an earlier time-table. But to this, legislators consider we are unequal—we are flabby—and a little mental deception is required to gild the legislative pill.

How would Daylight Saving affect us in South Africa? We must, first of all, remember that over the whole of South Africa, Portuguese East Africa, and Egypt zone or standard time of the second hour east of Greenwich is used. Capetown, Johannesburg, Salisbury, Lorenzo Marques all use the same time, and this is a very great convenience in long-distance travelling and trading. All places to the west of the adopted meridian use or save daylight, whilst those in the east lose it by the use of standard time. Thus Capetown, being in E. Longitude 1 hour 13.9 minutes, or 46.1 minutes west of E. Longitude 2 hours, benefits by 46.1 minutes of daylight. When a Capetonian rises at 8 hours a.m. standard time, he really rises at 7 hours 14 minutes mean time, and so on. For the chief places in South Africa the gain or loss is as follows:—

	Gain or Loss in Daylight on Mean Time.
Windhuk	52 mins. gain.
Capetown	46 „ „
Port Elizabeth	18 „ „
Bloemfontein	15 „ „
East London	8 „ „
Johannesburg	8 „ „
Pretoria	8 „ „
Bulawayo	5 „ „
Maritzburg	2 „ loss.
Durban	4 „ „
Salisbury	4 „ „
Lorenzo Marques	10 „ „

So the first point to consider is, what would be the effect, if in summer time clocks were advanced one hour on present standard time or, in other words, we adopted as our zone 3 hours E. of Greenwich. Then Capetown clocks would be no less than 1 hour 46 minutes in advance of mean time, whilst Johannesburg would benefit to the extent of 1 hour 8 minutes, and Lorenzo Marques by 50 minutes.

To consider the effect more closely, let us assume that summer time will be used from the 1st October until the 31st March —that is, six months out of the 12. We will only consider three towns, as the circumstances for others are not essentially different:—

		h.	m.	
Capetown:				
October 1.—	Sun would rise at	7	23	summer clock time.
	Sun would set at	7	48	,, ,, ,,
March 31.—	Sun would rise at	7	59	,, ,, ,,
	Sun would set at	7	40	,, ,, ,,
Bloemfontein:				
October 1.—	Sun would rise at	6	53	,, ,, ,,
	Sun would set at	7	17	,, ,, ,,
March 31.—	Sun would rise at	7	25	,, ,, ,,
	Sun would set at	7	12	,, ,, ,,
Maritzburg:				
October 1.—	Sun would rise at	6	37	,, ,, ,,
	Sun would set at	6	59	,, ,, ,,
March 31.—	Sun would rise at	7	9	,, ,, ,,
	Sun would set at	6	54	,, ,, ,,

These are the actual clock times that the sun is on the horizon, because of twilight, daylight is roughly 1 hour longer, namely, 30 minutes in the morning and 30 minutes in the evening.

Thus the effect at Capetown would be that, if a person usually gets up at 8 o'clock he would, during "summer time," do so when there had been at least half an hour of daylight, and if he finished work at 5 o'clock, he would have at least 3¼ hours of daylight for recreation, etc. There is no disability in getting up at dawn in summer time in Capetown, because it is a genial climate. Capetown will economise a lot by adopting these earlier hours.

Similarly, a person at Bloemfontein rising at 8 o'clock will do so when there has been at least one hour of daylight, and he will have over three hours of daylight after 5 in the afternoon. At Maritzburg the condition of affairs, even making allowance for its surrounding hills, is in much the same circumstances.

In the height of summer, that is, in December and January, there is a positive advantage in starting work earlier, because one can get about before the heat of the day has fairly set in.

I believe that there can be no valid objection to the adoption of earlier hours in summer time, and this can be secured by a Daylight Saving Order, although, for honesty's sake, I would prefer to see it done by the adoption of one hour earlier in all statute-fixed times, in railway and tramway time-tables, and in Government, Municipal, Bank and Corporation office hours. The public at large would then gladly adopt the earlier hours.

One word of warning may be required—we can alter our clock hours, but we cannot alter the times of the tides, and unless the "time," in which tides are predicted, is clearly set out, mariners may be deceived. The proper course would be to give all tide tables in Greenwich time, which is clearly defined and understood by all mariners.

These remarks will apply to all scientific observations in which the real time enters as one of the data. The British Act exempts astronomy and navigation, and the British Meteorological Office has instructed that all clocks used by observers for regulating their duties should continue to be set according to Greenwich time. In all the astronomical work done at the Union Observatory since 1908, the time used is Greenwich time. I would recommend all scientific workers to follow this example because it is free from ambiguity, and is readily understood everywhere. American astronomers frequently, but not generally, quote their observations in Eastern, Middle, or Pacific time, and these cannot be reduced to Greenwich time without a reference to some authority, such as the Nautical Almanac, which may not be at hand.

It may be assumed that the general public will use more and more conventional times, and even Standard Time is a conventional time, so that it will become more and more necessary for scientists and navigators to adopt one uniform time applicable to the whole world, and that is Greenwich time.

Lastly, if it is determined to make any time or clock-change, it is to be hoped that the distinction of a.m. and p.m. will be given up in favour of the consecutive numbering of the hours from 0 h. to 24 h.

In a country of long railway journeys such a course would make the interpretation of time-tables much simpler. I have frequently been asked what time 12 h. 25 m. p.m. or a.m. is. A recent film has the title 11.59 a.m., but the picture shows that 11.59 p.m. is meant, and so on. These and similar confusions and difficulties would be evaded by the simple and logical counting of the 24 hours of the day as 24 hours, instead of making two bites of the cherry.

This is already done in Belgium, Italy, and probably in other countries, but I have not a complete list.

June 12, 1916.

ON A UNIQUE OCCURRENCE OF MOLYBDENUM IN NATAL.

By Alexander Logie du Toit, B.A., D.Sc., F.G.S.

During the course of the prospecting which took place some ten years ago in the Hlatimbe Valley, a tributary of the Umkomaas River, in Impendhle County, Natal, an occurrence of ores of Molybdenum was noticed in association with the oil-shales, the mineral being present not in quartz veins carrying crystallised Molybdenite—its normal habit—but as an impregnation in coarse sandstone belonging to the Molteno division of the Karroo System and of Upper Triassic age.

The habit, therefore, is so unusual that a brief account of the ore-body will no doubt be of interest to mineralogists; indeed, as far as can be judged from a study of the available literature upon the distribution of Molybdenum ores, this deposit is unique.

The precise locality is on the right-hand side of the Hlatimbe Valley, and situated just within the area of Crown Land in the angle between the boundaries of the farms Memala and Duart Castle, below the escarpment of the Drakensberg.

The Sandstone in question is the identical horizon which has been mapped continuously from the Stormberg in the Cape, and known as the Indwe Sandstone. It is only 18 feet in thickness here, but its lithological individuality still persists; at the top it is soft, medium-grained and generally with glittering grains of quartz, while the lowest 4 or 5 feet is harder and coarser-grained, carrying small pebbles of white or grey vein-quartz sometimes as much as an inch across. The two parts are separated by a slightly uneven surface, along which are lenticles of extremely well laminated black shale set sometimes sparsely, at other times close together.

The sandstone stratum rests upon bluish mudstones, which at the adit are bleached to a pale tint; and the sandstone is followed by the oil-shale horizon, which is here of very inferior quality.

No signs of mineralisation are to be seen in the upper part of the sandstone, which is fully exposed, nor in the thick sandstone outcrops higher up the mountain-side; the Molybdenum appears to be confined to the lowest 4 or 5 feet of sandstone and to a distance of outcrop of 20 yards at most—less than that if slight impregnation be disregarded. Along this face of rock the sandstone shows two irregular dark-stained areas, each a couple of yards across; an adit was driven in at this point to a distance of about 200 feet, but the workings were ultimately abandoned. Prospecting had also been carried out with the aid of a diamond drill, boreholes being put into the hillside at various angles to the horizontal; records of these are published in the Reports on the Mining Industry of Natal for 1906 and 1907. Only one of these cut the pebbly zone with which the Molybdenum is associated; the rock was highly pyritic.

The exact boundaries of the deposit have not been determined, but the body appears to be irregular and small in size.

The ore on the dump is a peculiar friable black sandstone flecked with white, and carrying a fair amount of sulphide of iron; the latter is often very abundant in the form of spherical concretions from one to two inches across, and is mostly the mineral marcasite. Along one horizon they are crowded together, are about half an inch in diameter, and each concretion includes large numbers of quartz grains enclosed in the solid marcasite. Such concretions are present in fair number in the Indwe Sandstone generally, but usually they have been oxidised and give rise at the outcrop to hollow, spherical, ferruginous masses.

The black sandstone is made up chiefly of dull rounded and sub-rounded grains of *Quartz*, to which a black matter adheres that is insoluble in acids, and is principally *carbonaceous* in composition. Along certain bands in the sandstone the quartz grains are set in a minutely crystalline matrix, generally white, but occasionally a pale blue, due no doubt to the presence of molybdenum compounds. It is very soft, and was found to consist of minute plates of *Kaolinite* derived from the alteration of the potash felspar which is commonly a conspicuous constituent of the sandstone. More usually, though, by loss of the cementing material, the rock has been converted into a porous friable mass.

The sulphide of iron occurs as small crystalline aggregates; *Pyrite* is certainly present, but, from the fact that some of the specimens show an efflorescence of sulphates, there must be *Marcasite* as well.

The black amorphous matter surrounding the quartz grains is in great part, as already stated, carbonaceous, and as shown by the readiness with which it can be oxidised, cannot be graphite. It is insoluble in xylol, but with carbon disulphide or ether a small amount of *hydrocarbon* can be extracted which is not volatile, and the material is not unlikely to be of the nature of coal, streaks of which, it may be remarked, are not unusual in this sandstone. Lassaigne's test (with sodium), curiously enough, gave no reaction for nitrogen.

The molybdenum is associated with this black material, and can only be present in the form of the black sulphide, *Molybdenite*, MoS_2; minute scales of this mineral were observed upon microscopic examination of the powder, and confirmation of this was obtained by the following analysis of a sample of the rock made by Mr. C. Garthausen in the laboratory of the Geological Survey:—

Silica	83.8%
Alumina..	0.8%

Sulphur	4.4%
Iron	2.9%
Molybdenum	1.1%
Alkalies	*Nil.*

Unfortunately, lack of the necessary apparatus prevented the determination of the proportion of carbon, but its value is obviously less than 6%.

The sulphides are consequently present in the following proportions:—

Pyrite or *Marcasite*	6.53%
Molybdenite	1.85%

Most interesting are the oxidation products of the sulphide minerals in the rock. Some surfaces and joint planes are coated with a thin incrustation of bright yellow *Molybdic Ochre,* a mineral which is not trioxide of molybdenum, as usually stated in text-books, but, as pointed out by Schaller,* a hydrous ferric molybdate $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$, formed by the oxidation of molybdenite in the presence of pyrite or marcasite.

Its identification was confirmed by chemical and optical tests.

In one case a bright lemon yellow efflorescence formed on the specimen in the cabinet after collection in the form of small pin-points of a soft substance, which proved to be not molybdic ochre, but granular *sulphur* in part, originating most probably from the alteration of the molybdenite. On the same sample very small crystals of green ferrous sulphate had developed from the iron sulphide.

On the exposed face of sandstone there was a large patch of a thin incrustation which ranged in colour from nearly black to an intense prussian blue; the substance is soluble in water, and gives a strong reaction for molybdenum, and must, therefore, be the rare mineral *Ilsemannite*, $MoO_2.4MoO_3$, so far only known from Bleiberg, in Carinthia,† as a product of decomposition of wulfenite, molybdate of lead, and from Cripple Creek,‡ Colorado, as an alteration of molybdenite. In Natal, therefore, the mode of origin of this uncommon mineral is identical with that in Colorado.

The walls of the adit are coated with a friable yellowish incrustation which proved to be principally *Aluminite*, a basic aluminium sulphate with a certain amount of iron, but devoid of lime, magnesia or potash. A similar substance was found below the undercut base of the sandstone outcrop, where it was protected from the rain and is harder and more stalactitic in character, and dull whitish in colour, with tints inclining from yellow-brown on the one hand to pale blue on the other; it is of interest

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* W. T. Schaller, *Amer Jour Sci.*, 4th series, **23** (1907), *297*.

† W. Lindgren and F. L. Ransome, U.S. Geol. Surv., Prof. Paper 54 (1906), 124.

‡ E. S. Dana: "A System of Mineralogy," p. 202.

because it contains a small amount of molybdenum, though how this is combined has not been ascertained.

As regards the genesis of the deposit, no definite suggestions can be made, unfortunately. As far as can be judged, the black molybdenum bearing part of the sandstone is irregular in shape, and in places fairly sharply defined from the rest of the rock.

The molybdenum compounds could not have been of detrital origin, for then the deposit would gradually fade away into barren sandstone on either side; also the quartz pebbles, when broken, are free from enclosed flakes of molybdenite. The presence of pyrite and marcasite is common indeed in the Indwe Sandstone, but the amount present here is much higher than usual, and a great part of the sulphides of iron must therefore have been introduced later, probably along with the molybdenite.

Several such nodules from this sandstone at different localities in the Cape Province gave no indications of molybdenum when tested by the delicate reaction with stannous chloride.

The source of the carbonaceous matter is another difficult problem; its restriction to the ore-body will hardly allow of its being an original constituent, but on the other hand it is not volatile. In some ways it recalls the odd anthracitic "coals" found in irregular veins and fissures in the Western Karroo.

There are no signs of any channels up which ascending solutions could have made their way, and there are no dykes in close proximity. The only igneous intrusion is a nearly horizontal sill of dolerite, which crops out at a level fully 100 feet above the occurrence, and which might have been concerned in its genesis. This is not at all unlikely, for small amounts of iron and occasionally copper pyrites are found in these intrusions in the Karroo System; in the Insizwa Range, in Mount Ayliff, there is a good deal of nickel as well (in the form of sulphide) along with pyrrhotite.

This sporadic occurrence of molybdenum in Natal may quite well be genetically connected with the intrusion of the Karroo dolerites, but it is only fair to point out that prospecting has not brought to light any similar mineralisation at points a few miles away, where the sandstone has been cut through by the dolerite sheet in question.

METEORIC STONES.—Dr. G. T. Prior, Keeper of the Mineral Department of the British Museum, has contributed to the Transactions of the Mineralogical Society a paper on some meteoric stones, including those which fell at Kroonstad, Orange Free State, on 19th November, 1877, and at Daniel's Kuil, Griqualand West, on 20th March, 1868. Both these meteorites were analysed, and their mineral composition deduced from the results. The Kroonstad stone seemed to consist mainly of bronzite, olivine, and nickel-iron, the percentages being respectively 35.03, 29.44, and 18.49. The Daniel's Kuil meteorite showed 55.76 per cent. of enstatite and 25.45 per cent. of nickel-iron.

PAPER MONEY AND THE GOLD EXCHANGE STANDARD AT THE CAPE.

By Prof. R. Leslie, M.A., F.S.S.

When the Dutch first established their settlement at the Cape, they naturally introduced the Dutch coinage. The rix-dollar or reichs-thaler, the standard coin, was worth 48 stivers Dutch, or four shillings in British money. Six stivers or pence made a skilling, and eight skillings a dollar. Till 1782 the currency consisted solely of coins; there was no paper in circulation. In this year, as Holland was at war with England, the Governor at the Cape, Joachim van Plettenberg, found it impossible to import the usual supplies from the Mother Country for the military and civil establishments. On 31st May he therefore issued paper money to the amount of 47,696 Rds. 4 sk. A promise was given, first by the Governor and afterwards by the Dutch East India Company, that the paper would be exchanged for specie as soon as the necessary supplies could be obtained. Further issues continued to be made till by 1784 the amount in circulation had risen to 925,219 Rds. The notes were issued for amounts as small as two stivers, though, by the time of the British occupation, the lowest denomination in circulation was a skilling (6d.). The promise to pay specie for these notes was partially fulfilled in 1787, 1788, and 1789, when 825,904 Rds. were cancelled in exchange for specie and bills on Holland. This measure established the credit of the paper and made it easy for the Government to increase the circulation when, as happened immediately, the need again arose. At the surrender of the Cape to the British forces in 1795 the issues had risen to 1,291,276. Of this amount, 677,366 Rds. had been lent to individuals through the Lombard Bank, which was established by the Government with a paper money capital in 1793. This sum was secured by mortgages on the property of the borrowers. The Dutch East India Company was responsible for the balance of 613,910 Rds.

This forced increase in the supply of money naturally caused a fall in its value, though the extent of the depreciation is uncertain. A petition to the King by the inhabitants of the Cape in 1825 stated that these early issues passed in exchange with Holland at a premium of only 7½ per cent., which was regarded as about the equivalent of freight and insurance on specie. But this is the evidence of those who were trying to show that the calling down of the dollar to 1/6 was unjust. On the other hand, contemporary writers state that the paper money depreciated to the extent of 50 per cent. As usual when inflation occurs, the rise in prices was not uniform. Imported articles rose far more than local products, so that the farmers obtained only the customary prices for their produce, while they had to pay more for all they purchased. With the exception of meat and bread, all prices had risen enormously. The British Government, too, in deciding on the occupation of the Cape in 1795 to prevent it falling into the hands of the French, was influenced by the dissatisfaction which had been caused there by the Dutch East India Company's issue of paper in payment of their debts. In 1792 the Burghers had almost gone into revolt as a result of this grievance. When General Craig arrived at the Cape he reported that little specie was in circulation: paper money "might be procured at the rate of two for one of hard cash." This seems to be an exaggeration. The real depreciation, in terms of silver, at this time was probably about twenty per cent., the figure mentioned by General Clarke in October, 1795, though the quantity of silver paid out by the British might have had some influence in equalising values. This introduces the difficulty that in considering the fall in the value of the dollar at the Cape we have to deal with its depreciation in terms of commodities, of bills of exchange, and of silver which was then standard money all over the world. The depreciation measured in terms of any one of these need not be the same as the depreciation measured in terms of the others. Thus there is to-day no depreciation of the British coinage in terms of specie. But, owing to the excess of imports from America, it is depreciated in terms of bills of exchange. We shall see that in the later days of the cartoon, or paper, rixdollar, many held that its depreciation was solely an external depreciation. Again, the premium on specie is not an exact measure of the rise in prices.

When the British forces landed in 1795, attempts were made to obtain the good-will of the Dutch by showing that the English would maintain the value of the paper money, while the French could only exchange one paper for another. The commanders promised that they would recommend the British Government to use the property of the Dutch East India Company, of which a considerable part was detained in England, to liquidate the claims of holders. Their advice, however, was not acted upon. The Dutch Commander, Governor Sluysken, was fully aware of the dangerous condition of the paper currency, and was able to obtain the inclusion in the Articles of Capitulation of an agreement that

> the Lands and Houses, the property of the Dutch East India Company in this settlement, shall continue the security of that part of the money which is not already secured by Mortgages upon the Estates of Individuals by its having been lent to them.

The zeal of the Governor is shown by the use of "continue," for the notes had not been secured by anything but the good faith of the Dutch Company.

The arrival of the British forces at the Cape had an important effect on the value of paper money. The demand for local products was greatly increased. A year after the occupation, General Craig reported that the consumption of meat was two and a half times as great as it had been under the Dutch Government. Payment for military supplies was at first made by the import of silver coins which, it may be added, disappeared from circulation at once. Later, orders were given for payments to be made as far as possible in paper, which was purchased by the Paymaster-General for his bills on London at 25 per cent. advance. Either method of payment would result in a rise in prices or a depreciation of money relatively to commodities. But the sale of Government Bills on London checked the depreciation of money relatively to bills. The premium fell from 25 to 10 per cent., then to par. In April, 1797, General Craig reported that even at par no paper money could be obtained. He therefore ordered a further issue to be made of 250,000 Rds. Relatively to bills, the rixdollar was appreciating, but relatively to commodities the increased issues and greater rapidity of circulation caused a great rise in prices. Comparing prices in 1798 with those which existed under the Dutch Government, it is found that all prices had risen. Local products had mostly doubled or even more, while imported articles had also risen, though in a smaller proportion. This temporary alteration in the proportion was due, in part, to the fall in exchange. By 1798 bills were at a discount of 20 per cent.

The dangers of the paper money were realised in England. In 1796, when Lord Macartney was appointed Governor, he was instructed to hold an enquiry as to the amount of paper it might be safe to leave in circulation, and the best means of reducing issues. In October, 1797, he reported that the public property would not fetch a quarter of the amount supposed to be charged on it, and that some of the property could not be sold, as it was necessary for public purposes.

> The security [he said] of the lands and houses for the paper money is a mere illusion. In reality the paper money depends upon the credit and solidity of the Government alone.

This illustrates the statement of the textbooks on money, that securing issues on property is not sufficient to prevent depreciation. It will only be efficacious if it results in the limitation of the amount issued, and the same effect will be obtained however the limitation is made. The depreciation at the Cape was not caused by the fact that the security on which the paper was issued was inadequate. It would have been equally great if the mortgaged property had been four times as valuable as it was. Macartney thought that the issues on Government account, including the new issue of 250,000 Rds., were not more than sufficient for the internal trade of the country. The reduction should take place in the issues made through the Lombard Bank. He suggested that this might be done by transferring the mortgages to individuals. In this he was influenced by political ideas. Other countries had bound up the interests of the citizens with those of the State by making them its creditors : the Cape made them its debtors, and it was believed by many that a rebellion would wipe out these debts. Though not in favour of buying in the 250,000 Rds. issued by Craig, Macartney—in case the authorities in England thought it advisable—proposed a scheme for this purpose which showed a great ignorance of the causes that had brought about the depreciation. He suggested the issue of special coins containing one-fifth alloy, "which would probably not be worth while to export from hence." For that very reason, as the quantity of money would have remained the same, the depreciation would have continued. When Macartney's report arrived in London, England herself had an inconvertible paper currency. It is therefore not surprising that the War Office decided that no material alterations should be made in the Cape currency till the conclusion of peace. It agreed, however, to send out £5,000 in copper, as there was a great need of small change. No Government notes were in circulation of denominations lower than a skilling, and it had been found necessary to allow individuals to issue private notes for smaller amounts. On the arrival of the copper money, Sir George Yonge, who succeeded Macartney as Governor, ordered that the coins should be circulated at the rate of two pence or stivers for each copper to prevent their being exported. Hence the name of "dubbeltje" for the penny, a name which still survives in some places.

One of the misfortunes which attend an increase in the quantity of money is that once a higher level of prices has resulted, these come to be looked on as natural. The higher prices require, if they are to be maintained, the greater amount of circulating medium. In fact, it may even seem that there is not enough money in circulation to carry on trade with these prices. This happened at the Cape. In 1802 the Burgher Senate declared that serious inconvenience was experienced from the small quantity of money, and requested that more might be put in circulation through the Lombard Bank. Accordingly, 165,000 Rds. were printed and lent to individuals through the Bank, and an issue of 80,000 Rds. was also made to purchase grain. This latter amount was not intended to be a permanent addition to the money in circulation. A promise was given that it would be destroyed as soon as the grain had been disposed of to the public, but this promise was not kept.

When the Cape was given up to the Batavian Republic in 1803, the circulation had increased to 1,780,276 Rds. Prices had risen, but the depreciation relatively to bills had been reduced owing to the large remittances made for the support of the British forces. The large imports of silver had reduced the premium on specie to between five and ten per cent. Under the Republic the same principle of meeting part of the expenditure by the printing of notes was continued. The money was used for public purposes and to give relief to the inhabitants of Stellenbosch, where there had been a great fire. Then, as now, it seemed easier to raise money in this way rather than by increased taxation. But an increase in money does not cause an increase in commodities. The Government could only get the commodities it required by reducing the amount available for other purchasers. With its paper money it purchased some, and the money in the hands of the inhabitants necessarily purchased proportionately less.

When, in 1806, the Cape was again occupied by the British, the amount in circulation had increased to 2,086,000 Rds. The terms of the second Capitulation did not limit the powers of the British Government with reference to money to the same extent as the first agreement had done.

> The Paper Money actually in circulation shall continue current as heretofore, until the pleasure of His Britannic Majesty is known.

The expenditure on the British forces again caused a temporary rise in the external exchange value of the rixdollar. But the quantity of money was soon increased. In June, 1810, a proclamation announced that the currency would be increased by one million rixdollars, to be issued through the Lombard Bank. Of these, 500,000 Rds. were issued at once, and the balance in five instalments up to March, 1814. Depreciation continued. The average value of the rixdollar from 1806 to 1810 was 3/6, from 1811 to 1815 it was 2/6. By the end of 1813 the circulation had risen to 3,071,204 Rds., or almost £71 per head of the white population.

The effect of the increased issues first attracted the attention of the British Government during the administration of Sir John Cradock, who came to the Cape with instructions not to increase the issues without special authority. In February, 1814, a Finance Committee, appointed by Cradock to deal with the question, presented the following Majority Report:—

> 1. An excess of paper money exists, more than the commerce of the Colony requires.
>
> 2. An excess of paper money necessarily enhances the price of every commodity.
>
> 3. To counteract the evils arising therefrom, certain issues created for public purposes should be gradually destroyed.

Two members, the Receiver-General and the Secretary to the Colony, presented separate reports, which were opposed to the destruction of any of the money. They held that the increased prices were due to "augmented demand," though no explanation was given of how an augmented demand can operate except through an increased quantity of money or an increase in the rapidity of circulation. Both Cradock and the British Government agreed with the Majority Report. But a few months later Lord Charles Somerset became Governor. He consulted the Receiver-General and the Secretary to the Colony, who thought that the increase in paper money had made the people more wealthy. Of course, a rise in prices is never uniform. Dealers in the commodities which are the first to rise benefit from the better prices they obtain. But other classes suffer in equal proportion. The view was put forward, too, that increased issues had been necessary owing to the increased volume of trade. The same argument was used as long as issues were made. The notes scarcely circulated beyond Cape Town and the surrounding districts. In the frontier districts, business was carried on by barter or by private notes or bills of exchange, called "good fors," for small amounts. The evidence for or against an increased volume of trade where the notes circulated is inconclusive. Certainly the income tax figures, when allowance is made for the depreciation of money, do not show any expansion of trade after 1814, when this tax was first imposed. But the method of assessment was very defective. On the other hand, the returns of imports and exports show a great increase in the earlier years:—

Year.	*Imports.* Rds.	*Exports.* Rds.
1807	146,853	183,915
1810	659,315	644,319
1815	4,257,385	1,319,505
1820	3,414,336	2,142,753
1825	3,943,893	3,200,467

But even if there was a need for some increase in the circulating medium during the earlier years, the depreciation which took place shows that the increase was excessive. In any case there was such a fall in the volume of trade after the reduction of the garrison, that depreciation could only have been prevented by contracting the issues.

Somerset reported his disagreement with the findings of the Finance Committee. As practically the same discussions were going on in England at this time about the inconvertible paper there, naturally no attempt was made to enforce a reduction in issues in South Africa against the wishes of the Governor. But, though Somerset would not accept the recommendation of the Committee for a large reduction in the circulation, he only created 300,000 Rds., while a continuous destruction of small amounts resulted in a fall in the circulation to 3,099,204 Rds. by June, 1825.

In February of that year the Treasury in England had been considering the state of the currencies in all the British Colonies. It wished to introduce a fixed and uniform medium of exchange for all public payments. In all the colonies the Spanish dollar had generally been the money of account. Even if, as at the Cape, payment to the troops had been made in other money, its value was determined by reference to the Spanish dollar. Difficulty was being experienced in obtaining these, and the coin had ceased to possess the uniformity of weight and fineness which had established its circulation. The Treasury therefore thought it best to introduce English silver and copper throughout the Empire,

provided the same be made convertible, at the will of the holder, into the standard gold currency of the United Kingdom.

Thus came about an early experiment in the Gold Exchange Standard.

At the Cape, the average value of the rixdollar in bills on England had been 2/6 from 1811 to 1815. From 1816 to 1820 it was 1/10, and 1/6 from 1821 to 1825. In fixing exchange, the Treasury adopted the current value, and directed that the rixdollar, nominally worth 4/-, should be declared equal to 1/6 in British money. To prevent its falling below that value it was to be exchangeable, at the will of the holder, for bills upon the Treasury in London at the rate of £103 in value of rixdollars, computed at 1/6 each, for every £100 bill. As in the other colonies, bills were to be issued for silver at the same premium of £3 per cent. There was no intention to adopt compulsory methods to withdraw the paper currency, but money brought in for the purchase of bills was not to be reissued. In future, public accounts at the Cape were to be kept in British money. On 6th June, 1825, Somerset accordingly proclaimed that British silver should be legal tender at the rate of 1/6 for each paper rixdollar. This proclamation roused such an agitation that, pending the result of a petition to England, Somerset gave notice on 28th June that persons who wished to exchange British silver, received in payment of debts, for rixdollars, might do so at the same rate of one dollar for 1/6. The privilege was withdrawn in December, when it was found that the Treasury intended to adhere to its original decision.

All classes at the Cape protested against the calling down of the dollar, but naturally the ground of protest varied. There was, however, a general agreement that so long as the quantity issued had been limited, the value of the paper "was maintained without the prop of the precious metals," and that the subsequent depreciation was due to over-issue. The only objection that can be raised to this statement is that it was not recognised how early depreciation had set in. Most of the petitions went on to state that the proximate cause was the great excess of imports over exports. Now the Quantity Theory of Money shows that the value of money depends both on the quantity of money and the quantity of goods offered for sale. Other things equal, an increase in the quantity of goods would have resulted in a fall in prices or an appreciation of money. It was only because of the excessive issues that this result was not obtained. But it did operate to check the rise in the price of commodities, though the rise in the price of bills was accelerated Undoubtedly those were correct who stated that the internal depreciation had not been nearly so great as the external, if one confines attention solely to prices in South Africa. A point which seems to have escaped attention is that in a system of countries connected by commerce, one must deal not only with the forces operating in one country, but also with the more general forces which affect all countries. Now, this period of rising prices in South Africa was a period of falling prices in the countries with which the Cape traded. In 1800 the index number of prices in England stood at 235; in 1824 it was 147; in 1825 there was a temporary rise to 172, but thereafter there was a steady fall. Where trade is established, prices tend to move in the same direction, so, in the absence of an inconvertible and excessive currency, prices, instead of rising, would have fallen in South Africa. The internal depreciation was therefore much greater than appeared.

It was generally said in the petitions that the calling down of the dollar to 1/6 had reduced the wealth of the colonists to three-eighths of its original amount. Obviously this is simply the old confusion between money and wealth. So far as internal trade was concerned, if a man sold his goods for 1/6 instead of 4/-, he also bought at the same rate. The actual commodities remained the same as before. In external trade the dollar had in any case to be given to obtain 1/6 abroad. The evil lay in the depreciation of the money, not in the official recognition of that depreciation. The only just ground of complaint was the additional charge of 3 per cent. on bills. This, however, was soon reduced to 1½ per cent., as the charge was merely meant to cover costs. Some of the merchants recognised that the depreciation, and not the recognition of it, had been the evil, and, when the proposal was made to compromise by fixing the value at 2/-, they pointed out the dangers to trade of any further fluctuations in value.

Dr. Theal has suggested that the calling down of the dollar was disadvantageous to creditors, but advantageous to debtors. In view of the long period during which the dollar had been worth only 1/6, most contracts which were still current in 1825 must have been made at about this rate. To have fixed on any other rate would have involved far more injustice. In any case the general argument applies, that the evil consisted in the depreciation.

In May, 1826, the Treasury issued its decision on the petitions. It was pointed out that the debt had been contracted for purely colonial purposes, and could not be a charge upon the public funds of Britain. Any claim the holders had could only be against the Colonial Government. The burden of meeting it would fall on the landed proprietors and capitalists, who were the chief complainants. The Treasury therefore concluded to make no alteration in its decision.

Some of the rixdollar notes were exchanged for silver and for sterling notes, *i.e.*, paper money, of which the value was expressed in British money. But a considerable quantity remained in circulation until, in March, 1836, it was decided to withdraw them from circulation. The holders were given until 30th July to have them exchanged. But long after this a dollar continued to mean 1/6 in South Africa, often to the great confusion of newcomers. The value of the sterling notes was maintained by the Gold Exchange system in the same way that had been adopted for the rixdollars. They could be exchanged at Cape Town for bills on the Treasury at the rate of £101 10s. for a bill of £100. Sterling notes to the value of £202,698 were issued between 1832 and 1839. By 1843 the issues had been reduced to £71,086. In this year the British Government decided to rid itself of its liability on the Cape money. Accordingly, on 9th November, 1843, it was announced that the right of receiving bills on the Treasury for silver or sterling notes was withdrawn. Holders of notes were permitted to exchange them for specie or for Government 5 per cent. debentures.

The remainder of the subject can only be briefly dealt with. Since the conversion of the sterling notes the paper money at the Cape has been bank money, though the Free State and the Transvaal have since suffered from over-issues of inconvertible paper money by their Governments. The present Bank Act was passed as a result of the great crisis of 1890-1, which commenced with the insolvency of the Union Bank in July, 1900. Other failures quickly followed. These so shook the confidence of the public that, in country districts, payments in the notes even of the sound banks were refused. It was obvious that some regulation must be placed on note issues in the interests of the public. It will be sufficient to deal with the provisions of the Cape Act, as legislation in Natal, the Transvaal, and the Orange Free State followed the same lines. Banks which wish to issue notes must deposit with the Treasurer Government securities of which the par value is equal to the amount of the intended issue. The total sum which may be issued by a bank is limited to the amount of its paid-up capital and reserve. If a bank suspends payment on its notes, the Treasurer is to appoint a place at which "the same shall be paid in gold as presented by and for the account of the Government." The Treasurer, in the event of a bank's default, may sell the securities deposited, and has in addition a first lien upon all the assets of the bank. A halfpenny duty is charged on each note issued, and a tax of 10/- per cent. is levied each half-year on the notes in circulation. Before the war, only notes of £20, £10, and £5 had any wide circulation. Recently an attempt has been made to popularise the £1 note, and at least one bank intends to issue 10/- notes.

Recently the Bank Act has been subject to much criticism by those who wish to see a great increase in the use of paper money. Everyone will admit that we use too much gold, and that a great economy could be effected by the more general use of notes or cheques; but it does not follow that any radical alteration in the Bank Act is required at present. Those who demand it seem to forget that a much larger amount can be issued even under the present regulations. What is required at present is not so much a change in legislation as the education of the public in the use of paper. The history of paper money in this country shows how easy it is for over-issue and depreciation to occur unless there are stringent restrictions. Bankers, if they are opposed to the Act at all, usually confine their criticism to the regulations which require a double reserve, the compulsory reserve of Government securities against the total issue, and the reserve of gold which ordinary banking prudence requires. Government securities, in the past, have not given such a high rate of interest as the usual banking investments. It may therefore be admitted that if the necessity for this double reserve were removed, the banks could afford to pay a slightly higher tax on their note issues. But it is desirable that economy in the use of gold should be obtained by the wider use of small cheques rather than by a very great increase of notes. The cheque, as it may be drawn for odd amounts, is more efficient than the bank-note as an economiser of coin. Further, banking experience shows that cheque money requires a smaller gold reserve than note money does. France has recently discovered this. A few months ago the public there were requested to use cheques as far as possible in place of notes. On this ground I cannot agree with those who wish to see a great change in our banking legislation. Certainly the soundness of our currency position will be of great advantage to South Africa when other nations are experiencing a crisis at the end of the war.

AMMONIACAL SUPERPHOSPHATE.— Gerlach, in the *Zeitschrift für angewandte Chemie* (1916), 13-14, states that ammonia gas, on passing over superphosphate, is readily absorbed by the fertiliser with production of heat, one molecule of monocalcium phosphate absorbing four molecules of ammonia. This ammonia is not liberated from the superphosphate on keeping, even after several months, and produces a fertiliser in no way inferior to a mixture of superphosphate and sulphate of ammonia.

EXPERIMENTS WITH THE SUGAR BEET IN SOUTH AFRICA.

By Charles Frederick Juritz, M.A., D.Sc., F.I.C.

The sugar beet (*Beta vulgaris*), as we know it to-day, containing up to 20 per cent. of sugar, has developed entirely within the last century and a half. It was in 1747 that Marggraf, a German chemist, published the fact that the root of *Beta maritima* contained sugar. Its sugar content was then no more than 2 to 3 per cent. on an average, but careful cultivation has little by little augmented it, and so out of the maritime beet plant investigated by Marggraf has grown the variety, rich in sugar, which is now considered as a distinct species. Vilmorin introduced it from Germany into France in 1780; in 1827 it began a new industry in Belgium, and then spread over the greater part of Europe. More recently beet culture has been undertaken in Canada, the United States, and New Zealand.

Nearly twenty years ago a few samples of sugar beet, grown in the Sterkstroom Division of the Cape Colony, were analysed in the Cape Government Laboratories, and yielded results which compared very favourably with the best yields of Germany and Victoria. In 1905, in a paper read by me before Section B of the British Association,* I suggested the experimental cultivation of sugar beet in some parts of the Colony where the lack of lime is an obstacle to successful fruit culture. During the next five years beets grown at Woodstock, Tulbagh, Worcester, Caledon and Port Elizabeth were analysed, and although in some cases the sugar content was low, in others good results were obtained, practically up to the maximum (17.80 per cent.) of the Sterkstroom results. Five years later, in a paper printed in the *Cape of Good Hope Agricultural Journal*,† I pointed out that, few though the experiments had been, they had sufficed to show that beet containing a high percentage of sugar *could* be grown in South Africa, and that the questions remaining to be decided were: Where can we grow it to best advantage? and, Can we produce sufficiently large crops? On the other hand, from the commercial standpoint, assuming the availability of the requisite acreage and capital, would not some other crops be likely to shunt the beet on account of greater ease of cultivation and more abundant profit, and, in that case, would not capital then straightway be diverted into the new channel? These questions have not yet been satisfactorily answered.

In 1912 the subject of "Sugar Beet Investigation in the Cape Province" was again discussed by me,‡ when further details were added regarding cultural experiments and chemical

* Addresses and Papers, Brit. & S.A. Assoc. for Adv. of Sc., S. Africa (1905), 1, 229.

† (1910), 37 [11], 501-508.

‡ *Union Agric. Journ.* (1912), 3 [6], 767-777.

work carried out subsequent to the previous publication. In the Grahamstown branch of the Cape Government Laboratories investigations had been begun in 1905, and, in addition to those above mentioned, samples from Kingwilliamstown, Bedford, Albany and Graaff-Reinet had been chemically examined, and the practical growing of beet had been the subject of preliminary investigation in the Molteno and Knysna districts as well as on the Cape Flats, and at that stage the matter remained. Dr. Nobbs, who had initiated the practical experiments, left the Cape Service, and his experiments came to an end. They had shown all the more clearly that the country was capable of producing good sugar beet, but the problem that still remained unsolved was whether beet crops of high sugar content can be grown in sufficiently large quantities to make sugar extraction commercially profitable.

The purpose of the present paper is to record further experiments that have been carried out subsequently to those previously mentioned.

In September, 1911, three samples of sugar beet grown in the Eastern Districts were analysed, but yielded only small proportions of sugar, being apparently not yet properly matured. The figures were as follows:—

No. of Roots.	Description.	Average Weight. ozs.	Sugar. per cent.
3	Small, taper	$2\frac{3}{8}$	7.68
10	Medium, forked	10	3.04
2	Large, taper	24	7.20

During April, 1912, two further samples of sugar beet, experimentally grown by the Government Agriculturist in the Humansdorp District, were examined, and these, too, were apparently immature, as the following results show:—

Variety.	Sugar. per cent.
Vilmorin's improved white sugar beet	5.84
Danish improved sugar beet	9.30

Privately conducted experiments in sugar beet cultivation in the Eastern Districts gave much higher figures. Samples of beets were taken at intervals of a month, beginning about the middle of April, 1912, and yielded the following percentages of sugar:—

	Per cent.
Sample taken in April	16.64
Sample taken in May	14.02
Sample taken in June	17.46

In each of these cases the analysis represents an average of five to eight beets.

Four months later analyses were made of beet from the same source as the last, but grown in the winter season. Two separate lots were analysed, and gave respectively 7.31 per cent. and 8.93 per cent. of sugar, but another sample taken in November, 1912, showed 16.70 per cent. of sucrose, while one collected in December yielded only 7.58 per cent.

The last sample from the Eastern part of the Cape Province was taken in March, 1914, and yielded 10.3 per cent. of sugar.

There has been a fair amount of mangold cultivation in South Africa, and in the success or otherwise of this in any locality we have already an index to the suitability of the local conditions for sugar beet cultivation. C. A. Hawkes, in a concisely written article on "The Beet Sugar Industry,"* says:

> It will be well to remember that the sugar beet and the mangold belong to the same species (*Beta vulgaris*) and that the characteristics, requirements, and treatment of the two crops are very much alike. The ideal sugar beet soil is a nice deep friable loam, but successful crops can be obtained on almost any soil that will produce a fair crop of mangolds, providing there is sufficient depth. It is characteristic of beet cultivation that it greatly improves the fertility of all soils, particularly those of a poor quality, such as very light sands.

It may therefore be instructive to record here the results of some analyses of mangolds that were performed in the Grahamstown Laboratory during 1913 and 1914. The plants were grown at the Government Agricultural School at Grootfontein, and the 1913 set had been collected about three weeks before the analyses were undertaken. They represented the following varieties:—

1. Golden Tankard.
2. Yellow Globe.
3. Orange Globe.
4. Mammoth Long Red.
5. Giant Half Sugar White.

In addition, a sugar beet grown at the same time and place was examined, and is numbered 6 in the following table of the analytical results obtained from samples collected in July, 1913.

	1.	2.	3.	4.	5.	6.
Water %	86.24	88.19	86.91	85.20	87.11	67.11
Ash %	1.41	1.57	1.28	1.24	1.55	1.63
Fat %	.078	.108	.052	.041	.046	.048
Crude Fibre %	.75	.78	.74	.76	.85	1.46
Proteins %	1.69	1.76	2.01	1.54	1.84	2.80
Carbohydrates, excluding Crude Fibre, % ..	9.83	7.59	9.01	11.22	8.61	26.95

The percentage of sugar in No. 6 was 18.28. This sample showed an exceedingly low proportion of water. The average percentage in sugar beet, according to analyses conducted in other parts of the world, appears to be 81, and the extreme limits of variations recorded are a maximum of 88 and a minimum of 75.† The Principal of the Grootfontein School of Agriculture was unable to account for the low percentage of water in the sugar beet, but pointed out that, unlike No. 6 of

* *Journ. Chem. Technology* (1915), **2** [3], 109.

† Average of 76 analyses. König: "Chemie der menschlichen Nahrungsmittel" (1903), **1**, 761.

the above-mentioned samples, sugar beet is not, as a rule, grown in countries where atmospheric moisture is very low for the greater part of the year. It was, however, difficult to see why this condition should have affected the beet crops, and the enquiry has not been pushed any further.

In April, 1914, another series of mangold samples from the same locality was collected. On analysis these yielded the following results:—

	1.	2.	3.	4.	5.
Water %	94.46	93.00	92.06	91.54	91.09
Ash %	1.69	1.32	1.28	1.30	1.37
Fat %	.053	.051	.068	.067	.056
Crude Fibre %	.71	.98	.78	.88	.96
Proteins %	1.00	1.39	1.11	1.30	1.60
Carbohydrates, excluding Crude Fibre %	2.69	3.26	4.70	4.91	4.92

These samples all contained more moisture than those taken nine months earlier, and consequently lower percentages of solid constituents. Particularly is this noticeable in the case of the carbohydrates (consisting almost wholly of starch and sugar). Of these the fresh April mangolds contain only about half as much as the fresh July mangolds; and if we calculate what the quantities of these constituents in the mangold would be after the latter has been completely dried, some rather interesting results are obtained. These are given below:

Samples collected in July, 1913.

	1.	2.	3.	4.	5.
Ash %	10.25	13.29	9.78	8.38	12.02
Fat %	.57	.91	.40	.28	.36
Crude Fibre %	5.45	6.61	5.65	5.14	6.59
Proteins %	12.28	14.90	15.36	10.47	14.27
Carbohydrates, excluding Crude Fibre, %	71.37	64.27	68.83	75.81	66.80

Samples collected in April, 1914.

	1.	2.	3.	4.	5.
Ash %	19.68	18.86	16.12	15.37	15.38
Fat %	.96	.73	.86	.79	.63
Crude Fibre %	12.82	14.00	9.82	10.40	10.77
Proteins %	18.05	19.86	13.98	15.37	17.96
Carbohydrates, excluding Crude Fibre %	48.56	46.57	59.19	58.04	55.22

It is again strikingly noticeable that the carbohydrates other than crude fibre (*i.e.*, starch and sugar) are considerably higher in the July than in the April samples, indicating the change that takes place during three months, on the assumption that the 1914 crop had been sown at a time of the year corresponding to that for the 1913 crop. On the other hand, there is a diminution of cellulose (fibre), of proteins, and of mineral or ash constituents. From this general increase in carbohydrates in mangolds one may infer a simultaneous increase in cane sugar in sugar beet, but whether this latter increase is accelerated during certain months more than during others, what the period of growth of the plant is during which its maximum sugar content is attained, and whether there is an optimum sowing time if we would reach the maxima for both curves of increase simultaneously, are all points which still remain to be investigated, as well as the possibility of their being more marked in some districts than in others.

The average composition of mangolds has been recorded as follows*:—

	Large roots.	Medium roots.	Small roots.
Water %	89.5	88.0	86.5
Ash %	1.4	1.1	.9
Fat %	.1	.1	.1
Crude Fibre %	1.0	.9	.8
Proteins %	1.3	1.2	1.1
Carbohydrates, excluding Crude Fibre %	6.7	8.7	10.6

Large roots are more watery, richer in nitrogenous substance and crude fibre than small ones. One half of the ash constituents of mangolds consist of potash—that is to say, from .5 to .7 per cent. of each fresh mangold root is pure potash, so that a harvest of 10 tons per acre removes from the soil from 100 to 140 lb. of potash per acre. This reasoning may also be applied to sugar beet. Moreover, about one-seventh of the ash constituents of mangolds consist of soda,† so that a 10 ton harvest on an acre of soil needs about 30 to 40 lb. of soda for its development. In this connection one may note with interest that mangolds are "one of the few crops which are benefited by applications of common salt to the soil, and, perhaps for this reason, grow well on land near the coasts."‡ They yield very heavy crops on a deep, somewhat loamy, soil, with abundant nitrogenous manuring. On the other hand, the same author points out§ that for sugar beet "Nitrogenous manuring must be only sparingly done, or the roots become watery and deficient in sugar."

It remains to record the results of some experiments in sugar beet culture carried out, under the auspices of the Department of Mines and Industries, by Mr. E. T. L. Edmeades, of Pinehurst, Oudtshoorn, during the 1915-16 season, in the western coast belt districts of the Cape Province. These experiments are still in their initial stage, but it is hoped that they may develop into the investigation recommended by me in my earlier papers on the subject. During 1915 Mr. Edmeades imported different varieties of sugar beet seed from the well-known firm of Vilmorin, of Paris. He distributed this seed amongst about a dozen farmers in the Divisions of George, Mossel Bay,

* Thorpe: "Dict. of Applied Chemistry" (1912), 3, 397.

† König: "Chemie der menschlichen Nahrungsmittel" (1903), 1, 751.

‡ H. Ingle, in Thorpe's "Dictionary of Applied Chemistry," 398.

§ Thorpe, *op cit.*, 1, 435.

and Knysna, in order to ascertain the possibility of growing on a large scale sugar beet yielding sufficient sugar to warrant the erection of a mill. Planting was commenced about the middle of August and continued during September, in order to ascertain the most favourable time for planting. In addition to distributing the seed amongst farmers, Mr. Edmeades personally put an acre of his own lands in the George Division under beet during August, and another acre during September.

Towards the end of February, 1916, Mr. Edmeades furnished for analysis four lots of six beets, each representing four varieties of beet sown by him six months previously on his farm "Kraaibosch," 2½ miles south-east of George Town Hall. The soil had been fertilised by means of sheep-kraal manure, potassium chloride, and 300 lb. of basic slag per acre. The varieties of sugar beet grown were:—

I. French very rich white.
II. Vilmorin A.
III. Vilmorin B.
IV. Klein Wanzelebener.

The exporters claimed that No. 4 is capable of yielding 18 to 20 tons of beet per acre, with a sugar content of from 14 per cent. upwards.

The average weights of the beets taken in February were as follows:—

I. 3 lb. 5½ oz., or 1517.9 grammes.
II. 3 lb. 1 oz., or 1390.6 grammes.
III. 2 lb. 12¼ oz., or 1254.6 grammes.
IV. 3 lb. 0 oz., or 1359.9 grammes.

In each of these classes the beet nearest to the average weight of the class was taken and divided into two portions; one portion (*a*) representing all the external part of the beet to a thickness of approximately one inch, while the other portion (*b*) represented the inside part after removal of (*a*). Each of these portions was then separately mashed up and analysed. The following results were thus obtained:—

Class.	Weight (grammes).	Water per cent.	Ash per cent.	Cane Sugar (Sucrose) per cent.	Total sugar (calculated as Sucrose) per cent.
I (*a*) ...	1324.2	80.90	1.43	14.44	15.87
I (*b*) ...		83.46	1.50	14.44	15.25
II (*a*) ...	1597.7	77.58	1.29	17.90	19.70
II (*b*) ...		—	1.23	17.90	18.98
III (*a*) ...	1297.0	77.38	1.40	16.75	18.50
III (*b*) ...		78.65	1.54	15.59	17.05
IV (*a*) ...	1214.9	—	1.46	17.90	19.60
IV (*b*) ...		—	1.14	18.48	19.65

The above selection of one beet, of approximately average weight, from each of the four varieties naturally left the remaining five beets in each class divided into two sections, one section (*c*) consisting of beets under the average weight, and the other section (*d*) of beets over the average. The beets belonging to each section were then minced up together, and each section separately analysed as one sample. Thus the following results were obtained:—

Class.	No. of Beets.	Average weight (grammes).	Water per cent.	Ash per cent.	Cane Sugar (Sucrose) per cent.	Total Sugar (calculated as Sucrose) per cent.
I (*c*) ...	3	1236.2	—	—	14.44	16.54
I (*d*) ...	2	2037.1	82.72	1.44	12.70	—
II (*c*) ...	3	992.5	—	1.15	17.32	18.54
II (*d*) ...	2	1884.2	82.91	1.23	12.70	14.97
III (*c*) ...	4	1023.6	78.52	1.20	—	18.85
III (*d*) ...	1	2136.3	80.78	1.09	—	17.03
IV (*c*) ...	2	886.9	81.71	—	—	16.98
IV (*d*) ...	3	1723.5	79.83	1.27	—	17.47

The results in the above two tables bear out the generally accepted view that small beets contain more sugar than large ones of the same class. The best all-round results are those of Classes II and III, which, it will be noted, do not show a high moisture content.

The average results obtained from the four classes of beet are set forth in the following table:—

Class.	Water per cent.	Ash per cent.	Cane Sugar per cent.	Total Sugar per cent.
I	82.37	1.46	14.01	15.89
II	80.25	1.23	16.46	18.05
III	78.83	1.31	16.17	17.86
IV	80.77	1.29	18.19	18.43

In this table of averages, allowance must of course be made for the fact that in Classes III and IV there were only two determinations of cane sugar made, and in each case only in one beet. In Class IV the average percentage of cane sugar would certainly have been lowered by determinations in respect of IV*c* and IV*d*.

A second lot of beets of Class II, sown early in September, 1915, was supplied by Mr. Edmeades in March, from the farm "Gwaayang," 6½ miles south-west of George. This soil had had a little irrigation, and had been treated with cow manure. All the beets composing this lot were cut up together and analysed as one sample, the resulting percentages of cane and total sugar being respectively 18.91 and 20.59.

These records may justly include some reference to a few chemical investigations made in the Laboratory at Cedara, Natal, prior to Union. In 1907 roots of the Klein Wanzelebener and White Vilmorin varieties, grown at Inchanga, were harvested there, and the following results were obtained from them by analysis:—

Variety.	Average weight of Root. oz.	Water per cent.	Sugar per cent.
Klein Wanzelebener	28	82.04	13.72
White Vilmorin	—	81.38	13.36

Another set of samples, grown at the Central Experiment Farm, Cedara, gave the following results:—

Variety.	Average weight of Root. oz.	Water per cent.	Sugar per cent.
Cooper's Silesian	46	75.09	16.22
Klein Wanzelebener	52	78.96	12.43
Klein Wanzelebener	59	81.54	10.27
French very rich	21	79.36	11.24
Cooper's Imperial green top	44	86.01	8.91
Pink top half sugar mangel	53	87.89	7.38

In each case, it is stated,* medium-sized roots were chosen for analysis, as likely to represent an average crop. These were grown on vlei land heavily manured with kraal manure. With the exception of Cooper's Silesian, the roots were regarded as not perfectly matured.

Later in the season further samples of roots from other localities were analysed. The results obtained were as follows:—

Locality	Variety.	Average weight of root. oz.	Water. per cent.	Sugar. per cent.
Camperdown ...	Klein Wanzelebener	45	76.45	15.74
Inchanga	,, ,,	—	82.04	13.72
Thorny Bush ...	,, ,,	60	79.84	11.94
Inchanga	White's Vilmorin	31	81.38	13.36

It will be seen that in several instances the percentage of moisture is no higher than in the samples analysed at Capetown and Grahamstown.

If any part of South Africa is going to become a beet-producing country, it is clear that we have much to learn on the subject of beet culture and its adaptability to our conditions. Cultivation in Europe has greatly altered the chemical composition of the sugar-beet, as I have pointed out on former occasions. But cultivation has not only altered its sugar content. Ingle, in Thorpe's "Dictionary,"† says that "the proportion of ash is much lower than formerly, and the quantity of potash is only about half of what it was, while the soda has doubled." These are important points: with potash rendered a scarce commodity by the war, the potash requirements of a crop need

* *Cedara Memoirs*, **2**, 115.

† *Op. cit.*, **1**, 435.

careful watching, and with brack soda soils waiting to be cultivated, a crop capable of substituting soda for potash is worth keeping in view, especially as mangold ash contains unusually large proportions of chlorine, and "beets, being the descendants of a maritime plant, are found to be benefitted by applications of common salt to the soil in which they are grown."* Leach,† quoting Monier, states that 82.2 per cent. of the raw sugar-beet ash consists of the carbonates of potassium and sodium, and that potassium and sodium sulphate, together with sodium chloride, make up 11.1 per cent.

The whole matter is not one that can be taken up and settled off-hand; it is one of the many points points in which careful chemical investigation is needed, and all through the line of investigation this one thread of thought should twine itself: How are the needs and requirements of the crop responded to by the meteorological, agronomic, and other local conditions of South Africa, and is it possible to bring these into perfect correspondence with each other? Questions such as these are being studied in other lands; the Secretary of Agriculture of the United States mentions those investigations in more than one of his reports.‡

In his report for the year 1911 the United States Secretary of Agriculture urges the establishment of

> a system of well-equipped field laboratories in the beet-growing regions, where studies in pathology, breeding and agronomy can be carried out in close contact with the fields.

He adds that two additional laboratories of this kind had been started during that year. Later on, he says:—

> A representative of the Department has been sent to visit the beet fields and experiment stations of Germany, France, and Russia, with a view to adapting their practices to American conditions.§

It is to be hoped that the tentative investigations begun in South Africa years ago will soon be taken up in earnest and result in definite information on a comprehensive scale. There is the more reason for this because the cultivation of sugar-beet would be with us, as in the United States, an imported industry. The industry was transplanted from Europe, where it was first developed, into the United States, "where the basis of labour costs and farm methods are quite different from those of Europe. Therefore American beet-growers must work out many problems in adjusting their cultural practice to their labour, soil, and climatic conditions."‖ South Africa, too, has differences from

* Thorpe: "Dict. of Applied Chemistry," 1, 435.

† "Food Inspection and Analysis" (1913), 569.

‡ Year Book, Dept. of Agr., U.S.A. (1908), 13, 443; (1909), 77. See also U.S. Dept. of Agr. Report No. 92, "Progress of the Beet Sugar Industry in the United States in 1909."

§ Year Book, Dept. of Agr., U.S.A. (1911), 57, 58.

‖ H. B. Shaw: "Sugar Beets: Preventable losses in culture," U.S. Dept. of Agriculture, Bull. No. 238; July 14, 1915.

European conditions, and in South Africa, too, the necessary adjustments have to be made. This can only be done thoroughly when the effects of those differences on beet production have been properly studied. Even in the United States there is much to be learnt in this respect; for instance, the investigator last quoted points out that variations in soil and methods are not enough to account for the great discrepancies in yield everywhere to be observed, and this he illustrates by saying that "within a small area under similar soil conditions, with identical climatic conditions and employing like methods, one may find a farmer rejoicing as he hands 20 tons of beet from each acre to the factory, while his neighbour is almost too discouraged to load his pitiful seven or eight tons into his wagon."* No more need be added to emphasise the desirability of conducting investigations on our own account, both to ascertain what variations in yield are likely to occur within this country, as well as to discover and deal with the causes of such variations.

To illustrate the need for investigation, I may refer to what happened in Australia twenty years ago. There were two parties in Victoria relative to the sugar-beet question. One urged careful investigation and the testing of different parts of the country, in order to determine the best locality for the establishment of a sugar-beet industry. The other party was in favour of the immediate erection of a big factory. The Government advanced £62,000. The factory was put up, and it was capable of dealing with 400 tons of roots per day. Thus, a 100-day season would have meant 40,000 tons of roots. Only 9,000 tons were forthcoming during the first year and 6,000 in the second. The result was that the Government foreclosed.†

As already stated, many of the samples, whose analyses are recorded either herein or in my earlier papers, were grown by private enterprise—*i.e.*, without any Government control or supervision, and so the information that would make the chemical analyses valuable was largely lacking. The differing percentages of sugar found may be due to a variety of causes: the seed, the locality, the time of sowing, the season, the treatment of the plants during growth may singly or collectively contribute to great diversity in the yield of sugar, and if definite results are to be arrived at, of value to the whole community, all contributing factors must be closely noted, and as the cultural experiments from different localities and under varying circumstances should be co-ordinated, if instruction is to be gathered from the whole, it is clear that none but a central and far-reaching authority like the Union or Provincial Government can do this with any hope of success.

The chemical analyses of beet and mangolds grown in the Eastern Districts, and referred to in this paper, were carried out

* *Loc. cit.*, p. 2.

† A. N. Pearson: "The Sugar Industry in Victoria," and "Cedara Memoirs," 2, 107.

in the Grahamstown Chemical Laboratory chiefly by Mr. E. V. Flack; those connected with Mr. Edmeades's experimental cultivation were performed in the Capetown Laboratory by Mr. G. F. Britten.

TRANSACTIONS OF SOCIETIES.

Geological Society of South Africa.—Monday, July 3rd: P. A. Wagner, B.Sc., Ing.D., President, in the chair.—"*An interesting outlier of Karroo rocks to the north of Olifantsfontein Station, on the Germiston-Pretoria Railway*": Dr. P. A. **Wagner.** The outlier appears to have completely escaped previous notice by geologists, and, apart from its geological interest, is of great economic importance in containing what are perhaps the most valuable clay deposits hitherto discovered in South Africa. These clays are characterised physically by great refractoriness, and are fire-clays in the strictest sense of the term, the purest of the deposits being equal in fire stability to the very best English and American clays.

Monday, September 11th: P. A. Wagner, B.Sc., Ing.D., President, in the chair.—"*Notes on the geology of Natal*": Prof. E. H. L. **Schwarz.** The correlation of red arkoses and micaceous sandstones of Natal with the Table Mountain sandstone was discussed. The author considered it advisable for the present to regard the red sandstones of Natal as a separate formation, which he proposed to name the Clairwood sandstones. Dwyka conglomerate overlies all the older beds, granite, gneiss, marble, and sandstone as a boulder clay, with well-marked glaciated boulders, lying in considerable numbers round Port Shepstone. Immediately overlying the Dwyka conglomerate are beds which the author termed Ecca shales, although they have nothing in common with the Ecca beds of the Cape Province; in fact, the Karroo beds of the Cape Province proper suffer a distinct change to the East of the Kei River, and when dealing with those eastern deposits, the terms Umsikaba, Kentani, and Idutywa beds may well be substituted for Ecca, Lower and Upper Beaufort beds.

South African Society of Civil Engineers.—Wednesday, July 12th: W. Craig, M.I.C.E., Vice-President, in the chair.—"*Notes on railway construction during the* 1914-1915 *campaign in German South-West Africa*": Major A. J. **Beaton.** The author explained the organisation of the Reconstruction Section of the South African Engineer Corps, and then proceeded to outline the work performed by the corps during the campaign. The methods adopted for landing rolling stock, rails, and sleepers were first described. A short account was next given of the four classes of railways in German South-West Africa and the British territory at Walvis Bay at the commencement of hostilities. Then the nature and extent of damage done to the permanent way and bridges by the enemy was described, and the method of repairing these damages was explained. The author also dealt with the conversion of gauge of the Otavi Railway, 418 miles in length, and gave an account of the new railways which were constructed in order to facilitate the military operations, recounting the difficulties of water supplies and sand dunes that had to be overcome, and the land mines which had been laid by the enemy.—"*The survey and construction of the Prieska-Kalkfontein Railway*": N. K. **Prettejohn.** The construction of the line was decided on as a military necessity shortly after the outbreak of war. The distance covered is 315 miles, together with 20 miles of sidings. The survey was started within a fortnight of the outbreak of war, and staking was proceeded with at the rate of 3.4 miles per day. The construction of the entire length of line was completed in a little over ten months.—"*Notes on plate-laying and ballasting on the Volksrust-Heidelberg Section of the Charlestown-Johannesburg Railway*": A. J. **Humby.** The construction was carried on in 1894-6. The author gave a brief account of the ballasting and laying of the track.

Wednesday, August 9th: Prof. A. E. Snape, M.Sc., A.M.I.C.E., M.R.San.I., President, in the chair.—"*Railway water supplies, with special reference to Vryburg-Bulawayo section*": A. H. **Wallis.** After a short discussion of the effects of various saline constituents of water on locomotives, the author detailed a number of chemical analyses of waters used on the Vryburg-Bulawayo Section of the South African Railways and gave some account of practical experience of the use of some of these waters and of the treatment applied to them. The subjects of water storage, evaporation, and percolation and absorption by the soil were also discussed.

Royal Society of South Africa.—Wednesday, July 19th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*On* Pelodrilus Africanus, *a new Haplotaxid from South Africa*": Prof. E. J. **Goddard**. The species constitutes the first representative of the family Haplotaxidæ recorded from South Africa. The specimens were obtained in mud on Sneeuw Kop, near Wellington, Cape Province, at an elevation of 5,000 feet above sea level. The length varies from 20 to 40 mm.—"*Note on* Polysaccum crassipes, *a common fungus in Eucalyptus plantations around Pretoria*": Dr. P. A. **van der Byl.** *Polysaccum crassipes* is so common in eucalyptus plantations around Pretoria that it appeared interesting to determine in what relation it stood to the eucalypti. The author dealt brieflly with the morphology of the fungus, and suggested that the relation between the fungus and host is one of symbiosis.

Wednesday, August 16th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*The Granite of the Schapenberg, Somerset West*": A. R. E. **Walker.** The granite of the Schapenberg is essentially a gray, biotite-granito-porphyry, intrusive in fine-grained, argillaceous grits of the Malmesbury series. It is essentially an apophysis of one or other of the two large granite masses which occur, the one to the west, and the other to the east, of the Schapenberg. Both fine and medium-grained varieties occur. At certain points along the contact the granite, owing to absorption of material from the invaded formation, is andalusite-bearing.—"*On the Radial Lines in Röntgen Interference Patterns*": J. S. **van der Lingen.** The author briefly discussed the theory of radial lines, and pointed out that on Friedrich's assumption these lines ought to be present in all interference patterns. Experiments were described, which support the view that radial lines are caused by weakening of the lattice of a rigid crystal. The patterns of $Mg(OH)_2$, where the water molecules were driven off, and of re-sublimed iodine were exhibited. The pattern of this iodine shows the transition stage from a three-dimensional grating to a two-dimensional grating. MgO from $Mg(OH)_2$ shews the two-dimensional grating only.—"*Some Observations on* Ozobranchus branchiatus": Prof. E. J. **Goddard.** An account was given of the Leech—*Ozobranchus branchiatus.* Some historical interest attaches to the form, inasmuch as it was probably the first Annulate noted in the Australasian region. The somite is represented in a very primitive condition. The author dealt with the constitution of the somite in the various regions of the body, and the conclusions to be thence derived.

Wednesday, September 27th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*On some stages in the Life History of Gnetum*": Prof. H. H. W. **Pearson** and Mary R. H. **Thomson.** An account was given of an investigation of the ovule and embryo-sac of *Gnetum africanum* (West Africa) and *G. Gnemon* (Ceylon); the material studied included also *G. Buchholzianum* (West Africa) and *G. scandens* (Poona, Darjeeling, Penang, Singapore) and two species of doubtful identity, one from Singapore and one from Java.—"*The Theory of Automatic Regulators*": Prof. H. **Bohle.** Automatic regulators may be classified as sluggish and fast regulators. The theory of each form of regulator was explained.—"*Variation in the Mylabridæ illustrating a new Theory of Evolution based on Mendelism*": Dr. T. F. **Dreyer.**

FOREST PROGRESS IN THE DRAKENSBERG.

By John Spurgeon Henkel.

(*With two text figures.*)

The publication in the *Annals of the Natal Museum* of the two papers by Professor Bews, namely, "The Vegetation of Natal" (May, 1912) and "An Œcological Survey of the Midlands of Natal, with special reference to the Pietermaritzburg District" (August, 1913), has stimulated interest in the general question of œcology.

The writer, during the month of March last, visited the portion of the Drakensberg situated in the neighbourhood of Normandien, Newcastle Division, Province of Natal, more particularly the area surrounding the farm Mardenash, Normandien Pass, and northwards as far as Muller's Pass.

The primary object of the visit was a study of the forest vegetation and its distribution, and certain interesting observations were made in regard to forest growth, which are briefly recorded in this paper.

The tract of country is the usual high veld formation, with grasses predominating. For the most part it is used as winter grazing for sheep, and is not occupied, generally speaking, in the summer months.

The geological formation is that of the Upper Beaufort series. The altitude varies from 4,800 to over 6,000 feet.

The soil for the most part is of a clayey nature, being shallow on the ridges and somewhat deeper in the valleys and depressions.

The area has a summer rainfall, which is fairly heavy with frequent fogs, and in winter snowfalls are not uncommon. Snowstorms in winter occasionally do considerable damage by breaking off branches of trees.

The physical features in the neighbourhood described are characterised by numerous terraces crowned by precipitous ground and small krantzes, and an absence of the bold precipices met with elsewhere in the Drakensberg Range of mountains.

At the foot of krantzes and in deep kloofs and sheltered slopes having an eastern, south-eastern, or southern aspect are to be found numerous small patches of close-type forest, varying from less than one acre to several hundred acres in extent.

The accessible forests have, in past years, been heavily worked, and most timber of merchantable size extracted. At the present time the most abundant timber species are the following:—

Podocarpus Thunbergii	about 40	per cent.
Olinia cymosa	20	per cent.
Myrsine melanophleos	10	per cent.
Royena lucida	10	per cent.
Celastrus peduncularis	5	per cent.

Scolopia mundii	about	5	per cent.
Podocarpus elongata	..	3	per cent.
Pterocelastrus variabilis	..	3	per cent.
Other kinds	..	4	per cent.
		100	per cent.

Other species of trees and shrubs represented in the forests are: *Ekebergia capensis, Calodendron capense, Kiggelaria dregeana, Ilex capensis, Halleria lucida, Dais cotinifolia, Pittosporum. viridiflorum, Greyia Sutherlandi, Celastrus buxifolius, Heteromorpha arborescens, Myrsine africana, Zanthoxylon capense, Trimeria trinervis, Buddleia salviæfolia, Chilianthus auriculata, Cassinopsis capensis, Plectronia* sp., *Rhamnus prinoides, Schmidelia* sp., *Cussonia* sp., *Leocosidea sericea, Hippobromus alata, Carissa arduina, Rhus* sp., *Cliffortia, Asparagus, Myrica æthiopica,* etc., etc.

The forests on the precipitous slopes are not of tall growth, the majority of the trees being stunted, gnarled and branchy, indicating the somewhat hostile conditions under which they are growing. The forests are a mixture of trees and shrubs, the trees being more numerous at the foot of krantzes and in the valleys. In most cases scrub growth surrounds the portion containing the trees. The margins of the forest are for the most part fairly well defined when viewed from a distance, but on closer inspection of the perimeters there is usually present a marginal belt or transitional zone, more or less unstable, containing species which, it would seem, are primarily responsible not only for the

protection of the perimeter and the forest generally from fire, but for the aggressive extension of the forest into the surrounding veld. The perimeter is usually of irregular shape. For the most part the forests are broadest at the higher elevation nearest the krantzes, and gradually taper off to the lower elevation, and are drawn out into long, narrow points, which in numerous cases follow the streams for some distance into the main terrace of the upland which extends along the foot of the Berg. The ridges separating the numerous streams arising on the slopes of the Berg are not usually covered with forest.

Isolated patches of forest are also met with in the open grass land, away from krantzes or precipitous ground.

Growing in the veld, and thinly dotted about, are *Proteas*, *Cussonias*, *Greyia Sutherlandi* and *Celastrus buxifolius*, *Erica* sp., and *Leucosidea sericea* shrubs.

All the indications seem to show that until comparatively recent times grass with *Protea* was the principal vegetation, and that the close forest type of trees and shrubs is more recent in origin, and is taking possession of the localities possessing more favourable conditions for their growth and development, namely, those at the foot of krantzes and in the kloofs where there is perennial water, deeper soil, and offering more protection from insolation, from wind and grass fires. The general shape of the forest patches indicate a gradual spread downwards along the valleys and stream banks, and laterally up the slopes of the dividing ridges, wherever soil conditions are sufficiently favourable. Towards the mountain top spread is prevented by krantzes, absence of sufficient soil, and exposure to unfavourable climatic conditions.

The slopes of the ridges having a northern or western aspect, invariably have less forest or no forest at all. Where forest is met with on such aspects, it is apparently making less progress than on the eastern or southern aspects.

Within the forest there is, as a rule, excellent natural regeneration, having all species growing in the forest fairly well represented, but with *Podocarpus Thunbergii*, *Myrsine melanophleos* and *Olinia cymosa* dominating. The forest floor is usually covered with humus, and in places there is abundant ground herbage, such as ferns and bush grasses, mixed with the seedlings of forest trees, which prevent any erosion taking place.

In some instances the patches of forest consist of narrow strips along the foot of precipitous ground or krantzes.

Much of the forest at present is of little value for actual timber production, by reason of the shallow soil, etc., but is of great importance in water conservation, the prevention of soil erosion and torrents, and incidentally affording protection for stock during cold weather.

It was particularly noticeable, though the practice obtains of regularly burning the veld, that there was no serious destruction of, or injury to forest resulting from fire. This may be that the grass is burnt early in winter, and the forests, situated as they are in the more sheltered places, are comparatively moist, and the grass along their perimeters green, whereas on the ridges having shallow soil it is dry and parched.

From numerous enquiries made from old residents, it was ascertained that the general opinion prevailed that the existing Berg forests, notwithstanding occasional damage by fire and other causes, were slowly but surely increasing in size, and that this spread was taking place along the foot of krantzes and precipitous ground, from the valleys up towards the ridges, and along the streams and watercourses, but not upwards towards the higher points of the mountain range, where spread is limited by krantzes, shallow soil and unfavourable conditions generally, and further, that the spread would be faster if more care was exercised when firing the veld.

The foregoing general observations and considerations led the writer to investigate in detail the constitution of some of the forests, particularly those on the farm "Mardenash," with the following results:—

The farm "Mardenash," which has an altitude of about 4,800 to 6,000 feet, has been in the possession of the present owner for more than 30 years. The owner has continuously lived on the property, and consequently is in a position to give historical data which would either support or negative the general opinion already expressed. Mr. H. Moller, senior, the owner of the farm, expressed the opinion that the climate had changed since he first came to the neighbourhood, citing as instances that there used to be numerous vleis and swamps which have in recent years disappeared, and indicated some of the spots which are at present cultivated lands. Further, that formerly more rain fell in winter, and severe frosts were more frequent than at present. There are no actual meteorological data available for the locality, so that the opinion expressed cannot be confirmed or otherwise.

The forests on "Mardenash" are of the type described, but in the lower portions where the Berg merges into the low veld *Acacia caffra* makes its appearance, and the two types of veld meet, *i.e.*, the grasses with *Protea* and those with thorn trees—though *Acacia caffra* is the only one met with here, and seems to come up to a higher elevation than elsewhere, probably owing to the mild climate brought about by excellent air drainage.

The homestead is situated in the valley, about 4,000 feet elevation, and rising on all sides except the south-east are the slopes of the Berg.

Immediately to the north of the homestead, on a southern aspect there are several patches of close-type forest, which were examined as to stocking of trees, and the nature of the perimeters. The patches, having an elevation of about 5,000 feet, were found to be in rather shallow kloofs, more like depressions within a terrace crowned by a somewhat steep slope. Much of the forest, as soon as entered, gave the appearance of being comparatively youthful; the perimeters are fairly well defined, with a distinct transitional or marginal zone. The adjoining veld consisted of grasses in which a *tambooti* dominated, and gave no indication that at any time in recent years it had been covered with forest growth. Scattered about the veld were a few trees of *Cussonia* and *Celastrus buxifolius* and some *Proteas*, and along an outcrop of rock some *Greyia Sutherlandi*.

The patch of forest examined contained numerous *Leucosidea sericea*, many being dominated by such trees as *Myrsine melanophleos, Olinia*, etc., and apparently dying from suppression. Outside the forest, along its eastern perimeter, and scattered about the tall grass, were isolated shrubs of *Leucosidea sericea* of various sizes and ages, these being more numerous nearest the perimeter. Underneath the *Leucosidea sericea*, but never found by itself in the grass, were seedlings of *Myrsine africana*. The *Leucosidea sericea* provides a dense shade and abundant humus, the dense shade killing the grasses. Under old shrubs the *Myrsine africana* was more abundant, and assisted still further in ousting the grasses. Here and there, under the two kinds of shrubs seedlings of such trees and shrubs as *Myrsine melanophleos, Rhus* sp., *Halleria, Rhamnus, Podocarpus Thunbergii, Dais, Olinia, Cassinopsis* and lianes of various kinds spread over the bushes. Next, examining what was considered the actual perimeter, it was noticed that the *Leucosidea* was more numerous, and the floor almost completely covered with *Myrsine africana*. Penetrating the forest, it was observed that under the protection of the latter two kinds nearly all the forest trees were represented, and growing as vigorously as circumstances permitted. Numerous tufts of *tambooti* grass, dead but not yet decayed, were noticed, and in gaps still persisting were a few living tufts, proving clearly the succession from veld to forest.

Mr. Moller, junior, was able to confirm this by stating that some ten years previously he often used to hunt duikers in the grass, which at that time was abundant amongst scattered *Leucosidea sericea* shrubs. With the exception of some large gaps, all the grasses are now dead, and the area has completely passed over from open veld, first to scattered *Leucosidea* scrub, and finally to the type of close forest common in the neighbourhood.

The transition may be represented as follows:—

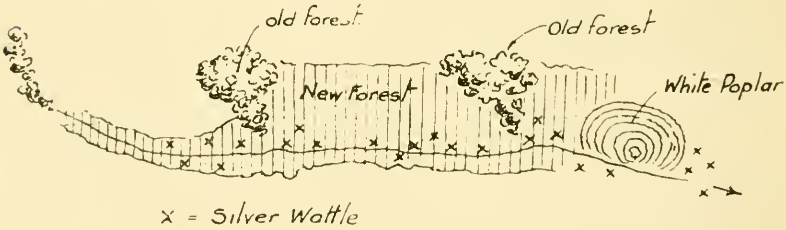
1.	2.	3.	4.
Grasses.	Grasses with scattered *Proteas.*	Grasses with scattered *Proteas, Cussonia, Celastrus buxifolius.*	Grasses with *Proteas, Cussonia, Celastrus, Leucosidea,* few *Sagewoods.*

5.	6.	7.
Grasses with *Proteas, Cussonia, Celastrus, Leucosidea, Myrsine africana.*	Grasses with *Proteas, Cussonia, Celastrus, Leucosidea, Myrsine, Lianes, and* seedlings of various forest trees.	Veld grasses disappearing, being replaced by ferns and bush grasses. *Leucosidea* being suppressed by forest trees and shrubs.

8.	9.
Forest grasses and weeds. Dead *Leucosidea*. *Myrsine africana* persisting. Forest trees and shrubs, such as *Myrsine melanophleos, Olinia, Yellowwoods, Cassinopsis*, etc.	Complete forest state with existing species all represented.

Another type of transition was observed at a lower elevation, and differs somewhat from the foregoing, principally by the absence of *Myrsine africana*.

Almost immediately opposite the homestead is a forest on a steep slope, which about twenty years previously was separated by an interval of veld 200 yards wide into two distinct patches. The two original patches are clearly visible at the present time by reason of the larger and older trees they contain. In the intervening forest *Leucosidea* is still visible where it has not been suppressed by forest trees and shrubs. The transition from veld to grass in the upper part is similar to that already stated, but at the lower elevation, and along the



stream bank and a short distance from it, the succession is different, though the difference in elevation is not much more than 300 feet. The whole area has been protected from fire—parts along the stream were cultivated lands at one time. As in the former instance, *Leucosidea sericea* is the principal shrub which makes its appearance in the veld. Its work in the suppression of the grasses is helped by other species, such as *Buddleia salviaefolia* and *Chilianthus auriculata*. That the work of extension is progressing rapidly was evidenced from a study of the perimeter. Immense numbers of seedlings of *Leucosidea* were observed in all stages of development. Under its protecting care were observed *Myrsine melanophleos, Acacia caffra, Dais, Heteromorpha arborescens, Cassinopsis, Cussonia, Trimeria, Plectronia, Halleria, Olinia, Rhamnus*, etc., and some *Acacia dealbata*. The absence, generally speaking, of *Myrsine africana* was noted in the lower elevation, but it was here and there sparingly represented.

The evidence of Mr. Moller as to the extension of the forest I have no reason to doubt, for the succession as outlined is quite clear and easily followed. Mr. Moller emphasised the point that the rapid extension is due largely to fire protection.

Mr. Moller has planted numerous kinds of exotic trees, the principal being *Acacia mollissima*, *Acacia dealbata*, *Casuarina*, *Pinus insignis*, *Pinus pinaster*, *Cinnamomum camphora*, *Quercus pedunculata*, *Acacia melanoxylon*, *Cupressus sempervirens*, *Eucalyptus globulus*, *Populus fastigiata*, and various kinds of fruit trees, all of which are in a thriving condition, many of the exotic trees being splendid specimens, and give an indication of the kinds of timber which can be successfully grown on a large scale in the neighbourhood.

The Silver Wattle (*Acacia dealbata*) was at first established with the greatest difficulty. To-day it is a tree so well acclimatised that its eradication is not an easy matter. It is spreading along the stream banks and into the indigenous bush, generally ousting the indigenous flora and taking possession of agricultural lands. It may be remarked that the rapid spread of the Silver Wattle is also noticeable in the Polela Division.

When Mr. Moller acquired the farm, there were growing near a stream-bank a few small suckers of White Poplar planted by a previous owner about 1880. The poplars, with comparatively little attention, have, by means of suckers, grown into a large grove containing trees up to one foot in diameter and 35 feet in height, though many of the best stems have been cut out from time to time for farm purposes. The wood is continually spreading into the surrounding forest, which itself is of recent origin. The floor is fairly clean, and contains a good layer of humus with a sprinkling of the usual forest weeds and ferns. Scattered amongst the poplars there are seedlings of indigenous trees, including *Leucosidea sericea*, which appears to be tolerant to the poplar shade. In the *Leucosidea* scrub, which partly surrounds the grove, it was noted that numerous poplar suckers were making their appearance, many having penetrated the canopy, and were developing into good boles. There is every indication that in time the White Poplar will, in competition with the indigenous trees, produce timber of high value for the various technical purposes.

It has been attempted, by recording the foregoing observations, to indicate that in the locality described the forests are progressive and not retrogressive; that *Leucosidea sericea* is one of the chief agents in assisting the succession of veld to forest in the cases of both indigenous and exotic species of forest trees and shrubs; and that, in itself, by reason of its power to withstand repeated injury by fire, and by its well-developed root system, and its abundant humus, *Leucosidea sericea* is of importance in preserving the water supply and preventing erosions, and in acting as a nurse for the better kinds of indigenous and exotic trees, which can successfully be grown on the Eastern slopes of the Drakensberg Range of mountains.

Though the writer has reports in his possession indicating that similar progression in regard to the indigenous forests is taking place in the neighbourhood of Olivier's Hoek Pass, he has refrained from referring to them until a personal visit has been made. It is only owing to unforeseen and unavoidable circumstances that the writer was not able to visit Olivier's Hoek, as was his intention, before the preparation of this paper.

It is hoped that, by collecting detail-data for numerous localities in regard to the nature of and distribution of the indigenous vegetation, it may be possible, where human agency is not pronounced, definitely to establish the point whether, taken as a whole, the indigenous trees and shrubs show an aggressive habit or a decadent one, or under what conditions of climate and soil observed changes are taking place.

Scientific Research in South Africa.—Reference was made in the last volume* to a resolution of a conference of scientific and technical societies, which led to the appointment of an Executive Committee consisting of Prof. W. Buchanan, M.I.E.E., W. A. Caldecott, B.A., D.Sc., F.C.S., R. T. A. Innes, F.R.A.S., F.R.S.E., C. D. Leslie (Chairman), and B. Price, M.I.E.E., A.M.I.C.E. The Minister of Mines and Industries has appointed an Advisory Board of Industries and Commerce, consisting of nine members, one being an elected representative of the Industrial Research Committee of the Technical Societies (Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.). The Advisory Board has recently appointed an Industrial Research Committee of its own, consisting of Mr E. Chappell, Sir Thomas Cullinan, and Prof. G. H. Stanley. This Committee has had a joint meeting with the Executive Committee above referred to, on which occasion the Executive Committee informed the members of the Advisory Board Committee that it would experience difficulty in rendering assistance until a Government organisation, with machinery and means for research work was established to make use of the information available and capable of collection. The meeting was adjourned in order to afford further opportunity for considering the matter.

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* Rept. S.A. Assoc. Adv. Sc. (1915), Pretoria, 611.

COTTON.

By W. H. Scherffius, M.S.

Introduction.

In an endeavour to introduce cotton culture into this country, I should not like to create an impression that we are dealing with a comparatively new crop. Cotton culture and the use of cotton fibre is almost as old as the human family. Cotton lint was used in the manufacture of clothing during ancient times; history records the use of it eight hundred years before Christ. The ancient historian Herodotus wrote of cotton trees growing wild in India, and stated, "the fruit of which is a wool exceeding in beauty and goodness that of sheep. The Indians make their clothes of this wool." The same writer, in speaking of the clothing of Xerxes' army, mentions cotton-wool. Pliny wrote about the cotton plant in India, describing the leaves as similar to those of the mulberry, and said the inhabitants sowed the seed in the fields, and gathered crops, from which they made linen clothes. From these ancient times down to the present cotton has been grown, at some period, in almost every country in the world where tropical or subtropical conditions prevail.

During the last half-century the production of cotton has advanced with tremendous rapidity. The United States of America is far in the lead, producing approximately two-thirds of the world's crop. The Continent of Europe leads in the consumption, with Great Britain a close second, the United States third, and India fourth.

Sixty years ago, less than 2,000,000 bales of 500 lbs. each of lint were produced; now something like 20,000,000 bales of 500 lbs. each are produced annually. When we consider the millions of people who are to-day either naked or only partially clothed, we realise the enormous possibilities still awaiting this industry.

In the foregoing statement, no mention has been made of the scores of other uses to which cotton lint and the seed are applied, such as the manufacture of high explosives, upholstering, mattress-making, the manufacture of various food products, stock foods, and fertilisers.

With these introductory remarks, it is my intention to discuss the cotton industry in so far as its possibilities and prospects affect South Africa.

Progress of the Cotton Industry.—For the past three years the Union of South Africa has produced annually approximately one half million pounds of seed cotton; of this amount there were about 170,000 lbs. of lint and 330,000 lbs. of seed. The lint has been sold at prices ranging from 6d. to 8d. per lb. There has been a demand for seed only for re-seeding purposes until recently. A Pretoria firm has been crushing the seed and selling seed meal; this new enterprise is making some headway.

Soil Suited to Cotton.—Where climatic conditions are favourable for cotton growing—that is to say, where low and middle veld conditions prevail, and with a fair rainfall—cotton can be produced on a variety of soils, such as sandy loam, black turf, alluvial, clay-loam, and calcareous soils. South Africa has large stretches of country where both soil and climatic conditions are favourable to the production of this crop. The most progress has so far been made in the middle or bush-veld of the Rustenburg district.

Cotton as compared with Mealies as a Drought Resister.—It has been proved repeatedly that cotton is far superior to mealies as a drought resister. We have a number of instances on record where farmers planted a portion of their lands to mealies and a portion to cotton; the drought was so severe that the mealies came to nothing, while the cotton gave a fair yield of lint. Last May, I had a report from a farmer in the Waterburg district, who informed me that last season he planted 400 acres to mealies, and, on account of the severe drought, he reaped nothing. He had two acres planted to cotton, and he reaped one and a half tons of cotton. This farmer intends to plant 200 acres to cotton next season. I have had many similar cases reported. These results obtained by farmers verify results obtained at our experiment stations.

I should like to make it clear, however, that the first few weeks after the seed are sown is a very critical period. The young plants must have a moist soil until they are well established, after which they will stand a lot of drought, and still recover to a considerable extent when the rains set in again.

Profits in Cotton Culture compared to those in Mealie Culture.—The average yield of mealies per acre in South Africa is about 4 bags; placing the value at 10s. per bag will give a total profit of £2 per acre, or a nett profit of about £1 per acre. A cotton crop of only 600 lbs. of seed cotton would give 200 lbs. of lint; placing an average value of 6d. per lb. on it will give a gross profit of £5 per acre, and a nett profit of approximately £2 10s., and there are still 400 lbs. of seed left, which, if ground, make an excellent stock food. If a larger yield of mealies or cotton is obtained, the relative values will increase in about the same proportions as those given above.

Varieties Suited to South Africa.—In the middle or bush-veld, some of the American varieties, such as Cleveland, Bancroft, Pullnot, Russell's and Bohemian give the best results. In the low veld, where the soil is very fertile, and on portions of the coastal belt, such as Natal and Zululand, Cook's Long Staple, Nyassaland, Allen's, and Sunflower have given the best returns. A new variety, Taylor's Long Silk Staple, is being bred at the Rustenburg Station; this variety has a beautiful long, silky staple, a scant foliage and upright trees, which are all points in its favour, but whether it is going to be superior to some of the old-established varieties we are not yet ready to state.

All of the above varieties are annuals, and should be re-sown every season. I have heard of a few instances where farmers have ratooned (pruned or cut back) their cotton trees and left them over for the second season with good results, judging from their reports. When this is done the second crop of cotton usually yields a shorter and inferior lint. A perennial variety by the name of Caravonica has been tried in many parts of the Union, but the results have been very disappointing, especially in the interior. Our records show that a few farmers have been successful with it, particularly in humid coastal areas. Mr. Loffler, of Zululand, is reported to have obtained good results with this variety.

Does Cotton Impoverish the Soil?—In theory, cotton could be grown continuously on the same soil, provided the stalks and seed are returned to the soil, as the lint is almost a pure hydrocarbon. In practice, we usually burn the stalks to prevent insects from harbouring in them during the winter, and the seeds seldom find their way back to the same land; therefore a rotation of crops is advisable, as it keeps the soil in a better physical and chemical condition. Cotton is the least exhaustive of soil fertility of most commercial crops grown in South Africa; for example, cotton requires in fertilising elements approximately two-thirds as much as wheat, one-third as much as tobacco, and a quarter as much as mealies.

In a series of fertiliser and rotation experiments we found that phosphates gave better results than either nitrogen or potash, but a complete fertiliser gave far better results than those obtained from the application of any one of the three elements. Similar results were obtained from tobacco, mealies, forage and legumes, which indicated that the soils were deficient in phosphates.

Ginning and Seed Crushing Plants.—Ginning facilities have been greatly improved during the last two or three years. There are two ginning plants operating in Rustenburg that are capable of ginning ten times the amount of the total production of the Union; in addition, there are several smaller plants operating in different parts of the country.

When the industry has made further progress, there will, no doubt, be a seed-crushing plant established to work up the seed into by-products. At the present moment certain firms have the question under consideration. Such a mill will be a great assistance to the cotton industry, as it will establish a further source of revenue.

Last year there were approximately 400,000 gallons of cotton-seed oil, valued at £48,000, sold in South Africa. Half of this quantity was sold as salad oil and half as crude manufacturing oil. At present but little cotton-seed cake is fed to stock in this country, but once it is produced here there should be no difficulty in disposing of it to dairymen and feeders of beef cattle, as it is recognised as one of the best-concentrated feeds obtainable.

Market for South African Cotton.—There is a spinning-mill at Woodstock, C.P., which is now operating 1,500 spindles; this mill is kept going 24 hours daily, and they require approximately the whole output of the Union, *i.e.*, 150,000 lbs. of lint annually.

As this industry grows, their requirements of raw material will likewise increase. Further, the English and European manufacturers, who are operating more than 100,000,000 spindles, have difficulty, at times, in obtaining all the raw material they require for their mills; so far as we are concerned, this demand is inexhaustible.

Prospects.—During the last two or three years the cotton industry has steadily improved, and I think I am justified in saying that there is probably no industry in South Africa, at present, with brighter prospects, and certainly none with greater possibilities. Once normal conditions are restored, I expect to see this industry make steady progress until cotton becomes one of the big agricultural products of the country.

In conclusion, I wish to state that seven years ago, when I took over the cotton work for the Government, the industry had been for a number of years practically discarded as hopeless, on account of the apparently insurmountable difficulties that had to be faced. Great credit is due to men like Mr. Burtt-Davy, of the Transvaal, the late General Sir Edward Brabant, of the Cape Colony, and Mr. Kirkman, of Natal, for keeping a bit of interest alive as to the possibilities of this crop during this depressed period.

Prehensile Toes in Humans.—In an interesting article on a journey to the summit of the little-known mountain Koraima, in British Guiana, Mrs. Cecil Clementi makes the following observation on the Makusi and Arekuna Indians of the higher tablelands of that Colony:—"How the Indians managed to negotiate that climb with loads on their backs, without breaking their legs, was beyond our comprehension. They were a good deal cut and scratched, it is true, but their prehensile toes saved them from all more serious damage. Indians catch hold of things by their toes, in truly monkey fashion; and if a man drops a thing on the march he picks it up by his toes and puts it into his hands to avoid stooping; our feet seemed stupid, clumsy things by comparison."*

* *Geographical Journal* (1916) 48 (6), 456-473.

ON THE SELECTION AND BREEDING OF DESIRABLE STRAINS OF BENEFICIAL INSECTS.

By Charles William Mally, M.Sc., F.E.S., F.L.S.

Although the writer is not a "parasite enthusiast," there is no gainsaying the fact that the control of the "fluted or cottony cushion scale" (known in South Africa as "Australian Bug"), *Icerya purchasi*, by the ladybird, *Novius cardinalis*, is an outstanding illustration of the practical importance of natural enemies in the control of insect pests.

On my arrival in South Africa in 1900, with very few exceptions the people were enthusiastic over the fact that the "Vedalia" (*Novius cardinalis*) was living up to its reputation for controlling the "Australian bug." Dr. L. Péringuey, Director of the South African Museum, however, claimed that the credit really belonged to a South African ladybird, *Aulis fœdata*, and that *Novius cardinalis* had been introduced just at the close of the fight, and having an established reputation for the control of the insect pest in question, it was given the credit of the good work done by the South African species.

Dr. Péringuey's advocacy of the claims of *A. fœdata* aroused my interest, and I decided to get a colony of each species and breed them side by side for comparison, more especially as I had not had the opportunity of studying live material of either species before coming to South Africa. *Novius cardinalis* impressed me at once as a quick, energetic species. *Aulis fœdata*, though larger, seemed slow and easy-going in comparison. *Novius cardinalis* matured a generation in a month, whereas *Aulis fœdata* was much slower, the published accounts in the *Cape of Good Hope Agricultural Journal* stating that only two generations matured in a year. For this reason alone it would soon fall far behind *Novius cardinalis*. Circumstances prevented my carrying the colony of *Aulis fœdata* through to maturity, but my observations led me to doubt its ability to cope with *Icerya purchasi* in the western portion of the Cape Province as perfectly as did *Novius cardinalis*.

I did not record the information given me by Dr. Péringuey at the time, and, to avoid any possible error, I wrote to him on June 4th, 1914, for his opinion as to the relative value of the two species, and received the following reply on June 7th, 1914:—

> You ask me what the respective value of the coccinelid beetles *Aulis fœdata* (a native) and *Novius cardinalis* (an imported article) as eliminating factors of the "Australian bug" (*Icerya purchasi*) has been in South Africa, and you quote a conversation you had with me on the subject soon after your arrival in South Africa (1900).
>
> Well, I will tell you. Had I been prone to bask in the shadow of editors of newspapers, . . . it is probable that the mantle that fell on Koebele would have adorned my shoulders. For, certainly four or five years before he brought back *Novius* from Australia to California, had enquiries been made here about the pest by the American authorities (you will perhaps remember that I was the first entomologist of your

Department . . .), I would have sent to California our indigenous coccinelid.

After 1880 all the orange groves of Drakenstein, Worcester, etc., were gone, destroyed by the *Icerya*. The "blackwood" (*Acacia melanoxylon*), imported from Australia, and a highly decorative tree, had also disappeared. The farmers could not very well spray with paraffin emulsion their secular orange trees, most of them 40 feet high and broad in proportion, and the few who made an attempt on my recommendation and instructions carried out the latter in such a manner that they hastened the death of their orchards, although the one I operated on myself remained immune for several years.

One day, however, I met the late Sir Thomas Scanlen, who, among other things, told me that at Cradock (whence he came) there were still blackwoods lining the streets, so that I lost no time and hied myself to this town. There were no bugs on the trees, but I could not find the reason why, until after visiting several towns or townlets, including Grahamstown, and having, by this time, ascertained the presence of *Aulis fœdata*, Muls., so named 60 years before, I succeeded at last in getting a large number of them in Seymour, where the *Icerya* food was in plenty. I sent fairly large consignments to the Department for distribution in the Capetown neighbourhood. I am sorry to say that no assistance was given. But I released myself those I brought with me, and within six months I could not find food enough for those I was breeding in my conservatory under highly favourable conditions. Then I foillowed them into the Worcester district, in the Tulbagh Valley, etc., but I hold these had found their way there from the east. I may add that *Icerya* never found a firm footing in Natal, where *Aulis fœdata* is endemic.

By this time the fame of *Novius cardinalis* had got abroad, and Mr. Rudd succeeded in obtaining a small supply, which he located, at great expense, under special contrivances, at Fernwood; and I was instructed to help in the breeding experiment. Well, it was very successful, and with a little tom-toming in the Press, the reputation of *Novius* was established. In vain did I point out that we had an excellent auxiliary, that modesty alone had kept me from proclaiming the same *urbi* and *orbi;* that, moreover, the work of extermination of the *Icerya* was by this time nearly completed, so much so that I could no longer find it even in the Stellenbosch district. I had to comply with orders, and the sending from my nursery of *Aulis* was to be replaced by *Novius*. Well, these orders came too late, for *Novius* had gobbled all my *Aulis* in the breeding cages, and, incredible as it may appear, the Australian importation (perhaps enlivened by a generation or two on American soil) would first devour my stock of *Aulis* before tackling the *Icerya*.

The truth, however, should be said, namely, that the Australian set about his work with much more rapidity than the South African. Question of temperament maybe, but he is not so thorough. The South African species set more leisurely to his work, but ended it thoroughly, which the other has not done. It has now disappeared owing to the close attention paid to him by its rival, but there are still sporadic outbursts of *Icerya*. Had not the indigenous species been devoured by the imported article, I doubt if any *Icerya* would have been left.

I was more concerned in multiplying and distributing here this useful indigenous ladybird (I have sent thousands, not only in the Colony, but in the Free State and even in Natal) than to proclaim the discovery, which after all, arose from a lucky bit of conversation, followed by a bit of field work on my part.

And this is the true story of the destruction of the scourge *Icerya purchasi*. Supplemented no doubt by *Novius*, the good, solid work was carried outside the Cape Peninsula by the indigenous *Aulis*. *Novius* is now seldom found north, in spite, I understand, of repeated supplies. *Aulis*, however, has remained there, and is far from rare. Draw your deduction!

You are, of course, authorised to publish this information. The officials of your Department had not then the halo of glory you and yours are now adorned with; we were three who formed the Department then —but even at this epoch the "Consuls were watching."

To my mind the outstanding weakness in *Aulis fœdata* was the fact that it was sluggish and slower to mature than was *Novius cardinalis*. This difference in the two species was also recognised by Dr. Péringuey, for he states that "the Australian set about his work with much more rapidity than did the South African." That *Novius cardinalis* was the more aggressive of the two species is also shown by his statement that "had not the indigenous species been devoured by the imported article, I doubt if any *Icerya* would have been left." My own observations in the Eastern as well as the Western Cape Province during the last 16 years do not bear out the belief that no *Icerya* would have been left had *Aulis fœdata* not been interfered with. Both species have come under my observation repeatedly, and there has never been any doubt in my mind that *Novius cardinalis* is the controlling species. My impression is that *Aulis fœdata* can endure cold better than can *Novius cardinalis*; but, on the other hand, conditions under which citrus trees thrive favour *Novius cardinalis*. When read in conjunction with the following paragraphs, this opens up an interesting problem that is at present receiving attention from the practical standpoint—*i.e.*, to develop a strain of one that can stand cold, and of the other that can stand heat.

In accordance with the old idea that we should study how to assist parasitic (beneficial) insects by creating conditions that would favour the parasite at the expense of its host, it was but natural, during my earlier observations to speculate on the possibility of assisting *Aulis fœdata* in some way in case it had been necessary to depend on it for the control of the newly-introduced host insect. During this time (1900) a colony of another Australian ladybird, *Cryptolœmus montrouzieri*, was sent by Mr. Geo. Compere to Mr. Chas. P. Lounsbury, then Government Entomologist for the Cape of Good Hope, Cape Town, and the work of breeding this new ladybird in large numbers in the hope that it would become established in South Africa and help to control the vine mealybug, *Pseudococcus capensis*, was entrusted to me. In my anxiety to prevent overcrowding with the possible destruction of ladybird eggs by the older larvæ, I followed the plan of removing the newly-transformed adults as promptly as possible to fresh food-supply. This resulted in an intricate series of colonies, in which the offspring of the first-maturing adults of any given brood were well advanced before the last adult of the same brood appeared. The ladybirds increased so rapidly that it was not long before there was no room for them, and colonies had to be liberated, and only "stock" colonies kept for breeding purposes. It was then apparent that, for the control of the vine mealy bug, *Cryptolœmus* was entirely too large, and would have to be reduced in size before it could hope to creep into the small creases and cracks in the bark of a grape vine—the hiding-places of the mealy bug. A very small indigenous species at work in the vineyards was found to have a parasite that proved to be a severe handicap. Would it be possible to find a strain of this species that would be distasteful to its parasites?

The isolation of the first-maturing *C. montrouzieri* impressed me with the practical importance of saving time by breeding from the quick-maturing specimens, and it occurred to me that it would have been a factor of great advantage had it been necessary to depend on breeding *A. fœdata* to control *I. purchasi*, and that in time it might have resulted in increasing the number of its annual broods. The practical need for this had disappeared with the advent of *Novius*, and hence remained mere speculation, and was all but forgotten till a request was received from Mons. D. d'Emmerez de Charmoy, Government Entomologist for Mauritius; for a colony of *Novius cardinalis*, in the hope that it would adapt itself to *Icerya seychellarum* and exert a more perfect control than does the indigenous species, *Vedalia chermesina*, of which, on April 27th, 1915, he wrote as follows: "I am not sure whether it is worth while trying to introduce this species (*Novius cardinalis*) here, as it is not proved that it will live on *I. Seychellarum*, which has already a similar enemy in *Vedalia chermesina*. Unfortunately this ladybird breeds very slowly, is sedentary, and cannot be relied upon as a serious auxiliary for controlling the *Icerya* pest all the year round, although it is undoubtedly due to it that this pest is kept within a tolerable limit in its depredations."

The opinion of Mons. D. d'Emmerez in regard to *Vedalia chermesina* agrees perfectly with my own opinion of the work of *Aulis fœdata* in South Africa, and my early impression that a desirable strain of it could have been developed if necessary is as vivid as ever, and I believe it is perfectly feasible. *Vedalia chermesina* supplies a practical case in point, for want of which I have refrained from discussing the matter seriously, and I have therefore decided to record the idea of developing desirable strains of beneficial insects and to make certain suggestions that may possibly be of value to others who are in a position to make practical use of them.

In studying the relationship between host and parasite as illustrated by *I. purchasi* and *Novius cardinalis*, in the writer's opinion the following facts deserve special consideration:—

1. Experience in South Africa has shown that *N. cardinalis* alone is able to keep its host under satisfactory control, and this is apparently due to its being a prolific, quick-maturing species that has specialised on one host. In other words, Nature has achieved her most brilliant success on the plan of *one host, one parasite*.

2. The host is what I shall call a non-fluctuating species—*i.e.*, it has a wide range of host plants, and left to itself, it goes on increasing steadily on any given plant and breeds throughout

the year. It therefore serves as a constant food-supply for any possible insect that feeds on it, and the parasite is thus enabled to develop without any serious check till it balances its host. Under these conditions there would be ample scope for the tendency to early maturity in certain individuals to make itself felt in gradually reducing the time necessary for the completion of any given brood, and thus increasing the number of broods per year. Perfect control suggests an association sufficiently long to enable the parasite to increase in fecundity until it equals its host. To my mind, this is precisely what has taken place under natural conditions in the case of *Novius cardinalis*. If this is correct, then it would seem that where control is imperfect the association of species is so recent that the parasite has not had time to come to perfection, and that by ascertaining the determining conditions we should be able to select and breed to type, and thereby hasten the establishment of a balance between species—*i.e.*, both host and parasite will remain at the minimum.

In the case of non-fluctuating species of insect pests (certain scale insects, for example), I believe that, given the men and the equipment to cope with the work, control through the perfection of natural enemies can be achieved. Host species that from causes other than insect parasitism are subject to violent fluctuations would be more difficult to deal with.

From the practical standpoint the great difficulty will be to enable the desirable strains to become dominant. Where the ordinary type of the same species is widely distributed, there would be a tendency for the selected strains to deteriorate, and hence they would have to be reinforced until they became dominant. In the case of *Aulis fœdata*, an area could have been selected where it was not represented, and the desirable strain liberated there, and reinforced until it gradually encroached on the weaker type in other areas. In fact, it would have been an advantage to destroy the natural type as the selected strain progressed.

In certain hosts (black scale, *Saissetia oleæ* and Hessian fly, *Mayetiola destructor,* for example) the problem is complicated through there being a number of species of parasites. If the different parasites were perfectly supplementary, they would no doubt be an advantage; but it is conceivable that they hinder each other through competition. In other words, they are supplementary up to a certain point, and then become competitive. This is an important consideration where natural enemies are being sought for species that have by some means been transferred unhampered to new surroundings. The ideal would be to make exhaustive investigations in the original home of the host and determine the parasite essential for satisfactory control (*Novius cardinalis,* for example), and transfer it to the new home of the host.

NOTE ON THE OCCURRENCE OF TRAPDOOR CATERPILLARS AT ALICEDALE.

By Frank Cruden.

(*Plate* 2.)

During the last three years, while searching for trapdoor spiders' nests in the veld round Alicedale, I often found tubes with very small round trapdoors. At first I assumed that these were also constructed by spiders, but on opening several I found the occupant to be, in each case, a caterpillar. As it was just possible that these had taken possession of nests that had been vacated by spiders, I placed half-a-dozen caterpillars beside holes bored for them in soft ground in a box. They at once entered the holes, tail first. The holes were soon lined, and in each case a lid was made.

The diameter of the largest lids seldom exceeds 6 m.m. They are usually concave on the outside, and fit very closely into the mouths of the tubes. The nests are difficult to detect. They are often found in soft ground under the shade of bushes, and in spots with a sparse growth of moss or grass. Moss is sometimes found on the outer surface of the lid, but whether the caterpillar attaches it, or it grows there naturally, I have not yet been able to ascertain. The tubes are frequently very tortuous, and measure in length from 12 to 16 cm. They are usually, if not always, slightly constricted just below the lid.

I must have opened scores of nests in the hope of finding the occupant in the pupa stage, but without success until the latter part of April and the beginning of May this year (1916), when I was fortunate in finding three or four, which were handed over to Mr. J. Hewitt, of the Albany Museum.

As I had dug out each nest in a mass of earth, I returned to each tube, from the lower end, its rightful owner. It was curious to note (though it seems quite natural when one thinks of it) how the pupæ wriggled up the tubes owing to the flexibility of the lower parts of their cases.

In a few hours the moths emerged from the tubes, the lids being pushed open, and the empty pupa cases left sticking in the constricted parts already referred to. One moth, whose pupa case was not returned to the tube, was unable to emerge until it was placed between two layers of cotton-wool pressed down just firmly enough to keep the case in position while the moth was pulling itself out.

These nests are very abundant, and at the time mentioned above (when the bulk of the moths emerge) they can be seen in great numbers with the empty pupæ cases projecting from their mouths.

The moth has not yet been fully identified: it is referable to the family Hepialidæ (*fide* Mr. C. J. Swierstra). Similar trapdoor caterpillars were taken at Port Alfred several years ago by Mr. F. S. Salisbury, who found them in abundance in the thick bush fringing the Kowie River. They have also been found on the flats adjoining the Cradock road, Grahamstown.

Trapdoor caterpillar and entrance to nests. Slightly enlarged. The lower nest shows pupa skin at entrance.

F. Cruden.—Trapdoor Caterpillars at Alicedale.

A CLASS OF ALTERNANTS WITH TRIGONOMETRICAL ELEMENTS.

By Sir Thomas Muir, LL.D., F.R.S.

(1) There is an interesting trigonometrical equality which I have not hitherto seen in print, but which deserves some little attention, both on its own account and by reason of some fresh results in alternants to which it readily gives rise. When the number of angles is 4, —— a, β, γ, δ, say —— it takes the form

$$A \sin a + B \sin 3a + F \cos a + G \cos 3a = \sin 5a$$

where A, B, F, G are symmetrical functions of a, β, γ, δ, namely,

$$\begin{aligned} A &= -\Sigma \cos (2a + 2\beta) - \Sigma \cos (2a + 2\beta + 2\gamma). \\ B &= \Sigma \cos 2a + \cos \Sigma 2a. \\ F &= -\Sigma \sin (2a + 2\beta) + \Sigma \sin (2a + 2\beta + 2\gamma). \\ G &= \Sigma \sin 2a - \sin \Sigma 2a. \end{aligned} \qquad \text{(I)}$$

To establish it, a simple course is to express $A \sin a + F \cos a$ as an aggregate of sines, namely,

$$\begin{array}{ll} -\sin (3a + 2\beta) & + \sin (a + 2\beta + 2\gamma) \\ -\sin (3a + 2\gamma) & + \sin (a + 2\beta + 2\delta) \\ -\sin (3a + 2\delta) & + \sin (a + 2\gamma + 2\delta) \\ -\sin (a + 2\beta + 2\gamma) & + \sin (2\beta + 2\gamma + 2\delta - a), \\ -\sin (a + 2\beta + 2\delta) & \\ -\sin (a + 2\gamma + 2\delta), & \end{array}$$

and $B \sin 3a + G \cos 3a$ in similar fashion, namely,

$$\sin 5a + \sin (3a + 2\beta) + \sin (3a + 2\gamma) + \sin (3a + 2\delta) \\ + \sin (a - 2\beta - 2\gamma - 2\delta).$$

On addition the fifteen sines reduce to the one forming the right-hand member of the equality.

(2) Since A, B, F, G involve all the angles symmetrically, the equality must hold when a is replaced by any one of the other angles. We thus have a set of four equations involving A, B, F, G: and viewing the latter as unknowns, we obtain, on solving for them in the usual way

$$\frac{\begin{vmatrix} \sin 3a & \sin 5a & \cos a & \cos 3a \\ \sin 3\beta & \sin 5\beta & \cos \beta & \cos 3\beta \\ \sin 3\gamma & \sin 5\gamma & \cos \gamma & \cos 3\gamma \\ \sin 3\delta & \sin 5\delta & \cos \delta & \cos 3\delta \end{vmatrix}}{\begin{vmatrix} \sin a & \sin 3a & \cos a & \cos 3a \\ \sin \beta & \sin 3\beta & \cos \beta & \cos 3\beta \\ \sin \gamma & \sin 3\gamma & \cos \gamma & \cos 3\gamma \\ \sin \delta & \sin 3\delta & \cos \delta & \cos 3\delta \end{vmatrix}} = -A = \Sigma \cos (2a + 2\beta) \\ + \Sigma \cos (2a + 2\beta + 2\gamma), \quad \text{(II)}$$

$$\frac{| \sin a \quad \sin 5a \quad \cos a \quad \cos 3a |}{| \sin a \quad \sin 3a \quad \cos a \quad \cos 3a |} = B = \Sigma \cos 2a + \cos \Sigma 2a. \quad \text{(III)}$$

$$\frac{|\,sin\,\alpha \quad sin\,3\alpha \quad sin\,5\alpha \quad cos\,3\alpha\,|}{|\,sin\,\alpha \quad sin\,3\alpha \quad cos\,\alpha \quad cos\,3\alpha\,|} = \mathrm{F} = -\Sigma\,sin\,(2\alpha + 2\beta) + \Sigma\,sin\,(2\alpha + 2\beta + 2\gamma). \quad \text{(IV)}$$

$$\frac{|\,sin\,\alpha \quad sin\,3\alpha \quad cos\,\alpha \quad cos\,5\alpha\,|}{|\,sin\,\alpha \quad sin\,3\alpha \quad cos\,\alpha \quad cos\,3\alpha\,|} = \mathrm{G} = \Sigma\,sin\,2\alpha - sin\,\Sigma\,2\alpha. \quad \text{(V)}$$

(3) Of course, these results, when known, can be verified by evaluating the five alternants concerned. Following the sure but lengthy process based on the substitution of exponential values for sines and cosines, we find

$$\begin{aligned} |\,sin\,\alpha \quad sin\,3\alpha \quad cos\,\alpha \quad cos\,3\alpha\,| &= -16\cdot\,sin\,(\delta - \gamma)\,sin\,(\delta - \beta)\,\ldots\,sin\,(\beta - \alpha) \\ &= -16\cdot\,\Pi\,sin\,(\delta - \gamma),\ \text{say}, \qquad \text{(VI)} \end{aligned}$$

and the others the appropriate multiples of this.

(4) Further, since

$$16\,cos\,\alpha\,cos\,\beta\,cos\,\gamma\,cos\,\delta\cdot cos\,\Sigma\,\alpha, \quad \text{or, say,} \quad 16\,\Pi\,cos\,\alpha\cdot cos\,\Sigma\,\alpha,$$
$$= 1 + \Sigma\,cos\,2\alpha + \Sigma\,cos\,(2\alpha + 2\beta) + \Sigma\,cos\,(2\alpha + 2\beta + 2\gamma) + cos\,\Sigma\,2\alpha \qquad \text{(VII)}$$

we have

$$16\cdot\,\Pi\,cos\,\alpha\cdot cos\,\Sigma\,\alpha = 1 - \mathrm{A} + \mathrm{B}$$
$$= \left\{ |\,sin\,\alpha\ sin\,3\alpha\ cos\,\alpha\ cos\,3\alpha\,| + |\,sin\,3\alpha\ sin\,5\alpha\ cos\,\alpha\ cos\,3\alpha\,| + |\,sin\,\alpha\ sin\,5\alpha\ cos\,\alpha\ cos\,3\alpha\,| \right\} \div |\,sin\,\alpha\ sin\,3\alpha\ cos\,\alpha\ cos\,3\alpha\,|$$

But the three determinants in the numerator here have two columns in common, and each takes its other pair of columns from a common three; their sum can therefore be expressed as one determinant, namely,

$$|\,sin\,\alpha + sin\,3\alpha \quad sin\,3\alpha + sin\,5\alpha \quad cos\,\alpha \quad cos\,3\alpha\,|,$$

and this is equal to

$$\begin{aligned} &|\,2\,sin\,2\alpha\,cos\,\alpha \quad 2\,sin\,4\alpha\,cos\,\alpha \quad cos\,\alpha \quad cos\,3\alpha\,| \\ &= 4\cdot\Pi\,cos\,\alpha\cdot|\,sin\,2\alpha \quad sin\,4\alpha \quad 1 \quad 4\,cos^2\alpha - 3\,| \\ &= 8\cdot\Pi\,cos\,\alpha\cdot|\,sin\,2\alpha \quad sin\,4\alpha \quad 1 \quad cos\,2\alpha\,| \end{aligned}$$

so that, on dividing by $16\cdot\Pi\,cos\,\alpha$, we obtain

$$cos\,(\alpha + \beta + \gamma + \delta) = \tfrac{1}{2}\,\frac{|\,1 \quad sin\,2\alpha \quad sin\,4\alpha \quad cos\,2\alpha\,|}{|\,sin\,\alpha \quad sin\,3\alpha \quad cos\,\alpha \quad cos\,3\alpha\,|} \qquad \text{(VIII)}$$

a more important result than any of those from which it is derived.

(5) It is noteworthy that the set of four equations obtained by substituting in (I) for $\alpha, \beta, \gamma, \delta$ their complementaries has the same determinant as the original four. There is thus secured without effort the evaluation of four additional alternants, namely,

$$|\,cos\,\alpha \quad cos\,3\alpha \quad cos\,5\alpha \quad sin\,3\alpha\,| = \left\{ \begin{aligned} &\Sigma\,sin\,(2\alpha + 2\beta) \\ &+ \Sigma\,sin\,(2\alpha + 2\beta + 2\gamma). \end{aligned} \right\} \cdot \mathrm{D} \quad \text{(IX)}$$

$$| \cos\alpha \ \cos 3\alpha \ \cos 5\alpha \ \sin\alpha | = \{ \Sigma \sin 2\alpha + \sin \Sigma 2\alpha \} \cdot D \qquad (X)$$

$$| \cos 3\alpha \ \cos 5\alpha \ \sin\alpha \ \sin 3\alpha | = \left\{ \begin{array}{l} \Sigma \cos (2\alpha + 2\beta) \\ - \Sigma \cos (2\alpha + 2\beta + 2\gamma) \end{array} \right\} \cdot D \qquad (XI)$$

$$| \cos\alpha \ \cos 5\alpha \ \sin\alpha \ \sin 3\alpha | = \{ \Sigma \cos 2\alpha - \cos \Sigma 2\alpha \} \cdot D \qquad (XII)$$

where D stands for either member of (VI).

By the same substitution (VIII) merely reproduces itself, and (VII), on which (VIII) was made to depend, becomes

$$\begin{aligned} 16 \cdot \Pi \sin\alpha \cdot \cos \Sigma\alpha = 1 &- \Sigma \cos 2\alpha + \Sigma \cos (2\alpha + 2\beta) \\ &- \Sigma \cos (2\alpha + 2\beta + 2\gamma) + \cos \Sigma 2\alpha \end{aligned}$$

which for present purposes is not helpful. If, however, we introduce

$$\begin{aligned} 16 \cdot \Pi \cos\alpha \cdot \cos \Sigma\alpha &= \Sigma \sin 2\alpha + \Sigma \sin (2\alpha + 2\beta) \\ &+ \Sigma \sin (2\alpha + 2\beta + 2\gamma) + \sin \Sigma 2\alpha \qquad (XIII) \end{aligned}$$

or

$$\begin{aligned} 16 \cdot \Pi \sin\alpha \cdot \sin \Sigma\alpha &= - \Sigma \sin 2\alpha + \Sigma \sin (2\alpha + 2\beta) \\ &- \Sigma \sin (2\alpha + 2\beta + 2\gamma) + \sin \Sigma 2\alpha \end{aligned}$$

and proceed as in § 4, we obtain the desired companion to (VIII), namely,

$$\sin (\alpha + \beta + \gamma + \delta) = \tfrac{1}{2} \frac{| 1 \ \ \cos 2\alpha \ \ \cos 4\alpha \ \ \sin 2\alpha |}{| \cos\alpha \ \ \cos 3\alpha \ \ \sin\alpha \ \ \sin 3\alpha |} \qquad (XIV)$$

(6) Results similar to all of the preceding exist in the case of every *even* number of angles. The fundamental equality corresponding to (I) having been obtained, the others flow easily and smoothly from it. It is important, therefore, and it is sufficient, to show the form which this equality takes in one other case. When the number of angles is *six*, it is

$$A \sin\alpha + B \sin 3\alpha + C \sin 5\alpha + F \cos\alpha + G \cos 3\alpha + H \cos 5\alpha = \sin 7\alpha \quad (XV)$$

where

$$\begin{aligned}
A &\equiv \Sigma \cos (2\alpha + 2\beta + 2\gamma) + \Sigma \cos (2\alpha + 2\beta + 2\gamma + 2\delta) \equiv \Sigma \cos_3 + \Sigma \cos_4 \text{ say} \\
B &\equiv - \Sigma \cos (2\alpha + 2\beta) - \Sigma \cos (2\alpha + 2\beta + 2\gamma + 2\delta + 2\epsilon) \equiv - \Sigma \cos_2 - \Sigma \cos_5, \\
C &\equiv \Sigma \cos 2\alpha + \cos (2\alpha + 2\beta + 2\gamma + 2\delta + 2\epsilon + 2\zeta) \equiv \Sigma \cos_1 + \cos_6, \\
F &\equiv \Sigma \sin (2\alpha + 2\beta + 2\gamma) - \Sigma \sin (2\alpha + 2\beta + 2\gamma + 2\delta) \equiv \Sigma \sin_3 - \Sigma \sin_4, \\
G &\equiv \Sigma \sin (2\alpha + 2\beta) + \Sigma \sin (2\alpha + 2\beta + 2\gamma + 2\delta + 2\epsilon) \equiv - \Sigma \sin_2 + \Sigma \sin_5, \\
H &= \Sigma \sin 2\alpha - \sin (2\alpha + 2\beta + 2\gamma + 2\delta + 2\epsilon + 2\zeta) \equiv \Sigma \sin_1 - \sin_6 ;
\end{aligned}$$

the related auxiliary equalities are

$$\begin{aligned}
2^6 . \Pi \cos\alpha . \cos \Sigma\alpha &= 1 + \Sigma \cos_1 + \Sigma \cos_2 + \Sigma \cos_3 + \Sigma \cos_4 + \Sigma \cos_5 + \Sigma \cos_6 \\
&= 1 + A - B + C, \\
2^6 . \Pi \sin\alpha \cdot \sin \Sigma\alpha &= \Sigma \sin_1 - \Sigma \sin_2 + \Sigma \sin_3 - \Sigma \sin_4 + \Sigma \sin_5 - \Sigma \sin_6 \\
&= F + G + H \qquad (XVI)
\end{aligned}$$

and the determinant of the coefficients of A, B, C, F, G, H, namely,

$$\begin{aligned} &| \sin\alpha \ \sin 3\alpha \ \sin 5\alpha \ \cos\alpha \ \cos 3\alpha \ \cos 5\alpha | \\ &= 2^{12} \, \Pi \sin (\zeta - \epsilon). \qquad (XVII) \end{aligned}$$

From these there drop into our hands, as it were, the results of the evaluation of fifteen alternants of the sixth order.

(7) The corresponding investigation in the case where the number of angles is *odd* is somewhat more complicated, and has to be at fully entered into as if the other case had not been touched. Is must suffice to give merely the main results in two cases.

When there are *three* angles the fundamental equality is

$$A + F \cos 2\alpha + L \sin 2\alpha = -2 \cot \alpha \,.\, \Pi \sin \alpha$$

where

$$\begin{aligned} A &= \cos(\alpha+\beta+\gamma) - \cos\alpha \cos\beta \cos\gamma, \\ F &= \cos(\alpha+\beta+\gamma), \\ L &= \sin(\alpha+\beta+\gamma); \end{aligned}$$

and the determinant of the coefficients of A, F, L,

$$| 1 \quad \cos 2\alpha \quad \sin 2\alpha | = 2^2 \sin(\gamma-\beta) \sin(\gamma-\alpha) \sin(\beta-\alpha).$$

When there are *five* angles the fundamental equality is

$$A + F \cos 2\alpha + G \cos 4\alpha + L \sin 2\alpha + M \sin 4\alpha = -8 \cot \alpha \,.\, \Pi \sin \alpha \qquad \text{(XVIII)}$$

where

$$\begin{aligned} A &= \Sigma \cos(\Sigma\alpha - 2\alpha) - 8\, \Pi \cos \alpha, \\ F &= \Sigma \cos(\Sigma\alpha - 2\alpha) - \cos \Sigma\alpha, \qquad G = -\cos \Sigma\alpha, \\ L &= \Sigma \sin(\Sigma\alpha - 2\alpha) - \sin \Sigma\alpha, \qquad M = -\sin \Sigma\alpha; \end{aligned}$$

the related auxiliary equality is

$$16\, \Pi \cos \alpha = \cos \Sigma\alpha + \Sigma \cos(\Sigma\alpha - 2\alpha) + \Sigma \cos(\Sigma\alpha - 2\alpha - 2\beta) \quad \text{(XIX)};$$

and the determinant of the coefficients of A, F, G, L, M

$$\begin{aligned} &| 1 \quad \cos 2\alpha \quad \cos 4\alpha \quad \sin 2\alpha \quad \sin 4\alpha | \\ &= -2^8 \,.\, \Pi \sin(\epsilon - \delta) \qquad \text{(XX)}. \end{aligned}$$

It will be observed that in both these cases there is no longer any difficulty (see § 4) in finding the alternant expressions for the sine and cosine of the sum of the angles, these functions now occurring themselves among the so-called "unknowns"

Fossil Man in Florida.—The *American Journal of Science* (1916), 1-18, publishes a report on fossil human remains recently discovered at Vero, on the Atlantic coast of central-eastern Florida. The results were found associated with verteb.ate, fresh-water invertebrate, and plant fossils. In all twelve species of vertebrate remains were found, including the fox, deer, sloth, and mastodon. In the older stream deposits fossils characteristic of the North American Pleistocene have been found, amongst which were vertebræ and teeth of a large and probably extinct crocodile. It is assumed that the human bones were contemporaneous with the fauna represented, and it is held that the bed in which they were found was undoubtedly deposited during the Pleistocene.

SOME FACTORS INFLUENCING THE SOLUBILITY OF PHOSPHORIC OXIDE IN MIXED FERTILISERS CONTAINING SUPERPHOSPHATES.

By Edmund Victor Flack.

Superphosphates are produced by treating bones or phosphatic minerals with sulphuric acid. The reactions which take place may be summarised as follows:

*$Ca_3P_2O_8$	+	$2H_2SO_4$	=	$2CaSO_4$	+	$H_4Ca\ P_2O_8$
Tricalcium phosphate.		Sulphuric acid.		Gypsum.		Superphosphate. (Monocalcium phosphate.)

It is well known that the water-soluble phosphoric oxide content of superphosphate gradually decreases in amount, and this decrease is known as "reversion" or "retrogression." The longer the superphosphate is kept, the greater will be the amount of reversion, and the rate of reversion varies with the process of manufacture. In some superphosphates there may be practically no reversion, whereas in a badly-made article, in which unsuitable materials have been employed, it may be considerable. Thus a mineral containing more than 10 per cent calcium carbonate, 3 per cent of oxide of iron and fluorides, would be very unsuitable.† Insufficiency of acid in the material used for preparation also causes considerable reversion. Such reversion may be due to any undecomposed tricalcium phosphate, or to calcium carbonate, iron oxide or alumina in the mixture acting on the water-soluble phosphate. In the case of the first-mentioned compound the reaction may possibly be very slight, and would be represented by the following equation:

$Ca_3P_2O_8$	+	$H_4Ca\ P_2O_8$	=	$2H_2Ca_2\ P_2O_8$.
Tricalcium phosphate.		Monocalcium phosphate.		Bicalcium phosphate. Reverted or retrograde phosphate.

When iron is present as pyrites or ferrous silicate in the mineral used, there is no reversion, but when present as ferric or ferrous oxide, the reversion is great. What actually takes place is not so clear as when tricalcium phosphate is present. If the acid used had dissolved a quantity of iron, the reaction of the resulting ferric sulphate with the superphosphate would probably be as under:

$Fe_2(SO_4)_3$	+	$H_4Ca\ P_2O_8$	=	$2Fe_2P_2O_8$	+	$CaSO_4$	+	$2H_2SO_4$
Ferric sulphate.		Super-phosphate.		Ferric phosphate.		Calcium sulphate.		Sulphuric acid.

* H. W. Wiley: "Principles of Agricultural Analysis," 2, 277.
† *Bulletin Imperial Institute*, 9 [1].

The sulphuric acid thus set free would dissolve more of the iron compounds, and so react again and again. In this case we have a continuously increasing quantity of insoluble iron phosphate, and a proportionately diminishing amount of soluble phosphates.*

On the other hand, the soluble phosphates may be rendered insoluble much more rapidly, thus:

Fe_2O_3	+	$H_4Ca\ P_2O_8$	=	$2Fe_2P_2O_8$	+	$Ca_3P_2O_8$
Ferric Oxide.		Super-phosphate.		Ferric phosphate.		Calcium phosphate.

The above would apply in the case of alumina as well as for iron compounds.

But the solubility of the phosphoric oxide in superphosphate is influenced by other factors than merely calcium carbonate, tricalcium phosphate, and compounds of iron and alumina. To test the extent to which this solubility is affected the following mixtures were prepared:

(*a*) Superphosphate and sulphate of ammonia.

(*b*) Superphosphate and sulphate of potash.

(*c*) Superphosphate and kainit.

(*d*) Superphosphate and guano from the Union Government Islands off the South African coast.

(*e*) Superphosphate and bone meal.

In the *Cape Agricultural Journal* of June, 1910, there was published a diagram—stated to have been compiled on experience and practice in South Africa—shewing what artificial fertilisers could be mixed together without any harmful effects, and what were the mixtures best suited for the farmer.

On consulting this diagram, it will be seen that the mixtures made by me were those there specially recommended to be made by farmers, with the exception of (*e*), the mixture of superphosphate with bone meal, a combination marked as unnecessary, although sometimes made use of by farmers.

The above mixtures were made to contain equal parts by weight of each of the two constituents: these were well mixed and at once placed in glass bottles, closed by means of corks, and the portions were weighed out after the mixture had stood for the required time. Before each weighing the sample was again well mixed.

The sample of superphosphate used throughout the first part of these experiments was a high-grade article containing 17.35 per cent of water-soluble phosphoric oxide and 26.92 per cent. of lime.

The guano used represented the average article as sold by the Union Government. It was a mixture from Malagas, Marcus and Jutten Islands, and had the following composition:

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* Aikman: "Manures and Manuring." Second Impression, 399.

	per cent.
Material capable of passing through a 1 mm. sieve	93.66
Phosphoric oxide:	
Total	13.80
Citrate-soluble	13.47
Water-soluble	4.11
Lime	12.49
Potash	1.69
Nitrogen	10.94

The methods adopted for analysing these mixtures were as follows:

20 grams of the fertiliser were extracted with distilled water for half an hour in a shaking machine, filled up to 1,000 c.c., well mixed and filtered. In an aliquot part of the filtrate the water-soluble phosphoric oxide was precipitated direct by means of ammonium citrate and magnesium mixture in the ordinary way.

By this method each of the five mixtures was analysed after standing for three hours, for twenty-four hours, one week, two weeks and three weeks, thorough mixture, as already stated, being again made before each testing. The following percentages of water-soluble phosphoric oxide were thus found in the various mixtures:

	Original Composition.	Composition after standing for— 3 hours.	24 hours.	1 week.	2 weeks.	3 weeks.
Superphosphate alone	17.35	—	—	—	—	—
(a) Superphosphate and Sulphate of Ammonia ..	8.68	8.58	8.67	8.71	8.79	8.89
(b) Superphosphate and Sulphate of Potash.. ...	8.68	8.65	8.65	8.65	8.74	8.64
(c) Superphosphate and Kainit..	8.68	8.62	8.76	8.62	8.76	8.69
(d) Superphosphate and Government Guano.. ...	10.73	10.06	9.54	9.22	9.08	8.47
(e) Superphosphate and Bonemeal...	8.68	8.49	8.52	7.82	7.41	—

The first column of figures shows the calculated amounts of water-soluble phosphoric oxide in the mixtures, the other columns being obtained, as already stated, by direct analysis.

For comparison I append a series of results obtained by Professor G. Gray, of the Canterbury Agricultural College, Lincoln, New Zealand,* from mixtures made up on similar lines to those above mentioned, and also consisting of equal parts of their respective constituents:

* Transactions of the Australasian Assn. for the Adv. of Science, Dunedin (1904).

	Original Composition.	Composition after standing for— 3 hours.	24 hours.	6 days.	12 days.	18 days.
Superphosphate alone ...	17.74	—	—	—	—	—
1. Superphosphate and Kainit...	8.87	8.87	8.87	8.50	8.25	8.25
2. Superphosphate and Coral Queen Guano	8.87	8.87	8.57	8.37	8.37	8.25
3. Superphosphate and Chesterfield Guano... ...	8.87	7.87	7.37	4.87	4.00	3.37
4. Superphosphate and Bone Dust	8.87	8.87	8.87	8.87	8.62	8.62

The guanos used by Professor Gray for his mixtures had the following percentage composition:

	Coral Queen.	Chesterfield.
Citrate-soluble phosphoric oxide	18.5	17.5
Calcium carbonate	1.1	37.9
Iron oxide	8.8	—

The following table shows the total percentage change in each of the mixtures during the periods specified:

	3 hours.	24 hours.	1 week.	2 weeks.	3 weeks.
(*a*) Superphosphate and Sulphate of Ammonia...	—1.15	—0.11	+0.35	+1.27	+2.42
(*b*) Superphosphate and Sulphate of Potash.. ...	—0.35	—0.35	—0.35	+0.69	+0.46
(*c*) Superphosphate and Kainit...	—0.69	+0.92	+0.69	+0.92	+0.12
(*d*) Superphosphate and Government Guano.. ...	—6.80	—11.09	—14.07	—15.37	—21.06
(*e*) Superphosphate and Bone meal	—2.18	—1.84	—9.90	—14.63	—

In this table a minus sign shows reversion, and a plus sign indicates an increase upon the original amount of soluble phosphoric oxide. In Professor Gray's experiments there was reversion in every case, and the percentages of the original water-soluble phosphoric oxide reverted are shown below:

	3 hours.	24 hours.	6 days.	12 days.	18 days.
1. Superphosphate and Kainit...	0.0	0.0	—4.1	—6.9	—6.9
2. Superphosphate and Coral Queen Guano	0.0	—3.3	—5.3	—5.3	—7.0
3. Superphosphate and Chesterfield Guano... ...	—11.2	—16.9	—44.8	—54.9	—62.0
4. Superphosphate and Bone Dust	0.0	0.0	0.0	—2.8	—2.8

The tabulated results of my analyses show that the greatest reversion took place in mixture (*d*), superphosphate and Government guano, and that in this respect the superphosphate-bone meal mixture (*e*), was not far behind.

The results obtained from mixture (*a*), superphosphate and sulphate of ammonia, are of great interest, in that they showed, after the first week, a very slight but decided increase in water-soluble phosphoric oxide. A further set of experiments was conducted to ascertain whether this slight increase of the water-soluble phosphates in mixture (*a*) could be accounted for. A high-grade superphosphate (manufactured in Japan) containing 19.37 per cent. of water-soluble and 20.39 per cent. of total phosphoric oxide, and a total of 28.03 per cent. of combined lime was employed in this and all subsequent work, and the tests were carried out on similar lines to those already detailed. The sulphate of ammonia employed in this set of analyses was the chemically pure salt, not the commercial article as usually sold for fertilising purposes, which was employed in the previous experiment.

The results obtained are as follows:

Original Mixture.	3 hours.	24 hours.	1 week.	2 weeks.	4 weeks.
9.685	9.48	9.48	9.67	9.66	9.65

Here again, as in the case of mixture (*a*), it will be seen that a similar drop in solubility took place within a few hours, from which there was a recovery after the mixture had stood for one week. The *increase* in solubility noticed in the previous experiment did not occur.

When, however, our attention is turned to the Government guano mixture (*d*), it will be seen that the actual loss of water-soluble phosphates is 21 per cent. of the amount originally present. It appeared likely that the large amount of ammonium salt, existing probably as ammonium carbonate in the guano, would account for the high percentage of reversion. So the experiment detailed hereunder was carried out.

Ammonium carbonate—extra pure—was freed from adherent moisture by extracting first with absolute alcohol. The alcohol was allowed to drain off, and the residue then taken up with chemically pure ether. The ether was allowed to evaporate off in the sun, the residual carbonate was then powdered, and after sifting through a 1 mm. sieve, it was mixed with an equal weight of superphosphate. This mixture was placed in a glass-stoppered bottle, and the gas (carbon dioxide) was driven off rapidly by the action of the acid of the superphosphate. After standing as in previous experiment, the following percentages of water-soluble phosphoric oxide were obtained:—

Original Mixture.	3 hours.	24 hours.	1 week.	2 weeks.	4 weeks.
9.685	2.58	.78	.42	.47	.42

Clearly, therefore, the considerable decrease of solubility when superphosphates are mixed with Government guano is due to the presence of ammonium carbonate in the guano.

In the case of kainit Gray remarks that this reversion may be put down mainly to magnesium salt. The most interesting mixture of all is that of superphosphate and bonemeal in the above mixtures prepared by me; the reversion had amounted to over $14\frac{1}{2}$ per cent. in two weeks. In Gray's experiment only 3 per cent. of the soluble phosphoric oxide reverted.

In a further experiment bone ash ($Ca_3P_2O_8$) was used, which was found to contain .74 per cent. of soluble phosphoric oxide.* The superphosphate was the same as previously used, analysing 19.37 per cent. of water-soluble phosphoric oxide.

This mixture (equal parts of bone ash and superphosphate) gave the following percentages of water-soluble phosphoric oxide at the end of the times stated:

Original Mixture.	3 hours.	24 hours.	1 week.	2 weeks.	4 weeks.
10.05	12.05	12.10	11.65	11.59	11.24

The figures obtained from the first two determinations were rather surprising, and as they might possibly have been due to improper mixing, a further independent mixture was made, which analysed 12.14 and 12.09 after standing for 3 and 24 hours respectively.

This increase was plainly due to the presence of free acid in the superphosphates used in the above set of experiments, or, in other words, there was enough free acid in the superphosphate used to bring about solution of the 2.00 per cent. of phosphoric oxide by which the original 10.05 per cent. was increased. In order to confirm this a solution of a superphosphate was made as follows: 100 grams were extracted for half an hour with distilled water in a 1,000 c.c. flask, shaken in a shaking apparatus for half an hour, filled up to the mark, and an aliquot part of the filtrate gave a result equivalent to 18.92 per cent. of water-soluble phosphoric oxide in the superphosphate. To 500 c.c. of the clear filtrate, equivalent to 50 grams of superphosphate 3.35 grams of pure precipitated tricalcium phosphate were added, and the mixture extracted in a shaking apparatus for half an hour, filled up to the 1,000 c.c. mark, well mixed and filtered. In an aliquot part the water-soluble phosphoric oxide was found to be equivalent to 19.84 per cent., again proving that in the mixture of superphosphate and bone ash an increase in the water-soluble phosphoric oxide results.

A blank determination of the water-soluble phosphoric oxide in the quantity of precipitated tricalcium phosphate actually used was found to yield 0.064 gram of water-soluble phosphoric oxide.

Calculated amount in a Mixture of 100 Grams of Superphosphate and 6.70 Grams of Precipitated Tricalcium Phosphate.		Percentage found in a Mixture of 100 Grams of Superphosphate and 6.70 Grams of Precipitated Tricalcium Phosphate after Shaking.
17.90 per cent.	....	19.84 per cent.

A further test, using some specially prepared $Ca_3P_2O_8$ from Kahlbaum, containing 0.0256 gram of water-soluble phosphoric oxide, gave the following results:—

*A duplicate determination gave .73 per cent.

Calculated amount.		Percentage found after Shaking.
17.78 per cent.	....	20.23 per cent.

In order to confirm the above, the following mixtures were made:

A. A medium high-grade superphosphate and bone ash containing 15.63 per cent. and 0.73 per cent. of water-soluble phosphoric oxide respectively.

B. A high-grade superphosphate and bone ash containing 18.25 per cent. and 0.65 per cent. of water-soluble phosphoric oxide respectively.

The results of the analyses being:—

No.	Original Mixture	3 hours.	24 hours.	1 week.	2 weeks.	3 weeks.	4 weeks.
A.	8.18	9.65	9.39	8.89	8.66	8.86	8.80
B.	9.45	10.04	9.94	—	—	—	—

This once more proves that an increase of water-soluble phosphoric oxide results when superphosphate and bone ash are mixed.

In order to confirm the above results, and ascertain if there would be such an increase when weighed quantities of calcium phosphate of different origin are extracted with a water-solution of superphosphate, the following quantities were taken:

A. 4.366 grams of pure calcium phosphate.

B. 4.366 grams of bone ash.

C. 4.366 grams of precipitated calcium phosphate.

These were all treated in the same manner, the quantity being extracted for half an hour in a shaking machine with 500 c.c. of superphosphate solution, then filtered, and in an aliquot part the water-soluble phosphoric oxide was determined, the results being:—

No.	Theoretical Amount of Water-Soluble Phosphoric Oxide.	Percentage of Water-Soluble Phosphoric Oxide found.
A.	16.81 per cent.	17.59 per cent.*
B.	16.83 per cent.	17.82 per cent.
C.	16.93 per cent.	17.89 per cent.

In the first column the figure given is the calculated amount of water-soluble phosphoric oxide in a mixture of 100 grams of superphosphate and 8.732 grams of the calcium phosphate, and in the second column the percentage of water-soluble

* This result was obtained by extracting the 4.366 grams with 500 c.c. of superphosphate solution, as already described, taking an aliquot part (equivalent to 2 grams) for analysis. The determination was repeated a second and third time with similar quantities of material, *viz.*, 4.366 grams of calcium phosphate were extracted with 500 c.c. of superphosphate solution, but the mixture was diluted to 1,000 c.c.; larger aliquot parts, corresponding to a 2½ grams and a 1 gram quantity respectively were taken for analysis, and gave 17.06 per cent. and 17.87 per cent. of water-soluble phosphoric oxide.

phosphoric oxide after shaking for half an hour in a shaking machine.

The quantity of material used, 4.366 grams, gave the following amounts of water-soluble phosphoric oxide:—

No.	Material.	Weight of Soluble Phosphoric Oxide.
A.	Pure Calcium Phosphate.	0.0164 gram.
B.	Bone Ash.	0.0284 ,,
C.	Precipitated Tricalcium Phosphate.	0.0793 ,,

Conclusions.

Superphosphate can remain mixed for as long as three weeks with either sulphate of ammonia or sulphate of potash or kainit without an appreciable loss of water-soluble phosphoric oxide, and if mixed with sulphate of ammonia there is a possibility of an actual increase of water-soluble phosphoric oxide in a period of three weeks.

If immediate reversion of water-soluble phosphoric oxide is to be avoided, Government guano should on no account be mixed with superphosphate, for in a mixture of equal parts of the two there is, even after three hours, a total loss of nearly 7 per cent. of the water-soluble phosphoric oxide.

In the case of bone meal there is a loss of 2 per cent. of water-soluble phosphoric oxide in three hours, but if left for a period of 14 days there is considerable loss, amounting to over 14½ per cent.

It is quite evident that the two samples of kainit as used by Gray and myself varied considerably, judging from the loss of water-soluble phosphoric oxide: the substance used by the former caused a loss of nearly 7 per cent. in 18 days, whereas in my case there was a slight increase of water-soluble phosphoric oxide. These remarks apply also to the two bone products used: in the former case there was a loss of only 2¾ per cent. in 18 days, as against 14½ per cent. in 14 days with the substance used by me.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, August 12th. B. Price, M.I.E.E., President, in the chair.—"*Note on the value of annealing the connecting attachments on winding plants*": J. A. **Vaughan.** After receiving a heavy blow from a skip to which it was attached, a timber trailer working in an incline shaft on the East Rand broke loose from the skip and dashed to the bottom of the shaft, killing six men who were working below. The direct cause of the fatality was the double fracture of a ring connecting the trailer with the skip. It appeared that this ring had never been annealed. A portion of the fractured ring was subsequently annealed, after which comparative tensile tests showed that the annealed portion possessed a greatly increased ductility compared with the unannealed portion; had this ductibility been present originally it was possible that the accident might have been prevented.—"*A few notes on repairing a large valve chamber by the quasi-arc system of*

Electric Welding": W. **Ingham.** Details were given of the electric welding process as applied for repairing, at a cost of £85, a defect in a cast steel valve chamber which it would have cost £200 to replace. The repaired valve chamber, though in subsequent use under a working head of about 1,000 feet for a period of two months, showed no sign of weakness.

SOUTH AFRICAN ASSOCIATION OF ANALYTICAL CHEMISTS.—Thursday, August 17th: J. McCrae, Ph.D., F.I.C., Vice-President, in the chair.—"*The Standardisation of Acid and Alkali*": J. A. **Campbell.** The author discussed the various methods which have been suggested for the standardisation of acids and alkalies, and also the indicators used.—"*Poisonous Plants of South Africa*": Dr. J. **McCrae.** The author pointed out that most of the investigation of these plants had been carried out by the Imperial Institute, although a little had been done by Juritz and Marloth. He outlined the properties of the poisonous substances which had been obtained from the hard pear tree, Transkei quinine tree, giftbol., *Senecio latifolius*, Transvaal tulip, Cape Slangkop, giftblaar, *Mesembrianthemum*, *Tephrosia*, *Cannabis sativa*, and others.

ROYAL SOCIETY OF SOUTH AFRICA — Wednesday, October 18th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*African Myxomycetes*": Miss A. V. **Duthie.** A list of the species of Myxomycetes previously recorded from Africa in various journals and monographs, and forms which have been accessible to or collected by the author.—"*On Hybrid forms in the genus* Satyrium, *with descriptions of two new forms*": Miss A. V. **Duthie.** A description of two hybrids from Tulbagh, one *Satyrium erectum* × *coriifolium*, the other *Satyrium erectum* × *bicorne*. A detailed description was given of the vegetative and floral structures in each form. The morphological evidence was supported by observations on the parent forms.—"*Ionisation of Gases and the Absorption of Röntgen Rays*": L. **Simons.** The independence of *X*-ray effects of molecular aggregations and the dependence only on the atoms present, together with the fact that it has been shown that the absorption of a given wave length in a solid varies as the fourth power of the atomic number of the solid, whilst for a gas the primary β ionisation also varies as the fourth power of the atomic number of the atom ionised, leads to the conclusion that absorption in solids (apart from scattering) is due throughout to the production of β particles.—"*Note on the occurrence of Daphnin in the Arthrosolen*": Prof. M. **Rindl.** The author has determined the presence of daphnetin and glucose in *Lasiosiphon polycephalus*, a perennial shrub which flowers in August and September, known to South African farmers as Januariebosje. He assumes that the glucoside daphnin had been present and was hydrolysed in the process of extraction.

CHEMICAL, METALLURGICAL, AND MINING SOCIETY OF SOUTH AFRICA.—Saturday, September 16th: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*Recent advances in chemical industry*" (Presidential address): Prof. J. A. **Wilkinson.** The address commenced with a brief survey of improvements made in the production of materials available for industrial chemical operations; after which improvements in the industries themselves were discussed. These included advances in the technical preparation of hydrogen for aerial navigation; methods of inducing combination between atmospheric nitrogen and oxygen, hydrogen, metals, and carbides, respectively; the sulphuric acid and alkali industries; the chemical industries induced by the utilisation of cheap electric power, and those resulting from the demands for high oxidisers and for efficient illuminants. In the field of organic chemistry, reference was made to synthetic dyes, synthetic drugs, and synthetic perfumes, and to other industries developed from wider applications of the processes of chemical synthesis.—"*The valuation of mines*": Prof. R. A. **Lehfeldt.** The author discussed the conditions that had to be fulfilled in order that the present worth of a given mine might be a maximum. An equation was found expressing the relation between the life of the mine and the scale of working. This equation could not be solved directly, but was capable of ready evaluation with the aid of a table of exponentials.—"*The man-*

ganese-silver problem": W. **Neal.** An account of progress made in solving the difficulties encountered in the treatment of rebellious manganese-silver ores.

Saturday, October 21st: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*The hardening and annealing of metals*": Prof. T. **Turner.** The effects produced upon the properties of metals and alloys by cold working, such as hammering or drawing, were discussed. The nature of the hardening which takes place under such treatment may be grasped by assuming that in a crystalline metal or alloy shearing results in the formation of a film of amorphous material, closely allied in its properties to those of a surface film in a liquid, and that annealing releases the state of strain existing in these thin films, thus leading to an increase of density, and permits of recrystallisation.—"*Testing the strength of explosives*": J. A. **Campbell.** A short account of the types of apparatus used for testing the strength of explosives, and of the methods of determining their sensitiveness and rate of detonation.

Saturday, November 18th: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*Neutralisation effect of ash on acid-sand in stope-filling.*" C. **Toombs.** Sand from a dump which had been used for stope-filling was subsequently found to cause trouble by reason of its extreme acidity. It was therefore decided to mix ordinary ash from the ash dumps with the acid sand, and to send this mixture underground as filler. The ash usually contains from 25lb. to 40lb. of free calcium oxide per ton, and it was found that 2,200 tons of ash and 13 tons of lime were needed to neutralise the acid in 22,000 tons of sand.—"*Flotation concentration experiments on a Transvaal Gold ore*": F. **Wartenweiler.** An account of an investigation having for its object the maximum recovery of gold from an arseno-pyritic gold ore developed below the oxidised zone of mine working at Barberton.—"*Ore treatment at the Falcon Mine, Rhodesia*": H. R. **Adam.** The mine is situated at Umvuma, 160 miles from Bulawayo, and its monthly output is about 600,000lb. of blister copper, 3,000 oz. of gold and 6,000 oz. of silver. An outline was given of the milling and smelting processes employed at the mine.

South African Institute of Electrical Engineers.—Thursday, September 21st: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*The main switch-board of the Johannesburg Municipal Electric supply system*": Major J. H. **Dobson.** The switchboard differs widely from any in use for mining on the Witwatersrand. It provides for three requirements: direct current power at 600 volts for traction; three-wire direct current at 460 and 230 volts in the Inner Area; and a 3,000 volt alternating current supply for the suburbs. All erection work connected with the switchboard was carried out by the Municipal Council's employés. A noticeable feature of the whole switchboard is the large margin of safety in connection with the insulation: porcelain is used throughout, and the size of all insulators is at least double that usually supplied by makers for a given pressure.

NEW BOOKS.

Plaatje, S. T.—"*Native life in South Africa before and since the European War and the Boer Rebellion.*" Post 8vo. pp. 352. Ports. London: P. S. King & Son. 1916. 16oz. 3s. 6d.

Rayner, W. S., and **W. W. O'Shaughnessy.**—"*How Botha and Smuts conquered German South-West Africa.*" pp. 200. London: Simpkin, Marshall & Co., 1916. 16oz. 2s.

Evans, Maurice S.—"*Black and White in the Southern States: A Study of the Race problem in the United States from a South African point of view.*" London: Longmans, Green & Co. 1915.

Theal, G. McCall.—"*History of South Africa, from 1795 to 1872.*" Vol. 3. pp. xvii, 496. 3 charts. London: Allen & Unwin. 1916. 7s. 6d.

Robinson, J. P. Kay.—"*With Botha's Army.*" London: Allen & Unwin. 1916. 3s. 6d.

THE WHEAT SOILS OF ALEXANDRIA DIVISION, CAPE PROVINCE.

By Charles Frederick Juritz, M.A., D.Sc., F.I.C.

(*With One Text Figure.*)

During the early part of 1914 it was reported to the Department of Agriculture that for some time previously the cereal crops in the Division of Alexandria had been observed to be deteriorating. The deterioration, according to local agricultural opinion, was apparently due to exhaustion of the soil, and the Under-Secretary for Agriculture, who had visited the area in question, thereupon requested the writer to undertake a physical and chemical examination of representative soils from the affected district.

Arrangements were made through the Magistrate of Alexandria to have twenty typical samples of soil collected for analysis from farms situated in the Field Cornetcy of Alexandria, *i.e.*, within a radius of about eight miles from Alexandria town commonage. The intention was to have in each case a cultivated soil and the corresponding virgin soil examined, but this course was not found invariably possible. The samples were collected during the latter half of 1914.

Description of the Samples.

The following details of the soil samples taken were gathered from the occupants of the farms:—

No. 1 was collected on Mr. Charles Gardner's farm, "Klein Jagers Drift," at a distance of about 12 miles from the coast, and 15 to 20 feet above sea-level. The annual rainfall is about 25 inches, and the land is level, but surrounded by bush-covered mountains. The upper layers of soil, to a depth of 10 to 15 feet, are grey in colour, and rather sandy above with underlying hardpan. The surface soil is reputed good for a depth of 3 to 5 feet, below which it becomes more sandy. The natural herbage is red grass (*rooi gras*) with a mixture of sweet grasses. Manures are not generally used, but for years all classes of cereals and rape had been successfully grown. Of late wheat has proved a total failure, and other crops rarely come to perfection. The soil represented by the sample formed part of a valley which had been well ploughed and cultivated during the last five years, but never manured, although under cultivation for 30 years.

No. 2 was a virgin soil taken from ground adjacent to the cultivated soil represented by No. 1.

No. 3 was taken from Mr. Charles Gardner's farm, "Spadona," nine miles from the coast and 250 to 300 feet above sea-level. The lands from which the sample was collected form part of a level plateau, with a fall of about 300 feet to the Bushman's River, and then a rise of 200 feet to the next plateau. The soil is deep red in colour, and is known locally as *rooi grond;*

its physical nature is clayey with a gravelly subsoil. The indigenous herbage here consists of *rooi gras* and *blauw gras,* the common grasses of "sour veld." Wheat, barley, and oats are all said to have been successfully grown years ago. The soil has been well ploughed and cultivated during the last five years, and was treated with superphosphates (containing 13 per cent. of phosphorus pentoxide) in August, 1913.

No. 4 was a virgin soil taken within a few yards of the cultivated soil whereof No. 3 was a sample.

No. 5 represented a cultivated but unmanured valley soil from the farm "Dekselfontein," of Mr. J. J. van Rooyen, distant seven miles from the sea, and roughly 100 feet above sea-level. As in the previous cases, the approximate annual rainfall for the area is taken as 25 inches. The country is level, and the soil is a brown to white sandy loam, 2 feet deep, with a grey sand subsoil of uncertain depth below. The natural vegetation is a mixture of sour and sweet herbage. Kraal manure and some guano are generally used in these parts in order to fertilise the lands, but the particular soil represented by No. 5, as above stated, has never been manured. During the last five years this soil has been cultivated every year, and planted in alternate years with maize and barley. The most successful crop has proved to be barley, and next in order maize, and then oats.

No. 6 was a virgin soil in other respects similar to No. 5.

No. 7 was a cultivated unmanured valley soil from Mr. F. H. Collin's farm, "Lange Vlakte," situated approximately 2½ miles from the sea, and at about 400 feet above sea-level. The annual rainfall is 30 inches, and the surrounding country is undulating. The surface soil is a dark sandy loam varying from 3½ feet to a much greater depth, with a subsoil varying between a sandy limestone and a light yellow sand. The natural herbage consists of *kweek gras* when not under cultivation, and generally of red grass. Where manures are used in this district kraal manure is generally employed. Wheat, oats, barley and maize have been successfully grown on the lands of which No. 7 is a type, wheat becoming less successful each year, although the soil has been subjected to the usual yearly ploughing and harrowing during the last five years.

No. 8 was a virgin valley soil taken from a different part of the same farm as No. 7, about 450 yards from the latter. The surface soil is a dark sandy loam about 3½ feet deep, with a subsoil below varying like that of No. 7. The surrounding *veld* is sweet, and the natural herbage consists of red grass and indigenous forest growth.

No. 9 represents a cultivated but unmanured soil collected from a hillside on the farm "Kruisfontein," of Mr. S. C. van Rooyen, three miles from the coast and about 100 feet above sea-level. The surrounding country is level, and the annual rainfall is 25 inches. The surface soil is a black, sandy loam, 15 inches deep, with a sandy subsoil of unknown depth. The lands are "sweet veld," and support a natural vegetation of mimosa and forest trees. Kraal manure and guano are generally used in the district for fertilising the soil. Oats and maize are the most successful crops raised, but barley is also cultivated. The soil has received no other treatment than cultivation during the last five years.

No. 10 is also a hillside soil collected on the same farm as No. 9, and is representative of the same class of soil. It has been under cultivation for only one season—about 1906—but was never manured, so that it is practically a virgin soil.

No. 11, a cultivated but unmanured soil, represents a low, sloping hillside, exposed to south-westerly winds. Formerly splendid wheat crops were grown here, but wheat production now meets with very little success. The sample was taken on the farm "Island View" (part of "Groote Vallei"), about one mile distant from the sea and three to four hundred feet above sea-level. The country is undulating, with a rainfall said to be about 26 inches per annum. The soil, to a depth of 12 to 15 inches, is a dark, sandy loam, with a light sandy subsoil. Limestone is exposed along the ridges. The present natural vegetation consists of couch grass, but prior to cultivation "tol bos" (*i.e.*, monkey apple) and ordinary sweet veld grass prevailed. There are no indications of brack, nor has the land ever been irrigated. The crops grown are wheat, barley and oats, the last two being most successful. The only manuring practised is green soiling, and the soil has received no other treatment during the last five years.

No. 12 represents a level surface of virgin soil from plains on the same farm.

No. 13 was a cultivated but unmanured sandy loam from a valley on the farm "Kruisfontein," of Mr. J. J. van Rooyen, about seven miles from the coast. The country around is level, and the dark-coloured, sandy loam which composes the surface soil extends downwards some three or four feet with a grey sand of unknown depth below it. The *veld* is a mixture of sour and sweet vegetation. Kraal manure is generally used for fertilising the soil of the district together with some guano, and the crops generally grown are barley, maize, and oats, the first two being the more successful. Wheat grows, but is subject to disease.

No. 14 represented an uncultivated soil from land adjoining the ground in the valley whence sample No. 13 had been taken, on Mr. J. J. van Rooyen's farm "Kruisfontein." It was in all other respects similar in character to No. 13.

No. 15 was a valley soil from the farm "Doornkloof," of Mr. J. M. Scheepers, distant seven miles from the sea, and about 100 feet above sea-level. The rainfall is stated to be about 26 inches per annum. The country round about is hilly, and the sandy surface soil goes down to a depth of about 3 feet, its colour varying between grey and red. The subsoil is potclay of unknown depth. The veld is what is locally known as "broken," *i.e.*, sweet in some parts, and sour in others. Guano is generally used in this district, but not on the soil represented by the sample. Mealies and barley are grown, the former being the more successful. The lands from which the sample was taken have been ploughed three times per annum during the last five years, and straw was thrown on the land about three years before the soil was sampled. With that exception the lands have received no addition during the previous 26 years.

No. 16 was a virgin soil from a hillside in the neighbourhood of No. 15, and in other respects typical of the same class of soil as the latter.

No. 17, a cultivated hillside soil, was taken from the farm "Brakfontein," of Mr. C. K. Scheepers, situated about 10 miles from the coast, and approximately 200 feet above sea-level. The rainfall is about the same as at the last-mentioned farm. The country is, for the most part, flat with occasional slight undulations. The soil is slate-coloured and sandy to a depth of from 6 to 15 inches, below which is a clay, generally about 6 feet deep. Sour grasses grow on the land, the trees in the valleys and on the hills being of the same character as those in the Crown Forests. Patches of mimosas likewise occur, and a shrub locally known as monkey apple, or "tol bos" (*Royena pubescens*), from 2 to 10 feet high, predominates in the open veld. There are indications of brack on the lands, as, in fact, the name of the farm indicates, and all the water on the farm is of a brackish nature. Guano, superphosphate and basic slag are generally used in the district, but the land whence the sample was taken had never been manured, nor had it received any other treatment during the last five years, although oats, barley, maize and rape had been grown on it.

No. 18 was a virgin hillside soil, identical in all other respects with No. 17.

No. 19 represents a cultivated unmanured valley soil, and was collected on Mr. J. F. Coltman's farm, "Wycombe Vale," about nine miles from the coast, and approximately 300 feet above sea-level. The nature of the surrounding country is hilly, and the soil consists of reddish sand, which persists to an unascertained depth. The veld is sweet. Guano is generally used as a fertiliser in the district. The soil originally grew barley and corn, but is at present said to be fit only for the production of oathay on account of deterioration. The soil has not received any treatment during the last five years.

No. 20 was a virgin soil from the same farm, and similar in all other respects to No. 19.

In no case had any of the above lands ever been under irrigation, and, with the exception of Mr. C. K. Scheepers' farm, alkali salts had not been perceived on any of the soils sampled.

Physical Composition of the Soil.

Mechanical analyses were made of all the soils above described, following the method described on pages 7 and 193 to 195 of my *Agricultural Soils of Cape Colony*. The results obtained are given in the following table:—

MECHANICAL ANALYSES.

(Percentages by weight of absolutely dry field samples.)

No.	Character of Soil.	Class of Soil	1 Pebbles. > 3 mm.	2 Coarse gravel. 3–2 mm.	3 Fine gravel. 2–1 mm.	4 Coarse sand. 1–.5 mm.	5 Medium sand. .5–.25 mm.	6 Fine sand. .25–.1 mm.	7 Very fine sand. .1–.05 mm.	8 Silt. .05–.01 mm.	9 Fine silt. .01–.005 mm.	10 Clay. < .005 mm.
1.	Cultivated	Fine sandy loam	Nil.	Nil.	.02	.02	5.92	38.44	20.92	12.51	12.71	9.46
2.	Virgin	Fine sandy loam	Nil.	Nil.	.03	.03	6.57	37.02	15.71	14.89	14.01	11.74
3.	Cultivated	Fine sandy loam	Nil.	Nil.	.20	.85	8.93	38.33	14.17	14.57	14.03	8.93
4.	Virgin	Fine sandy loam	Nil.	.06	.44	.70	8.52	38.24	14.21	16.82	12.53	8.49
5.	Cultivated	Medium sand	Nil.	Nil.	.06	.06	42.02	35.90	4.19	4.97	6.26	6.54
6.	Virgin	Medium sand	.67	Nil.	Nil.	.04	44.20	38.60	4.02	4.19	5.30	2.89
7.	Cultivated	Fine sand	Nil.	Nil.	Nil.	.02	10.18	66.22	5.29	6.85	6.00	5.45
8.	Virgin	Fine sandy loam	.01	.11	.17	.10	13.04	59.76	3.72	8.08	7.55	7.47
9.	Cultivated	Medium sand	Nil.	Nil.	Nil.	Nil.	25.67	49.56	7.41	7.64	6.05	3.67
10.	Virgin (practically)	Medium sand	Nil.	Nil.	Nil.	Nil.	25.31	50.31	8.19	7.41	5.99	2.79
11.	Cultivated	Fine sandy loam	Nil.	.03	.02	.02	4.58	55.90	9.42	11.28	12.14	6.62
12.	Virgin	Fine sandy loam	.02	.06	.13	.06	8.24	62.18	8.24	8.81	7.39	4.88
13.	Cultivated	Sandy loam	.05	Nil.	.14	.04	30.44	38.85	5.82	8.59	9.52	6.56
14.	Virgin	Fine sandy loam	Nil.	Nil.	.06	.02	14.80	44.66	9.10	14.84	9.99	6.52
15.	Cultivated	Fine sandy loam	.79	.19	.28	.21	3.21	49.55	17.03	11.62	9.57	7.55
16.	Virgin	Fine sandy loam	.03	.03	.13	.08	1.61	35.53	16.77	19.98	15.89	9.95
17.	Cultivated	Medium sand	Nil.	Nil.	.03	.04	26.69	47.50	10.07	7.16	5.39	3.12
18.	Virgin	Sandy loam	Nil.	Nil.	.05	.05	20.99	40.76	14.18	12.46	7.92	3.60
19.	Cultivated	Sandy loam	Nil.	Nil.	.11	.08	29.48	34.81	10.76	10.06	6.74	7.95
20.	Virgin	Sandy loam	Nil	Nil.	.04	.08	26.20	33.16	12.44	13.55	9.21	5.23

The foregoing table may be simplified by presentation in a more summarised form, thus:—

No.	Pebbles. > 3 mm. Per cent.	Gravel. 3–1 mm. Per cent.	Sand. 1–.05 mm. Per cent.	Silt. .05–005 mm.. Per cent.	Clay. < .005 mm. Per cent.
1	0	0	65	25	9
2	0	0	59	29	12
3	0	0	62	29	9
4	0	1	62	29	8
5	0	0	82	11	7
6	1	0	77	9	3
7	0	0	77	16	7
8	0	0	82	13	5
9	0	0	83	14	4
10	0	0	84	13	3
11	0	0	70	23	7
12	0	0	79	16	5
13	0	0	75	18	7
14	0	0	69	25	7
15	1	0	70	21	8
16	0	0	54	36	10
17	0	0	84	13	3
18	0	0	76	20	4
19	0	0	75	17	8
20	0	0	72	23	5

This table shows that the soils collected were all more or less sandy, some, however, with a fair proportion of silt, but most containing but little clay. They are all fine-grained soils, and for all practical purposes devoid of pebbles, gravel, and even coarse sand.

From the above mechanical analyses these soils may be classified as follows:—

	Medium Sands.	Fine Sands.	Sandy Loams.	Fine Sandy Loams.
Cultivated Soils ..	5, 9, 17.	7.	13, 19.	1, 3, 11, 15.
Virgin Soils ..	6, 10.		18, 20.	2, 4, 8, 12, 14, 16.

In this last table, the cultivated soils have been placed immediately over the virgin soils to which they correspond, except where the two fall into different classes, in which case the space above (or below) has been left blank. The coarsest soils of the series are Nos. 5, 6, 9 and 10, and these all lie within about four miles from Alexandria, in a south-westerly direction. No. 13, a sandy loam of the less fine character, is situated in the same area. Broadly, the coarser soils incline to grey, and the finer soils to brown in colour.

The most pronouncedly brown soils are Nos. 16, 19, 20, and these all come from farms some 24 miles west of Alexandria village, in the field-cornetcy Congo's Kraal. The most definitely grey soils are Nos. 5, 6 and 7, all of which form part of the area three or four miles west of Alexandria.

Physical Requirements of Wheat Soils.

Comparing the results of the foregoing mechanical analyses of the Alexandria soils with what is known regarding the best wheat areas and the physical composition of soils investigated in the United States, one cannot regard the former as in all respects ideal for wheat cultivation. They do not contain the proportions of clay and humus usually regarded as indispensable for wheat soils, and incline more to the light and sandy nature which is less suited for the purpose.* It is true that soils approximating in composition even to the coarser Alexandria soils *are* used for wheat cultivation; and that soils of the type of Nos. 5, 7, 9 and 17 may be placed alongside even lighter soils satisfactorily used for wheat in America. Thus No. 7 is somewhat heavier (*i.e.*, is physically of finer grain) than the Clyde sand, in the State of Michigan, described by the United States Soil Survey, as may be seen from the following:—

	Fine gravel. Per cent.	Coarse sand. Per cent.	Medium sand. Per cent.	Fine sand. Per cent.	Very fine sand. Per cent.	Silt. Per cent.	Clay. Per cent.
No. 7	0	0	10	66	5	13	5
Clyde sand	1	6	23	47	8	9	5

Yet the Clyde [illegible] produce good crops of maize

ERRATA IN JANUARY NUMBER.

Page 216, 4th and 5th lines from bottom. For "and these all" read "the last two of which"

[illegible]

A convenient method of classifying the cultivated Alexandria soils examined according to their mechanical analysis is the following:—

No.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Medium Sands—							
5	0	0	42	36	4	11	7
9	0	0	26	50	7	14	4
17	0	0	27	48	10	13	3
Fine Sand—							
7	0	0	10	66	5	13	5
Sandy Loam—							
13	0	0	30	39	6	18	7
19	0	0	20	35	11	17	8
Fine Sandy Loam—							
1	0	0	6	38	21	25	9
3	0	1	9	38	14	29	9
11	0	0	5	56	9	23	7
17	0	0	3	50	17	21	8

* See Ingle: "Elementary Agricultural Chemistry (1913), 121.

† United States Soil Survey Field Book (1906), 156.

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7	0	0	77	16	7
8	0	0	82	13	5
9	0	0	83	14	4
10	0	0	84	13	3
11	0	0	70	23	7
12	0	0	79	16	5
13	0	0	75	18	7
14	0	0	69	25	7
15	1	0	70	21	8
16	0	0	54	36	10
17	0	0	81	13	3
18	0	0	76	20	4
19	0	0	75	17	8
[illegible]	[illegible]	[illegible]	[illegible]	23	5

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The most pronouncedly brown soils are Nos. 16, 19, 20, and these all come from farms some 24 miles west of Alexandria village, in the field-cornetcy Congo's Kraal. The most definitely grey soils are Nos. 5, 6 and 7, all of which form part of the area three or four miles west of Alexandria.

Physical Requirements of Wheat Soils.

Comparing the results of the foregoing mechanical analyses of the Alexandria soils with what is known regarding the best wheat areas and the physical composition of soils investigated in the United States, one cannot regard the former as in all respects ideal for wheat cultivation. They do not contain the proportions of clay and humus usually regarded as indispensable for wheat soils, and incline more to the light and sandy nature which is less suited for the purpose.* It is true that soils approximating in composition even to the coarser Alexandria soils *are* used for wheat cultivation; and that soils of the type of Nos. 5, 7, 9 and 17 may be placed alongside even lighter soils satisfactorily used for wheat in America. Thus No. 7 is somewhat heavier (*i.e.*, is physically of finer grain) than the Clyde sand, in the State of Michigan, described by the United States Soil Survey, as may be seen from the following:—

	Fine gravel. Per cent.	Coarse sand. Per cent.	Medium sand. Per cent.	Fine sand. Per cent.	Very fine sand. Per cent.	Silt. Per cent.	Clay. Per cent.
No. 7 ...	0	0	10	66	5	13	5
Clyde sand ...	1	6	23	47	8	9	5

Yet the Clyde sand is said† to produce good crops of maize, wheat, oats and rye. The Clyde sand, however, contains much organic matter.

Nos. 5, 9 and 17 are of lighter, looser texture, and, judged merely by their *physical* condition, one would expect them to be, *chemically*, amongst the poorest soils of the entire series: such, indeed, the subsequent chemical analysis proved them to be.

A convenient method of classifying the cultivated Alexandria soils examined according to their mechanical analysis is the following:—

No.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Medium Sands—							
5	0	0	42	36	4	11	7
9	0	0	26	50	7	14	4
17	0	0	27	48	10	13	3
Fine Sand—							
7	0	0	10	66	5	13	5
Sandy Loam—							
13	0	0	30	39	6	18	7
19	0	0	29	35	11	17	8
Fine Sandy Loam—							
1	0	0	6	38	21	25	9
3	0	1	9	38	14	29	9
11	0	0	5	56	9	23	7
17	0	0	3	50	17	21	8

* See Ingle: "Elementary Agricultural Chemistry (1913), 121.

† United States Soil Survey Field Book (1906), 156.

Dr. H. W. Wiley* deals with the adaptation of a soil to different crops, which, he says, depends largely on the percentage of the silt classes of soil ingredients in the soil. He then proceeds to discuss different types of Maryland soils, which, for comparison with the table just above, may be designated by the letters A to F.

	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
A	½	5	40	28	12	10	4
B	0	2	29	41	11	7	9
C	2	6	14	8	16	39	15
D	0	½	½	24	33	19	23
E	0	0	1	4	12	49	34
F	1	½	1	1	7	43	46

Comparison of this table with that immediately preceding shows a fair resemblance between A and No. 5, and a closer resemblance between B and No. 17. The remaining four soils quoted from Dr. Wiley are each distinctly *heavier than any of the Alexandria soils.* Now Dr. Wiley says of A and B that they are

Altogether *too light in texture* for the profitable production of wheat, and it would cost altogether too much to improve them so that even a moderate yield of wheat could be obtained.

C represents a Southern Maryland tobacco soil. Dr. Wiley says of it:—

Wheat is commonly raised on these tobacco lands to get the after-advantage of the high manuring. . . . The finest tobacco lands are, however, *too light in texture* for the profitable production of wheat.

This means that Dr. Wiley considers a soil which is heavier than any of the Alexandria soils still too light for wheat production.

D is a type of the wheat soils of Southern Maryland. It will be observed that it contains 75 per cent of very fine sand, silt, and clay, whereas the heaviest of the cultivated Alexandria soils contains only 45 per cent. Yet of D, Dr. Wiley says:—

These soils represent about *the lightest texture* upon which wheat can be economically produced UNDER THE CLIMATIC CONDITIONS WHICH THERE PREVAIL. They contain from 18 to 25 per cent. of clay, and are much more retentive of moisture than the best tobacco lands. *This type is about the limit of profitable wheat production.* These soils will maintain about 12 per cent. of water during the dry season.

In order to ascertain how much water the Alexandria soils can retain, investigations on the spot would be necessary.

E represents the heavier wheat soils of Southern Maryland, which contain about 30 per cent. of clay. This soil is much more retentive of moisture than D, and produces very much larger crops of wheat.

F is a heavy calcareous soil, and is a strong and fertile wheat land.

* "Principles and Practice of Agricultural Analysis." 1 (Soils), 277-280.

In the United States Department of Agriculture, Division of Soils, Bulletin No. 5, it is also laid down* that

> The best wheat lands contain from 20 to 30 or 35 per cent. of clay, and maintain about 12 or 15 per cent. of water.

It would not be wise, on the basis of the above results alone, to condemn the Alexandria soils as unsuitable for wheat cultivation, but it would be very sound policy to follow up a clear *prima facie* case for fuller investigation of the problem, and of others therewith associated, in a country where the climatic conditions which prevail are, in their way, as characteristic as they are in Southern Maryland.

With regard to Dr. Wiley's views on the suitability of light soils for wheat cultivation, two points must not be overlooked. Dr. Wiley said that the soils to which he referred represent

> the lightest texture upon which wheat can be economically produced *under the climatic conditions which there prevail.*

So it does not follow that the limit of profitable wheat production in Southern Maryland will operate in identically the same way in Alexandria.

It is not unreasonable to suppose that in the Cape Province wheat may be economically grown on lighter soils than Maryland conditions permit, and points such as these we should set ourselves to find out.

And then due weight must be given to another word employed by Dr. Wiley—" for the *profitable* production of wheat " is the phrase used by him.

Wheat may, indeed, have been produced in the past on certain soils which can no longer produce it, but the question is, was it *ever* produced there profitably?

From the moment you take your first crop out of a soil which you never manure, you begin to impoverish that soil, and it is only if you incur the expense necessary to replenish this lost soil fertility as you go along, and to keep the soil in good physical condition, that you can gauge whether production is profitable or not. The mere fact that in any given year I spent no money on my lands—except the cost of the seed—and received £100 for the harvest, does not entitle me to say that my profit for the year was £100, less the cost of the seed. The debt to the soil must be reckoned in—the debt incurred by removing a certain part of the soil's plant-food constituents and not replacing them.

A business that involves a constant drain upon capital is by no means profitable.

English Wheat Soils.

Just here I may interpose some remarks from Hall and Russell's " Report on the Agriculture and Soils of Kent, Surrey and Sussex." On page 142 the authors give the mechanical

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* P. 11.

composition of nine typical wheat soils belonging to different formations in the South-Eastern Counties. On each of these soils wheat is at present grown successfully.

The physical composition of these soils may be summarised as follows:—

	Fine gravel.	Coarse and medium sand.	Fine sand and silt.	Fine silt and clay.
Thanet sand	1.2	5.2	65.6	19.3
Upper greensand	5.0	4.8	52.4	26.1
Brick earth	0.9	1.3	51.5	29.2
Clay-with-flints —				
Loyterton	1.1	1.0	55.6	28.1
Coulsdon..	1.7	5.7	47.0	29.6
London clay—				
Tolworth	0.4	12.8	36.8	34.8
Sheppey	0.5	0.3	31.0	52.1
Alluvium	0.1	0.0	49.2	32.6
Weald clay	0.5	2.5	38.9	43.8

The ten cultivated soils from Alexandria may be tabulated in the same way:—

No.	Fine gravel.	Coarse and medium sand.	Fine sand and silt.	Fine silt and clay.
1	0.0	5.9	71.9	22.2
3	0.2	9.8	67.1	23.0
5	0.1	42.1	45.1	12.8
7	0.0	10.2	78.4	11.5
9	0.0	25.7	64.6	9.7
11	0.0	4.6	76.6	18.8
13	0.1	30.5	53.3	16.1
15	0.3	3.4	78.2	17.1
17	0.0	26.7	64.7	8.5
19	0.0	29.5	55.6	14.7

Of these ten soils, six, Nos. 5, 7, 9, 13, 17 and 19, are at once seen to be lighter all round than any of the wheat soils referred to by Hall and Russell. The remaining four Alexandria soils average 20 per cent. of fine silt and clay, as against 33 per cent. in the nine English soils. The former are, therefore, the lighter. Further than this, they are not easy to compare, for Hall and Russell draw the line between fine silt and clay at .002 mm., instead of at .005 mm., as in my analyses. Bearing this in mind, however, the differences between the fine silt and clay in the two sets of soils may be compared as follows:—

English Soils—	Fine silt.	Clay.
Thanet sand..	7.4	11.9
Upper greensand	12.9	13.2
Brick earth	13.3	15.9
Clay-with-flints—		
Loyterton	9.4	18.7
Coulsdon.	9.6	20.0
London clay—		
Tolworth	11.1	23.7
Sheppey	15.3	36.8

	Fine silt.		Clay.
Alluvium	12.9	......	19.7
Weald clay	23.7	......	20.1
Alexandria Soils—			
No. 1	12.7	......	9.5
No. 3	14.0	......	8.9
No. 11	12.1	......	6.6
No. 15	9.6	......	7.5

Even if the difference in the respective sizes of the clay particles are allowed for, it appears clear that these four Alexandria soils contain less clay, and are therefore definitely lighter than those from the English wheat lands. Hall and Russell mention another soil—an alluvium from Weybridge—on which they say "good wheat used to be grown, but which has now been laid down to grass for many years." Its physical composition is as follows:—

Fine gravel.		Coarse and medium sand		Fine sand and silt.		Fine silt and clay.
1.3	....	38.4	....	45.5	....	8.9

Here we have a soil which to some extent resembles No. 5 of the Alexandria soils. Hall and Russell say of it:—

Although so light in texture, the field from which this sample was taken grows wheat excellently, *because it lies below river level and has permanent water at little more than two feet below the surface.* This will serve to illustrate the fact that the association of wheat with a particular type of soil really depends upon the way the soil maintains the supply of water to the plant, and is therefore greatly affected by the climate, or other external conditions which may cause variations in the amount of water in the soil. The conception of wheat soil, then, which may be obtained by considering the group of analyses, must only be regarded as true for the south-east of England, with an average rainfall of about 30 inches distributed very evenly throughout the year; it would indeed serve well enough for all the wheat-growing districts of England, but is unlikely that it represents the best type of soil under such very different climates as prevail in many extensive wheat-growing areas.

Of the nine soils in Hall and Russell's table, the lightest is the Thanet sand, but even that is heavier than any of the Alexandria soils: the four heaviest of the latter are those that approach nearest to it, *viz.*, Nos. 1, 3, 11 and 15. Hall and Russell say of the Thanet sand:—

This soil, though evenly textured, would be often of too light a character for wheat, but the Thanet sands in East Kent are well supplied with subsoil water, and crops on them rarely suffered from drought.

One would like to know whether in former years the Alexandria soils were better supplied with subsoil water than they are at present, and whether such a change may be included in the causes contributing to the deterioration of the wheat lands. It is said that even the best virgin soils of the area, if now put down to wheat, seldom produce a healthy crop, and this seems to show that some such change as that may have affected both virgin and cultivated soils alike.

PHYSICAL DETERIORATION OF SOILS.

In considering the deterioration of the Alexandria soils, it is evident that there are two main directions in which such deterioration may have proceeded, *viz.*, physical and chemical. The varieties of physical deterioration are more or less closely associated with changes in soil texture. The general effect of rain or irrigation on a cultivated soil is, as I have pointed out elsewhere,* to carry the finer silt and clay particles from the surface down to the lower soil levels, and so gradually to denude the surface soil of silt and clay, and to increase their proportion in the subsoil. This process also tends to impoverish the surface soil in plant food, for it is chiefly in those silt and clay particles that the plant food constituents, in a form available to the crops, reside: hence the improvement, chemical as well as physical, effected in poor soils by admixture of the silt deposited by overflowing rivers.

In the soils now under discussion, the above effect of water has not been strongly marked all round, but it is nevertheless apparent to some extent, *e.g.*, when we compare the virgin soil No. 2, which contains 41 per cent. of silt and clay, with the cultivated soil No. 1, which contains only 34 per cent.; or the virgin soil No. 14, containing 32 per cent. of silt and clay, with the cultivated soil No. 13, which has only 25 per cent. Similarly, No. 16 has 46 per cent., but No. 15 only 29 per cent., and No. 18 has 24 per cent., but No. 17 only 16 per cent. In two cases this rule seems to be completely reversed, *i.e.*, as between Nos. 5 and 6, and again between Nos. 11 and 12. In both these cases the cultivated soil has not lost, but gained in silt and clay, and, as we shall afterwards see, in both cases the loss of plant food has been less general than with almost all the soils of the series—in fact, in some respects in these two spots, the cultivated soil has more of some elements of plant food than the corresponding virgin soil. This may possibly be due to deep ploughing returning the finer soil particles to the surface.

From the above, it follows that the effect of frequent rain or irrigation on a soil inclined to be light and sandy (and therefore already less suited for wheat cultivation) is to render it still lighter and sandier. To what extent such a purely physical alteration of the soil may go before the wheat crops begin to be seriously affected is a matter for direct investigation, *under South African conditions*, for the local climatic conditions, as Dr. Wiley justly points out, constitute an important factor.

POSSIBILITY OF BRACK.

It will have been observed, from the description of the various samples taken, that, with one exception, brack or alkali has not been observed on the lands represented. It was never-

* "Soils of Cape Colony," 192.

theless thought desirable to test each soil, at least partially, in this respect, and thus the following percentage results have been obtained from the soil after sifting, in each case, through a 1-millimetre sieve.

No.	Total soluble salts. Per cent.	Chlorine. Per cent.	Chlorine calculated as sodium chloride. Per cent.
1	.092	.009	.015
2	.166	.016	.026
3	.128	.014	.023
4	.128	.017	.028
5	.124	.013	.021
6	.096	.011	.018
7	.136	.013	.021
8	.172	.014	.023
9	.092	.017	.028
10	.100	.016	.026
11	.132	.021	.035
12	.164	.022	.036
13	.112	.017	.028
14	.136	.017	.028
15	.104	.020	.033
16	.112	.020	.033
17	.092	.014	.023
18	.100	.016	.026
19	.120	.019	.030
20	.116	.015	.024

These results do not indicate any danger from brack in the soil, not even in Nos. 17 and 18, taken from lands which were said to show indications of brack. It was, therefore, not deemed necessary to examine more closely into the nature of the soluble salts. With regard to Nos. 17 and 18, it is, of course, possible that the brack salts may be found at lower levels, *e.g.*, three or four feet below the surface.

Plant Food Constituents.

With regard to the presence of moisture, of organic and volatile matter (lost in ignition of the soil), and of plant food in the soil, the determinations detailed in the following table were carried out:—

No.	Percentage of Field Sample.	Percentage of Soil Sifted through 1 mm. Sieve.			Percentage of Soil Sifted through ½ mm. Sieve.				
								Phosphoric Oxide.	
	Fine Earth < ½ mm.	Water.	Loss on Ignition.	Nitrogen.	Lime.	Magnesia.	Potash.	Soluble in Hydrochloric Acid.	Soluble in Boiling Sulphuric and Nitric Acid.
1	98.99	.97	2.73	.076	.156	.174	.155	.046	.065
2	98.61	1.33	3.51	.106	.188	.241	.157	.037	.064
3	97.89	1.07	2.41	.061	.134	.149	.117	.026	.044
4	97.72	1.09	3.31	.093	.134	.162	.140	.020	.032
5	99.08	.80	1.93	.083	.172	.094	.055	.019	.032
6	98.77	.52	2.69	.069	.104	.120	.063	.023	.032
7	98.53	1.45	3.90	.174	.108	.074	.050	.084	.152
8	97.57	2.05	8.03	.219	5.520	.090	.059	.079	.169
9	99.45	.55	1.72	.120	.122	.043	.028	.019	.041
10	99.42	.58	1.62	.097	.620	.049	.020	.017	.037
11	97.86	2.08	5.19	.229	.584	.089	.107	.132	.221
12	98.00	1.73	5.20	.222	3.980	.089	.103	.148	.230
13	98.55	1.22	2.83	.125	.204	.074	.062	.020	.029
14	98.22	1.70	4.13	.159	.250	.078	.097	.022	.028
15	97.88	.66	1.38	.080	.092	.070	.087	.019	.037
16	98.34	1.39	3.93	.139	.254	.092	.104	.023	.059
17	99.40	.53	1.69	.090	.076	.050	.039	.014	.018
18	99.10	.80	1.99	.097	.082	.071	.046	.012	.013
19	98.70	1.11	2.13	.090	.432	.082	.090	.035	.061
20	98.28	1.60	2.06	.139	.360	.072	.095	.046	.090

Organic Matter.

Before proceeding to discuss the proportions of mineral plant food in the soil, a word or two may be said regarding the organic matter and the moisture present. Except in the case of the pronouncedly calcareous samples, the loss on ignition was inconsiderable, which means that the soils were poor in organic matter generally, and more particularly in humus. Such soils are usually deficient in moisture, a defect which is accentuated when the soil is inclined to be sandy. The addition of an organic fertiliser, such as kraal or stable manure, would therefore be beneficial, and this, as well as the stubble and waste of former crops that would be ploughed into the soil from time to time, would enrich its content of humus, under the action of the soil bacteria, and would, moreover, increase the water-holding capacity of the soil, which is now low throughout the area. Naturally, green-manuring would further improve this condition, by tending to enrich the soil with humus, not to mention the nitrification which goes on in the soil during the growth of the catch crop.

That the conversion of organic substances into humus and plant food is effected by bacteria, there is good reason to believe, but the evidence is not yet regarded on all hands as conclusive.* At the same time, no thread or clue should be left unpursued, and the work that Prof. Bottomley has devoted to this line of research should be followed up wherever possible. There is now an opportunity of doing so, also in the present connection. The rather sandy nature of the Alexandria soils and their lack of humus more than suggest that the requisite soil bacteria that convert cellulose and other organic matter into humus may also be lacking; if so, inoculation of the soil by the agency of bacterised peat may undoubtedly produce good results. At the same time, it must be quite clear that even the soil bacteria cannot convert organic matter into humus if there is no organic matter to convert; hence the addition of stable and green manure may be found of advantage, particularly if the latter be derived from a leguminous catch crop, which is enabled, in the presence of suitable nodule-forming bacteria, to draw supplies of nitrogen from the air.

Plant Food Constituents.

The nitrogen in these analyses was determined by the Kjeldahl method, as described in my book on *The Soils of Cape Colony*, p. 8. The lime, magnesia, potash, and phosphoric oxide were also determined, as there described (pages 13-14), by extracting the soil for five days with cold hydrochloric acid of specific gravity 1.115. Phosphorus pentoxide was determined in addition by oxidising the soil with concentrated sulphuric and nitric acids, according to Mærcker's method.†

* Russell: "Soil conditions and plant growth," 100.

† See the author's book above quoted, p. 14.

The salient facts shown by the above table are first of all that, from the point of view of *general* crop-raising, the only two constituents in which these soils may be said to be really deficient are potash and phosphatic material. One or other of these is present in too small quantity in 13 out of the 20 soils sampled; and it must be remembered that abundance of some other constituent—such as nitrogen, for instance—cannot atone for deficiencies like these; if anything, its very abundance only accentuates the lack, and may even help to exhaust the soil of the deficient constituents all the more rapidly. The next broad feature is that in several cases cultivation has removed from the soil plant food constituents which were present in larger proportion in the virgin soil. Compare, for example, the percentages of lime and nitrogen in sample No. 1 with those in No. 2; the proportions of lime and potash in No. 4 with their proportions in No. 3. Between Nos. 5 and 6 no such deterioration is noticeable, but the cause of this divergence may lie in the thorough turning up of the soil by deep ploughing, as already suggested.

Of the virgin soils, which represent the lands in their original condition, it becomes evident, from the foregoing results, that Nos. 8 and 12, which contain the largest proportions of lime, are also the richest in nitrogen and phosphates, and contain more moisture and organic matter than any other virgin soils of the series; in fact, there is a close parallelism between the proportions of water, organic matter and nitrogen—and to a certain extent also phosphoric oxide—all through the series, Nos. 8, 12, 14, 16, 20 and 2 forming the better group, and Nos. 4, 18, 10 and 6 the worse. Another parallelism is noticeable between the magnesia and potash in the soil, the largest quantities of both being found in Nos. 2 and 4, along the banks of the Bushman's River, and the least in Nos. 18 and 10, while there is an intermediate group comprising Nos. 16, 12, 14, 20, 6 and 8.

There is at least a fair amount of nitrogen in all the soils, and in Nos. 7, 8, 11 and 12 the proportion is really good, but for wheat soils a larger proportion of nitrogen would be a decided advantage. All the soils also contain at least a moderate proportion of lime, while Nos. 13 and 14 contain a good quantity, and Nos. 11, 12, 19 and 20 are rich in this respect. Nos. 7, 8, 9, 10, 17 and 18 are poor in potash, and none of the other samples showed more than a fair proportion except Nos. 1 and 2, in which the amount of potash is satisfactory. As to phosphorus pentoxide, Nos. 1, 2, 19 and 20 have a fair amount, Nos. 6, 7, 11 and 12 are good, and the virgin soil No. 16 contains a moderate proportion; but all the other soils are poor in this respect, Nos. 17 and 18 particularly so.

Magnesia is also an essential plant food, but several recent investigations tend to show that in some cases it may cause injury to crops if its proportion is greater or not much less than

Page 226, 7th line from bottom. For "6, 7" read "7, 8."

the proportion of lime. This, however, does not seem to apply unless the absolute quantity of magnesia in the soil is large.

In most of these soils the amounts of magnesia present, though doubtless adequate for crop requirements, are far from high, and certainly not sufficiently large—relative to the lime present—to cause any injury to cereals.

Some of the soils of the series, *viz.*, Nos. 1, 2, 3 and 4, from farms situated in the eastern part of the division, along the banks of the Bushman's River, contain somewhat larger amounts of magnesia—not only larger than those in the other soils of this series, but also larger than the quantities of lime in the soil. There is, however, no ground for ascribing the crop deterioration to this cause, for, even where they are higher in proportion than the lime, the quantities of magnesia seem still too small to do harm. The whole question of injury to crops through abnormal lime-magnesia ratios is still under investigation, and if there is any doubt in respect of individual soils whether the quantity of magnesia is not too high relatively to the lime, the difficulty may be easily settled by adding more lime to the soil.

It is in caves along the Bushman's River bank that the peculiar mineral, Bushmanite—a manganese magnesium alum—occurs, covering the floors of the cave to a depth of several inches. The roof of the cave contains magnesia, and it rests on a bed of magnesium sulphate. The above analyses point in the direction of these beds being attributable to the magnesia in the soil of the adjacent farms.

Taking in order the ten localities represented by the twenty samples collected, general consideration of the results leads to the following conclusions:—

Nos. 1 and 2 are greyish-brown soils, both containing a satisfactory amount of lime and potash, the percentage of the former being slightly lower in the cultivated than in the virgin soil. The amount of nitrogen in the virgin soil No. 2 is satisfactory, but there is only a moderate proportion in No. 1. Phosphates are present in not more than fair amount in both soils. There is much more magnesia in the virgin than in the cultivated soil, seemingly due to extraction by the crops, a consideration which shows conclusively that progressive deterioration of the crops cannot be due to excess of magnesium in the soil, seeing that the cultivated soil now contains less than when first put under cultivation. The fertilisers most needed here are nitrogen and phosphates.

In colour, Nos. 3 and 4 are slightly more inclined to red than the preceding two soils, to which they are chemically decidedly inferior. They do not contain more than fair amounts of any of the mineral plant foods. This is the case not only with the cultivated soil, No. 3, but also with the virgin soil, No. 4. The cultivated soil although poor in phosphatic material, contains more of the latter than No. 4 does, due, no doubt, to the treatment with superphosphates which the lands had received. Potash and nitrogen are both present in smaller quantity in No. 3 than in No. 4, and these lands are therefore in need of all-round manuring. Basic slag would, at the same time, supply lime and phosphates, and correct the acidity of the soil.

Nos. 5 and 6 are also very poor in phosphates, and contain very little potash—the cultivated soil in particular. Both have fair proportions of nitrogen, and in No. 5 the amount of lime is quite satisfactory. Phosphatic fertilisers are very necessary here, and in this connection it must be remembered that in soils containing so little clay, readily soluble fertilisers like superphosphates are easily washed out again; besides, basic slag would be more suitable than acid superphosphates on soils which are already, as stated, to some extent acid.

In Nos. 7 and 8 there are good quantities both of nitrogen and phosphates, but potash is rather poor, and lime, though present in abundance in the highly calcareous virgin soil, is more moderate in amount in the cultivated soil No. 7. Potash manures are particularly required here, and during these days of potash scarcity, anything capable of yielding potash should be pressed into service, such as kraal manure and its ash, the ashes of leaves generally, and wool washery refuse, if procurable.

Nos. 9 and 10 are sandy soils, very poor both in potash and phosphates, and in serious need of fertilising in these directions. Magnesia, too, is present in very small quantity, though quite sufficient for wheat crops.

The lands represented by Nos. 11 and 12 are perhaps the best of the whole series, from a chemical point of view. The soil is a dark grey sandy loam, almost entirely (*i.e.*, 91 to 95 per cent.) composed of grains smaller in diameter than one-fourth of a millimetre, and containing from 20 to 30 per cent. of silt and clay. The proportions of nitrogen and phosphates in both these soils are good, and both are rich lime soils, especially No. 12, which, like No. 8, is highly calcareous. Potash, too, is satisfactory in amount, and magnesia, in these soils alone out of the whole series, is present in precisely the same proportion in both cultivated and virgin soils. In every other case, except Nos. 19 and 20, there is less magnesia in the cultivated than in the virgin soil. It will be noticed that the soils which are specially calcareous, Nos. 8 and 12, are situated on a strip some eight miles long near the south-east coast of Alexandria division.

Nos. 9, 10, 13 and 14, which are also well supplied with lime, lie between the area last mentioned and Alexandria Town Commonage, immediately to the south of the latter. The virgin soil, No. 14, has likewise a good percentage of nitrogen, but the cultivated soil, No. 13, though not inadequately supplied, has a smaller proportion. Potash is present in moderate amount, but phosphates are sorely lacking in both soils. The soil is said to be acid in parts, and hence the addition of basic slag is highly desirable, at the same time, to neutralise the acidity in the soil and to supply the much-needed phosphate. To provide against potash exhaustion it would also be advisable to add kraal manure, wool washings, or leaf ash, as procurable.

Nos. 15 and 16 represent soils of medium class, of which No. 16—the virgin soil—is definitely the better, No. 15 having undergone partial exhaustion by cultivation. There is still a fair amount of nitrogen in the soil, but half the amount formerly there has gone—judging from a comparison between Nos. 15 and 16. Lime has diminished to about one-third of its original proportion, potash has decreased by one-fifth, and even the small quantity of phosphatic material, once present, has suffered reduction. No. 15 is the lightest-coloured soil of the entire series, No. 16 being much darker brown, resembling Nos. 19 and 20. All-round manuring is really what such a soil needs, and phosphates in particular.

Nos. 17 and 18 are both poor in potash, and exceedingly poor in phosphates, and should, therefore, be well supplied with fertilisers containing these elements of plant food. In fact, these are about the poorest soils of the entire series, and, while they need potash and phosphatic material primarily, the application of complete, *i.e.*, all-round, fertilisers is desirable. These soils are more deficient in plant food generally than Nos. 10 and 9, which they also resemble in their physical composition, being, however, a little darker in colour.

Nos. 19 and 20 are brown sandy loams rich in lime. They contain fair amounts of potash and phosphoric oxide, but could very well be supplied with more.

Plant Food Lost by Cultivation.

Comparing the various cultivated with the corresponding virgin soils, it is interesting to observe in how many cases cultivation has spelt, at all events, partial exhaustion for the soil, and it will have been noted that throughout the series of soils sampled there has been nothing in the way of replenishing the soils—originally poor as many of them were, particularly in phosphates, and further depleted by cultivation—with fertilisers. The amounts removed from the soil have been calculated by comparing the analyses of the cultivated soils with those of the virgin soils, and, taking the weight of an average sandy loam at 3½ million pounds per acre-foot (Hilgard "Soils," p. 107), it is estimated that the following quantities have been removed during the course of cultivation* from every acre of soil, to a depth of one foot, of the various localities indicated:—

* This remark obviously cannot apply where the virgin sample and that of the cultivated soil do not fully correspond, *e.g.*, with regard to the lime content of Nos. 7 and 8.

No.	Nitrogen. lb.	Lime. lb.	Magnesia. lb.	Potash. lb.	Phosphoric Oxide. lb.
1—2	1,050	1,120	2,345	70	—
3—4	1,120	—	455	805	—
5—6	—	—	910	280	—
7—8	1,575	189,420	560	315	595
9—10	—	17,430	210	—	—
11—12	—	118,860	—	—	315
13—14	1,190	1,610	140	1,225	—
15—16	2,065	5,670	770	595	770
17—18	245	210	735	245	—
19—20	1,715	—	—	175	1,015

In some cases the proportions of phosphoric oxide were found to be higher in the cultivated than in the virgin soils, but the differences were so small as to be easily accountable for by experimental error and the exceeding difficulty of getting a virgin soil sample that would exactly correspond to the sample of cultivated soil. One fact, however, stands out prominently in the last table. Even if we assume, as we may fairly do, that the difference in lime content between the virgin and cultivated soils may be largely due to unequal distribution of lime in the soil, and therefore that the lime in the cultivated soil is more evenly distributed than in the virgin samples which may have been taken from spots particularly rich in lime, it still remains clear that successive crops have depleted the soil of relatively large quantities of nitrogen and lime, but of comparatively small amounts of potash, and still less of phosphates. The explanation seems clear that lime and nitrogen were present in abundance, and so the stocks on which to draw were large; but there was very little potash, and still less of phosphatic material to draw on, and so the crops were soon straitened for lack of these latter.

A few calculations may serve to enforce this point. A wheat crop of 30 bushels per acre removes from an acre of soil the following*:—

	lb.
Nitrogen	48.0
Lime	9.2
Magnesia	7.1
Potash	28.8
Phosphoric Oxide	21.1

That is to say, an ordinary wheat crop requires, roughly, half as much potash or phosphoric oxide as nitrogen, or from two to three times more potash or phosphoric oxide than lime. In the Alexandria soils examined, the process has been reversed, and far more of nitrogen and lime have gone than of potash and phosphoric oxide; it is more than possible that the entire

* Cameron and Aikman: "Johnston's Elements of Agricultural Chemistry," 19th ed., 278-9.

loss is not due to wheat, but it is equally certain that in most of the soils analysed the distribution of the several plant-food constituents is by no means co-ordinated to the requirements of wheat crops. We may put this in another way. Excluding Nos. 8 and 12, which were evidently taken from highly calcareous spots, the average composition of the remaining eight virgin soils, Nos. 2, 4, 6, 10, 14, 16, 18 and 20, is as follows:—

Nitrogen	.112 per cent.
Lime	.249 ,,
Magnesia	.111 ,,
Potash	.090 ,,
Phosphoric Oxide	.042 ,,

Such an average soil would contain the following weights of these plant-food constituents in an acre,* one foot deep:—

Nitrogen	3,920 lb.
Lime	8,715 lb.
Magnesia	3,885 lb.
Potash	3,150 lb.
Phosphoric Oxide	1,470 lb.

Roughly, therefore, there would be enough nitrogen, in such an average soil, for 80 crops of wheat, lime for nearly 1,000 crops, magnesia for 560, potash for about 110, and phosphoric oxide for only 69.† At the same time, as was pointed out by me many years ago,‡ the crops cannot by any possibility extract all the phosphoric oxide to the last grain within one foot depth of soil, and so, *long* before the 69 years have elapsed, the soil will have become hopelessly barren and unproductive, and as the fertility of the soil diminishes year by year the crops will become poorer and poorer, until at length a stage is reached when it will cease to be worth while cultivating the land at all.§

Now it must be remembered that the above type represents an average *virgin* soil of the Alexandria Division, as yet unexhausted by cultivation; and many of the soils of this type have now been under cultivation for many years—and that without manure; small wonder then that they can no longer grow wheat.

A similar process of calculation may be applied to the soils that have been through the exhausting process of continuous cultivation without manure, and so the following table is arrived at, showing (*a*) the quantities, (in pounds per acre to a depth of twelve inches) of the various plant-food constituents remaining in the soil, and (*b*) the number of wheat crops that would

* Taking the weight of an acre foot of loam at 3½ million pounds.
† *Cf.* Hopkin's "Soil Fertility and Permanent Agriculture," 74.
‡ C.G.H. Dept. of Agr. Senior Analyst's Report (1893), 14.
§ See also C.G.H. Dept. of Agr. Senior Analyst's Report (1894), 21.

theoretically suffice for the complete withdrawal of all these constituents:—

No.	Nitrogen.		Lime.		Magnesia.		Potash.		Prosphoric Oxide.	
	lbs.	Crops.	lbs.	Crops	lbs.	Crops.	lbs.	Crops.	lbs.	Crops.
1.	2,660	55	5,460	593	6,090	857	5,425	188	2,275	108
3.	2,135	44	4,690	509	5,215	734	4,095	142	1,540	73
5.	2,905	60	6,020	654	3,290	463	1,925	66	1,120	53
7.	6,090	127	3,780	410	2,590	364	1,750	61	5,320	252
9.	4,200	87	4,270	464	1,505	212	980	34	1,435	68
11.	8,015	167	20,440	2,221	3,115	438	3,745	130	7,735	366
13.	4,375	91	7,140	776	2,590	364	2,170	75	1,015	48
15.	2,800	58	3,220	350	2,450	345	3,045	105	1,295	61
17.	3,150	65	2,660	289	1,750	246	1,365	47	630	30
19.	3,150	65	15,120	1,643	2,870	404	3,150	109	2,135	101

The soils of the great wheat belt area in Southern Michigan contain, per acre-foot:—

Nitrogen	8,050 lb.
Potash	57,700 lb.
Phosphoric Oxide	14,400 lb.

On the other hand, the large tract of light sandy lands known as the "Jack Pine Plains," because practically nothing else will grow here, contain only:—

Nitrogen	1,300 lb.
Potash	9,700 lb.
Phosphoric Oxide	1,160 lb.

Tobacco Crops.

On a previous page, Dr. Wiley was quoted as saying that some soils which are too light for the profitable production of wheat are amongst the finest South Maryland tobacco soils. This view was expressed wholly on the basis of the light *physical* nature of the soil and its consequent inability to retain an adequate amount of moisture for wheat-raising purposes. Looking at the matter from the *chemical* side, one should not expect a soil which is deficient in potash to grow good tobacco, even if physically suited for it, because tobacco is a crop that needs large quantities of potash; *vide* the following comparative table of plant-food constituents taken from one acre of soil by wheat and tobacco respectively:—

	Wheat.			Tobacco.	
Weight of Crop:	Grain. lb.	Straw. lb.	Total. lb.	Leaves. lb.	Stems. lb.
At harvest	1,800	3,158	4,958	1,600	1,400
Dry	1,530	2,653	4,183		
Plant-Food Constituents:					
Nitrogen	33	15	48	76	
Potash	9.3	19.5	28.8	200	
Phosphoric Oxide ..	14.2	6.9	21.1	16	

This shows how rapidly tobacco deprives the soil, whereon it is grown, of its potash, and if there is any thought of putting the lands down to tobacco, this aspect of the problem should receive due attention. Even for wheat (unless the straw be all ploughed in again) the proportion of potash in at least five of the cultivated soils is not high, and this deficiency would be much more severely felt in the case of tobacco. The fact that tobacco grown on some of the Alexandria soils is reputed to burn badly, may quite easily be due to lack of potash therein. Mayer says*:—

> The more ashes there are in tobacco and the more potash there is in these ashes, and the smaller the amount of non-volatile acids in combination with the potash, so much the better will the tobacco burn.*

I have already referred to the losses that wheat soils undergo if *all* the produce, *i.e.*, both grain and straw, is constantly removed from the farm, and the increased loss in potash due to tobacco culture, as above indicated, would also be felt in its full intensity if the entire crop were sold off year by year. In wheat culture, however, the soil would not only save two-thirds of its yearly loss of potash if the straw were regularly ploughed in again, but would at the same time gain in organic matter, which subsequently becomes changed into humus; and so, too, in tobacco culture, a great deal of the potash and other plant-food constituents is saved by ploughing in the stems and waste. Tobacco stems contain, on an average—

Nitrogen	2½	to	3	per cent.
Lime	About	3½		,,
Potash	5	to	8	,,
Phosphoric Oxide	½	to	1	,,

This means that if the tobacco production on one acre (stems and refuse as well as leaves) totals 3,000lb., and would, if removed in its entirety from the farm, deprive the soil of 200lb. of potash, the stems, aggregating in weight 1,400lb., would again restore to the soil about 93lb. of that potash, and would also supply it with a considerable amount of organic matter capable of conversion into humus.

Manurial Needs of the Soils.

For the cultivation of wheat without further manuring, sandy loams of the general type of the Alexandria soils should contain, per acre, to a depth of one foot, at least 5,000lb. of nitrogen, 3,000lb. of potash, 2,000lb. of phosphoric oxide.†

From these data it may easily be calculated what quantities of these plant foods should be added to the defective soils to

* Storer: "Agriculture in some of its relations with Chemistry" (1897), 3, 504, 515.

† Approximately .14 per cent. of nitrogen, .09 per cent. of potash, and .06 per cent of phosphoric oxide.

bring them up to normal. These quantities are approximately as follows:—

No. of Soil.	Plant Foods required (in pounds per acre). Nitrogen.	Potash.	Phosphoric Oxide.
1.	2,400	—	—
3.	2,900	—	500
5.	1,100	1,100	900
7.	—	1,300	—
9.	800	2,100	600
11.	—	—	—
13.	700	900	1,000
15.	2,200	—	800
17.	1,900	1,600	1,400
19.	1,900	—	—

These results may be achieved by adding the following quantities of the fertilisers specified below to the respective soils:—

No.	Nitrate of Soda. lb. per acre.	Sulphate of Potash. lb. per acre.	Basic Slag. lb. per acre.
1.	16,800	—	—
3.	20,300	—	3,500
5.	7,700	2,200	6,300
7.	—	2,600	—
9.	5,600	4,200	4,200
11.	—	—	—
13.	4,900	1,800	7,000
15.	15,400	—	5,600
17.	13,300	3,200	9,800
19.	13,300	—	—

The nitrate of soda is assumed to contain about 14.3 per cent. of nitrogen, the sulphate of potash 50 per cent. of potash, and the basic slag 14.3 per cent. of citric-acid-soluble phosphoric oxide.

The above would naturally be regarded as enormous quantities to add to the soil in one year, but they are mentioned primarily to emphasise the fact of the soil's poverty in those essential constituents of plant food. Whatever one may do in times of peace and plenty, all that can be aimed at under present conditions is to anticipate the needs of the next annual crop. If half a ton per acre of good average *unburnt* kraal manure, together with 125 lb. of 16 per cent. superphosphate, were supplied to the soil at sowing time, and later on 75 lb. of sulphate of ammonia or 100 lb. of nitrate of soda, good provision will have been made for the ensuing harvest. The additional amount of nitrogen needed would be supplied by sowing clover as a catch crop and ploughing it under when it has gathered sufficient nitrogen from the air to provide fully for next season's wheat crop. When this course is adopted, the method of manuring would probably undergo some readjustment; 300 lb. of kraal manure *ash* and 25 lb. of 16 per cent. superphosphate would then be supplied to each acre of clover sown, followed by 100 lb. of superphosphate and 50 lb. of Government guano when the wheat is put in.

If on any soil within the area wheat is at present doing well, it is highly essential that such soils should be thoroughly investigated, in order to compare them with the soils which have ceased to produce good wheat crops. If we know the conditions under which good crops are produced—and produced profitably, we shall have a standard of comparison for other soils within the area.

Acknowledgments are due to Mr. G. G. Malan, B.A., for his assistance in the determination of moisture, loss on ignition, lime, magnesia, potash and phosphoric oxide in these soils.

Summary.

1. For some years past, deterioration has been observed in the crops—especially wheat—grown on certain farms in the Alexandria Division.

2. A series of twenty soils—ten cultivated and ten virgin—was accordingly collected from the affected farms, where cultivation had been carried on for many years without manure.

3. Mechanical analysis showed the soils to range in physical character from medium sands to fine sandy loams, the proportions of very fine sand, silt and clay together varying between 16 and 63 per cent., while pebbles, gravel and coarse sand were practically absent.

4. The medium sands are very light in texture for wheat-growing, and according to Wiley, a soil containing as much as 70 per cent. of very fine sand, silt and clay is still too light for profitable wheat production.

5. The Southern Maryland wheat soils of the lighter type contain about 75 per cent. of very fine sand, silt and clay, and the heavier type of wheat soils contain about 95 per cent.

6. The wheat soils of the South-Eastern Counties of England are generally heavier than those of Alexandria, and even those which are lightest in texture are well supplied with subsoil water.

7. The general conclusion, therefore, is that, judged by English and United States standards, the Alexandria soils are rather light for wheat-growing. Wheat soils, moreover, should retain a considerable amount of water, and be fairly well supplied with organic material. In both these latter respects the Alexandria soils fall short. They would be improved, both physically and chemically, by admixture of river silt deposits.

8. Rain and irrigation tend to denude the surface soils of silt and clay, and so render soils which are already inclined to sandiness all the less suited for wheat. Assuming the correspondence between the samples of cultivated and of virgin soils from Alexandria to be true, some of them have lost, under cultivation, nearly one-half of the silt and clay which they originally contained.

9. Brack (Alkali) salts have not been observed on any of the lands represented by the Alexandria samples, with one exception. In no case, however, did analysis show any marked proportion of such salts in the samples of soil collected.

10. The samples examined are not rich in organic matter, and, from this cause and their rather sandy nature, they are not very retentive of moisture.

11. Bacteria are now generally supposed to be the active agents in converting into humus for the requirements of plants any organic matter present in the soil, but without organic matter even the presence of the necessary bacteria becomes nugatory.

12. Of the usual constituents of plant food, phosphates in particular are deficient, and potash next in order. For wheat culture more nitrogen in the soils is desirable.

13. Magnesia is present in all the soils in quantities sufficient as a plant food, and not large enough to act injuriously.

14. Comparing the proportions of plant food in the cultivated and in the virgin soils, there have been losses of magnesia and lime during the course of cultivation in almost every case, but the soils still contain sufficient of these constituents to render their addition unnecessary. Losses of potash and nitrogen were less general, but these were not present in the soils in such relative abundance, and for the most part their disappearance from the soil must be made good. Phosphoric oxide has markedly diminished in only four cases out of the ten, and in two of these cases it could well be spared; most of the other soils are very deficient in phosphates.

15. The causes of inadequate production, therefore, seem to be—(1) the rather sandy character of some of the soils, conjoined with their inherent poverty in plant-food constituents; (2) the removal of some of those constituents by continuous cropping without manure; and (3) the further losses caused by the surface soil suffering depletion in respect of silt and clay. The moisture conditions of the soil have not been investigated.

16. Out of the ten localities investigated, only one is not in immediate need of manuring of any kind, in order to fit it for wheat-production. Eight require manuring with nitrogen, five need potash fertilisers, and six need fertilising with phosphates.

17. The fertilisers that would be desirable are nitrate of soda, sulphate of potash and basic slag, in proportions suited to the requirements of the respective soils for these fertilisers. Under present conditions it would probably be necessary to use kraal manure and superphosphate, with a top-dressing of sulphate of ammonia, employing a nitrogen-gathering catch crop to provide the bulk of the nitrogen.

18. If the soils were laid down to tobacco, their potash requirements would be very much greater than in the case of wheat, as potash is the plant food most needed by all tobacco crops, and when deficient, the burning qualities of the leaf are seriously impaired.

MILITARY SERVICE. —It is proposed to compile as full a list as possible of Members of the Association who are, or have been, on Active Service during the present war, or engaged on Munition work, and any information available that may be sent for record to the General Secretary will be greatly appreciated. In particular the full name, rank, regiment, corps, etc., and date of joining should be supplied. Information of similar character will also be gladly received in respect of any Member not serving at the present time, who may hereafter go on Active Service. The following interim list of Members who have rendered, or are rendering, service of this description, though far from complete, is published with a view to the acquisition of additional details :—

A. E. Bancroft : understood to be in France.
G. F. S. Barratt.
R. L. Barratt.
G. N. Blackshaw, B.Sc., F.C.S., in Mesopotamia
Lieut. G. F. Britten, B.A., German S.W. Africa.
M. R. Collins : in France.
D. C. Crawford, M.A., B.Sc., B.Sc.Agr. : British East Africa.
W. Cullen, M.I.M.M. : on Munition work in England.
O. J. Currie, M.B., M.R.C.S. : German East Africa.
E. L. Damant : understood to be serving in the Navy.
Dr. S. M. de Kock : German S.W. Africa.
Capt. E. G. Dru Drury, M.D., B.S., D.P.H. : S.A. Medical Corps.
M. W. Duirs : killed in action.
Sir George Farrar, Bart. : killed in German S.W. Africa.
F. D. Farrow, M.Sc.
C. L. Fischer : In France (Missing).
Lieut. F. Flowers, C.E., F.R.G.S. : 1st Pioneers, German East Africa.
J. Frew : Glasgow Munition Factory.
H. W. Garbutt, J.P., F.R.A.I. : on service in England.
Capt. **F. H. Harrison** : 2nd Kimberley Battalion. Killed in action at Trekkopjes, German S.W. Africa.
Lieut. W. J. Horne, A.M.I.C.E., A.M.I.E.E. : Heavy Artillery, German South-West Africa.
A. G. Howitt, B.Sc. : in Europe.
W. R. Hunt : South African Scottish.
Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. : S.A. Medical Corps.
E. M. Jarvis, F.R.C.V.S. : German East Africa.
2nd Lieut. E. Jacot, B.A. : Royal Flying Corps, in France.
A. E. Jensen : on Munition service in England.

A. King.

Capt. the Rev. A. M. McGregor, M.A., B.D., Chaplain, German S.W. Africa.

Capt. C. W. Mally, M.Sc., F.E.S., F.L.S.: S.A. Medical Corps, Sanitation Section, German S.W. Africa.

A. M. Miller.

Col. G. T. Nicholson: Cape Garrison Artillery, German S.W. Africa.

Staff Capt. E. A. Nobbs, Ph.D., B.Sc., F.R.H.S.: German S.W. Africa.

Prof. A. Ogg, M.A., B.Sc., Ph.D.: on Munition service in England.

Capt. W. Paisley, M.B., B.Ch.: S.A. Medical Corps.

K. B. Quinan: on Munition work in England.

Lieut.-Col. J. G. Rose, D.S.O., F.C.S.: Director of Mechanical Transport, British East Africa.

Major F. B. Smith: Army Service Corps, Transport Department, England.

Lieut.-Gen. the Rt. Hon. J. C. Smuts, K.C., B.A., LL.D., M.L.A.: Commander-in-Chief of the Union Forces, German East Africa.

Major H. A. Spencer, M.R.C.S., L.R.C.P.: S.A. Medical Corps.

A. M. A. Struben, A.M.I.C.E.: in Europe.

F. G. Tyers, M.A., in France.

Capt. R. O. Wahl, B.A.: Karroo Rifles.

Capt. James Walker, S.A. Veterinary Corps, German East Africa.

Staff-Sergt. L. H. Walsh: S.A. Medical Corps, in France.

A. H. Watkins, M.D., M.R.C.S., M.L.A.: R.A. Medical Corps.

T. H. Watson: German S.W. Africa

M. White, M.A.: died on service in German East Africa.

Prof. D. Williams, B.Sc.: Royal Garrison Artillery, England.

H. E. Wood, M.Sc., F.R.Met. S.: in German East Africa.

ENCKE'S COMET.—It is announced that Wolf has succeeded in detecting Encke's comet, one month after aphelion: its magnitude was 16½, which was also the magnitude of Halley's comet when first found on the occasion of its last approach to the sun.

OIL FROM FRUIT STONES.—Dr. K. Alpers describes in the *Chemiker Zeitung* (1916) **40**, 645, a process for preparing oil from the stones of such fruits as cherries and plums. The cracked stones are treated with a solution of calcium chloride of specific gravity 1.15. The shells sink in the liquid, and the floating kernels are skimmed off, washed and dried, and the oil expressed. Plum stone oil had the taste and smell of bitter almonds, but these disappeared on treatment with a current of steam, or by exposing the oil to the air for a fortnight or heating it.

NOTES ON HUMUS, HUMOGEN, AND ITS ACCESSORY PLANTFOOD SUBSTANCES.

By Arthur Stead, B.Sc., F.C.S.

In the early days of Agricultural Chemistry humus was regarded as a simple substance. (**1**) De Saussure, in 1804, described it as a "brown combustible powder soluble in alkalies and ammonia." (**2**) Mulder, in 1849, showed it to be chemically very complex. He considered it to consist for the most part of ulmin and ulmic acid, humin and humic acid, crenic, apocrenic, and geic acids, to which substances he assigned formulæ. Notwithstanding Mulder's work, it is still quite common to see humus referred to in text-books of agriculture as if it were a single substance; probably because the agriculturalist looks more to the humus effect on tilth than to its composition. According to modern views, humus is even more complex than ever Mulder imagined; while it only requires a perusal of the literature on the subject to show that chemists are very guarded in their statements concerning its composition.

(**3**) Hall describes it as "the black or dark brown material of vegetable origin, which gives to the surface soil its characteristic darker colour as compared with the subsoil."

(**4**) Wiley refers to it as "the active principle of vegetable mold," and states that "its composition has never been definitely determined."

(**5**) Hilgard is very non-committal, but states that it is "only the *matière noire* that counts," *viz.*, the soluble humus. He also suggests that the relationship between natural and artificial humus is a very close one, pointing out that once artificial humus has absorbed nitrogen it holds it as tenaciously as the natural substance.

(**6**) Ingle describes it as "the somewhat indefinite nitrogenous and carbonaceous material resulting from the decay of plants."

These opinions, compared with Mulder's definite statement, show that the modern chemist regards humus as a very delicate subject to deal with.

(**7**) Russell, in referring to organic matter as *the* distinguishing characteristic of soil, classifies the organic matter furnished by recent vegetation as—

(*a*) Material that still retains its definite cell structure.
(*b*) Partially decomposed and still decomposing material.
(*c*) Simple decomposition products.
(*d*) Plant or animal constituents not decomposable in the soil.

Of Group (*b*) he says: "The partially-decomposed material forms a particularly vague and indefinite group containing all the non-volatile products of bacterial, fungal, enzymic, and other actions on plant residues." He states that "numerous studies have proved that this group possesses at least six properties not shown by Group (*a*)—

(1) It gives a dark brown or black colour to the soil.
(2) It can withdraw various ions from their solutions.
(3) It causes the soil to puff up and so leads to an increase of pore space.
(4) It increases the water-holding capacity of the soil.
(5) It swells when wetted.
(6) Although essentially transitional, it has a certain degree of permanency, and only disappears slowly from the soil."

Russell then goes on to say that "the group of substances possessing these properties is generally called 'humus.' From these half-dozen properties we may infer that humus is a brown slowly oxidizable colloid, but unfortunately we cannot get much further."

That several types of humus exist there is not the least doubt, as witness the studies of P. E. Muller and of the British Vegetation Committee.

(8) P. E. Muller has examined the types of humus occurring in Danish forests, and describes two principal types, *i.e.*, "mull" and "torf," or mild humus and peat. The former is free from all trace of acidity, and bears a characteristic and varied vegetation, while the latter is acid and not so favourable to plant growth. In fact, "torf" so inhibits the growth of young trees that as the old ones die the forest tends to become open heath. Muller seems not to attribute any great part in the formation of type to soil or climatic conditions; but to the nature of the living organisms in the soil he assigns an important significance. He would seem to consider earthworms the chief factor in the formation of "mull," their absence and the presence of fungi the chief factors determining the production of "torf." The British Vegetation Committee recognises at least five distinct types of humus, *i.e.*—

(1) Dry peat found on heaths on poor dry sandy soils.
(2) A peat formed under similar conditions, excepting that the rainfall is greater than in (1).
(3) Wet peat formed in districts of high rainfall. The drainage water from them is acid and very deficient in mineral salts.
(4) Fen, formed in the presence of calcium carbonate and other mineral salts. Its drainage waters are alkaline
(5) Carr, closely related to (4).

The work of the British Committee, while not discrediting Muller's observations, seems to show that climatic and soil conditions have much to do with the type of humus formed. In this connection it may be pointed out that Hilgard insists that calcium carbonate is the factor which determines the transformation of plant residues into mild humus.

Be this as it may, one fact seems to stand out very clearly, *i.e.*, that there are two chief types of humus, viz.:—

(*a*) Acid Humus.
(*b*) Neutral or Alkaline Humus.

Of the two types the latter is the valuable and desirable one. So much for the classification of humus types. Although much has been accomplished in the resolution of humus into its various constituents, there remains still more to accomplish. A good deal has been done in the way of grouping these constituents, and in elucidating the connection between the natural and artificial varieties, viz., those found in the soil and those made from sugars by boiling with acids.

(**9**) Schreiner and Shorey group the constituents of humus as follows:

When the soil is decomposed by treatment with acid and then extracted with alkali, a part of the humus (the *matière noire de Grandeau*) goes into solution and a part remains undissolved. The insoluble portion is called the Humin Group. So far, it has defied all efforts to analyse it. If the alkaline solution be acidified a precipitate is formed, which, however, does not contain all the matter that the alkali dissolved from the soil; a part remains in solution. To this portion is assigned the designation Crenic Acid Group. The precipitate is the Humic Acid Group. This is still further subdivided into soluble and insoluble humic acids, both of which are groups of compounds. The differentiation between the two is dependent on their different behaviour towards alcohol. The compounds grouped as Insoluble Humic Acid comprise that portion of the precipitate obtained on acidifying the alkaline soil extract which is insoluble in alcohol.

The whole grouping is concisely illustrated hereunder:

Humus, extract with alkali

- Alkaline solution, acidify
  - Remaining in solution
    - CRENIC ACID.
  - Precipitate, wash, boil with alcohol
    - Remaining insoluble
      - INSOLUBLE HUMIC ACID.
    - Going into solution
      - SOLUBLE HUMIC ACID.
- Insoluble residue of HUMIN, which only dissolves on fusion with alkalies.

The Insoluble Humic Acid and the Humin Groups have so far defied all attempts at chemical analysis, but from the other two groups at least 20 distinct compounds have been isolated, *of which only one is a carbohydrate.* Is the absence of carbohydrates due to the fact that humus is the product of the breaking down of carbohydrates in the soil? Looked at side by side with the fact that carbohydrates on acid decomposition yield artificial humus, there is a great deal to say for that view.

It has long been known that substances akin to the humic acid and humin groups are formed when sugars are heated with solutions of mineral acids. According to (**10**) Bottomley, however, no humin is produced if the action of the acid is not allowed to go too far; humic acid alone is first formed when lævulose, dextrose, and sucrose are heated with 3% hydrochloric acid; but if the boiling is continued long enough, much humin will be formed. Further, freshly precipitated humic acid is readily converted into humin on boiling with acids. It would therefore appear that humic acid is a stage in the conversion of sugars, by boiling with acids, into humin, both humic acid and humin being used in the group sense.

In appearance and in solubility in alkaline solutions the natural and artificial humic acid groups are very similar, yet when analysed they differ very much.

(**11**) Robertson, Irvine, and Dobson, state that the average composition of both products is as follows:

	Carbon	Hydrogen	Oxygen
Artificial Humic Acid (sugar) ..	64.74%	4.69%	29.81%
Natural Humic Acid (peat) ..	54.29%	4.94%	38.16%

They concluded that structural differences must exist between the two substances.

Van Bemmelen (1888) established the colloidal nature of humic acid, while (**12**) Baumann and Gulley described its properties in 1909 in much greater detail, including its power to decompose salts, and the facility with which it forms adsorbtion compounds. In view of the latter property, and in view of the fact that, if natural humic acid is formed from carbohydrates, it is formed in association with many adsorbable substances, it appeared likely that the difference in composition between it and artificial humic acid might be due to adsorbtion by the natural material. In order to test this view Bottomley prepared some humic acid from peat. He extracted a portion of this with alcohol to remove supposedly alcohol soluble substances. Chemical analysis then gave the following results:

	Carbon	Hydrogen	Oxygen
Natural Humic Acid	48.64%	4.55%	46.81%
Ditto (purified by alcohol) ..	60.37%	5.39%	34.24%

The latter results bear close resemblance to those obtained with Robertson, Irvine, and Dobson, while they are almost identical with those obtained by Bottomley with an artificial humic acid made from dextrose and hydrochloric acid.

Lactic acid, acetic, butyric, propionic, citric, oxalic, tartaric, and other organic acids all yield humic acid, and humin when boiled with sugars. Humic acid and humin are also obtained when sugars are simply heated to charring point. It would therefore seem only fair to infer that humic acid and humin are merely stages in the carbonisation of sugars. It is noteworthy that proteins yield neither humic acid nor humin when boiled with acids unless their molecule contains a carbohydrate. For example, tyrosine and asparagine failed to give any humic substance even after eight hours boiling with hydrochloric acid, while under similar conditions mucin and white of egg (both of which contain carbohydrate) yielded 0.021 and 0.035 gram. respectively. Still more interesting is the fact that Sphagnum moss, when boiled with acids, mineral or organic, yields from 2 to 12% of humic acid, the actual amount varying according to the acid used. Now, many organic acids are produced in the decay of vegetable matter; it should not, therefore, require much imagination to suggest that natural humus may be the product of the action of acids on the decaying matter in the soil.

If Bottomley has done nothing else he would seem to have established the relationship between natural and artificial humin and humic acid groups. The origin of both is the same, but the composition of the natural product is much modified by reason of its pronounced colloidal properties causing it to adsorb substances with which it comes in contact in the soil.

Gulley and Baumann assign the following colloidal properties to humic acid:—

1. High retentive capacity for water.
2. Power of forming adsorbtion compounds.
3. Power of decomposing salts.
4. Coagulability by salts, acids, electric current and frost.
5. Reversibility.
6. Great contractility.
7. Forms difficultly soluble, but easily decomposable colloidal mixtures with other colloids.
8. Masks certain ion reactions.

With this brief outline of the modern conception of humus, I must pass on to the consideration of the next portion of my paper, *i.e.*, Humogen and its Accessory Plant-food Substances.

Humogen or Bacterised Peat.

Higher up reference was made to Muller's two types of humus, *i.e.*, "mull" and "torf," the former highly beneficial in the forest the latter very detrimental, causing the forest to become open heath.

Gardeners are well aware, by reason of costly experience, that manure made with peat litter is very harmful unless it be first exposed to the weather for about two years. It is very obvious that peat is very deleterious to plant life; this, because of its acid nature.

The highly antiseptic nature of peat is another of its remarkable properties. A dead body recovered weeks after submergence in a peat bog will show little or no decomposition. This shows that peat has very great power to inhibit and even prevent bacterial life processes.

The gardener knows that he can safely use manure made with peat provided it has been exposed long enough. This long exposure to weather results in the acidity of the peat giving way to a condition of neutrality or alkalinity, while the inhibitory properties towards bacterial life have given place to an ability to support an intense bacterial activity.

In its acid state, peat contains very little soluble humus, but after exposure it has become rich therein. (**14**) Bottomley, prompted, apparently, by what happens during the weathering of peat moss litter, experimented and found that this weathering process could be speeded up by saturating it with certain aerobic bacteria. Peat that has been changed by these aerobes, sterilized, and then saturated with nitrogen-fixing organisms of the groups *B. Radicicola* and *Azotobacter*, is the Bacterised Peat or Humogen of Bottomley. Bottomley discovered Humogen during a search for a suitable medium in which to convey cultures of nitrogen fixing organisisms to the soil.

Soil inoculation came to be practised as a result of Hellriegel and Wilfarth's discovery of the nitrogen fixing bacteroids in the nodules frequently found on the roots of legumes. These bacteroids live in symbiosis with the plant, providing it with more nitrogen than it requires in return for carbonaceous and mineral food. Often, however, the roots of legumes are not infected under field conditions. This may be due to the fact that the biological conditions of the soil are such that the organism is unable to live in it, or it may be due to other causes. In Norfolk it has long been the practice to grow legumes, especially clovers and trefoils, before wheat. For wheat, the dominant plantfood in England, is nitrogen. The Norfolk practice, although much older than Agricultural Chemistry, is evidently based on the foundation that the clover crop adds nitrogen to the soil, by reason of the bacteroids that live in symbiosis with it on its roots. In the light of Bottomley's researches, however, it would seem that there is also an additional reason, *i.e.*, that the radicicola bacteria produce accessory plantfood substances. As has already been stated, soil inoculation came to be practised subsequent to the discovery by Hellriegel and Wilfarth that a legume whose roots were infected by the bacteria was not only independent of soil nitrogen, but added to the soil, on its decay, the excess of nitrogen that had been gathered from the air for the plant by the nodule bacteria. It is obvious that agriculturalists were high in the hope that provided they grew legumes occasionally and ensured the infection of the roots by the nodule bacteria, they could turn their backs on the need for manuring with expensive nitrogenous manures. But everything did not turn out so simple as had been expected. Many failures have been experienced in endeavours to produce a successful inoculation of the roots of the legumes; but it is not possible to discuss these here.

Mention should be made of the fact that the radicicola group is not the only nitrogen fixing group of organisms. There are the azotobacter organisms which live in the soil and assimilate nitrogen from the soil air just as the other group does, but with this exception, that they do not live on the roots of plants. The Azotobacter group obtains its carbonaceous food from the plant residues in the soil; likewise its mineral salts. It obtains nothing from the living plant.

The gain in nitrogen due to the azotobacter organisms is very considerable, provided the soil conditions are suitable. These are an adequate air and moisture supply, together with plenty carbonaceous material, mineral salts and calcium carbonate; the latter evidently to ensure that the carbonaceous matter shall be present, in part, as soluble humus, the *matière noire de Grandeau*.

Bottomley seems to have come to the conclusion that the ideal in soil inoculation would be to add both groups of bacteria to the soil in a medium that would provide them with food, and thereby render them independent of suitable soil conditions. Nitrogen fixation would, under such conditions, proceed whether radicicola infected the roots of legumes or not, because both groups would be active in the soil by reason of a bountiful food supply, provided only suitable air and moisture conditions prevailed.

Bottomley, therefore, searched for a medium that would suit both radicicola and azotobacter groups, and at the same time place them in circumstances in which they would be as independent of soil conditions as possible. Such a medium would be one rich in soluble humus [because of the latter's richness in carbonaceous matter, and because of its colloidal properties, which would keep the organisms well supplied with mineral salts. The alkalinity of such a medium would, moreover, be very favourable to both organisms].

Well-rotted farmyard manure would fulfil these conditions, but its great bulk was against it. Bottomley, therefore, fell back on peat, which he treats as follows:—

The peat is infected with certain aerobic bacteria, and kept moist at a temperature of 26° C. for about a week. Steam is then forced through the mass to sterilize it. A sterile, neutral, or slightly alkaline mass is the result. The material is very rich in soluble humus, as will be seen from the table given below. The sterilized, bacterially changed peat is then infected with cultures of radicicola and azotobacter organisms, and kept moist until the whole mass has become saturated with them. It is then dried, put up in bags like manure, and sent out for use on the land. No further cultures have to be made by the farmer; all that he has to do is to apply the material to the land in a similar manner to which he would apply any other fertilizer.

Table showing the Percentages of Soluble Humus in the Materials mentioned.

Raw Peat	0.038
Garden Soil	0.012
Fresh Stable Manure	0.433
Rotted Stable Manure	1.460
One-year-old Peat Moss Litter	1.050
Bacterised Peat	15.194

The outstanding richness of bacterised peat in soluble humus needs no other emphasis than that afforded by the above comparative figures. The richness of rotted stable manure is also worthy of note.

Such, briefly, appear to be the circumstances that led Bottomley to discover humogen. As to whether humogen possesses all the virtues claimed for it remains to be seen.

Reference will now be made to some of the properties of this remarkable substance.

In order to test its nitrogen-fixing power, a mixture consisting of 10 parts of humogen and 90 parts of Rothamsted soil was incubated at 26° C. The gain of nitrogen amounted to .054 gram. [or the equivalent of 28 cwt. of sodium nitrate per acre, if the increase had been proportional throughout to a depth of 3 inches]. This, according to Bottomley, in the *Illustrated London News*.

It should be continually borne in mind that it is more than likely that this and similar experiments were carried out under conditions favourable to humogen. In the case just mentioned, it should be noticed that the proportion of humogen to soil is far greater than it would be possible to use in farming practice. If, however, in practice it would be possible to achieve even one-thirtieth of this fixation, the result must be considered remarkable.

There would seem to be little room for doubt that the beneficial effects of humogen (or of rotted manure) by no means end with their plant-food constituents, or their power to stimulate nitrogen fixation, but extend to a power to render increased amounts of plant food in the soil available. (Such effects are, indeed, deducible from a consideration of the colloidal properties of soluble humus; while, in addition to these, the increased output of carbonic acid consequent on the increased bacterial activity must count for something.)

It is claimed for humogen that it produces more vigorous and earlier-maturing plants than any other fertilizing mixture, a fact which led to the thought that there might be accessory foodstuffs in it of a nature somewhat similar to Hopkins' vitamines of animal growth. A. Machen, writing in the *Fruit, Flower and Vegetable Trades Journal*, makes the following claims on behalf of humogen:—

1. It is an entirely organic material, a large portion of which is soluble ammonium humate.
2. It directly introduces nitrogen fixing organisms into the soil and provides the food necessary for their rapid multiplication.
3. It is a source of accessory food bodies which act by stimulating the natural growth of activities.
4. Plants will grow in a water extract of humogen.

Rosenheim, for instance, potted primulas in what is considered by gardeners to be an excellent mixture, *i.e.*, leaf mould, loam and sand. Each pot was treated in precisely the same manner, excepting that some pots received a water extract of 0.18 gram of humogen twice a week. In six weeks the plants receiving the extract of humogen were double the size of the others, while the number of roots and blooms was equally increased. Experiments with tomatoes, potatoes, etc., gave similar results, with the sequel that the sensation-loving Press told the world that, in consequence of Bottomley's discoveries, it would be possible for a family to grow its vegetables in the drawing-room—pure nonsense, of course.

Let me now summarise the genuine claims made on behalf of this wonderful substance:—

1. It leads to an increased nitrogen-fixing power in the soil, and serves to infect legumes.
2. It increases the availability of potash and phosphoric acid in the soil.
3. It increases the development of both root and leaf.
4. It increases the yield of seed.
5. It leads to earlier maturity.
6. It protects plants not only from disease, but also from insect pests, *i.e.*, eel worm.

In considering these properties, it is necessary to bear in mind the specific action of nitrogen, potash and phosphoric acid on plant growth.

Nitrogen is potent in increasing growth above ground, in delaying maturity and in increasing susceptibility to attacks by disease and insect pests.

Potassium also delays maturity; it produces a well-filled seed, and renders the plant resistant to disease.

Phosphorus increases root development, the yield of flowers and seed and brings about an earlier maturity.

An examination of these two sets of properties would seem to show that in humogen there are combined all the desirable specific effects of the three principal plant-food elements. The difficulty had always been to get increased growth by nitrogenous manuring without its evil effects. How is it that humogen is able to accomplish the ideal? Is its action on soil potash and phosphoric acid proportionately greater than its power to bring nitrogen to the plant? This would at least afford a partial explanation of its properties. Moreover, this explanation is supported, in a way, by the announcement that Bottomley has patented the action of certain bacteria which, given *suitable food* and added to insoluble phosphates, will render them soluble.

Bottomley, however, seems to ascribe the exceptional properties of humogen principally to its content of plant vitamines [" auximones " or accessory substances, as he calls them], substances which stand to the plant in a similar relationship that Funk's and Hopkins' vitamines do to animals.

There is really nothing wonderful in this, for every year some progress seems to have been made which has brought the life processes of plant and animal into closer relationship.

Bottomley's claims in respect of the " auximones " in humogen are supported by the following facts:

1. The amounts of auximones present are of the same order of magnitude as the amounts of vitamines in foodstuffs.
2. A very concentrated, if not pure, extract of auximones can be prepared from humogen by using precisely the same methods as were used in isolating the vitamines of beri-beri and scurvey.
3. The extract thus prepared has just as potent an influence on plant growth as Hopkins's vitamines have on animal growth. For instance, 200 c.c. of a water solution containing 0.35 gram per million grams of water of what is known as the silver nitrate fraction in the isolation of vitamines, *viz.*, 0.00015 gram of silver nitrate extract, is able to nourish, in conjunction with Detmer's solution, germinated wheat embryos that have been deprived of all trace of endosperm.

These points, placed alongside the fact that scurvy vitamine is produced during the germination of seeds, would seem to suggest a remarkable connection between auximones and vitamines.

In recognising that there are considerable differences between the two classes of bodies, it should also be remembered that vitamines differ much among themselves. For instance, the scurvy vitamine differs much from Hopkins' vitamine in that the latter is fairly resistant to boiling temperatures, while such a temperature absolutely destroys the former. Bottomley's auximones, although much resembling the scurvy vitamine, are unlike it in that they are able to withstand much higher temperatures.

In 1912 the writer first suggested that lamziekte was a disease belonging to that class of deficiency diseases to which scurvy and beri-beri had recently been proved to belong. Although this view has been discredited by Professor Hedinger, who favoured a parasite, and Sir Arnold Theiler, the writer is still of the opinion that the disease will one day be classed among the deficiency diseases. It would seem, too, that if auximones are what is claimed for them, then—

1. The great similarity between auximones from plant food (humogen) and vitamines from animal food (plant juices, seeds, etc.);
2. The effect of climatic and soil conditions on the prevalence of lamziekte;
3. The production of auximones by soil bacteria,

afford additional strong support to the deficiency theory of lamziekte.

At a meeting at Vryburg, in August, 1913, a farmer asked whether a plant obtained its vitamines from the soil, to which the writer replied that he thought not. In view, however, of the discovery of auximones, it is quite likely that the soil origin of vitamines is the correct one. If so, then many interesting facts in connection with lamziekte would seem to be capable of full explanation.

As regards plant life, if soluble humus and humogen possess the properties claimed for them, there is in humogen remarkable scientific corroboration of the best farming practice—that is, the best according to practical experience. More than ever is it established that the farmer's first endeavours should be in attending to the biological conditions of his land. He cannot do this if he neglect to cater for the needs of the nitrogen-fixing organisms, which are also auximone producers. What are the needs of these bacteria? These: moisture, air, carbonaceous organic matter, mineral salts and calcium carbonate. Without the latter soluble humus will not be formed, but the acid material, the "torf" of Muller, the destroyer of forests and the inhibitor of beneficial bacterial life in the soil. Moisture and air will avail little be there no organic matter to feed the microbes; neither will the organic matter make for the welfare of the plant if there be too little mineral food and calcium carbonate; while a sufficiency of the latter is of no account in the absence of organic matter for humification. Who has not heard of the old adage:

Lime and lime without manure
Will make both land and farmer poor.

What a flood of light humogen throws over it all!

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Elementary Chemistry.—"A knowledge of chemistry, even if it never goes beyond the elementary stage, is of advantage in *all* phases of life." So opens the preface to a little chemical text book* compiled by Dr. F. Mollwo Perkin and Miss E. M. Jaggers, and based on a course of instruction followed for some years in the laboratories of the Borough Polytechnic Institute. To continue: "there is no manufacture in which chemistry does not play a part. The production of steel for engineering work, the minting of coins, the manufacture of explosives and of medicines, the polishes for our boots, and the ink with which we write, all demand a knowledge of chemistry." In these days of stress and strain, while Britain slowly awakes to a sense of the fundamental importance of chemistry in industries vital to national progress, the President of the South African Association of Analytical Chemists points out that "practically every process nowadays requires a chemist for efficiency," and adds "South Africa does not hesitate to run a steelworks without a chemist." This would not be if all who are anxious to "do their bit" for their country would get home to their minds the quotation at the head of this paragraph, and realise it in practice. Although quite suited for elementary chemistry classes, the book above quoted is well adapted as a handbook for private study, and in this direction, it is to be hoped that it will find extensive use. The course therein followed does not proceed along the ordinarily accepted—and scientifically more correct—lines of chemical study, the aim being rather to proceed from the familiar to that which is new and strange, leading from fact to fact in an interesting and logical sequence. First water and then the atmosphere are discussed, their properties examined, and the student familiarised with the various appliances essential for their study: most of the non-metals and the principal metals are next briefly treated, and finally electroplating, and some of the chief technical processes, such as coal distillation, the aniline dyes, and explosives are described, and, wherever possible, directions are introduced for the performance of experiments.

* F. M. Perkin and E. M. Jaggers: "Text book of elementary chemistry." Sm. 8vo. pp. viii, 384. London: Constable & Co., Ltd., 1916. 3s. nett.

NATIVE SUPERSTITION IN ITS RELATION TO CRIME.

By Hon. Justice Cecil Gower Jackson.

A well-known writer recently remarked that "every kind of knowledge can be gauged by the rule of mathematical calculation, save only the knowledge of human nature. The Creator has kept that secret to Himself. . . ."

If this be true in reference to ourselves, who speak the same language, observe the same customs and conventions, and whose lives generally are regulated more or less in conformity with the same ideals and the same standard of living, it must apply *a fortiori* to any attempt to fathom the intricacies of human nature in a people of a different speech, and whose ideas and modes of life are widely separated from our own. And the greater the study the greater is the realization of the difficulties, surprising and unexpected, which confront the student of Native character at every turn. This may possibly be the reason why some who have had unique opportunities for pursuing this study, and who have acquired a fund of information in regard to Zulu superstitions, customs and beliefs, which others, less fortunate, can never obtain, have yet passed from our ken, leaving no written record of the fruit of their labours. It is to the tourist who spends a few months in South Africa that we look for an assured and comprehensive review of Native life in all its variations; the real student too often keeps silence.

Perhaps the most fascinating and certainly one of the most difficult of the many problems interwoven in the study of the South African Native is that which has reference to his superstitions and beliefs. He guards his secrets well, and little can be learned in ordinary conversation with him. He will listen, and perhaps give a polite assent to what is said, not necessarily in confirmation of its truth; but hardly, if at all, can he be persuaded to throw enlightenment upon one of the most potent factors in his being—his belief in the supernatural. Yet this belief pervades his whole system, regulating his conduct and subconsciously shaping his most trivial actions; it is an ingrained and vital force ever present in his mind, and ever putting him upon his guard. Not lightly, indeed, is such a subject to be discussed; the very anxiety of the questioner to know something of it is sufficient to arouse distrust.

Occasionally may be gained the confidence of an old man, versed in the eccentricities of the European, and indulgent towards his curiosity, who, with a little persuasive diplomacy will be induced to satisfy perhaps a fractional part of that curiosity. Something, too, may be gleaned by observation, by a study in comparisons, by noting the conduct of various natives under circumstances of a similar nature. Certain surface truths can be acquired and accepted as such; evidence on points more obscure may tend to establish their reliability; and yet, as even the most profound observer will readily admit, there remains much of mystery, much that is difficult of understanding or explanation. The subject, as a whole, opens up so wide a field that to attempt to do justice to even one or two phases of it in a prescribed time is impossible.

In venturing to touch lightly upon that portion of it which may serve to illustrate the connection between superstition and crime, I cannot hope to adduce any points of scientific interest, or to enunciate theories new to anthropology, but merely to present certain facts indicative of the extent of the sway, direful in its results, which superstition exercises on the mind of the Native at the present time. And in so far as the subject may receive indifferent attention to subtler problems which suggest themselves, or be dealt with in too perfunctory and disconnected a manner, I can only plead that it is on short notice, and during a busy time, that I have been invited to prepare this paper.

Excluding a comparatively small number of Basutos resident in this Province, the term Zulu may be held sufficiently comprehensive to embrace all the Zulu-speaking Natives of Natal and Zululand, the majority of whom are members of tribes which were at one time under the domination of Tshaka. There is no need to recall legends of that time, or to delve into records of a much later date, to obtain material with which to typify the correlation between superstition and crime. To do so might be regarded as affording data of academic interest only when applied to a rapidly changing people, susceptible to the influences of civilization, in regard to whom events of even a quarter of a century ago may have little bearing to-day. That barbaric instincts do not always, however, succumb to civilizing influences, not decades but centuries old, we have much evidence to-day outside of Africa; and although I do not wish to cast any aspersions on Bantu tribes by unfair comparisons, yet it is scarcely matter for surprise if their deep-rooted superstitions are found to be difficult of eradication, and form a channel leading to many tragedies.

Customs and beliefs may, and do, vary largely in different Bantu tribes; but the belief in magic and witchcraft is general, and admits of no variations in its essentials. It may be doubted if even the most highly educated of them are entirely free from it. They may not admit it; but in their heart of hearts they know they would not voluntarily expose themselves to risks which their inmost nature tells them might tend to place them at the mercy of a reputed evil-doer or *umtakati*, even though no physical danger could possibly result. There would be no magic in it if the danger could be seen, if physical violence were feared. It is the inherent dread of the unknown and illimitable power of witchcraft which creates that fear—the power to blight the home, to cause sickness and death among its inmates, to bring disease into the herds; a power held accountable for every untoward incident. State intervention, civilizing influences and missionary endeavours have not yet sufficed to dispel this belief, scarcely indeed to pierce it. Not for a moment would it be suggested that the teachings of Christianity have had a negligible result. On the contrary, it is to these we chiefly look for the gradual elimination of the evil. Natives who have come directly under religious instruction may find it difficult to subjugate their ingrained fear of wizardry, but they learn to keep it under control. It is pleasing to note that it is seldom that an avowedly Christian native allows his old superstitions to lead him into crime.

Although it is the Natives of Natal and Zululand to whom reference throughout is intended, they do not stand apart from other Bantu tribes in their fear of witchcraft. Those resident in the other Provinces, not excluding the Cape, with its older civilization, are under the same thraldom. Viewed in retrospect with the dark centuries, when Europe groaned under the yoke of witchcraft, it would be remarkable were it otherwise.

For the purpose of illustrating the direct incentive to crime which superstition supplies, reference will be made to certain concrete cases which have come under my personal observation; and in order to show their present-day application, they will be confined, unless in one or two instances otherwise stated, to events which have taken place within the last five or six years. No exhaustive inquiry will be attempted; crimes of a minor nature due to superstition will not be touched upon; and indirect instances, founded only on suspicion, will be avoided. The facts given will be those substantiated by judicial proceedings, and the cases cited restricted to two distinct examples—the hunting to his doom of a supposed *umtakati*, whether witch or wizard; and human sacrifices having for their object the acquisition of certain portions of the body for medicinal or other purposes.

The reputation of being possessed of the powers of witchcraft is not one which any Native will voluntarily seek to acquire. He knows too well the fate which awaits an evil-doer; he does not, even for the sake of notoriety, or the enjoyment of a temporary ascendency, fearfully accorded him in the minds of his fellows, dabble in sorceries which would encourage a suspicion that he is in league with the spirits of evil. It is, perhaps, unnecessary to emphasize that an umtakati must not be confounded with the witch doctor or diviner, whose function it is to expose him, and who, while being credited with mysterious and occult powers, is recognised, not as an evil-doer, but as a benefactor, by aid of whom protection is secured. His energies are directed against the *umtakati*; with disastrous consequences to the man he smells out. His office is illegal, but he is seldom brought to justice; the loyalty of those who consult him is usually proof against inquiry, and he continues to flourish in the land.

But little is required to engender suspicion that a person is an "evil-doer" in the sense used by Natives. A peculiarity of temperament, an idiosyncrasy of which he may be ignorant, a tendency to solitude, is sufficient. And so in silence he is watched, and suspicion is crystallized into certainty at the first untoward occurrence. Or it may be that there transpires some dread omen, or some natural mischance not attributed to nature but to witchcraft. No one in particular is suspected; the secret enemy remains unknown. Recourse is then had to the diviner, who is expected not only to reveal this enemy, but, if his incantations take place at the kraal where the mischance has occurred, to disclose also the means by which the evil spell has been wrought. A search in the vicinity, or a little digging coupled with a sleight of hand, will unearth a piece of old rag or bone, or some other substance through which, as is apparent to all, the mischief has been worked. The person smelt out under these circumstances will probably be one on whom no suspicion has hitherto rested. His or her fate in the old days would be sharp and summary, subject only, and not always, to the necessary authority being received from the King or ruling Chief. In these enlightened days such authority is dispensed with; retribution may be swift, or it may be delayed possibly for years. At best, social ostracism is immediate, but once suspect, always suspect. Cumulative evidence is gathered from one source or another; each unusual occurrence strengthens the chain; and the end is certain. This is not, in my judgment, an exaggeration. The death of the suspect may not take place at the hands of those first aggrieved, but he is a marked man. At his door the misfortunes of others are laid; he is an evil-doer, the enemy of mankind. Let him take refuge in flight; this may save him for the moment. Distance will lessen the potency of his magic, and the vengeance of his accusers be averted. But in time his reputation will follow him, the reason for his removal be known, and he can count on no security in his new environment. Once an umtakati always an umtakati. Each disaster since his arrival is traced back to him as its *fons et origo*; a new and sinister significance is assigned to insignificant events, each mystery explained; he is a man to be rid of. Unaware, perhaps himself, of this new-born suspicion, he may have no opportunity of further flight. Many such instances are within my knowledge—in one case where, for his protection, a man moved from one end of Natal to the other, and lived for years in peace and goodwill with his neighbours. Then in some way the secret leaked out, and it was discovered why he had left his former district. The precautions he had taken to sever the past were defeated: Nemesis found him, and the penalty was duly paid.

In contradistinction to a vengeance long deferred may be mentioned a case in which no sporting chance was accorded the victim. The occurrence took place in Zululand about five years ago. A native named Magebeni, had sickness in his kraal, resulting in the death of five persons. For some reason or other, not disclosed, he suspected a neighbour, Baleni, of having caused these deaths by means of witchcraft. It is probable a diviner was consulted, and the unfortunate man smelt out, but this was not admitted. Baleni, so far as could be determined, was in complete ignorance that he was under suspicion. Mageheni and four of his relations met together and decided to direct him to leave the neighbourhood. Before, however, making any communication to him, they changed their plan and determined to get rid of him in a more effectual manner. Together, they went to his kraal at night, and set fire to his hut. He attempted to escape, only to be met outside by these five men. Short shrift was accorded him. He was killed with a cane knife and his body carried to the Icupa Lake, into which it was cast. A passing native witnessed the tragedy by the glare of the fire, but maintained silence until other evidence led to the arrest of the murderers, who admitted their guilt.

In a similar case, a woman was believed to be a witch, but no accusation was made to her, and it is improbable that she knew she was under suspicion. Four women, who held her responsible for certain deaths in the family, obtained the assistance of a native doctor, and proceeded at night to her kraal. To prevent her escape they placed bundles of grass, on which paraffin was poured, in front of the door of her hut, and set it alight in several places. Not alone did she perish, her three young children being burned to death with her. As is usual in such cases, it was some time before the true facts were ascertained, and the murderers brought to justice. It is only natural, perhaps, that with this belief in and horror of witchcraft, natives who are cognisant of these doings should seek to shield those who have, as they conceive, rendered a service to the community by ridding it of an evil-doer. There is often a conspiracy of silence which baffles every attempt on the part of the police to obtain evidence. The facts are apparent; it is clear that a murder, prompted by witchcraft, has been committed, and that the attendant circumstances are known to those who affect ignorance; but the mystery remains unravelled. It is safe to say that in some instances crimes of this nature, committed in remote districts, have never been reported. One in which a newly-married man and woman were accidentally discovered, stabbed to death, as they escaped from their burning hut, has never been elucidated. Inquiry proved that the man was an alleged evil-doer, but the closest investigation failed to point suspicion to anyone in particular.

The only definite case, occurring more than half-a-dozen years ago, to which reference will be made, is one which is of some interest as showing the vain endeavour of a suspect to avert her fate by placing herself under what was considered adequate protection. No report was made at the time, and it was only recently that the circumstances were divulged. This was a crime in "high life," occurring in the kraal of one Bulawa, a brother both of the late Chiefs Tshanibezwe and Mkandumba (the latter of whom will figure in another case), and a son of Mynamana, who was Prime Minister of the Zulu nation under Cetshwayo, and the fighting Commander-in-Chief against us in the Zulu War.

Bulawa died, and thereafter some of his children became ill. A diviner was called in, and smelt out one of the widows, Kayakonina, as the cause of these misfortunes. Knowing that her fate was sealed, Kayakonina fled to the Chief Tshanibezwe, her late husband's brother, to seek for protection. This was readily accorded, and a man was detailed off to guard her until a kraal could be built for her; and in the meantime her safety was further secured by sending her to her brother. On the completion of this kraal it was named Godhlekwapani (preserved under the arm-pit), in signification of its being under the Chief's protection. She was duly installed therein, and two men were sent to guard her. Notwithstanding this precaution, within a week, eight of the widows of Bulawa came to a field in which Kayakonina was hoeing, near to her kraal, and set upon her with their hoes and with stones. Having killed her, they buried her in an antbear hole. These women, the same day, the deaths in the family being avenged, shaved their heads, anointed their bodies, put on their ornaments, and went out of mourning for their husband. There was no attempt at secrecy; the facts must have been widely known; even the deceased's brother, with whom she had taken refuge, placed stones round her grave in the antbear hole. Yet no word of this reached the authorities until after the lapse of some 12 years, when a son of the murdered woman voluntarily told what he knew, and pointed out the grave. The skeleton was exhumed and examined by the District Surgeon, and the women implicated made a full confession. Two native men were also convicted in this case as being accessories after the fact.

To point the consequences which may attend the disregard of an accusation of witchcraft, reference will now be made to a case in which indeed the intended victim escaped with his life, but which resulted in tragedy for two young men not under the ban, and against whom no vengeance was contemplated.

The death of a native woman caused suspicion to fall on one Msombuluko, and he was regarded as an *umtakati*. This was made clear to him, and social estrangement followed his previous friendly relations with his neighbours. Possibly because he was living in a European community, and close to a town in Natal, he made no attempt to leave the district. He was a man of standing, and had a large kraal. Active steps to injure him were then decided upon. Eight huts, five of which were used as dwelling huts, and three as grain huts, were burnt to the ground one night, the inmates narrowly escaping. Realising the danger he was in, Msomboluko, while still determined not to leave, slept outside with his wives and family. Another hut was burnt, but still undaunted he held his ground. His one remaining hut was, a night or two afterwards, set fire to. Being on the alert, and sleeping outside, he was able to extinguish the flames, the incendiary escaping undiscovered. His store of grain had been destroyed, and all that was left to him was a partially burnt hut. Still he evinced no disposition to vacate his kraal site. It was, however, imperative for him to go away to collect some debts due to him, wherewith to purchase provisions. He secured the services of two friends, young men who were strangers in the neighbourhood, and, arming them with assegais for the protection of themselves and his family, left them in charge during his temporary absence. The fact that he had gone away appears to have been unknown to his enemies. The night he left was a moonlight one. The young men and the inmates of the household slept outside, as usual. During the night, one of Msombuluko's wives saw three men approaching. She gave the alarm to her guardians, and they sprang up to meet the invaders. Both the young men were stabbed with assegais and succumbed to their injuries, not, however, before they were able to make dying depositions, which were of assistance in bringing the murderers, one of whom was a relative of the woman who had died, to justice. This occurrence took place three and a half years ago.

How fate pursued a man, who took no such risks as Msombuluko, will now be shown. The victim was one Mbemu, who some five years ago, being suspected of witchcraft, was cast aside by his people, and left them. He joined another kraal, but on the illness of one of its inmates, the accusing finger was pointed at him, and he again moved his residence. His wife forsook him, and he erected a hut for himself at some little distance from other natives. This was set alight to by four men, one of whom was a son of the man who had been taken ill, and as he sought to escape he was stabbed to death by them. His body was covered with dry grass, to which a match was applied. The scene of this tragedy was a native location in Natal. An immediate investigation brought the facts to light, and led to the arrest and conviction of those implicated.

It cannot, perhaps, be maintained that the old-time idea of death by burning as a punishment for witchcraft is the governing principle among the natives, or the primary reason why fire so often figures in their schemes of vengeance. The main object is to be rid of the offender, and this can, with ease and certainty, be accomplished by the simple expedient of incendiarism. This was especially so in the days of the Zulu kings, where a smelling-out involved the destruction of the whole kraal. If it were decreed that all the inmates were to perish, their escape was effectually cut off by the ring of watchers outside. On a smaller scale the same system prevails to-day, as has been shown in some of the illustrations cited, and is also seen in the case which follows. One Somcuba, living in Zululand, was believed by his own son to have cast a spell over him. The accidental burning down of the hut erected by the youth in a neighbouring kraal (he having separated himself from his father in consequence of the idea that he was a wizard) confirmed his suspicion. Somcuba's hut was surrounded at night, set fire to, and he was killed as he sought to escape, and his body thrown into the flames. The son admitted his guilt, his accomplices remaining undiscovered.

Close ties of kinship create no barrier of mercy when once a man is banned. A few weeks before the last crime was perpetrated (September, 1911), but this time in Natal, a young man named Manqane, assisted by a near relative, deliberately planned the murder of his father. The death of three persons was attributed to the latter by both these men. In pursuance of their plan, they sought their victim in the open, killed him with an axe, and hurriedly buried the body. Both were subsequently convicted.

The same year was witness to another tragedy in Natal. The victim in this case, Magabela, was a wealthy man who was thought to have recourse to witchcraft, and to have compassed the death of a child of one of the prisoners. This man, with two others, laid in wait for him in a donga, killed him with a knife, and cast his body into the Tugela river.

No distinction is drawn between witch and wizard, and her sex affords no protection to a woman. But little more than a year ago, on a European farm in Natal, a native woman named Mamadiba was believed to have compassed the death of two children. The father of these children met her at a beer-drink, and made it clear that he contemplated revenge. She fled in alarm, but was pursued by this man and beaten to death with knobkerries. The prisoner offered no defence at the trial, merely saying that the woman was an umtakati.

Arsenical poisoning was resorted to in one instance as the method of ridding the land of a supposed *umtakati* named Gwele. This man was smelt out by a diviner as having killed another man by witchcraft. These facts, and the manner of his death, were clearly proved, but a conspiracy of silence rendered the trial abortive, and those alleged to be implicated, and who were indicted for the murder, were discharged. There are many other instances of a similar nature in which there was no room for doubt that the motive for the crime was witchcraft, but in which there was insufficient evidence to convict.

It is a common idea that a girl may be bewitched by an unsuccessful suitor, and his failure or refusal to remove the spell may lead to serious consequences. In one such instance the girl immediately reported the fact; her lover, a man named Cetshwayo, was pursued, and on his denial of the allegation that he had bewitched the girl, and his refusal to return and set her free, he was killed.

The credulity of the natives in all matters savouring of witchcraft and their unshaken faith in the powers of diviners is well shown in an occurrence which took place last year. A batch of men went up from Zululand to work in Johannesburg. Some three months later, as they were partaking of fermented gruel out of a common vessel, a small piece of fresh meat was found in the gruel. This was too serious an incident to be capable of explanation. Accordingly, by mutual consent they consulted a witch doctor in Johannesburg, who said that one of their number, Ngulube, was the guilty person, but that he was acting as the agent of some one in power. Greatly alarmed, the party returned to Zululand, and acquainted their Chief of the circumstance. Ngulube, a relative of the Chief's, was summoned to appear before him, and an inquiry was held. To protect himself, Ngulube demanded that another diviner, a man of renown in Swaziland, should be consulted. His request was acceded to by the Chief, who seemed anxious to shield him, and a deputation was sent to this man. His verdict confirmed that of the Johannesburg witch doctor. He implicated Ngulube, but pointed out the real offender as one Tshankala, an uncle of the Chief's, who had acted as regent during the minority of the latter. Tshankala, he said, had supplied the piece of meat before the party left Zululand, and had given it to Ngulube in order to cause injury to the Chief by undermining his influence. That the meat could have been kept fresh for three months before use was made of it did not occur to any of them as an unlikely feature in the case. The deputation returned to Zululand and made their report to the Chief. Within four days Tshankala was shot by two men who went to his kraal at dusk. The prisoners made a full confession at the trial, averring that they were the emissaries of the Chief. No evidence in corroboration of their allegation was procurable, and the Chief was not proceeded against. The death sentence in this case was commuted to one of imprisonment for life.

If a person upon whom the stigma of witchcraft has been cast is discovered at night within the precincts of a kraal, custom decrees one recognized method of summary punishment—death by impalement. Three years ago, within twenty miles of this town, a man named Wele met such a fate. He was believed by his brother Sitendeni, and others, to be an umtakati. Returning one night from a beer drink, something the worse for his libations, Wele lost his way, and found himself in his brother's kraal instead of his own. His presence there after dark was proof incontrovertible of his evil intentions. He was seized and tied up, and his doom pronounced by his own mother, and carried into execution by his brother, Sitendeni, and two other inmates of the kraal. After being impaled he was driven forth, and managed to crawl a short distance and make his cries for assistance heard. His life was past saving, but a deposition was taken from him before he died, which, with other evidence, established the facts narrated, and secured a conviction against the four persons charged.

Without having exhausted recent examples of the fate which overtakes the supposed umtakati, enough has been said to indicate the prevalence of this form of superstition and its consequences.

Brief reference will now be made to a few instances in which the victim was under no suspicion of being an evil doer, in which, indeed, it was immaterial who was selected for the sacrifice so long as a "human buck," to adopt the usual term, could be procured for the purpose of obtaining portions of the flesh. Of the potency of human flesh for medicinal purposes no native doctor entertains a doubt; but, fortunately, few will take the risk of possessing themselves of it. The ordinary practitioner is content with his herbs and the dried flesh and fat of various beasts and snakes, and the other marvels of his pharmacopeia, without endangering himself to secure at first hand those tit bits of the human body in which efficacy lies. It is the Court Physician, or the doctor of renown, who combines the diviner's art with his Æsculapian pursuits, and has a reputation to maintain, who is most often called upon to meet an emergency in which human flesh is a *sine qua non*. And this may necessitate an intermeddling with witchcraft by one whose function it is to defeat it, if by no other means can a powerful medicament in the hands of an enemy be neutralized. A Chief, for instance, may wish to strengthen his hands, and obtain some advantage over a rival Chief. To this end the services of a trusted doctor are requisitioned, and the coveted fat or flesh from a human being is in due time procured. His rival gets to know of this, and dreads the evil which will result. He, too, must in self-protection, render futile the witchcraft he fears by having recourse to other witchcraft in order to arm himself with a sufficiently potent antidote; and thus a second sacrifice is offered up.

A case in point is that in which the Chief Mkandumba, who has been previously mentioned, and twelve others, were charged with murder. The history of the case presents many interesting features, but a bare outline of some of them must suffice. A year or so previously a native woman was openly murdered, the object being, it was alleged, to furnish another Chief, who was not kindly disposed towards Mkandumba, with portions of her body. This placed the latter at a disadvantage; human flesh was required, not only to frustrate the machinations of a rival, but also to fructify the corn. (Ukukanda amabele.) The victim must for preference be an alien; and an opportunity presented itself when the Chief, with his retinue, was visiting another section of his tribe in a district distinct from his own. An old man, Sitebe, a comparative stranger who had no kinship with the tribe, came to pay his respects. Here, in broad daylight, and in the presence of many people, the Chief gave directions to "watch his buck," followed by the fatal order to take it away. The old man was seized and killed by twisting his head round. The body was conveyed to another kraal, where the required parts were removed by a native doctor, who was accepted as King's evidence at the trial; and after further dissection was conveyed at night to the Pongola river, into which it was thrown. Eleven of the thirteen prisoners, including the Chief, were convicted. The Chief himself was a fine specimen of the best class of Zulu, a son of Mnyamana, the late Prime Minister of the nation; beloved by his tribe, respected even by his enemies; conspicuously loyal to the British Government whom he faithfully served, and under whom he had succeeded to the Chieftainship; yet, imbued with all the untutored instincts of the savage, he fell a prey to the superstitious beliefs of his race.

Certain relations of this Chief were indicted a year or so later for the murder of another old man who had suffered death by strangulation, and whose body had been mutilated. Flesh and fat, containing human hairs, were found in the possession of one of the prisoners, a doctor; but the death of the principal witness and the reluctance of others to give evidence resulted in an acquittal.

It may have been observed that in both these cases the method of killing was similar. When a human sacrifice is required it is necessary that no weapon should be used; the victim is seized and killed with the hands, it matters not whether by suffocation or, as is most usual, by twisting the head until the neck is dislocated. Whatever device is followed, it must be one which causes no external injury. In more than one instance where a district surgeon has been led to assign the cause of death to injuries, which are afterwards shown to have been inflicted *post-mortem*, a subsequent examination has revealed a dislocation of the neck. Some five years ago a boy was murdered for medicinal purposes; his eyebrows and lips cut off, and the body thrown into a river, where it remained for some days. The medical report considered that death might have been due to drowning, and that the portions missing might have been eaten off by crabs; but evidence to the contrary having established the real facts, the body was exhumed and the neck found to be broken.

The prisoner in a recent case was said to be an accredited wizard who wanted human fat. The body was not discovered for more than a year, and an examination of the skeleton showed that a twisted neck was the only injury ascertainable. There was, however, insufficient proof to connect the accused (Umzubeki) with the crime.

Seven men, one of them a doctor, were all found to have taken part in the murder of a boy of 13, four or five years ago, near the Usutu kraal in Zululand. They enticed him into a donga and killed him in the usual way. The eyebrows, lips, and other parts were removed, and the body thrown into a pool. This particular boy was probably selected because his father and other male relations were dead, and his mother was a sickly woman. There was no one, therefore, who would be likely to worry about the matter. The mother was discouraged from making any report that her boy was missing, but she persisted in sending word to the Magistrate, and the facts in the case were thus brought to light.

Not long ago, and in this county (Pietermaritzburg), a youth met his death under similar circumstances. There was no doubt that witchcraft was the motive, and the body had been mutilated. There were allegations that a Chief of considerable influence had given instructions that a potent medicine must be procured without delay to increase his power, but the evidence was not clear enough to insure a conviction against the ten men charged with the crime.

Cases of this nature are hard to prove; almost invariably a large number of natives are involved, and the loyalty of their relatives and friends, or of the whole tribe if it be a tribal matter, renders it difficult for the police, even if they get to hear of them, to break through the compact of silence observed by those cognizant of the true facts.

The potency of human flesh as a war medicine is unquestioned in the native mind; but it would not be germane to the subject to refer to mutilations said to have been made on the bodies of some of our countrymen who fell in the last native rebellion. The object of the killing *per se* was to kill, and not to perpetrate a crime in satisfaction of superstitious beliefs.

One other case, which is *sui generis*, is of sufficient interest to deserve mention, as showing how an unwitting disregard of native superstition may have tragic results to the European. A chief of the royal house of Swaziland was buried on a farm in the Northern district of Natal. His burial place was regarded as sacred, and could only be visited once a year at the command of his son for weeding purposes. Any unauthorised visitor would be viewed with suspicion and regarded as an *umtakati*, who had evil designs, and who might wish to resuscitate the corpse to turn it into a familiar of his own. A European, who knew nothing of this, rented the farm, and cut down some trees near the grave. His action was reported to Msweli, the late Chief's son, who gave orders that he was to be killed. A meeting was held, at which Msweli was present, and the necessary arrangements made. Two men were dispatched to carry out the order, and they proceeded forthwith to the homestead. The farmer himself was absent for the day, and his absence appears to have been well known, and advantage taken of it. His wife was busy in the kitchen, when an elderly native, named Nqenqeza, entered by the front door and walked through the house into the kitchen. A native girl was witness to what transpired. "If a person were to kill you what would you say," he demanded. The frightened woman made no reply, and Nqenqeza then killed her with a battle axe and severely injured her young child. The girl, who had seen all this, was threatened with death if she divulged the matter. She fled into Swaziland, but was subsequently traced, and Msweli and his accomplices were brought to justice, and received the death sentence.

Crimes of a capital nature only have been selected in illustration of the subject under consideration. There has been no wish to pile tragedy upon tragedy; still less has there been any desire to depict the native at his worst, and to present him as a blood-thirsty savage only. We know his many good points, his loyalty, his faithfulness, his willing service; we must understand, too, something of the handicap under which he labours, and will continue to labour, so long as his belief in witchcraft continues. We can afford now to pity this belief, to smile at it perhaps; but we must remember it would have evoked no derision from our forbears of the 14th, 15th, 16th and 17th centuries when, by State authority, witchcraft was punishable by death in Europe. The last trial in England was in 1712, and on the continent, in German Switzerland, in 1782; while in Mexico, so late as 1877, five witches were burned under cover of religion and with the consent of the populace.

The ethics of the question, as applied to our own natives, cannot here be discussed. The cry of the innocent who meets a cruel death has to be considered when the plea is raised that ignorant belief is an extenuating circumstance. Our chief responsibility lies in the removal of that belief. Is it too much to hope that, with State recognition of the evil, the spread of civilisation, and the extension of Christian influence, superstition will in a few decades have no relation to crime?

TRANSACTIONS OF SOCIETIES.

Thursday, October 19th: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*Large generator and transformer failures on the Rand Power Companies' Systems*": A. E. **Val Davies.** Several examples of breakdowns of generators and transformers were discussed, taken from the experience of the Power Companies during the previous four years. In every case the plant was of German design and manufacture. The generators were of the turbo-alternator type, of ratings varying from 3,500 k.v.a. to 18,000 k.v.a., and their speeds were either 1,000 or 1,500 r.p.m.; the aggregate rating of the generating plant being 218,800 k.v.a. The transformers were all of the water-cooled type, the ratings varying from 4,000 k.v.a. to 12,500 k.v.a., the total k.v.a. being 388,500. The failures dealt with in the case of generators were (1) faulty design of stator end connections; (2) failure of rotor binding wire; (3) heating of rotor end winding binder; (4) failure of insulation on end winding stays; (5) fire in a dry air filter; (6) failure of insulation of a stator bar. The transformer breakdowns discussed were (1) puncture of water-cooling coils in iron and lead pipes; (2) failure due to lightning; and (3) failure of magnetic circuit.—"*Some problems connected with electrical testing*": A. C. **Hall.** The author presented a series of problems met with in the work of a Supply Company's testing department, under the following heads: (1) Accuracy of test figures; (2) switch tripping by primary batteries; (3) accurate measurements of alternating E.M.F.'s; (4) unbalanced load on a power system; (5) three-phase power factor of unbalanced load; (6) measurement of unbalanced three-phase power factor.

BANTU PLACE NAMES IN AFRICA.

By Rev. W. A. Norton, B.A., B.Litt.

Underneath the bergs, kops, dorps, spruits, laagtes, kloofs, fonteins, banks, bosches, velds, plaats, hoeks, pans, poorts, rands, riviers, vleis, klips, gats, bults, draais, burgs, kuils, vlaktes, neks, and last (but not least) dams, with which the maps of Dutch South Africa abounds, lie a multitude of outworn or forgotten Bushmen and Hottentot, Portuguese and Bantu place names, of which a remnant still adorn the map; but the rest, except a few which may be recorded in lessening numbers by careful enquiry from the older natives, have gone under the palimpsest of time

The native territories, however, yield a harvest of names to the philologist, replete with geographical and historical interest (when the meaning and origin can be traced), and contributing very specially to the comparative philology and ethnology of the nations of this continent.

My concern to-day is with the Bantu names merely, and these lie, as I shall shew more precisely presently, between a northern limit, running roughly from the Gulf of Biafra to Zanzibar, and a southern limit running from Windhoek, through the Kalahari to the junction of the Vaal and Orange, and then across the Free State, where Bantu names are scarce on the map, to the conquered Territory, Basutoland, and—roughly again—along the East London line from Bethulie. That is to say, the southern part of South-West Africa and Cape Colony, except the Eastern Province and the dependencies to the East again, are practically free from Bantu names (I do not forget Lendlovu, just to the north of the Bay). Besides the recent English and Dutch names, Portuguese is represented, Bushman and Hottentot, but not Bantu.

Thus only about half of South Africa, south of the Tropic, contains Bantu names, the south limit of which practically bisects it from north-west to south-east. Besides which, the Bushman and Hottentot names, not to say Portuguese and other European, encroach upon the Bantu sphere; but from the Tropic to the Equator, and now considerably beyond (except on the east side), the Bantu, except for quite modern names and a few Portuguese and Arabic, hold the field.

But before we proceed to discuss this field, let us revert for a little to the moot question of the intermingling of Bushman, Hottentot, and Kaffir names. And here I shall refrain from entering into the delicate point of the distribution between the two former, nor shall I enter into the like deep question of the phonetic origin of the co-called clicks. I shall content myself with referring to Dr. Péringuey's learning on the former question, and shall take for granted what Professor Meinhof has, on the latter question, as it seems to me, so clearly proved in his work on *Hottentot Sounds in Kaffir*, *viz.*: that clicks (with *hh* and *r*) are amongst these, or, at any rate, non-Bantu; and, therefore, names containing them do not directly concern us in this paper. On the other hand, to be clear, I propose rapidly to trace the *north and east limit* of these ancient *non-*Bantu place-names left behind in the Bantu advance to south and west. This is comparatively easy in the south-east, as far north as the land occupied by the Southern Basuto, *i.e.*, to the north margin of the "Conquered Territory." The reason for this ease is the presence of clicks, represented in Kaffir and Zulu by *c q x* and their variants, the middle or *q* group alone being used in Sesuto. There is no need for me to dwell on them, as they lie outside our subject; but there was need to mention them, since these clicks have been so completely adopted into Zulu and Kaffir that it requires care to note their presence, and block out the names containing them from among the pure Bantu names. Thus, the native name for Kingwilliamstown (*eQonce*) begins with the regular Kaffir locative prefix *e*, and the name of the mountain *Qhoqholosing* ends with *ng*, the normal Suto locative; and this is apt to withdraw attention from the fact that both contain non-Bantu sounds, and should not, therefore, enter into our present consideration. I hope, on another occasion, to be allowed to treat more fully of these Bushman and Hottentot names, but at present we must only note their existence and avoid them, after determining their limits on the border of the Bantu sphere.

An examination of these on a large scale map reveals the Nqakaka and Xora Rivers as the last names on the coast towards the east, which contain a non-Bantu sound (excepting, of course, the Portuguese and Arab names). These rivers are just south of the Umtata. From thence the limit line seems to pass to Ixopo (Stuartstown), and thence to a group of clicked names near the Buffalo. These are Nqutu Mountain, below the junction of its tributary, the Blood River, with Mcenci Hill to the north, and Qudini Forest to the south-east of the Buffalo, and between Sunday's and Tugela Rivers, Qanqana Mountain and Umqwendu. Further up, on the east of the Drakensberg, we find Incandu and Ingcubu, respectively southern and northern tributaries of the Buffalo, and Umbumrana, with the tell-tale *r*, due east of these, on latitude 27.40.

In Basutoland, we find several on the Orange River, or Senqu, and also south of it, up to its source, where Qhoqholosing Mountain, already mentioned, stands as a gigantic outpost of the non-Bantu names. Coming down the Orange again, we meet the click *not* adopted into Suto, but occurring in Kaffir, in Xaba, north of Herschel district, Nxaxa in Qumbu, and Mcoseli's in Umzimkulu districts. Westward, throughout the whole of the old colony, we find pure Hottentot and Bushman names, differently spelt (with variations) from those adopted into Kaffir in the Eastern Province, and hence phonetised with more precision, by the missionary grammarians, than it was the fate of the names to be, which had, in earlier times, been learnt from the Hottentots by the Colonists. Thus the place which appears on our maps as Komgha is spelt with more precision by Kaffir scholars as Qumra, and our Klu-Klu is really Xu-Xuwe!

It will be convenient to deal, at this point, with the western limit of the southern Bantu names, which we shortly sketched at the beginning. We shall thus complete the southern sector in which Bantu and Hottentot names overlap, a sector stretching roughly from North Zululand to the right bank of the Keiskama, and from North Basutoland to the southern sea. Our westernmost southern Bantu names seem to reach to the Umtata, and the Umgeto stream, just east of the Great Salt River, and Bokana's River, west of the Bushman's River. Further north we find Umtlouli's and Kwenkezile's, Matomela's and Jokweni's kraals in the Peddie district (the last name, however, is, of course, not Bantu, but from the English "yoke"). Going north, we meet with Debe, near the Keiskama, and Gonzana, west of the Tyumie. Lastly, east of the Zwartkei source, we get Ntaba-kaMoses, obviously a recent name, since the Kaffirs have been penetrating the interior of the Colony, and Musa Umtwakazi, with Umaleki and Lovani east of Middelburg. Going northward again, we find a huge gap in our native names, owing to two invasions, the one from the east, due to results of Tshaka's rule, and one from the south, less violent but more effectual and permanent, of the Dutch Voortrekkers of the '30's.

The Orange Free State contains almost no native names on the map, and was, no doubt, but sparsely populated at the time of the Great Trek, having been largely depopulated by the earlier raids of Moselekatse, stretching from Thaba Bosigo, in Basutoland, to Marico, near Zeerust, his earlier settlement, and far beyond. Most of the town sites, however, have native names (*e.g.*, Bloemfontein is *Mangaung*, where *large wildcats* are), and also the rivers, *e.g.*, Linyana is the Vet at Menschvretersberg.*

Before we find Bantu names again in any strength on our maps, we must pass up once more east of the Drakensberg, till we reach the district on the border of the East Transvaal and Swaziland, where we get a western limit of Bantu names on my large map (in Wakkerstroom and Piet Retief districts); thence by Maviriestad, northward by the Godwan River and Marola to the Zoutpansberg. North-west of Marabastad, the rivers still maintain their native names on the Railway map, but Lehoe is the only station or siding that preserves one on the Pietersburg

* It has been thought that no Bantu had occupied the present Free State before the Dutch, but this certainly does not apply to the eastern part between the Upper Vaal and the Caledon. A casual perusal of Mr. Ellenberger's excellent "History of the Basuto" will show that these tribes often settled there on the way from the North to the present "Conquered Territory."

line; nor indeed do I know of another between Pretoria and the Colony through the Free State, though Machavi and Maquassi stand on the road to Kimberley, with Sivonel to the south-west of the latter, apparently the last important surviving outpost of the Secoana names (Sefunela) southward. Thence northward Bantu names crowd the line right away through Rhodesia to the railhead, and down the Beira line also. Westward, the Bantu runs to the Molopo, and possibly to Tsebe, south of this and near to the Orange. Northward of the Molopo is the Kalahari Desert, putting a limit to Bechuana migrations to the west, though some of the desert stations are named by them, and there is a legend, mentioned by Stow, of an adventurous party reaching the Atlantic, and there being astonished at the sight of a whale. As an illustration of the difficulty with which they must have found credence on their return, I may mention that an old native woman (daughter-in-law, by-the-bye, to the Great Moshesh), with whom I happened to be discussing the nature of a whale, suggested as its Sesuto name that of the *barbel*, showing how little she realised the hugeness of a monster of the deep—a hippo big as our Church, as I had to explain to her.

Before dealing with the western Bantu, it will be well to round off our view of native place-names of British South Africa by considering how far Dutch and English place-names bear witness to the presence of native races, who have left their own trace in surviving names of sufficient importance, in our complex history, to appear on the white man's maps. The rarity of *Bantu* natives, as distinct from Bushmen and Hottentots, in the experiences of the Voortrekkers, is marked by the names Kaffir River, 20 miles south of Bloemfontein, on the line, and Kaffir Kop, east of Winburg, both, we may note, in the Orange Free State. But the traces of both Bushman and Hottentot are much more frequent. We get Bushman River, east of the Bay and at Estcourt, in Natal; Bushman's Kop on the Kaap Plateau and west of Smithfield, in the Orange Free State; Bushmans Drift, at the far west corner of the Orange Free State, near Ramah; Bushmans Hoed, west of Colesberg; Bushmans Fontein, east of Middelburg; Bushmans Poort, on the Orange, near Bethlehem; and Bushmans Berg, south-west of Prieska. We have again for the Hottentot: Koranna Berg and Spruit, Orange Free State, the latter running into the Modder River; another Koranna Berg, west of Kuruman; Korannafontein, at Lichtenburg, Transvaal; and possibly Taaibosch Spruit, west of Winburg, and Taaibosch Bult, between Potchefstroom and the Vaal, commemorating the famous Hottentot Kaptein, and Koksfontein, north of Philippolis, with Kokstad, the leader of the Griquas. To the Bushman names we may add Keang Kop, called after Kaang, the Bushman sky-god.

It is to be noted, in regard to these names, that they carry us beyond the limits, mentioned above for Bushmen and Hottentot, into districts where no name in their language survives, at least on our maps; but they have left their trace in a Dutch or English name, from Lichtenburg and Potchefstroom to Natal, as well as in the south and west. Some such names, however, would not necessarily imply the presence of the people mentioned, *e.g.*, Bushmans How, presumably from the form of a kopje, and Kaffirkuil's River, in Stil Bay.

To complete the south-west boundary of the Bantu names, we must pass from Tsebe, near the Orange, in Bechuanaland, which appears to be the utmost name on the south-west, northward over the Kuruman and Molopo, through the Kalahari, by Malibeng (the pools), Mokopong (where pumpkins are) and Matsa (the lakes), to Saviko Pan and Bulibeng (at the deep pool—note how characteristically *thirsty* the names are here), by Lake Ngami. Then, again, due north to Nokanin (at the streamlet), and westward by the Bell and Norton valleys, to meet the Herero names, with their characteristic O prefix: Okatuovatyonu, Otavi by Grootfontein, and so by the now familiar Okahandya and Otyimbingwe, to Walfisch Bay.

The Hottentot names spread from Damaraland and Great Namaqualand on the west coast (where the last north is the Kaurasib) to the southern capes, and eastward, from well into the Transvaal, as far as Zululand, as we have seen.* So great was the spread, in the south of our continent, of these Hamites, whose remote cousins, the Egyptians, we know so well from our childhood, as occupying the north-east corner thereof. Doubtless, wide tracts of Central Africa, also, are strewn with buried Hottentot names, of which all trace has disappeared; and doubtless, also, had I better knowledge of the central dialects, I should have been able to trace Hottentot phonetics in those tracts in some degree, but I have never heard that any other dialects but the Kaffir-Zulu have adopted Hottentot sounds and words to any extent; not even the south-western group of Bantu, whom we now find in close contact with these people, except, of course, the case of Damara, recently enslaved to them.

Having discussed the southern boundary of our names, it remains to distinguish the Portuguese names of both coasts, and the Arabic names of the eastern, from the other coast-names, practically all Bantu, and finally to define the northern limit across the Equator.

On the east coast we find the Bantu names run up by Somaliland to Mtoni, just north of Wubushi (Port Durnford), and along the rivers of British East Africa, while inland the Hamitic tribes hold the pastures of the highlands far into the north of German East, opposite Zanzibar. At Magila, in the Bondei, we

* And in the North-East Kalahari to Kama-Kama, between Livingstone and the Saltpans.

used to get numbers of Masai to be doctored, and they and their congeners occupied much territory to the west of us, and to the south-east of Victoria Nyanza; indeed, on its east side it was only the *shores* of that lake that were occupied by Bantu, till we reach the solid Bantu sphere at its southern point.

Not only do Bantu and Hamites overlap in East Africa, like Hamites (the Hottentot) and Bantu in South Africa, but some Arab names are naturally found in their settlements as far south as Sofala.* The number of these names is, however, remarkably few, and even these have often Bantu terminations or prefixes, as Saada-ni, or alternative Bantu names, as Unguja for Zanzibar (or Zangue-bar, *i.e.*, the coast of the Zeng, or black folk). So, too, the latter part of the name of Songo-Minara Island is Arabic for tower or lighthouse (*minaret*). Dar es Salaam is, of course, pure Arabic: "Home of Peace," a little inappropriate lately. I do not find any other originally Arab name but those mentioned, on this coast.

To turn to the Portuguese. These are usually obvious; they commemmorate famous men, such as Lorenço Marques, Bartholomew Diaz, Fernao Velloso, northward to Almeida Bay, with many more on the old maps. The Waldseemüllers (early 16th Century) seem almost to exhaust Portuguese royalty, not to say the Saints of the Calendar, in naming rivers and capes. The festivals on which places were discovered, were often used for naming, as is well known, so much so, that these names are of considerably value for the chronology of the voyages. Natal, S. Lucia, and northward, Cape S. Sebastian and S. Antonio are of this class. Portuguese names like Beira, Conducia (Bay), (Cape) Burra (and Burra Falsa, so called from its likeness to the former), Cape Corrientes, Caldeira Island, and Cape Delgádo and Angoxa B. are again sufficiently obvious. These are mostly features noted from the sea, and therefore useful in navigation. On landing, the Portuguese adapted native names, which would more easily be spelt in a southern European language than in English or Dutch, but one does wish that our own race were not quite so anxious to blot out often quite beautiful native names, for the sake of an English name, representing some narrow or even private association of their own, not in any degree descriptive of the place named. Our own community farm is an illustration. The native name is Pass of Lions, which is descriptive, historical and romantic. The Dutch must needs call it Modderpoort, which is at least too descriptive, unfortunately, but so unpoetic, that a brass in Bloemfontein Cathedral translates it as Moederpoort, Matris Porta, which would have been delightful, if genuine. We are saved the last degradation of some English name, describing aptly enough some village in England, but here perhaps totally inappropriate philologically to the geographical situation.

* Waldseemüller spells it Zafalo. Is it old Bantu? Some suppose a chief's name and *cf.* Xosa *so*—prefix; but the Arabs spell it with *sad*, and Zulu names in *s* with *sin*.

De la *Goa* Bay speaks for itself (Algoa is spelt likewise in a 1640 map). Moçambique at first sight seems Portuguese, but the word is Mzambiji, probably the same as Zambesi. This river has many names in the many dialects of those who dwell near it: Europeans know it as the great river of the MoZambique province. For the many Portuguese names surviving in South Africa further south, see Mr. Pettman's interesting book.

Noting other European names, such as Penguin and Pantaloon Islands, on the east coast, let us now pass again to the west. Here the Portuguese names are much more frequent. Thus, coasting Angola northward, from C. *Frio* ("cold" after equatorial waters): Sacco Armazao, Albino Point, Sta Rosa, C. Negro Bay, Annunciation Point, Chapeo Armado, S. Nicolas Bay, Capes SS. Martha and Maria, Pta. Salinas and S. José, Egito (*i.e., Egypt*, cf. the Nylstroom in the Transvaal), Novo Redondo, C. Morro, Pta. Longa, Pta. das Palmeirinhas (and in Cabinda, Pt. Palmar), C. Lagosta, Pequena, S. Antonio again, Pt. Padrao. But the names here are by no means confined to the coast. We have S. Salvador, Duque da Bragança, Kapelle (though I am not sure that this is not a native name adapted), Silva Porta, S. Januario, S. Bento do Sul, S. Miguel. This shews the more complete occupation of the western colony as nearer to Portugal, and the wider spread of Saints' names seems to reflect fuller evangelisation, more numerous missions. Mozambique remained more dependent on India; Angola was less the mere half-way house.

French Congo has Capes Lopez, Sta. Clara and Esteiras, but not a French name, except Point Noire and Cape S Catherine, unless we count Point Ognoné and Nazareth Bay; and up-country, in the Congo, there are, of course, several French and Belgian *villes*. Spanish Guinea has Cape S. Jean, S. Tome, Benito, and Campo. Little Fernando Po, on the other hand, has scarce any *native* names on the map. Cameroons (the name is Portuguese) have Lobethal, Tappenbach's Rapids, Soden Island, Rio del Rey, (?Lolo) dorf, Carnot, and Joh. Albrechts Hohe. Roughly speaking, the names you will find, except those mentioned, are, throughout the west coast, all Bantu, until we reach the northern limit, over against the Sudan and Hamitic fields, to which boundary we must now turn.

The most northern point of the Bantu speakers (according to Struck's map in Meinhof's Hamburg Lectures, which here I am mostly following), is in the Cameroons, just east of Kororofa, on the parallel dividing North and South Nigeria, which territory bounds them on the West. North Cameroons, like North Nigeria, contains both Hamites and Soudanese (speaking linguistically), the Bantu boundary falling away (to the east of the Kwili and Isubu) to the Bangi, which it crosses about 3 deg. North, and then runs irregularly midway between the Congo River and the northern boundary of the Belgian state, reaching the Uelle about Bima. The remaining country between the Arumwini River and the Congo border to the north is almost entirely *Soudanese* in language (I use Meinhof's considered term for the loosely-knit negro family of tongues in West and North Central Africa, as the *tertium quid* to Bantu and Hamite). To the south, however, of the line just traced, from 7° N. to the Equator at Lake Edward, we have to reckon with Soudanese intrusions as far as 2° N., into the Duala-Tanga-Fan Fields on the west, and east of the Congo as far as to the Line, while some are found as far as south as the neighbourhood to the east of Lake Leopold II.

In the fork between the Albert-Kivu chain of lakes and the Victoria Nile is almost solid Bantu; the eastern shore of Victoria Nyanza, as we have already pointed out, is mainly Bantu, relieved with Soudanese, but a great arm of the Hamites (*e.g.*, the Ngiewa, but mainly Masai, with Ndorobo stretching to Speke Gulf) runs down the highlands from the Galla country to that opposite Zanzibar; the Bantu, however, of the valley of the Athi runs up through this Masai country to Kikuyu, and another smaller line runs along the Shambala Hills and Pare Mountains to the Chagga of Kilimanjaro, where the Bantu have held their ground, including an enclave of Mlugu, a remote tribe of Soudanese. The Nege pigmies, near Lake Njarasa, have a language allied to Bushman, which has itself some touch with Soudanese peculiarities.

In these last pages I have been mainly dealing with the sphere of Bantu-speaking tribes, but as we have seen in South Africa that many Hottentot and Bushman names survived the Bantu invasion (and even the European), even where those languages have entirely died out, so we must be prepared to find, on the northern border, Soudanese and Hamite names intermixed with the Bantu, and possibly some Bantu names left behind in the present Hamitic territory.

We have now traced the Bantu place-names limit on the west coast and on the east as far south as Walfisch Bay, and the Kaffirland borders respectively; and from the Cameroons also to the Swahili coast. The remainder of our paper will but touch the fringe of the great problem of the meaning of the place-names, and the recurrence of similar names in widely sundered territories.

But first we must pause to envisage, however vaguely, the probable line of advance of different divisions of the great Bantu race; and here we must note the geographical characteristics of Central Africa.

The entry into East Africa in prehistoric times is usually considered to have been through Arabia. Taking for granted an immigration from Asia by this route, we picture the immigrants brought up against the Abyssinian plateau on arrival. They can either follow the Red Sea to the north, or turn to the south of the plateau. However this obstacle was negotiated by various immigrant races, the trek southward must have been mainly along two paths: (1) along the highlands between Albert and Victoria Nyanza—where even to-day there is, so to speak, a "jam" of population (over 50 to the square mile, crowded, as it were, in the gate to South Africa, whereas in the rest of native South Africa, it is under 50 on an average: a friend tells me there are traces of a great prehistoric road to the east of Mount Elgon, coming from Lake Rudolf and passing north of Victoria Nyanza); or (2) brokenly along by the sea-coast, or skirting the mountains to the east of Victoria Nyanza, where to-day there is a great mixture of races. West of Albert the Congo forests stretch as far as the Atlantic (leaving indeed an eastern edge of grassland which Stanley rejoiced to emerge upon, and which the early Hottentots may have followed), and these tend to turn immigrants southward, along the eastern shore of Tanganyika. Here again the river of peoples would find a gate and tend to pass west of Nyasa toward the Zambesi. Except in early days, the pressure along the east coast of the pioneer Bantu, whom the Arabs found in the 10th century as far south as Sofala, would forbid all but strong races returning eastward to that side.

How, then, did the lower Congo become populated? I assume that as the main paths became blocked, tribes would pass between the smaller lakes north of Tanganyika down into the forest, and down the tributaries of the upper Congo from Lakes Bangweolo and Mweru (so the BaLuba in modern times. See Haddon, p. 105). It is, of course, quite possible that some tribes passed north of Albert Nyanza and down or across tributaries of the Congo, as the line to Stanleyville does now, but there there was probably already pressure from the westward trek of the pure negro.

That the Basuto tribes arrived at the Central Zambesi from the north-east, and therefore passed between Tanganyika and Nyassa is probable from the fact that their legendary place of origin is Ntsoana-Tsatsi, or "Sunrise." There is a Ntsoanatsatsi in the Orange Free State (Tafel Kop, by Vrede), but the tradition is too widespread and old for this to have been the original. That they should have come from the East coast, their other traditions, language, features, etc., forbid, but that they marched with their backs to the equatorial sunrise in remote days is probable enough, and might well be remembered in later days as they marched south; till, on arriving at the Zambesi, they would tend to ascend the river for a crossing,* again marching with their backs to the winter sunrise (their treks would naturally follow the Kaffir corn harvest) and so southward again. Thus would the north-east be kept in mind as their home, and it is looking to

* Cp. M. Ellenberger, who says the Barolong (senior clan of Bewana) left the Great Lakes at the end of the 10th century, crossed Zambesi in the 12th, and settled Zeerust and Mafeking, having adopted the baboon as their crest in the Dwarsberg at the end of the 14th century. The Bahurutse separated and extended over the Transvaal.

Ntsoanatsatsi in the north-east their dead are buried. They then streamed across the highland bridge between the Kalahari and Limpopo basin till they were stopped by the Drakensberg.* The south-western Bantu may have come by a similar route at no very remote period, perhaps by a higher crossing of the Zambesi, but the phonetic data are puzzling for the relation of the southern branches, including the easternmost or Zulu-Kaffir. Thus SIxosa and SIzulu share with the SEsuto the S, e.g., of this prefix (Herero *otyi-*), and, among other things,, the prevalence of the laterals (hl, *e.g.*), which are wanting in most of the other Bantu dialects; also they share the labialisation in the passive. Yet, on the other hand, Zulu-Kaffir and Herero preserve the Bantu sharp surds K, T, and P, which the central group changes into H, R, and F, etc.† Neither grammatically nor phonetically do we find much connection between Herero and *Suto*, while, strangely enough, there is some phonetic likeness between the latter and Duala in the north-west, opposite Fernando Po. The Herero, again, has vowel-assimilation developed in common with the central (Northern Zambesi) dialects, and to some extent with Suaheli and the north-east Bantu dialects. This might seem to show (1) a remote branching of Basuto and Duala possibly north of Tanganyika from one primitive offshoot of Bantu, and (2) another branching of south-west from south-east Bantu, possibly west of Nyassa. Thus Haddon says: "The Ovaherero probably represent a branch of the cattle-keeping south-eastern Bantu," but I reach the same conclusion on independent grounds. The south-eastern Bantu is also extraordinarily like Suahili, so much so that many words and some phrases are practically identical in these extreme dialects of the East Coast. The closeness of Transvaal Venda and Tonga, midway between the Suto and the Zulu-Xosa group has to be reckoned with: I am not prepared to say how. Room for borrowing not only of words, but of sound-system and actual dialects must, of course, be left.

This excursus is not intended even to approach a serious attack on the highly questionable problem of the grouping of the Bantu, but only as a general rough guide in our task of tracking place-names.

In concluding this digression we may summarise the present distribution of dialects by saying that in the main the Bantu spread from the lakes Albert and Victoria westward (*e.g.*, the

*Not a little light is thrown on this Völkerwanderung by the Suto-Chwana names (*i.e.*, those of the South Central group we are discussing) for N. and S. Both dialects agree on BoRwa (*i.e.*, Bushmen, driven southward before them to the mountains of Basutoland) for S.: but the S. Basuto use for N. Le-Boea, from *ho boea*, to return—*i.e.*, whence they came out. But among the N. Bakwena of Molepolole, I am told that this word is used for grassless country, and Kgalagali is used for N., showing that these Becoana did not succeed in avoiding the desert after crossing the Zambesi.

† See author's previous paper, "The study of South African Native Languages." *Rept. S.A. Assn. for Adv. of Sc.* Kimberley (1914), 384-395.

Duala), south-east towards the coast, and southward to the bridge between Tanganyika and Nyassa. This last line branched southward and westward, the latter direction to avoid the Kalahari, which runs almost to the Falls, with its Bushmen. Whether the Bechoana crossed the Zambesi *after* this trek I cannot say, but should think it probable. The main partitions are, therefore, the line Albert—Tanganyika—Bangweolo, and along the Northern Rhodesia railway track and Zambesi to the Kalahari.

All Bantu, then, except those who may have crept along the coast from Somaliland, found themselves inevitably, in their southward trek, on the plateau of the Great Lakes. This falls gradually from the shore of Victoria Nyanza, at near 4,000 feet, westward to the Congo forest basin, eastward by the coast rivers, southward ultimately to the Zambesi.

In turning at last to the place-names, let us remind ourselves of more familiar ones and their characteristics. Towns get their names either from those of men, or from more natural features (*cf.*, Edin-borough, Der-by, *i.e.*, the abode of deer or wild beasts). Usually the names are connected, even in constricted England, with the experiences of travel, with waterways and landways. It is remarkable that out of the few English shires no less than five (named, of course, from the county town) contain the word "ford"—of the Staff, Ox, Hart, Here, *i.e.*, Army.

In Ford and Ham, in Ley and Ton,
The most of English surnames run—

and names of places, therefore, also, from which surnames are mostly derived. Out of the four types, two are natural features, two man-made abodes, the "town" and "home" being preceded by the names of the people whose home they were, thus Nottingham, of the Sons of Snot. These place-names correspond to those after people, chiefs, etc., in Bantu. We shall therefore note and set aside this class in Africa, and confine ourselves to those marking natural features, since in these alone can we usually hope to find much connection with names in other dialects.

The place-names of Dutch Africa are, likewise, either personal names, as Reitz, or derived from such, as Maritzburg, Pretoria, Potchefstroom (from Potgieter), Orange River (from the Prince); or qualified otherwise, as Blaauw-berg (Blue Mountain) or sometimes unqualified, as Bank; sometimes contracted, as Rand, for Witwatersrand. But the majority of names, even of towns, that are not merely borrowed from older countries, are called after natural, not man-made, features. Thus, in the exhaustive list of Dutch geographical elements with which I began my paper, against plaats, dorp, and burg, the man-made elements, there are berg, kop, kloof, bank, klip, hoek, poort, nek, gat, bult, kuil, connected with high ground; vlei, vlakte, laagte, with low; and spruit, fontein, rivier, draai, dam connected with water; there remains bosch, and names of trees.

Now the same characteristics appear in Bantu names, and we may well arrange these as having to do with water, that most important element, especially in South Africa; with trees, and other natural features, as mountains, valleys. It will be found that hills are often called after the neighbouring valley, and the name of this may be taken from its stream, as with us (or *vice-versa*), but sometimes from the configuration of the valley itself.

But we must certainly add, in the case of Bantu names, the very characteristic category of names called after game, which, as we shall see, are very numerous: thus, among the Kaffirs, Nalanga (vulture), Indwe (crane), Umzi-mvubu (hippo-town), Umkoma (whale) on the coast of Natal (is it from a grounded whale, the form of the coast, or the number sighted thence?—local men kindly help me), Lunda Hill (ox's hump), Mbulu (jackals,* ? monitors), Inkwelo (water-beetle), Isandlwana (ox's second stomach. Maneering has been explained as MaNaring, where the wild oxen are, but an early map gives Myneering, *i.e.*, where Mynheer, the missionary, is!

Among the Becwana and Basuto this category is still larger: Thus:

Matlakeng (Rouxville) vultures		Moruakhomo (personal name?) (taming cattle) is the old name of Molopolole.	
Pudumong (Pudimoe), gnu		Kudu (Ladybrand) Koodoe	
Pitsane, little zebra	Likabi,	Phala (Palla) and Tsebe, buck	Tsesebe, bastard hartebeest
Ma-ngaung large wildcat		Mokhotlong black bird with red beak, *i.e.*, ibis.	

Lions are naturally in evidence, *e.g.*, Taungs, Lekhalong la Botau (Modderpoort, v.s.), and less dignified beasts: Likolobeng, in Basutoland, *e.g.*, where the pigs are; Ma-tsieng, from locusts; Kuruman, "croaking," the welcome sound of frogs, showing presence of water, I am told, is a possible etymology, but have doubts, though I prefer it to that from Khudu, a tortoise. Marico is said to be really Ma-disho, eating places, pastures. Bo-tla-nama, where game comes; Bo-n(w)a-pitsi, where qwaggas drink; and Nko-a-khomo, said to be so called from the mountain's likeness to the nose of an ox; Ramokuabane (better Ra-mo-kgoe-bana) is the name of a spotted bird and perhaps of a man so-called. The Dutch names after animals are usually combined with Fontein or other words for water.

I am confining my lists at present to the languages I know best, *viz.*, Suto-Chwana, and Kaffir-Zulu; we will deal with remoter districts and dialects later. Having dealt with the names

* Macloutsie = Matlhotse, jackals. The camp at Leribe called Hlotse, from the river beneath, is not from Tlhotse, a jackal, but means a hide.

commemorating the presence of game, corresponding to such Dutch names as Olifantsfontein, Katteberg—names, by the bye, which would illustrate an interesting paper on the fauna of South Africa, past and present, and their habitats—let us turn to the other categories, names to do with water and trees, and other natural features:—

I.—*Linokana*—little streams.
Nukanning—at the little stream.
Metsi matlaba—sandy water.
Maritsane—dregs (*rita* is to stir up). But it may mean a little *morifi* (dish), *cp. Bizana,* a round pot, in Kaffir.
Maliba-matso—deeps which are black. *cf. Bulibeng,* and *Malibe* (spruit).
Matsa—lakes. *cf. Dikeni* = Alice.
Semene—*Mena* is to roll up one's clothes to cross a river.
Seate (in Basutoland)—*Ata* is to swell, *e.g.*, in flood.
Tebe-tebe are quicksands.
Maribogo—drifts.
Selika is a river island—holm.
Tsitsa (River) means oozing out, trickling; *cf. Nyiti-nyiti* (near Keiskama Hoek), meaning Marshy.
Nathwane (from *natha,* to break off a bit)—a part of a big river, or from the river breaking off its bank.
In Zulu-Kaffir:—
Amanzi-mtoti—sweet-waters.
Amanz-amdaka (near Cala)—foul waters.
Ikanye (bright) = Glen Grey.

II.—Among Trees:—
Tlaring Reserve, near Kuruman—"at the Trees."
Meru-metsane—black forests. *cf. Emnyameni,* on the Keiskama.
Makhaleng—at the aloes.
Morokweng—in the bush.
Moralana—Bush with red berry and black spots on bark.
Mashomeng—where bulbs are.
Litlhaka is the *Riet* River, O.F.S.
Lotlhokoane—little reeds.
Lotsane is a withe.
Lesuoane—grass for tobacco granary.
Mokopong—where pumpkins are.
Mokopu = Pampoensberg, South of Thaba Patsoa, Orange Free State.
Moroko—husks.
Moshow—*Moshung* in the *Mimosa* bush (*lesu*). *cf. Shoshong.*
Machache (mountain)—dry wood.
Koning (*Kgonying*)—place of firewood, near Kuruman, and doubtless rare enough.

III.—Other features:—

Kalakani ("at the chalk") is Dutch.

Makeleketla—descent, dropping.

Mafeking, sefiking—at the rock (s).

Sefikaneng—at the little rock.

Mparane (Ficksburg) means the *flat* mountain.

Majoana a mabeli, near Ladybrand, O.F.S., means Two Stones.

And *Mabula*, near by, is "openings."

Litsetlung, at the large *round* stones. *cf. Embokotwa*, in Kaffir.

Called after parts of the body are—

Tlimele—a teat.

Sehuoa—collar bone, necklet.

Dipetung—chest.

Mafika Lisiu (Le Souvenir)—rock-like granaries.

A farm called *Ha Lehakoe*, "at the Flint's" only describes the *farmer's* character!

Leribe, Chief Jonathan Molapo's place in Northern Basutoland, means "Nodding" head, or stick. *cf.* Seribi, south of Francistown.

Buthe-buthe—"lying down," *cf.* the mountain to an animal.

Maseru—sandstone.

Maluti (mountains)—companions, or puzzles. *cf. Molopolole*, a tangle.

Maletsunyane (Falls). *Tsu* is the Dutch *spitz; motsu* is an arrow. *cf. Tsolo*, a pointed hill near Umtata.

Thaba 'Nchu is the black mountain.

Thaba Chicha, Patsoa —round, dappled (with bush), etc.

Taba Nkulu is the big mountain in Kaffir.

I must take a leaf out of my friend Mr. Pettman's book, and continue this wide subject of place-names some other time.

Those that we have considered, chiefly from South Africa, will give us a lead for others further north.

I shrank from contributing a paper which must seem too little finished, but the subject is so large as to be beyond the power of one man, even in many years, since Bantu comprises 182 languages and 119 dialects, and ideally a work on Bantu place-names would not be completed till all such were recorded, with the meaning in the dialects which had provided them—obviously an impossible task for one man. I give therefore what I have to offer at present, in the hope that those from many parts of Africa who have the patience to follow my remarks may help, with local knowledge and kindly criticism, to correct my suggestions from the philological side, and to fix the derivation of names where I have failed or erred.

South African Flora.—Three years ago when Dr. Marloth issued the first volume of his "Flora of South Africa," the London *Times Literary Supplement* referred to it as a "sumptuous work," and observed that "nothing of the kind has been attempted for any other country." The same author has just published a modest-looking little volume* which he describes as a "supplement" to his greater undertaking. Notwithstanding its unassuming appearance, the labour involved in compiling it must have been great indeed. The book is divided into three sections, the first of which is mainly an alphabetical list of the common names, current in South Africa, of plants indigenous to the country. The same species are enumerated in the second part of the book but in systematic arrangement. If either the common name or the botanical designation of a plant is known the searcher will find the other name in the appropriate section of the work. The third, and smallest, section comprises a list of foreign plants cultivated in the open, a list which the author regards as only accessory to the main subject of the book. The popular names are, of course, largely Dutch, but by no means exclusively so, and in practically every case a few notes descriptive of the plant, and often of its actual or possible applications, are added, and information is occasionally given to direct the reader to practical proofs of these applications. Thus one gathers that the furniture of the little English Church at De Doorns illustrates the use of which the *Rooi Els* (*Cunonia capensis*) may be put; of the Cape gooseberry—which, by the way, is neither a gooseberry nor of the Cape—the potentialities for jam manufacture are pointed out; and of the *Witgat boom* (*Capparis albitrunca*) the roots are stated to be used as a coffee surrogate. As already remarked, a great deal of valuable pioneer work has been packed into the small compass of this little work, and the author has indeed—to use a stock phrase thoroughly applicable in this case—met a long-felt want.

*R. Marloth: "Dictionary of the common names of plants; with list of foreign plants cultivated in the open." 8vo. pp. 175. Capetown: Speciality Press of South Africa, Ltd. 1917.

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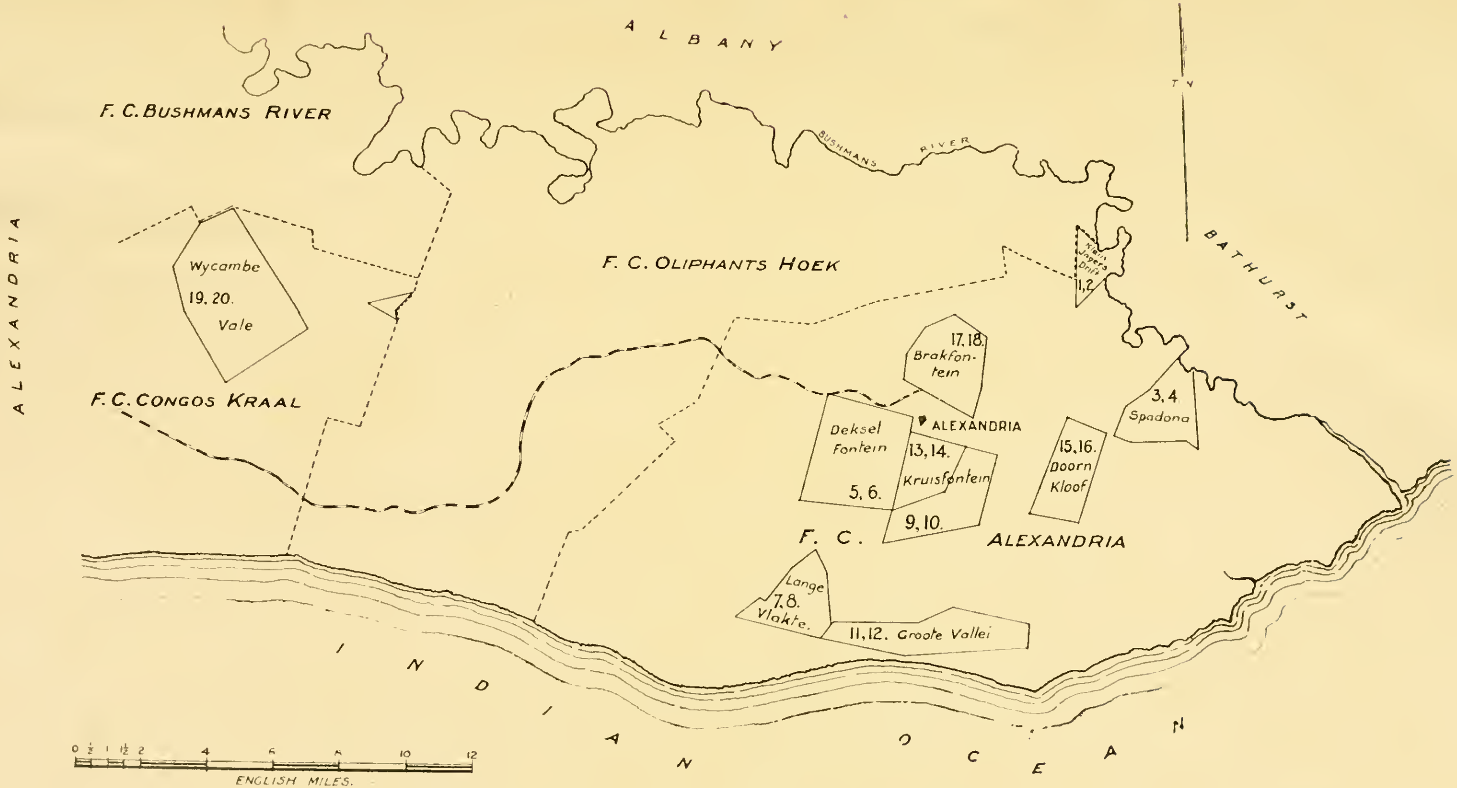

THE WHEAT SOILS OF ALEXANDRIA DIVISION.

THE BLACK WATTLE INDUSTRY—*ACACIA MOLLISSIMA* WILLD., *ACACIA DECURRENS* WILLD., VAR. *MOLLIS* BENTH.

By Thomas Robertson Sim.

The black wattle industry has been for many years, is now, and will permanently be, one of the most important of Natal's assets.

It has already brought in nearly £3,000,000 of oversea money for bark exported, which, during the past five years (including war restrictions), has averaged £266,000 per annum; it has brought into circulation a further unknown amount, probably £2,000,000, for mining timber and firewood used in South Africa; it has paid to the Government a nearly equal amount for railway freight on bark and wood; to the shipping companies it has provided a welcome addition to the home load; it has found occupation and maintenance for a very large industrial population, and provided a congenial outlet for the energies of the raw natives when hungry; it has provided the homesteads of South Africa with cheap and good fuel, and the gold and coal mines with an absolutely necessary part of their equipment, otherwise unobtainable except by import; it has created a demand for certain machinery and power, which also means money circulated; it has settled the Province with a contented and prosperous lot of farmers, who spend money freely, and maintain the town stores; and it has done all this on ground unsuitable for other classes of intensive agriculture without ousting any other industry, except to a small extent, grazing, for which the available area is still very large.

It also provided the late Natal Government with one Prime Minister and several Ministers and members of the Legislative Council and Legislative Assembly, and even the Union Government of South Africa has had representatives of this industry in its Ministry, its Senate, and its Legislative Assembly.

The black wattle is an Australian tree, and is believed to have been introduced into Natal originally as an ornamental tree, but on its tan value being ascertained, planting on a small commercial scale began about 1880, and increased regularly, year by year, up till 1911, since which date the increase has been slow, if any, for reasons mentioned later.

In 1905 I estimated the area under wattle in Natal at 30,000 acres; now I estimate the area to be about 160,000 acres, though no full and exact figures are available, and some estimates go much higher.

The exports give the best clue to the expansion of the industry; these have been:—

Year.	No. of Packages.	Average price per ton. £ s. d.	Value. £
1886	39	——	11
1887	449	——	315
1888	864	——	410
1889	4,623	——	2,783
1890	7,911	——	3,389
1891	13,972	——	5,588
1892	19,408	——	9,234
1893	22,976	——	9,304
1894	40,485	——	12,569
1895	57,666	——	17,209
	Tons.		
1896	3,378	4 17 5	16,450
1897	4,098	4 6 2	17,659
1898	9,427	3 3 6	30,929
1899	11,070	5 4 7	57,885
1900	8,900	5 4 5	46,479 (affected by war.)
1901	13,771	5 1 6	69,850
1902	15,537	4 15 11	74,554
1903	12,135 (and 168,767 bags.)	——	70,581
1904	14,125	6 12 6	93,578
1905	15,636	5 8 0	84,434
1906	14,756	6 0 9	89,056
1907	23,839	5 14 9	136,873
1908	24,587	5 8 7	133,510
1909	35,292	5 9 4	192,950
1910	41,048	5 1 6	218,309
1911	49,407	5 17 10	288,365
1912	52,776	4 15 0	250,686
1913	65,052	4 15 0	308,997
1914	58,479	4 18 6	286,399
1915	40,050	4 17 6	195,244 (affected by war.)
Approximately	535,047 tons, at Average	£5 1 9	£2,723,609

And from other Provinces of South Africa a small value, perhaps £30,000.

These figures do not include shipments from one South African port to another, but Capetown has, at various times, purchased a good deal for local use, and other ports some.

In 1905 I prepared a Government Bulletin, in which full details of routine practice and experience up to that date was embodied, and as that is still obtainable, I do not propose to-day to repeat any part of that, but simply to state further experience, and bring the history of the industry up to date, indicating what developments have taken place, and through whom, and in what lines research and development is still in progress or is wanted.

In 1905 every wattle-grower was a wattle expert; each one's methods differed in some respects from that of his neighbour, and each claimed to have the best possible method, and that he knew his subject, and had nothing further to learn.

To-day, most wattle growers, and especially those who know most, admit that they have learned more since then than all they knew before, and that they are still learning daily, and have much to learn.

In 1905 and onward, while the industry was developing enormously, large areas were planted on second-rate or third-rate wattle land, and have since proved that though such land can carry a crop of wattles, and can even do so with profit, the risks on such land are far greater, the need for first-class management is much more pronounced, and, in any case, the profit is much less than when first quality land only is used.

There used to be an optimistic idea prevalent that because certain measured areas and crops had yielded four tons of bark per acre in six years, therefore every acre of wattle land would do so; to-day it is known that though under exceptional circumstances some crops may be even much better than that, there are more acres in Natal carrying under three tons than over four tons, at that age.

There were few at that time who thought of a longer rotation than six or seven years; to-day, periods up to twice that length are receiving serious consideration, and being worked toward by the most advanced growers.

At that time, final espacement 6ft. x 6ft. was considered the standard, except in very favourable spots; to-day, most of the better plantations are on much wider espacement from the start, especially where longer rotation is contemplated.

It used to be the practice to thin only after the thinnings had value, say at four or five years' age; to-day, the practice is growing of thinning out all the weak and dominated trees as soon as they show that condition, say at two years' age, even if it costs something to do that, and brings nothing in return.

There used to be little endeavour to clean a weedy plantation, the idea being that the trees would find their way through and eventually dominate; to-day it is recognised that, besides other disadvantages, the time lost thereby meant the loss of at least one season on each crop, or the loss of one full crop every 50 years, and that mechanical cultivation pays its way well.

There used to be a firm conviction that the various insect, fungoid and bacterial pests were part of Divine Providence and unavoidable, and therefore had to be endured; to-day the wattle farmer is keen on the application of scientific research into the possibility of the control of his pests.

In 1905 the production of bagged bark was the limit of the farmer's ambition, and was beyond the scope of half the farmers, who were satisfied to sell as stick-bark; to-day we see compressed shredded bark bales and tons of dry bagged extract leaving Natal, and opening new markets and new possibilities previously only dreamed about.

Till lately, the wattle grower has thought of bark as the product, and timber as the bye-product; now he finds he can come out as well on timber as the product, and bark as the bye-product.

He used to rely entirely on Germany as his market; now he relies on all places except Germany, and still there is a demand for all the bark that shipping can be got for.

Till now he has thought of the oversea market as his only outlet; to-day the export of beef and consequent abundance of best hides, scientifically handled in bulk, at one or a few centres, instead of drysalted separately with no attention when a beast dies on the farm, opens the way to the production in Natal, from Natal materials entirely, and by Natal labour, of as valuable leather as can be produced elsewhere, and the creation of another industry.

There are also those now who have found out that beyond its value for bark and timber, the wattle can be used as a political handle, and that if they plant enough wattles in some remote and outlandish place, where land and labour cost next to nothing, there is a prospect that the Government later on will send a railway to the door, and the price of land will jump straight off from 10s. to £5 per acre.

It is the rare combination of a few simple factors which has given Natal its monopoly in this industry. It has suitable climate, suitable land which is not more valuable in anything else, suitable and low-priced labour, and the right men to direct that labour; these are all the special requisites. Australia and New Zealand have all other conditions, but labour is too expensive; in the few parts of the United States where climate is suitable, land is too valuable under fruit and lucerne until the supply of other local tan producers is more completely depleted. In tropical Africa, the usual demand of new countries for immediate returns has so far prevented extensive plantation of wattles; in India, the industry has not taken on; in the Mediterranean conservatism, and in South America the absence of conservatism have prevented even a start being made; in Cape Province land suitable for wattles is often more valuable for stock-raising, and in the North-Eastern Transvaal long freight, or a Portuguese port are adverse influences.

As the local grower often wishes to know what is actually being done elsewhere, the following facts, which have been ascertained may be recorded:—

Australia has suitable areas, but labour conditions are prohibitive, consequently no commercial planting of wattle has been done. The natural wattle scrubs are, in some places, being felled for bark with some regularity, and natural regeneration without culture or labour is allowed to replace stock. This is equivalent to the method once prevalent here of leaving regenerated crops unthinned, taking the best trees out of the plantations as they become fit, and leaving the balance to struggle on till fit—a practice long since condemned here as unsatisfactory. In other places, bark is being realised as wattle is cleared for agriculture. But there are Australians so satisfied with these methods that in the past the export of such product to Europe used to run to thousands of tons per annum, and being fairly mature, usually fetched a good price, whereas now the import into Australia from South Africa is running to thousands of tons, and the Australian Governments are being urged by their constituents to place an import duty of 30s. per ton on South African bark as a protective measure—a duty which, considering other markets for Natal bark, and also considering Australia's local supply, will not affect the Natal grower, but will eventually be paid by the Australian consumer without keeping the Australian grower alive as such.

Australia exported tanning barks, including mallet, wattle, mangrove, and all other kinds, as under:—

1911, 12,680 tons, value £103,971.
1912, 7,884 tons, value £67,525.

But still, during 1911, 3,908 tons, value £22,570, were shipped from Durban to Australia and New Zealand. No later returns have been seen by me, but I am aware that bark continues to be sent to Australia in quantity.

New Zealand has suitable areas, and has planted to some extent, the latest report I have being about ten years ago, when 4,500 acres were in wattle. The experience there is that labour is expensive, and there is no demand for the timber, consequently bark alone has to carry the crop.

East Tropical Africa.—In the S.A. Trade Commissioner's Report on the Wattle Industry (as it appeared in the Natal press) there were included figures so enormous and so extraordinary in regard to the export of bark from British and German East Africa, during 1910-1911-1912, that enquiries were instituted as to their correctness, and the official replies by the Conservator of Forests, British East Africa, and the Controller of Customs, Mombasa, show that the wattle-bark industry there is still in its infancy, and that, according to Blue-Books, the export has been:——

1910-1911 ..	10 tons Wattle Bark, valued at	£47, all to Britain.
1911-1912 ..	43 " " " "	£333, .. Germany.
1912-1913 ..	20 " " " "	£200, to Germany.
	32 " " " "	£308, to Britain.

No tannic acid was exported, except in bark form, but the export of mangrove bark was:—

1910-1911, 6,442 tons, value £6,059, mostly to Germany and United States of America.

1911-1912, 1,995 tons, value £1,950, mostly to Germany and United States of America.

Up to 1915, about 12,000 acres were planted with wattles in British East Africa, of which very little was then mature, but it is anticipated that the export of wattle bark may increase considerably about 1917.

In view of the above figures, the S.A. Trade Commissioner's Report is inexplicable, and evidently founded on error, as even taking mangrove and wattle together, or either separately, the figures he gives are far beyond the fact, so far as British East Africa is concerned.

Concerning German East Africa, I have no figures except those given by him, which I believe to be all wrong.

In India the various wattles were introduced many years ago, but no systematic cultivation has ever been done.

Gamble (1902) states: "Nothing seems to have been done on the Nilghiris, where the wattle is a weed, and miles of it can be grown at a very small cost, and cut over at five years' rotation." Probably this is because *A. dealbata* seems to be most abundant. The various Forest Inspectors' reports up to 1908 show that the same condition still holds, and I have no later information. Samples of *A. pycnantha* and *A. decurrens* from the Nilghiris, analysed in India, were found to contain 33.8 and 33.4 per cent. of tannin respectively, which does not go to support the popular theory that all tanning materials are richer in tan the hotter the country in which they are produced; and comparison of Natal's coast and upland wattle contents, so far as I know, also fails to support that theory.

Ceylon and Japan have both been buyers of Natal wattle bark, not growers so far. Japan used a good deal during its war with Russia.

In the United States of America, the value of land not subject to severe frosts is too high under fruit and lucerne to admit of wattle meantime on other than experimental scale, but in the American island Hawaii, where it has been growing for about 50 years, and apparently does well, the harvesting of the first and only six-acre block in 1905, raised rather a sensation, and brought out Bulletin No. 11, 1906, of the Hawaii Agricultural Experimental Station, by J. C. Smith, which shows that when 13 years old, 38 tons of bark were obtained from the six acres.

In South America, I am not aware of any planting.

In the eastern part of Cape Colony there are possibly 10,000 acres altogether, but the industry is not increasing rapidly there, owing to the high grazing value of much of the climatically suitable areas.

In the Eastern Transvaal there are a few thousand acres mostly approaching harvesting condition, which, unless special arrangements can be made, will be severely handicapped so far as bark is concerned, by long rail freight, or the use of a foreign port. A Transvaal tanning company is the suggested remedy.

Thus it happens that Natal has had, and is likely to retain, for the present, nearly a monopoly in this culture.

MARKETS.

The pre-war markets for wattle bark were Hamburg and Antwerp, with only a very small porportion to England and elsewhere. Hamburg was the principal centre, distributing to Germany, Austria, Russia, Holland, Scandinavia, etc.

Consumers everywhere prefer extract to dry bark, but the German policy was the importation of raw bark, so as to monopolise in Germany the manufacture of extract, and with this in view, there was an import duty of £4 per ton, which applied to quebracho and other barks, as well as to black wattle, but which had the effect of retarding commercial enedavours to produce extract in Natal.

Under what was known as the Hamburg contract, the arbitration clause gave the Hamburg Chamber of Commerce the official adjudication on points in dispute, and debarred sellers from having any voice in the selection of arbitrators, except outside friendly arbitration was agreed to by both.

Also all bark was sold at "fair average quality" (F.A.Q.) without analyses or sample, consequently anything claimed by the buyer to be below F.A.Q. went to arbitration, and unfair losses to consignors were numerous.

These, and other similar grievances recorded by the South African Trade Commissioner, led to the formation first of a Wattle Committee of the Natal Agricultural Union, and later to the formation of the Agricultural Co-operative Union, with a view to the protection of growers' interests. Private dealers in Natal kept aloof or came into direct opposition, which resulted in a certain amount of dislocation in the wattle business during 1911-1912, consequent lowering of prices, and a stoppage to the expansion of the wattle industry, which, till then, had been brisk.

The declaration of war closed the German market entirely, and growers may thank the Agricultural Co-operative Union, and other dealers, who, in face of enormous difficulties raised by the war, have opened up new and permanent markets quite apart from German intervention, and have done so without lowering the local price more than a few shillings.

The present position is that the British buyer is using, and prepared to buy at enormous prices, whatever can be landed; that the shipping companies, running enormous risks, are earning enormous freights; that sufficient shipping is not available, and consequently the price in Natal remains low, and the export comparatively limited. New markets in many other countries, which the exigencies of trade prevent me from mentioning meantime, have been opened, and on the whole, I can only look on the closure of the German market, under the circumstances which have brought it about, as an unmixed blessing. It must also be noted that Britain has prohibited re-export of wattle bark to Scandinavia.

And to those who say that as soon as the war is over the demand will be off, I can only say I do not concur, as I think it will take years of active operations to repair the wastage of war and again arrive at normal conditions, and that if there is meantime rather an accumulation of mature bark, that will be worked off easily while the pressure is still high.

There used to be a hesitation about using wattle bark in England, lest the supply would be insufficient, and irregularity in delivery might occur, necessitating the closing down of specially prepared appliances, and the return to former materials and methods.

Recent years have proved conclusively that there need now be no fear about 50,000 tons per annum being forthcoming, and much more if it is wanted. When the Hon. W. Deane and Mr. Harrison (Acting Trade Commissioner) visited Hamburg in 1910, they found that that market alone could absorb 50,000 tons per annum, at nearly the same rates as were then in force, or 100,000 tons on prices based on demand and on consideration of what other tan this would displace.

What may happen after the war, no one can predict, but this is sure: that if the demand existed somewhere in the world in 1910, it still and perpetually will exist, even though worked through other channels, and probably much of that was in addition to the new markets since opened up.

Consequently there is an assurance for the grower that he will have a market, and the consumer that he will have a supply. And though the export of extract, and of compressed bark are now accomplished facts, and in daily use, there can be no doubt but that it will take years before the whole of Natal's bark products take one or other of these forms, and the grower who is so placed that he cannot conveniently have his bark shredded or compressed or made into extract need have no fear that the market for stick bark or chopped bark is already gone for ever; such a process comes gradually, and necessarily takes a long time.

The methods of stripping and drying the bark, detailed in my previous Bulletin, require little to be added further than this: that where it can be done, drying in the open and close to the place of felling is usually less costly than drying in sheds, though on many farms the constant use of sheds is an absolute necessity.

It is found that large and airy sheds are better than any other, and that it is necessary to be able to close the sides to prevent the entrance of mist where mist prevails. The final stages of the drying may be done stacked outside under a roof of 6-ft. iron, if loose pieces of iron are kept at hand for standing up as sides during rain or mist, or at night, to be taken down again as soon as the reason has passed. This considerably relieves the pressure on space inside the drying shed, and also keeps apart what is almost dry from what is still very moist.

The wattle bark, after drying, is usually cut into approximately 2-inch lengths by strong chopping machines, many of which are of local manufacture. The stream of chopped bark is led direct into sacks, which are packed by special packing machines, all made in Natal, which vary from the single-drop stamp, which takes extremely little power and packs one ton per hour, to the heavy machines working on the screw-propeller principle, which handle about 30 tons per diem, and require 8 to 10 B.H.P.

It used to be the case that all shipping charges were per ton weight, and there was consequently no very great inducement to go to expense in regard to special packing. The war and the scarcity of shipping has, however, had marked effect on this industry, in that it has led to serious endeavours to economise shipping space. Various locally-made stamp and rotary machines for packing have been in use for some years, including Collins' packer, Arthur Wood's packer, and Macdonald's packer; by all of these, about 200 lbs. chopped bark is packed in a grain bag, and in this condition, which has, during recent years, been the standard, the bulk for shipment is 85 to 90 cubic feet per ton weight (2,240 lbs.), and is regarded by the shipping companies as 90 c.f.

Mr. A. Collins is now producing a rotary packer, packing chopped bark into bags in an oblong container, and these are afterwards bound square with iron hoop, whereby sacked packages, 14in. x 14in. x 28in. are prepared for shipment, working out at about 60 cubic feet per ton weight, with an inexpensive outfit. Various hydraulic and lever presses are in use, and others under order or construction, whereby, with a pressure of 200 tons, chopped bark, at about 50 cubic feet per ton and shredded bark at about 48 cubic feet per ton are managed in bales covered with hessian and banded with steel hoops, usually 20in. x 21in. x 16½in., of about 190 lbs. to 200 lbs., and I am informed that shredded bark has been packed to about 40 cubic feet per ton, but this I have not seen. A good deal of bark is now being exported shredded by disintegrators, mostly in compressed bales, and is in demand in this form, and though the chemist may say there is more loss of tannin in the escape of loose crystals and fixation of others by this than by other methods, the demand is likely to control the output till something better is forthcoming.

A good many of these grinding plants are being erected in various centres, and usually consist of a disintegrator requiring 20 B.H.P., which grinds or shreds the chopped bark to a fibre resembling coir. The process is a very dusty one, and can only be done in comfort by adopting an exhaust fan and collector, with probably an added dust-room attached. The local specialists for the mechanical requirements of the industry are giving every consideration to this development, and have produced what is required, and the baling is done by the presses already mentioned, to the same size as the chopped bark bales.

The rate of freight, Durban to London, which before the war was at 25s. per ton, has been raised to 62s. 9d. per ton measurement (40 cubic feet), or when in bags estimated at 90 cubic feet per ton weight, at £6 per ton weight (2,240 lbs.). This gives considerable encouragement to the reduction of bulk.

Extract.—For a few years the practicability of exporting wattle tannin as extract has been under consideration, but the war may be considered the factor which has given the opportunity, and made this an accomplished fact during the present year.

The Natal Tanning Extract Company has its factory in working order, and is busy making extract, having already shipped some quantity in bulk, as a clear, dry, solid extract, packed in bags of about 90 lbs. weight, and containing about 65 per cent. tannin.

Another factory is in course of erection in Durban, and expects soon to be in active operation, in which Bilbrough's process is to be in use, and public experimental crushings at Mount Edgecombe, May 4th, 1915, showed to be also practical, the machinery for this having been ordered in January, 1916.

It is understood that in both these factories it is mechanical expression of tannin from the bark by pressure between heavy bronze rollers, that is used, hot water and tan liquor washes being applied to the pressed bark between each set of rollers. By these means, extract as satisfactory can be produced in a few hours as was formely done by months or years of leaching under the slow diffusion or infusion process. So far, green bark only has been treated, but it is held that dry bark can be similarly treated, though taking longer time to get into a soaked condition which allows of pressure.

It has always been held by the advocates of extract-production that twigs and branches, which meatime are waste, can be similarly treated, and that thereby the production of tannin per acre can be increased. Whether or not that can be done with profit still remains to be proved, and will probably depend largely on how far the factory is from the plantation. Williams has shown (Bulletin No. 72, 1915, p. 7) that there is only 6 to 7 per cent. tannin in dry twigs and leaves, or 3.4 to 4.4 per cent. in the green samples. It is not yet clear what is the capacity of each factory, or if it will eventually be necessary to have factories every few miles along the railway lines, as happens with sugar; but it is clear that a saleable article is being produced instead of one which formerly the British tanner was not keen on using; and that whereas the bagged bark only yielded a ton (2,240 lbs.) of tannin from 270 cubic feet shipment, the extract yields a ton from about 40 cubic feet, without having more expensive packing than the other. What the shipping companies will do in regard to freights after the war, cannot be guessed, but it is evident that such a difference in cubic measurement means an immense saving.

In regard to the use of extract in Great Britain, the S.A. Trade Commissioner (Mr. C. Chiappini) gave the following interesting statement, showing for 1911 the import of bark, of extract and of other tanning materials into the United Kingdom, and the re-export of these articles:—

" 1911.	Total imports. £	Total re-exports. £	Percentage of re-export to total import.
Bark, almost entirely Mimosa (= Wattle)	243,128	187,587	77 per cent.
Extract	739,323	28,142	3.8 ,,
Other Tanning Materials	563,563	41,729	7.4 ,,

" In other words, in 1911 the United Kingdom used 96.2 per cent. of the extract, and 92.6 per cent. of other tanning materials imported, as against only 23 per cent. of the bark imported."

From this it would appear that wattle bark went from England to Germany to be made into extract, and was then shipped back to England.

The very extensive use of extract in England is amply shown in this, and gives every encouragement to the further production of extract in Natal.

Grading.—In my former bulletin (page 148) I urged that high-grade bark only be sent to Europe, or, at least, that such be sent separate from mixed, mouldy, and low grade material. On November 8th, 1912, Dr. J. Gordon Parker, on behalf of the United Tanners' Federation of Great Britain and Ireland, wrote to the South African Trade Commissioner suggesting that instead of sending all bark forward either as " fair average quality," or on sample, or for sale as bark without sample, it would be better for all concerned, grower, seller, and buyer, if some system of grading could be adopted whereby mature and immature bark, as also perfect and damaged bark, would be sent forward under different recognised brands. This matter was seriously taken up by the growers and the Government, with the result that grading from Durban port was begun by Government Notice 2032, December 23, 1913, and a Government grader appointed.

The classification was amended by Notice 655, April 17, 1914, to be—

H 1. Heavy (choice).
H 2. Heavy (fair average quality).
M 1. Medium (choice).
M 2. Medium (fair average quality).
T 1. Thin (choice).
T 2. Thin (fair average quality).
B.G. Below grade.

This continued in force and worked satisfactorily until September 30, 1914, when the grading was discontinued in view of the European situation.

An important enquiry is whether successive crops of wattle on the same ground are better or worse than earlier crops.

Experience varies much on this, and so does practice in the production of them, and I am convinced that the man who burns badly for renewal, and cultivates badly or not at all afterwards, usually has poorer succession crops, whereas the man who secures a thoroughly good burn and cultivates well has better succession crops.

Not many men can go back into many rotations, under regularly good cultivation, with any exactitude, but from Ravensworth Estate, where wattle culture has been up to date at all times since wattles were introduced, we have this important testimony from Messrs. Angus and Co.:

"The yield of bark per acre varies according to the prevalence of drought, hail, snow, frost, hurricane, bagworm, froghopper, locust, caterpillar, etc., and to freedom from all or some of these. We have had an average yield of two tons per acre from eight-year-old trees damaged by hail and other plagues and disabilities, and an average of 8⅓ tons from six-year-old trees, where conditions of soil and good rainfall, etc., have been favourable. This was from a fifth rotation; four previous heavy crops had been taken from the same plantation during about 35 years.

"Where there has been very severe burning of branches on the site of a rotation, trees are incomparably better than where the burn has been slight or missed altogether. And when (as now practised) the rotation has the soil broken up by heavy disc cultivation, it is, of course, more like the soil condition of a first crop than when merely cleaned between rows of new trees by hand hoe."

Messrs. Holley Bros. report the succession crops to be "better owing to better knowledge";

Mr. E. T. Hill says: "Under good treatment practically the same";

While Sir George Leuchars says: "Equal if well cultivated; third crop has been better than the first."

It is evident from such testimonies as these, and from what one can observe in going over many estates, that the wattle does not, of itself, impoverish the ground for future wattle crops, but that it is the farmer who makes or mars his future crops by his treatment from the burning stage onward.

Indeed, I go further than that and say that bad ploughing for the first crop, and consequent grassy condition, will continue in evidence through several rotations, say, for 20 years, unless it be rectified by sufficient burning on renewal, which is difficult in such case through absence of branches.

The practice of negligent ploughing, or of contractors ploughing on lowest quotations, must therefore be condemned, as 2s. per acre saved in the first cost may result in 20s. per acre loss per annum for 20 years or more.

A difficulty sometimes arises where felling has to go on all the year round, or at certain seasons to suit flow of sap or other controlling conditions, in getting a satisfactory burn during summer, and I have seen this better managed by leaving the ground unburned till winter, and then, after hoeing all rank herbage, securing an excellent burn, even at the sacrifice of a full crop of seedlings already 18 inches high.

To many this would appear wanton waste, and the loss of nearly a season, but actually it acts in the opposite direction, for the growth on the well-burned ground more than compensates for the loss of the destroyed seeding crop, which on unburned ground would sooner or later show the baneful effect of the absence of fire.

This brings us to another important question as to whether or not the application of bacterial cultures to the soil has any effect upon the crop.

The black wattle produces abundant nitrogenous nodules on its roots, from its earliest stages onward, and in view of experience with other leguminous plants, clover, lucerne, etc., it has been held that the application of artificial cultures from these nodules would facilitate the production of a crop, or would make unsuitable ground suitable for wattles.

I had experiments made in this direction with carefully-prepared laboratory cultures applied in fresh veld, but the results gave nothing in favour of the culture.

I feel satisfied that in all suitable wattle land in South Africa the bacterium is present, and was present before wattle existed in South Africa; in other words, that the wattle has adopted an ever-present indigenous bacterium; or, perhaps, rather, that that bacterium has adopted the wattle; but that land unsuitable for wattle is unsuitable for the bacterium also, and that no such artificial bacterial application will in any way affect the crop, either on the suitable or the unsuitable site, except possibly in a few rare cases not yet clearly understood.

But in this connection the effect of burning grass before first ploughing, and of a thorough burn when renewing requires scientific explanation. It does not seem likely that any bacterium on or close to the surface could endure these fires, but it does seem likely that the fire sterilises the ground from injurious bacteria, and at the same time gives a particularly suitable charred and open medium, in which the favourable one finds a suitable nidus. Whether it arrives from the air or from the subsoil is not clear, but the regrowth and formation of nodules on a charred mass where a pile of refuse has been burned, irrespective of whether that pile was wattle wood or grass refuse, shows within a month that the bacterium is present in abundance, while the poorer growth on adjoining unburned spots shows that it is not yet active there, and this early advantage is maintained through life.

But my experience does lead me to believe that the application of ordinary complete fertilizers can be made with profit. This is best seen where ground barely fit to carry mealies is well fertilised on purpose to obtain a catch-crop of mealies between the young wattles during their first summer. Such catch-crop usually pays the labour and manure, and the wattles undoubtedly benefit from the residual manure and from the cultivation unavoidable with the mealie.

But here again curious phenomena are noticed, for upon an old cattle kraal, or the site of a former Kaffir kraal, both of which sites should be particularly rich, it is hardly possible to get a wattle crop raised, and even individual trees which survive are seldom up to the average of similar widely-spaced trees elsewhere.

And again, on native lands which have been cultivated in mealies for years without manure a wattle crop germinates freely, but continues a somewhat languid existence as compared with what happens on adjoining land which has not been cultivated.

I cannot think that the mealie has removed any necessary manurial ingredient, as the effect is not the same or, at least, not so pronounced after good European cultivation, but I do think that the continued bad cultivation of mealies has either encouraged the abnormal propagation of some bacterium inimical to the wattle, or it has produced conditions unfavourable for the production of the wattle-aiding bacterium.

If such be the case, that is an instance where the artificial application of Nitragin might be of advantage, but this has still to be proved.

It is well-known that the open mountain sourveld resulting from the decomposition of dolerite is the soil on which the best growth of wattle is obtained, though it is the worst for most other agricultural crops; also that the wattle bearing quality decreases with an increase of clay, and that, generally speaking, what are known as sweet-velds and thorn-velds are not suitable for wattle.

The proximity of shale, or its admixture in the soil, is usually injurious, and though wattles do sometimes do well on sandstone or quartzite, more selection of site has to be exercised there than elsewhere.

In Natal the mist-belts and the doleritic soils often go together, and these are undoubtedly the best localities; on the other hand, the close-grained thornvelds and absence of mist usually go together, and are the worst wattle sites.

An article by Mr. C. Williams, Chemist of the Cedara School of Agriculture, appearing in the *South African Agricultural Journal*, 1914, pp. 79 to 88, gives a series of chemical analyses made at Cedara, the first of which shows the percentage of tannin contents of trees of various ages from one to nine years, which is far from uniform or progressively increasing from youth onward, and proves nothing in that respect, but in which the lowest percentage 28.6 per cent. is from trees on thin soil over shale, while the highest normal percentage, 34.5 per cent., is from a dolerite ridge; though two interesting abnormal cases are also given, in which a three-year-old plantation damaged by hail a few months earlier gave 35.3 per cent., though its bark weight was low, while an eight-year-old plantation "below average in growth" gave 34.7 per cent., also on low bark weight.

It appears from this and from other experience, that certain classes of injury or retardation of growth tend to increase the percentage of tannin though they reduce the production of bark.

Williams says (page 83): "It is, however, the total amount of 'tanning matter' obtained per tree that should govern the market value of a plantation, and that factor is seen to vary more regularly with the age of the trees, especially in case of plantations on a similar type of soil."

I do not agree with this. It is the total amount of 'tanning matter' obtained *per acre*, combined with cost of harvesting and value of timber, that should govern the market value of a plantation, and though that may vary with age, with some regularity in a uniform espacement the regularity is quite upset when different espacements are compared together.

Valuable as Williams' report is, it has a weak point in that he does not state at what espacement the trees stood, nor if the espacement was quite regular, and this omission much reduces the value of his work, especially as in one case showing somewhat abnormal results he states that the area was "fairly well stocked with trees of irregular growth." Does that mean that the espacement varied and the result was irregularity?

Similar analyses taken from plantations having full stock at various espacements, and thinned at various ages and in various manners are, however, urgently wanted, and I direct the attention of Government to this as an early duty.

Williams's figures much condensed, and taking the average arrived at in each case, show as follows:

Age.	Soil.	Total Weight of Dried Bark.		Amount of Tannins. In Dried Bark.	Amount of Tannins. In Green Bark.	Total Weight of Tannin.	
		lbs	ozs.	per cent.	per cent.	lbs	ozs.
1. 3 years.	Reddish grey soil. Damaged by hail a few months previously	4	1	35.3	17.4	1	7
2. 3 years.	Chocolate loam from dolerite; trees of irregular growth	12	9	33.0	16.1	4	2
3. 4 years.	Soil thin, over shale	11	0	28.6	13.4	3	2
4. 5 years.	Deep red chocolate soil	26	11	32.4	16.5	8	10
5. 6 years.	Cholocate loam from dolerite	26	7	29.2	14.3	7	11
6. 7 years.	Chocolate doleritic soil	38	0	31.7	15.9	12	1
7. 8 years.	Red soil over shale. Below average in growth ..	34	3	34.7	18.4	11	15
8. 9 years.	Moderate growth over shale	32	7	32.7	17.9	10	12
9. 9 years.	On dolerite ridge	47	7	34.5	17.4	16	7

The above table shows that most of these barks lost 50 per cent. weight through drying.

Further experiments proved that the loss of weight in drying varied from 38 to 58 per cent., but that 50 per cent. might be considered usual, though it was found that thin bark lost more than thick bark. I am satisfied that no plantation at nine years' age should be standing at the same espacement as at three years' age, and consequently that the above comparison, if based on that condition, is defective there; and if not based on that condition is misleading.

I am also convinced that under suitable conditions the bark yield, and also the tannin content per acre of mature trees is higher from a wide espacement than from a close one, while the timber value is greater and the cost of stripping is much less.

It has been asserted that the bark becomes old and is corky (*rhetidome*) when eight or nine years old, but that is usually a matter of management, and subject to the control of the farmer.

It is not uncommon for bark to be barkbound and practically useless when two or three years old, and at any age thereafter, through bad selection of site, and such trees seldom quite recover except under exceptional weather and good management; it is also common experience of those who care to observe, that individual trees can be grown to two feet diameter and still have fresh marketable bark of great depth and of immense weight per tree, and that this can be done almost anywhere if conditions are proper for wattle doing its best.

Keep in mind that the wattle is a great light-demander, and that the golden rule in thinning wattle is to always leave enough trees to maintain canopy without leaving enough to seriously injure girth growth.

These are the guides which have led to the wider espacement now being adopted. It is found that mechanical cultivation among the young trees, together with sufficient light, gives the desired growth and greater cleanness of ground surface, with less risk of the trees being barkbound, than does closer planting without these accompaniments, and that once canopy is secured there is less difficulty in keeping the canopy right, and in handling; and that by judicious thinning the crop can be carried on for a much longer period than has so far been attempted except under crowded conditions, also that the bark product in weight or cash is heavier, while the timber becomes valuable poles instead of low-value laggings; altogether, that the long rotation and allowing the tree space to become to some extent mature (which never happened under the old method) is the more valuable one. Williams, in the same report, gives another series of analyses (page 84) showing variation in the amount of bark and in the distribution of the tannin matter according to height above ground, which summarised is as follows, taking one sample tree of 3, 6, and 9 years of age respectively, and dealing with each 6 feet length from the ground upward separately.

	Percentage of Tannin in Dry Bark.			Total Weight of Tannin.		
	3 Year Old Tree.	6 Year Old Tree	9 Year Old Tree.	3 Year Old Tree.	6 Year Old Tree.	9 Year Old Tree.
				lbs. oz	lbs oz.	lbs. oz.
7th 6ft.		27.6	28.9		0 8	0 12
6th 6ft.		28.5	30.1		0 12	1 1
5th 6ft.	26.8	30.1	31.4	0 3	0 14	1 5
4th 6ft.	29.0	28.7	32.3	0 7	1 0	1 10
3rd 6ft.	31.4	30.4	32.9	0 12	1 5	1 14
2nd 6ft.	30.3	32.9	35.1	1 2	1 11	2 5
1st 6ft.	37.1	36.3	40.6	2 1	2 7	4 1

	lbs. oz.	lbs. oz	lbs. oz.
Total weight of tannin, per tree	4 9	8 9	13 0
Total weight of dry bark, per same tree ...	13 12	27 0	37 10

This shows what his previous experiment failed to do, that the younger bark on the upper part of the tree, besides being thin and light, has a lower percentage of tannin than the lower bark.

The lower third part of the tree contains usually more than half the tanning matter obtained from the complete tree. Consequently, to secure bulk of uniform grade of bark, only the lower portion, say the first 12 feet may be used together, leaving the balance for a lower grade. The thickness and weight of the bark naturally are less, the further up the tree the sample is taken from, and the bark on the upper portion of a nine-year-old tree is less thickness and weight than on the lower portion of a three-year-old tree. This introduces an element of selection in grading, which so far has received little attention. While the bark of young plantations which are being thinned, and which is all thin bark, is easily segregated as thin bark, it is doubtful if many growers separate the upper portion from the lower portion of the same tree; 32 per cent. has usually been regarded as the standard for f.a.q. bark exported, and for all reasonably thick bark is easily reached.

In grading, the thickness of the bark has been adopted as the basis of classification except in the case of damaged bark, and a further table in Williams's report shows that this is justified; that dry bark under 0.1 inch in thickness contains usually under 30 per cent., and sometimes as low as 24 per cent., whereas thicker bark is of gradually higher percentage up to samples 0.17 inch thick, yielding about 40 per cent.

How this affects even thicker bark is not shown, but in view of the later developments in wattle culture and the tendency toward thicker and more mature bark it is of great interest, and should be ascertained.

Wider espacement also tends to carry mature and heavy bark further up the tree, and to increase its proportion per acre in that way.

Williams made further experiments comparing bark dried in the open air with other portions of the same sample dried in an oven at a temperature approximating to 60° C. (or 140° F.) These agreed so closely that up to 150° F. is considered safe against damage or loss, especially if accompanied by thorough ventilation to dry quickly without destruction of tanning matter.

This may eventually be useful toward the coast, where the humidity of the atmosphere often makes successful drying difficult. All these experiments by Mr. Williams were duplicated the following winter, and proved that summer and winter felling give practically equal results, and that the first experiments were confirmed throughout. This was issued by Government in pamphlet form as No. 72, 1915.

I have only casually referred to what bark constitutes a crop. Of course, this varies immensely in accordance with conditions and culture.

But, allowing average suitable conditions, the usual weight of dry bark obtained is from half a ton to a ton per acre during thinnings, which hardly do more than pay expenses, and about three tons per acre final crop in a 6-year rotation, or four tons in an 8-year rotation, if no pests or troubles have interfered.

That is to say, apart from the unremunerative thinnings, half a ton per year per acre of bark increment is a good crop up till the eighth year, and very many indeed are the crops which are not up to this standard meantime.

We have no sufficient data on which to base calculations of further increment, but if thinnings have been satisfactorily done and conditions are favourable, I estimate the increase after the eighth year at three-quarters of a ton per acre for several years, and probably often more.

Meantime we do not have reliable data on which to base yield tables or yield curves, but the necessity for these is urgent, and I suggest that Government take the preparation of such tables or curves in hand at once.

The farmer or the company is only interested in his or its own crop; it is a Government duty to compile such tables, applicable to all cases.

An erroneous idea is common that wattle, in addition to drying out the local soil, has a drying effect upon the district generally. In Bulletin No. 7, 1905, I wrote:—

"A plantation of mature black wattle transpires regularly an amount of moisture equal to about 40 inches of rainfall under the ordinary temperatures of Natal Midlands, consequently, if the supply of moisture from all sources is less than that, the plantation will eventually dry out the ground and suffer; whereas, if the supply is too heavy, the trees become lichen-clad to an undesirable extent, and otherwise suffer, though this seldom happens. It is on account of its absorptive powers that the black wattle can, like blue gum (*Euc. globulus*) be used for drying up swamps, and although it requires more care than blue gum at the start, it is quite as effective in its action afterwards; indeed, so absorptive is it and so wide-spreading its roots, that few trees survive intermixed with black wattle, except the rainfall is heavy, or the soil very deep."

This has been misconstrued by some, and I now wish to make clear that the drying out referred to above is entirely local; that the black wattle is pumping its 40 inches of water into the atmosphere so long as it can find it, and that consequently the surrounding atmosphere becomes more moist, though the underlying soil may become depleted of water to the extent of drying out streams or springs served by that area. In proof of this I submit the following table showing the rainfall at Maritzburg during 20 years (all there is on record) as supplied by the Chief Meteorologist, Pretoria, on March 22, 1915—the first ten years being before wattles were abundant round Maritzburg, the second ten years, since they became so.

	Inches Rainfall.	Days.		Inches Rainfall.	Days.
1895	45.97	129	1905	42.10	130
1896	35.76	133	1906	34.18	115
1897	31.66	113	1907	51.64	137
1898	43.64	138	1908	32.53	141
1899	31 78	128	1909	36.17	134
1900	25.19	106	1910	42.66	130
1901	36.76	137	1911	38.26	123
1902	28.73	118	1912	Incomplete	—
1903	26.64	117	1913	43.71	140
1904	33.51	107	1914	37 73	133
	339.64	1226		358.98	1183
Average 10 years 33.964 inches on 122.6 days.			Average 9 years 39.88 inches on 131.4 days		

The fact that the average rainfall has been six inches higher during the past ten years than during the previous ten years may, of course, be open to cyclic or other explanation quite apart from wattles, and may be found to correspond with similar increase elsewhere where wattles can have no effect, but till one or both of these propositions are proved it is fair to accept the greater general humidity caused by the transpiration of wattles as at least a contributory cause.

No paper on wattles could be complete without reference to the wattle pests.

But as Mr. Hardenberg is to contribute a paper on these, I will omit practically all of what I would otherwise have said.

Government's action in investigating these pests is highly appreciated, and though we are still a long way from out of difficulty in regard to pests, the knowledge is gradually accumulating which a few years ago was altogether absent, and from which ultimately good results may be expected.

From the purely practical side this much may be said in regard to bagworm (*Chalioides junodi*). The bagworm belongs naturally to the hot dry Thornveld, and is not at home in the mist belt.

The wattle belongs naturally to the mist belt, and is not at home in the Thornveld.

Very seldom do these two velds overlap, and it is found in practice that healthy wattles in the mist belt suffer much less from bagworm than the usual wattles found in the Thornveld. In other words, if wattles were grown only in what are properly wattle areas, the trouble would be insignificant, and the farmer who extends beyond that must take the commercial risk attached to his venture.

Fuller, in Union *Agricultural Journal*, June-July-August, 1913, deals exhaustively with bagworm, and suggests shelter as a means of prevention. Though he himself condemns this as impracticable, there is more in the suggestion than he seems to think, especially as belts of tall gums put in on purpose to break the insect-bearing winds, do themselves grow into money as fast as the wattle. If the gum has any prohibitive effect upon the spread of bagworm, it has that effect without loss in the returns from the ground, and with very little extra expenditure.

Much alarm has from time to time been expressed by growers by the presence of the disease now known as "mottled disease of the black wattle." This has been carefully investigated by Dr. P. A. van der Byl, and his report was issued as *Science Bulletin* No. 4, Division of Botany, Union Government, 1914, and contains much of interest. The following are the most important results arrived at, *viz.*:—

"The disease known as 'mottling in wattles' is due to physiological derangements caused by unfavourable conditions of growth."

"Methods of control should be directed toward improvements of the conditions which produce the disturbance."

In addition to all that is stated therein, I would add that the trouble often occurs among the most healthy and vigorous wattles as soon as they become crowded and cannot obtain sufficient light or moisture. In such case thinning, even after the disease shows is beneficial, though thinning a year earlier prevents the disease, gives finer trees from what are left, and is consequently the method that should be practised.

Dr. Van der Byl has also produced another valuable bulletin on the disposition of tannin in the wattle bark.

The profit of the industry is closely associated with the utilisation of the timber.

Fuel and laggings used to be the timber product, and are so still to a considerable extent, but the longer rotations are being adopted mostly with a view to obtaining heavier timber suitable for mine props.

If an equal weight of props per acre is obtained, as formerly was of laggings, then the value is about doubled, while the bark value also is about doubled, the cost of harvesting is reduced, and the cost of one renewal and maintenance through early stages is avoided. This, of course, cannot be done everywhere; it can only be done in what is really first-rate wattle ground, not too far from rail, but if carried out extensively there the market for these other products from poorer sites is relieved and maintained.

The question of utilisation of the wattle timber from remote farms has always been a difficulty. So long as it can profitably be railed for mining timber and for fuel, that of course is the simplest utilization. But at distances which will not allow of that the timber so far has mostly been burned.

To a small extent charcoal has been made, and this might be extended on the remote farms, as the transport to rail of the same value on rail is thereby much reduced.

But allowing that the estimate of 160,000 acres now growing in Natal is correct, and that each acre when mature will yield 20 tons of timber in eight years, and that half the total is too remote from rail to allow of marketing as fuel or mining stuff, then we find that there are 200,000 tons of timber being burned as waste every year, besides what may be burned on farms nearer the railway. This amount, of course, is scattered over a wide area, but the total is sufficiently large to place before the chemist and the Government as a problem worthy of investigation with a view to distillation or any other utilisation which may be suggested; anything, in fact, rather than waste.

When in London at the S.A. Products Exhibition, in 1907, I had experiments made in making this timber into paper. The result went to show that the wattle timber taken alone is unsuitable for the manufacture of "mechanical" pulp, while pulp prepared by the sulphite process and also by the alkali process is of inferior quality, and has low commercial value.

I have bleached and unbleached samples of the paper made by the sulphite process, and I was informed by experts that the fibre of the wattle is too short, and that consequently the paper is deficient in strength, but that if mixed with an equal weight of pulped sugar cane or other grass fibre, the paper produced might be satisfactory.

Meantime the wattle woodpulp is considered fit for cardboard or boxes if manufactured in Natal, but that the cost of freight is prohibitive against taking the timber elsewhere for manufacture. It is evident this must only be for local use, as many other countries are exporting either pulp or paper, and as the machinery is expensive, there is a commercial risk connected with the start.

The announcement made by Prof. J. A. Wilkinson, in his Presidential Address to Section B, that synthetic tanning has been successfully carried out, will no doubt have caused some excitement in Natal. This has been the bogey which pessimists have kept before us for many years as likely to sound the death-knell of wattle culture here and elsewhere, and it has in the past influenced men and money from going into the business.

At one time it would have sounded such a death-knell; to-day, through what science has done and what we know science can do if promptly and methodically applied, it comes as the announcement that we are about to turn another corner and must be ready for the swing.

The parallel case of indigo was quoted by Prof. Wilkinson, and its results mentioned. In that case it took 20 years after discovery of the process before it became commercially applicable, and after other 20 years, though indigo culture has waned considerably,it is not dead, and has promptly revived to some extent since war shut out or shut in the German synthetic factories. The indigo was, and still is, a comparatively high-priced commodity, whereas the wattle tannin is a very low-priced one, and it seems doubtful if synthetic tanning can touch a lower price than tanning by bark.

Assuming that the war and the experience gained in regard to indigo, camphor, and other subjects allow us 20 years' grace, instead of 40 years enjoyed by indigo, the wattle growers need not be disconcerted.

I have already stated that on some farms the timber is now the product and the bark is the bye-product, and that the tendency, quite apart from the prospect of synthetic tanning, is to go further in that direction, on what is really good wattle ground.

We have also the fact that on all wattle areas and especially on the less satisfactory wattle areas, the crop can, if desired, arrive at harvestable condition in from seven to nine years from sowing, and that there is no need to renew if conditions then appear unfavourable.

Also we know that the land is not ruined, but rather improved for grazing and other purposes after the culture of wattle is discontinued.

Also we know that the export of beef now in operation opens the way not only for utilisation of increased and improved grazing land, but also gives local hides for tanning in Natal with local tannin.

Also we can see that tanneries all over the world will not close down on a day's notice, and that under any circumstances it must take many years to work out the full change even after the synthetic process becomes commercially applicable.

Also that if in the still distant future the black wattle industry does become affected to a very appreciable extent by synthetic tanning there is still likely to remain a local market in local tanneries for the bark from heavy timber (bye-produce bark) for the tanning of local hides and the reduction thereby of our leather import.

Also that the present leather product is a durable one (more or less), and that this can with certainty be maintained, while the durability of the other is still unknown, and to some extent improbable.

Also that if some plantations must of necessity drop out, it will be the poorest plantations, *viz.*, those of the lazy man, and those on Thornveld ground, which should never have been under wattle, and which are in the natural home of the bagworm and most of our other pests.

Also that the export of extract and of compressed bark will receive a present impetus from the alarming prospect, and that in any case the reduction of freight to one-eighth of the bulk it formerly occupied, places the product in a new position on the home market.

Also that the alarming prospect will certainly call into operation extended and more scientific methods of utilisation than have existed hitherto.

Putting all these together, I can only conclude that the prospect is likely to do more good than harm, and that the biggest harm likely to arise may come from an immediate scare of the pessimists, unless the simple fact stated by Prof. Wilkinson is, when published, accompanied by some such assurances as those given above.

The chemist has rightly sounded the warning note, and we thank him for it, but looking at the subject with knowledge of many outside factors with which the chemist is not concerned in this connection, it seems to me that if the wattle industry takes advantage and makes practical application of scientific research, it has little to fear beyond the gradual changes which may be dictated by circumstances as they arise, and which are likely to ruin no one who was fit to stand, apart from these.

Manganese as a Fertiliser.—The *International Review of the Science and Practice of Agriculture* (7 [9] 1256-1257) summarises a series of experiments by R. A. de Gregorio, which show that crops are increased by fertilisers containing manganese, provided an optimum of .006 per cent. of soluble manganese in the soil be not exceeded.

NOTE ON THE FEEDING HABITS OF A LADYBIRD LARVA.

By C. W. H. Smit.

Every child is familiar with the ladybird, and in these days of economic entomology practically every gardener recognises in this pretty little insect a friend—the natural enemy of Australian bug, scale, aphis, and other pests. Not least interesting is an inconspicuous little member of the family, *Scymnus casstromi* Muls., a small black ladybird about one-twelfth of an inch in length, with two red markings on each wingcase, the whole wingcase being covered with a light pubescence. I say *inconspicuous*, but this is true only as regards the adult stage; for in the larval stage the insect is conspicuous enough, being covered with a pure white woolly covering of wax which gives it a strong resemblance to mealy bug—in fact, it is very often mistaken for that pest, and, I fear, receives short shrift at the hands of the enthusiastic gardener who discovers it on his plants. It is noticeable that the Argentine ant, which at once attacks the ladybird larva feeding on the rose aphis, does not molest this particular larva, possibly on account of this resemblance to mealy bug, which the ant protects.

Our little friend feeds on the aphis infesting the potato creeper (*Solanum Wendlandii*) and the *Gardenia*. Doubtless there are other plants similarly favoured, but I have not hitherto found specimens of the larva elsewhere.

The life history of this ladybird is, so far as my observation goes, similar to that of other species. The larva appears to cast its skin three times before the final change, and numbers of woolly sloughs of various sizes are to be found on leaves frequented by the ladybird. When full grown, the larva, now about one-fifth of an inch in length, attaches itself by the posterior to some suitable surface, and pupates. About three days after attachment the woolly covering splits longitudinally, and the characteristic ladybird pupa is revealed, and seven days later the mature insect extricates itself from the pupa case. One ladybird which I watched emerge, after wandering about for a while in the tube in which it was confined, returned to its cast-off woolly sheath, crept in, and made itself comfortable, remaining there for a considerable time. I have since often observed adult ladybirds in captivity thus hidden. As they are shy insects, preferring the under to the upper surface of a leaf, and making off as soon as they notice they are being watched, I suspect the pupa case is resorted to for concealment rather than for any other reason.

It was the feeding habits of the larva which specially attracted my attention. The adult ladybird seizes the aphis and proceeds, without ceremony, and in spite of the vigorous protests of his victim, to devour it, eating down through the back of the living insect. He is a ravenous savage, caring for nothing, apparently, but to fill himself up as quickly as possible. Not so, however, the larva; he has a capacity for lengthening out the enjoyment of a meal which might have excited the envy of a Roman glutton, and lingers over each aphis as though it were the only one he was ever likely to capture.

The larva's method of taking a meal is exceedingly curious, and I was at first doubtful whether I had correctly interpreted its actions. Observation under a microscope served, however, only to confirm my first impressions. As the mode of procedure varies but little, I do not think I can do better than describe an actual encounter which I witnessed between a medium-sized larva and a large aphis.

The larva seized his victim at the lower extremity of the tibia of the middle leg. The tibia, I may remark, is the usual point of attack, but the exact spot appears to depend on the position of the leg when the larva comes into contact with it rather than on deliberate selection. At first the aphis struggled vigorously, and the larva kept shifting his front feet as though to secure a firmer footing, while with his hind legs he made a series of rapid spasmodic forward lunges, apparently intended to intimidate his victim or to warn off possible intruders. This latter movement is almost invariably executed during the first few minutes after he has seized his prey, and is quite distinct from that required for securing a better foothold with which he sometimes varies the proceedings. The jerking motion thus imparted to the woolly tufts on the anterior segments of the body gives the little creature a ludicrous resemblance to an excited porcupine.

After ten minutes the struggles of the aphis had moderated somewhat, and a tinge of green appeared in the tibia and femur of the leg held by the larva. The movements of the aphis now became less violent, as though the injected fluid had a narcotic effect. Three minutes later the green fluid moved back towards the larva. Thereafter a steady flow of liquid was maintained, alternately from and to the larva, the amount circulated increasing until the aphis was alternately drained to translucency and filled out almost to bursting, in a manner strongly suggestive of the inflation and deflation of a kid glove by a child. At each successive injection the fluid was perceptibly darker, containing a larger proportion of the larva's digestive juices; and during the later stages the distended body of the aphis appeared almost black. The larva sucked the aphis dry, and then regurgitated his meal, continuing to repeat the process until, apparently, nothing further was to be gained, when he drained the aphis for the last time, elevated the skin above his head as though to make sure of getting the very last drop, tumbled it to one side, and then shuffled off in search of another victim. During the final stages of the meal, only sufficient fluid was injected to fill the lower part of the body of the aphis, which still appeared to contain some pickings.

From the first appearance of the green in the leg of the aphis to the final act I counted fifty regurgitations, and the whole process, from start to finish (*i.e.*, from the seizing of the leg to the discarding of the empty skin), lasted an hour and three minutes. The time taken varies, of course, with the relative sizes of larva and aphis. A small aphis will be emptied by a fair-sized larva in from fifteen to twenty minutes.

Though the legs are the usual point of attack—probably because they are the extremities with which the larva generally first comes in contact—I have on several occasions seen a larva fasten on to an antenna; and, incredible as it may appear, one aphis was thus completely drained, the larva attaching itself to the base of the third segment of the antenna and never shifting its grip.

A short while ago I was fortunate enough to witness an extraordinary performance on the part of a larva I had in captivity. I happened to be examining it through a pocket magnifier, and noticed it had seized a winged aphis. It had attached itself to the leg of the insect. I was at once interested, as it has always appeared to me that the legs of the winged aphis are more brittle and somewhat harder than those of the wingless specimens; and I was curious to see whether the results of the larva's operations would confirm this view. After an ineffectual attempt to penetrate the leg, the larva, apparently dissatisfied with the position, moved round to the head of the aphis, and failing to establish a satisfactory connection here, it shuffled off to seek a more convenient point of attack. Presently its head came into contact with the left fore wing, the costal margin of which it immediately seized. Shortly after I observed a drop of dark liquid protruding beyond its head and then disappearing. In a few seconds a larger drop appeared and disappeared, and the process was repeated a considerable number of times, the amount of liquid—which was of a dark green colour—increasing each successive time until it covered upwards of half of the wing to quite a considerable depth. The larva was evidently under the impression that it had at last succeeded in gaining access to the juices of its prey; and when it had performed the proper number of regurgitations and withdrawals it went off in search of another victim.

Notwithstanding the fact that this larva went through all the usual procedure in connection with its barmecide feast, there seems little doubt, from its behaviour when devouring small and large aphides, that the insect is able, as a general rule, to judge when the juices of its victim are exhausted; for, so long as the amount withdrawn exceeds that injected, it will not let go, except, occasionally, to move to some point where the juices will flow more freely. I have seen a larva, after cleaning out an aphis, go round to two or three other legs and suck them dry, regurgitating little more than enough to fill the leg in each case.

On another occasion I saw a larva attach itself to an aphis which a smaller larva had already started on. It was curious to note the rapidity with which the aphis was alternately emptied and refilled. As I had nothing better than a pocket magnifier with which to watch the operation, I was unable to determine which larva got the lion's share of the repast. Probably one went away emptier than it came!

The question which naturally occurs to one is, why does the larva devour its prey in this extraordinary fashion? Why does it not simply suck it dry, as other members of the tribe do? It appears probable that the habit originated in the injection into the aphis of some of the larva's digestive juices in order to still its struggles, and thus render it an easier prey. From this to the full withdrawal and regurgitation of the juices of the aphis would be merely a question of gradual evolution. The usefulness of the process seems obvious, as very little but the bare, almost transparent skin is left when the larva has finished its meal. This is in marked contrast with the appearance of an aphis off which an adult ladybird has dined. Probably, as Mr. Mally suggests, the digestive process goes on during the operation of feeding, the juices of the larva's stomach dissolving the contents of the body of the aphis. I have noticed, particularly towards the end of a meal, when the lower and more solid part of the body of the aphis is being absorbed, that while the injected fluid is usually clear and thin, that withdrawn is charged with what appear to be fatty globules, some of which are of considerably larger diameter than the leg of the aphis, and become elongated when passing through it to the mouth of the larva. These globules may, indeed, be watched in process of detachment from the interior of the aphis.

I have not as yet been able to ascertain the nature of the larva's feeding apparatus, but hope to be able at some future date to furnish a note on it.

I may mention that I have observed another ladybird, *Hyperaspie hottentota* Muls., with similar feeding habits. The larva in this case is almost oval in shape and of a dark colour, with a large yellow spot on each side. It has no woolly covering. Specimens of the adult insect of both species have been supplied to Mr. C. W. Mally, Cape Province Entomologist, Agricultural Department, Capetown. He submitted them to Dr. L. Peringuey, Director of the South African Museum, who indentified them as the species indicated above.

TREE-PLANTING COMPETITIONS IN NATAL.

By John Spurgeon Henkel.

Before dealing with Tree-planting Competitions in Natal, it is desirable to review what was done in a similar direction in Cape Colony, as it has an indirect bearing on the results obtained in Natal.

In 1894 the Honourable Colonel Schermbrucker, an enthusiastic tree-planter, introduced a motion in the Cape House of Parliament relating to prizes for tree-planting. In terms of a resolution of the Honourable the House of Assembly adopted, on 17th July, 1894, reports were obtained from Forest Officers and others on the subject of the encouragement of an extensive system of tree-planting (*vide* Blue Book No. 62, 1895).

As a result of the reports a tree-planting competition was approved by Resolution of the Honourable the House of Assembly on 24th July, 1895. The terms of the competition were published in Government Notices 758 of 1895 and 207 of 1896. For purposes of this competition Cape Colony was divided into five areas, and three prizes of £500, £300 and £200 were offered for each of the five areas.

The main conditions were the following: Awards were to be made in 1901 by the Secretary for Agriculture. Intending competitors were required to submit their names before the 1st May, 1896. Each plantation was required to contain a minimum of 100,000 trees planted or sown in one block. No part of the block to be less than 100 yards wide. The trees to have an espacement of not less than 3 feet x 3 feet, or more than 6 feet x 7 feet. Areas having fewer trees than 1,000 per acre to be disqualified. The plantations were required to be properly protected. Choice of species was left to the competitors, but it was stipulated that each species was to be planted in separate groups. At the time of judging the plantations were not to be less than three years or more than six years old from seed, and reached the stage of clean stems and close canopy.

For this competition entries were received as follows:—

4	for No.	1	Area,	comprising	Western Districts.
11	,, ,,	2	,,	,,	Midland Districts.
8	,, ,,	3	,,	,,	South-Eastern Districts.
20	,, ,,	4	,,	,,	North Eastern and Transkei.
—	,, ,,	5	,,	,,	Bechuanaland.
Total 43					

Of this number only 2 for No. 2 Area, 3 for No. 3 Area, and 4 for No. 4 Area actually were judged, the remainder either being withdrawn or were never started. For each of the areas separate judges were appointed. It was found that some of the conditions could not be complied with. The three prizes in terms of the judge's awards were given in Area No. 4. In Areas 2 and 3 the plantations were disqualified, but bonuses were awarded.

The actual results obtained may be summarised as follows:

Area No. 2.	2 Plots.	110,000 trees on	130 acres.	Bonus	£115
Area No. 3.	3 Plots.	180,000 trees on	90 acres.	Bonus	200
Area No. 4.	4 Plots.	450,593 trees on	149 acres.	Bonus	1,000
	9	740,593	369		£1,355

Eight out of the nine competitors received either a prize or a bonus. It will be observed that, for an expenditure of £1,355, an area of 369 acres was planted with 740,593 trees, costing in bonus and prize money £3 13s. 5d. per acre. No account is taken of any trees that may have been planted by competitors who entered but withdrew.

The results of the competition were disappointing. Full details were published in the Cape *Agricultural Journal* of September 12th, 1901. No further competitions were held in Cape Colony.

In Natal, shortly after the inception of the Durban and Coast Agricultural Society, that Society offered a medal for the best essay on Tree-planting for the Coast Districts. The medal was won by Mr. M. S. Evans, C.M.G., F.Z.S. The records of the Society have, unfortunately, been lost, and consequently the details of the offer or a copy of the essays submitted are unobtainable. The prize essay is said to have been published.

Mr. M. S. Evans, having studied the subject of afforestation, was impressed with its importance, and in order to stimulate interest offered prizes for the best plantation of forest trees, through the Pietermaritzburg and Richmond Agricultural Societies. No entries were received by either Society. The offer, however, appears to have stimulated tree-planting, for at least one plantation of considerable extent was established by Mr. Niemack at Ingeli. Notwithstanding any treatment other than protecting it from fire for a few years, the plantation has developed, and now is of considerable value, and the fortunate present owners, when the new railway is open to Harding, should realise a large profit on their investment. The plantation, consisting of *eucalyptus* principally, is now ready for utilisation. The encouraging feature is the abundant natural regeneration, so that with a minimum amount of care a new crop will establish itself and thrive better than the original one. No award appears to have been made to Mr. Niemack, the reason probably being that the plantation did not comply with the stipulated conditions.

In the discussion which followed the reading of this paper, Rev. James Scott stated that Mr. Niemack's plantation was established before the inauguration of the tree-planting competition. Mr. T. R. Sim, however, remarked that he distinctly understood from the late Mr. Niemack that the plantation was put down in response to Mr. Evans' offer, and that he (Mr. Niemack) was annoyed that no prize was awarded.

In 1902 the Forest Department in Natal was reorganised under the superintendence of Mr. T. R. Sim, a Cape Forest Officer, who held the appointment of Conservator of Forests.

Mr. Sim started the Cedara Nursery and Plantation, and endeavoured in every possible way to stimulate afforestation both by Government and by private individuals, and from that date numerous persons throughout Natal began to plant timber trees of various kinds on their farms. Though it is not to be supposed that tree-planting had not been carried on successfully in previous years, for there are many honoured names of individuals who realised the importance of the industry, such as Messrs. Handley, Wilkinson, Menne, Sclanders, Sutton, Honourable T. Angus, Alfred Henderson, Robert Topham, and Honourable Sir Liege Hulett, all of whom planted trees more or less extensively. From many of the plantations established in the early days of the Colony considerable returns have been and are being obtained.

It may not be out of place to mention that in 1889 Mr. H. G. Fourcade, of the Cape Forest Service, visited Natal, and prepared an exhaustive report on the indigenous forests and their timbers, and submitted recommendations for creating artificial forests of exotic trees. As a result of the report, in 1891 Mr. Schöpflin, a Baden Forest Officer, was appointed Conservator on a three years' engagement. Mr. Schöpflin only remained some two years in Natal, but during that time endeavoured to arouse enthusiasm in afforestation. It will thus be seen that the general public were not without advice from experts.

In October, 1903, Mr. M. S. Evans, C.M.G., again took up the question, and offered, through the Farmers' Conference at Maritzburg, the sum of £500 to be divided into prizes and awarded for the best plantations of forest trees planted between 1st 1st January, 1904, and 31st December, 1905. Mr. Evans' letter, dated 13th March, 1903, stipulated the conditions to be observed. This letter was printed, and under a covering letter, dated 13th May, 1903, by the President of the Conference, Mr. George D. Alexander, was circulated to all the societies and associations affiliated to the Natal Farmers' Conference.

Mr. M. S. Evans' offer was briefly as follows: A money prize of £50 to each of the electoral divisions of the Colony, with the exception of Alfred, Alexandra, Eshowe and Melmoth for plantations of trees planted in the years 1904 and 1905. For the four divisions mentioned above the prize would be £35, on account of the sparseness of population. In each case the larger prize to be divided into first, second and third, £30, £15 and £5 respectively, and the smaller one £15, £7 10s. and £2 10s. Formal notice was required from intending competitors not later than 31st December, 1905. The minimum area was fixed at 10 acres, and all trees to be planted in their permanent sites between 1st January, 1904, and 31st December, 1905. It was further stipulated that areas above 10 acres in extent and up to 50 acres would count for points. No one plantation to be less than 5 acres. The plantations to be judged in 1910, when the youngest trees would be at least five years old. The choice of species was left to the individual competitors, with the exception of the following kinds—Blue Gum, Black and Silver Wattle and Insignis Pine—which were debarred.

The response was again disappointing; there was only one entrant, namely, Mr. Andred Selanders, of Kelvin, in the Bergville Division, though it is reported several others started plantations. Mr. Selanders planted over 100 acres. In April, 1910, Mr. M. S. Evans personally judged the plantation and awarded a first prize of £30. The writer last year visited the plantation, and, generally speaking, it is a splendid success, containing many varieties of useful timber trees.

The net result of Mr. M. S. Evans' second effort was a plantation 100 acres in extent, costing in prize money 6s. per acre.

It would appear that Mr. M. S. Evans did not renew his offer.

In 1907 Mr. T. R. Sim was retrenched and his office abolished.

When Mr. Sim was retrenched Mr. Orlando Hosking, with a view to keeping alive the interest in tree-planting, moved at the Annual Farmers' Conference at Maritzburg, held in April, 1909, a resolution submitted by the Royal Agricultural Society, to the effect that steps be taken to draw the attention of the Governments of South Africa to the advisability of tree-planting (wattles not included), and that the Farmers' Union start the movement by offering awards for Natal as follows: Say, £100, £50 and £25 for the best 15 acres laid down in good timber trees, 20 entries to be received or no awards made. The Government to be asked to appoint a judge at their own cost. Judging to take place in May, 1915. Entrance fee, 10s. 6d.

Various views were expressed by the members of the Conference, it being pointed out that the amount required, *i.e.*, £175, amounted practically to the whole of the Society's income. The resolution was lost.

Mr. Hosking, not discouraged, approached the individual members of the Conference, and succeeded in obtaining a guarantee for the required sum, and at a later stage of the Conference stated that the matter in regard to the tree-planting competition had been arranged so that no financial burden fell on the Agricultural Union, and proposed that the Agricultural Union and the Royal Agricultural Society co-operate in the management of the scheme, and he moved that a Committee be appointed. This was agreed to, and the following gentlemen were appointed, namely, E. W. Evans (Chairman), Colonel Leuchars, O. Hosking, J. Marwick, T. W. Dukes, A. W. Smallie, W. J. T. Newmarch, C. H. Mitchell, Colonel Crompton, T. R. Sim, and Rev. J. Scott.

The committtee, in whose hands the matter was left, drafted rules and regulations, and published notices of the tree-planting competition. In the meantime, Mr. Orlando Hosking approached the Government, with the result that at the Farmers' Conference, held in April, 1910, the President announced that Government had provided £1,000 for a tree-planting competition, on the instigation of Mr. Orlando Hosking.

The Conference directed that a lettter of thanks be sent to Government for the gift of £1,000, and also expressed appreciation of the work done by Mr. Hosking.

The £1,000 was passed as an excess to Vote 34 (Agriculture) by Governor-in-Council on 22nd April, 1910. The money was granted for the purpose of the Natal Agricultural Tree-planting Competitions. The trust deed was signed by the Treasurer of Natal, and Edward William Evans and Orlando Hosking, Trustees. The deed provided that the principal, together with the interest thereof, may from time to time be applied in prizes for the encouragement of tree-planting in Natal.

It was further provided that the trustees shall pay out from trust all prizes awarded for the encouragement of the growing of trees of commercial value within the Province of Natal, according to such scheme as may from time to time be adopted by the committee appointed by the Agricultural Union in connection with the tree-planting competition, such scheme or schemes to be approved of by the Governor of Natal or Administrator of the Province of Natal.

The first competition under the auspices of the Royal Agricultural Society of Natal and the Natal Agricultural Union was started in the summer of 1909-10. The main conditions of the competition being the following:—

Objects of Competition.

(1) To encourage the growing of trees of commercial value, to the end that in time the Colony may become a timber-growing country, thereby enhancing its assets and promoting the development of the Colony.

(2) By growing plots of various trees in different parts of the Colony to afford an object-lesson to the community upon the suitability of different trees for various districts, soils, altitudes, and conditions.

Rules and Regulations.

(1) This competition is open to any farmer in Natal and Zululand.

(2) The Colony, for the purpose of judging, is divided into three sections, according to altitude, *viz.*: Section 1, from sea-

level to 2,000 feet; section 2, from 2,000 feet to 4,000 feet; section 3, from 4,000 feet upwards.

(3) The plots of trees planted shall be each 5 acres in extent. At least 600 trees per acre to be growing when judged.

(4) Should a plot be planted with more than one variety of trees, one acre shall be the minimum of any variety.

(5) A competitor may enter any number of distinct plots of 5 acres.

(6) The plots will be judged according to the prospect of commercial value of the timber.

(7) The dates of planting shall be from 1st September, 1909, to 31st March, 1910. Blanks may be filled in at any time.

(8) Entries must be forwarded to the Secretary, Natal Agricultural Union, on or before 1st April, 1910, to be accompanied by a certificate from a neighbouring land-owner that 5 acres have been planted in each plot with Natal grown plants.

(9) There shall be no entrance-fee. Entry forms can be obtained from the Secretary, Natal Agricultural Union.

(10) Date of Judging, April and May, 1915.

(11) The prizes are as follows:—Section 1, first prize, £40; second prize, £20; section 2, first prize, £40; second prize, £20; section 3, first prize, £40; second prize, £20.

If there are less than ten entries for any section, the judge has the power to reduce the value of prizes in that section.

(12) Wattle trees are not included in this competition. *Acacia melanoxylon* (Blackwood) is not included as a wattle tree.

Each year, since the inauguration of the competition, the Secretary of the Natal Agricultural Union has called attention to the competition in the public press, and by distributing notices to persons who are likely to become competitors. The various members of the committee have also assisted in giving publicity to the competition.

The entries for the competition to the 1st April, 1916, are as follows:—

No. of Competition.	Year.	Section 1, Plots.	Section 1, Persons.	Section 2. Plots.	Section 2. Persons.	Section 3. Plots.	Section 3. Persons.	Totals. Plots.	Totals. Persons.
1.	1910-15	3	3	8	7	20	8	31	18
2.	1911-16	1	1	46	16	19	8	66	25
3.	1912-17	—	—	12	8	16	7	28	15
4.	1913-18	—	—	10	9	5	3	15	12
5.	1914-19	—	—	22	13	16	6	38	19
6.	1915-20	4	2	11	9	20	6	35	17
7.	1916-21	—	—	21	7	39	5	60	12
Totals to date ..		8	6	130	69	135	43	273	118

It will thus be seen that the position to-day is that at least 1,365 acres have been planted as a direct result of the tree-planting competition.

The first competition matured in 1915.

The Tree-planting Committee decided to appoint a single judge. The judging results of the first competition were briefly as follows: 31 plots were entered, four competitors withdrew, and the remaining ones did not wish all the plots to be judged leaving in all 22 plots competing for prizes, namely:

1 in Section 1.	Total area	5 acres.
9 in Section 2.	Total area	46.5 acres.
12 in Section 3.	Total area	64.58 acres.
22		116.08 acres.

Of these, five were disqualified. First and second prizes for sections 2 and 3 were awarded. For section 1 the only plantation entered was disqualified.

The net gain to the country in afforestation, which may be attributed to the first tree-planting competition, is 116 acres, costing in prize money £1 0s. 8d. per acre.

The choice of species as provided in the rules was left, with the reservation in regard to wattles, to individual competitors. The genera planted were:

Eucalypts	54.4	acres.
Pines	32.2	,,
Juniper	2.64	,,
Cypress	17.14	,,
Casuarina	2.	,,
Grevillea	5.5	,,
Robinia	5.5	,,
Blackwood	1.2	,,
	116.08	acres.

The second competition has not been judged yet.

The results obtained as shown from the report of the first competition, and the numerous entries for the following years, indicate that the tree-planting competition has been a success. As will be observed from the statement of the entries, the farmers falling within the coastal section have not availed themselves of the opportunities offered. In the other sections the entrants in the majority of cases have taken their work seriously. One of the results of the competition has been to induce a live interest in the commercial side of tree-planting, and the importance generally to the country of providing its own timber requirements.

It would seem clear that the amount of £1,000 granted by the old Natal Government is earning magnificent interest in results to practical forestry.

As provided by the trust deed, both capital and interest are being used as prize-money, and so far as can be seen at present, funds remain for one more competition, and unless a further amount becomes available, it may be necessary to discontinue the excellent work which is being accomplished.

The success attained in Natal seems to indicate that the system of tree-planting competitions under the auspices of the Royal Agricultural Society and Natal Agricultural Union is well worthy of extension to other Provinces of the Union of South Africa.

JOHN MEDLEY WOOD, D.Sc., A.L.S.—The 1915 volume of the *Kew Bulletin* recently received, contains a brief, but interesting memoir of the late Dr. J. Medley Wood, over the signature of N. E. Brown. Medley Wood was born in Nottinghamshire during the reign of George IV, and therefore lived under the rule of five British sovereigns. F. M. Bailey, the veteran Colonial Botanist of Queensland, whose obituary notice appears in the same volume, predeceased Dr. Wood by some two months, and was about nine months the older of the two. The present writer had the privilege of making personal acquaintance with both these distinguished botanists within a few months of each other—with Medley Wood when the Cape University honoured itself in 1913 in conferring on him the honorary degree of D.Sc.; and with Manson Bailey in his herbarium in Brisbane. Closely resembling each other in the venerable dignity of their personal appearance, they were alike unremittingly enthusiastic in their devotion to botanical science, and they were equally valued and long-standing contributors to the Royal Botanic Gardens at Kew. Medley Wood landed at Durban in 1852, but although his inclinations from early boyhood pointed in the direction of botany, and his first years in South Africa were largely occupied in the cultivation of crops suited to the climate, it was not until 1875 that he first entered into that correspondence with Kew which was terminated only by his death. In 1882 he was appointed Curator of the Botanic Gardens at Durban, and two years later he was instrumental in establishing in the Colony the Uba cane now so well known to the Natal sugar planters. Subsequently he became Director of the Gardens, and afterwards of the Natal Herbarium. His botanical zeal found a lasting monument in the six volumes of "Natal Plants," and at the time of his death he was engaged on an almost completed seventh volume. The eulogium pronounced on Dr. Wood on the occasion of the conferring of the doctorate by the University of the Cape of Good Hope, thus summarised his work for botanical science and for South Africa: "For sixty years Mr. Wood has been engaged in botanical investigation of an essentially pioneer character, and during this long period he has consistently been one of the most diligent and disinterested of the scientific workers in the country. Much of what he has accomplished will only be adequately appreciated when a more intensive study of the South African flora than has yet been attempted can be undertaken."

THE METRIC SYSTEM OF WEIGHTS AND MEASURES AND THE DECIMALISATION OF THE COINAGE.

By Robert Thorburn Ayton Innes, F.R.A.S., F.R.S.E.

The metric system is the most important decimal system, and it is more than a mere decimal system; it is a system in which measures of weight, length, area, and capacity are all simply interrelated.

In the *Journal of the Royal Society of Arts*, No. 3,293, of 31st December, 1915, Colonel Sir Charles M. Watson makes a spirited defence of the English measures of length which in his last paragraph he claims to be prehistoric. Now, there is a good deal to be said for our inch, foot, yard, and mile, cumbersomely as they are related to each other. But too much should not be said. The English acre has no obvious or indeed simple relation to any one of them. The side of an acre square is $22\sqrt{10}$ yards, which is a bad coordination. But if we gave way on measures of length, what about those of capacity and weight? That is just it! We have to learn three distinct systems, not one of which is in the decimal notation or any other notation, but a mixture. We may learn these systems, but they are so artificial that unless we use them regularly, we must perforce forget them.

In practice I find a millimetre a very convenience starting point, and for mental estimation I remember 25 millimetres (25 mm.) are equal to the length of the middle bone of my little finger, or about an inch, and that a metre is roughly equal to a yard, and is 1,000 mm. A millimetre is the smallest distance which can be conveniently or easily seen by the eye. One can visualise a yard or a metre, but I do not think that without actually measuring anyone could distinguish between a yard and a metre length if shown individually.

A cubic metre of water weights a ton (a metric ton), which is subdivided into 1,000 kilograms. A metric ton is equal to 2,200 lbs., an English ton to 2,240 lbs, and a short ton(such as our ton of coal in South Africa), 2,000 lbs. But the especial point to notice is that a cubic metre of water weighs a ton, because this being so, a cubic metre of anything else weighs its specific gravity in tons. What simplicity! The specific gravity of iron is 7.8, therefore a cubic metre of iron weighs 7.8 tons, or 7 tons 800 kilograms. The specific gravity of oak or beech is about 0.75, therefore a cubic metre weighs three-quarters of a ton, or 750 kilograms.

For liquids measures of capacity are generally used, and capacities differ, although some liquids should be and are now sold by weight, such as sulphuric acid. In English measure we have—

A pint of water weighs a pound and a quarter.

and

A cubic foot of water weighs 62.4 lbs.

Here are the metric relations—

A 100-millimetre cube of water contains one litre and weighs one kilogram.

The system is so simple that once one has handled and studied a cubic litre, these simple relations can never be forgotten.

Colonel Watson believes that if England adopted the metric measures of length, it would be to Germany's benefit, but I cannot follow his reasoning. Formerly Germany did employ measures of length corresponding to our inches and feet, and it deliberately abandoned them for those of the metric system. None of us will be so foolish as to assert that in the race for commercial supremacy Germany would deliberately handicap Germans by adopting a second-rate system of weights and measures.

I shall, however, offer an entirely different argument in favour of the adoption of the metric system. In these days of truly international trade and exchange, the advantage of one uniform system is self evident. The question is which system is it to be? At the beginning of last century there were the metric system and the English system—one legal in France, the other in British possessions and the United States. Which has made progress? The metric system alone! It has been adopted by one country after another until the only outstanding countries of any importance are Russia, Japan, and the United States, but these countries have systems based upon metric standard and mainly decimal in character

In the United Kingdom the metric system is permissive.

Holland, Portugal, and South America use solely the metric system.

Hence it has made great strides, and no nation having once adopted it has ever abandoned it. It must, therefore, be accepted that it is a good system.

On the contrary, the English system has continuously been losing ground—some British possessions, such as Malta, Mauritius, and the Seychelles have made the metric system compulsory—not, perhaps, very important possessions in themselves, but they indicate the direction of change.

As to the English-speaking peoples themselves: In schools pupils are taught both, and if they progress to science classes, they are taught to use almost exclusively the metric system. Thus they are in an unfortunate position. They have to remember best as they can two systems. At least it is a handicap, which Germans and others avoid. But in pharmacy, both in the United Kingdom and in the United States, the metric system is now alone used, and in the diamond trade the metric carat has been universally adopted.

Expediency is therefore an additional argument in favour of the adoption of the metric system to the exclusion of all others.

When we come to the decimalisation of the coinage, the demand is slightly different. It is only demanded that the pound sterling should be decimalised, by dividing it into 1,000 parts. There is no suggestion that we should express the pound in terms of the dollar or 20-franc or mark-piece. The present and the suggested coinage would compare as follows:—

The 1,000 parts would be called mils, and as one pound is equal to 960 farthings, one mil would be equal to one farthing within 4 per cent.

The decimal coinage would be as follows:—

Sovereign—same value as at present.

Half-Sovereign—same value as at present, equal to 500 mils.

Silver:

Florin—.	.. ..	100 ,,
Half-Florin—same value as the shilling	.. ..	50 ,,
Quarter-Florin—same value as the sixpenny piece	.. ..	25 ,,

Nickel:

Cent—nearly equal to the threepenny piece	.. ..	10 ,,

N.B.—The threepenny piece is = 12.5 mils.

Copper:

Demi-Cent	,, ,,	5 ,,
or		
Penny	.. ..	4 ,,
Halfpenny	.. ..	2 ,,
Farthing or *Mil*	.. ..	1 ,,

The new penny of 4 mils would be 4 per cent. less in value than the present penny. If the new penny was the unit for penny postage, then the cent would be the cost of the present 2½d. foreign postage.

It will be seen that practically all our present coin-values would be maintained.

In accounts the values would read as follows:—

Sovereign	1.000
Florin	0.100
Half-florin (or shilling)	0.050
Quarter-florin (or sixpence)	0.025
Cent (or "tickey")	0.010
Penny	0.004
Mil	0.001

and articles be priced in mils, thus "cheap at 1s. 11¾d." would be "cheap at 99," and "bargain at 5¾d." would be "bargain at 24," as mils would be habitually omitted, as is the custom in the United States with cent values; articles over £1, such as, say, £1 2s. 6d., would be written 1.125. Without some practice the price of three articles at 1s. 11¾d. and of two at 5¾d. can hardly be done mentally, but in the mil coinage it is quite simple, namely, 350 less 5 = 345 mils = 3 florins 1 quarter and 2 tickeys. In the present coinage it would be 6s. 10¾d. = 3 florins, 1 sixpence, one tickey, one penny, and halfpenny, and a packet of pins.

Calculations in interest and discount become simple. In all considerable interest and especially in compound interest sums, it is necessary to convert our present coinage into decimals, work the sum, and reconvert into £ s. d. This circumlocution will be avoided when a decimal system is adopted.

The general adoption of decimal systems will greatly simplify the teaching of children and liberate time for other and more profitable study, business operations will be facilitated, and account books more simply ruled.

I believe the difficulties of the transition stage tend to be exaggerated. Those who have travelled abroad will have personal experience of how short a time it takes to get accustomed to strange money.

June, 1916.

Use of Meteorites by Primitive Man.—G. F. Zimmer recently contributed to the *Transactions of the Iron and Steel Institute* a paper containing a table, which included practically all known falls of meteoritic iron, showing in each case the original weight of the meteorite, and whether it was or was not sufficiently malleable to be wrought into objects of utility. The table was compiled with the object of removing the opinion prevalent amongst archæologists that such iron could not have been used by primitive man because of its supposed non-malleability. A shorter article by the same writer appears in *Nature* of January 4, 1917 (**98**, 350-352), in which illustrations are given to show the fragmentary form of some meteorites and the comparative ease with which small fragments could be detached from such meteoritic masses. Amongst the meteorites illustrated is one of 92 lb. weight from Kokstad, and another of 141 lb. from the Hex River Mountains. The weight of meteoritic iron known at the present day is about 250 tons, of which total the very considerable amount of over 99 per cent. is malleable. As all this meteoritic iron has been accumulated practically within the last century, the writer argues that the alleged scarcity of meteoritic iron could not have been an obstacle to its use by primitive man.

THE MODIFICATION OF SOUTH AFRICAN RAINFALL.

By John M. Sim.

With the semi-arid conditions pertaining to-day in South Africa, one of the most serious questions we have to face is the question of the continuance of the water supply. Already we have to accept the fact that a large portion of South Africa has an entirely inadequate water supply, that the water supply of a further portion is threatened by the spread of desiccating conditions, and that even on those regions on which the rainfall as yet can be said to be sufficient desiccation is proceeding, the ultimate effect of which must be in time the conversion of them into arid or semi-arid localities. For both historically and scientifically it is an established fact that for the last two hundred years or more there has been a steady and persistent decrease in the rainfall, and an equally steady change in the character of it. The result we see to-day in the conversion of many parts of South Africa into what may almost be designated as desert. With these desert conditions extending, the whole productiveness of the country is threatened.

I would commence by briefly enumerating some of the more important proofs of the continued desiccation of South Africa. These proofs I would divide into two classes: firstly, those which may rightly be called historical proofs, and those which are forced on us by natural facts. Both are convincing, but since written proofs are mostly to be obtained from proclamations and writings having primary reference to some other subject, the natural proofs must be taken in conjunction with them to entirely establish their point.

Historically, we have no proof at all of the hydrological conditions existing in South Africa prior to the advent of the Netherlands East India Company in 1652. Even after the coming of the Dutch our proof lies in the proclamations they issued mainly in the relation to timber-felling and grass-burning, and not in any direct reference to the rainfall. But such facts as the following allow us to deduce hydrological conditions very different from those of the present time:

About 100 *placaats* issued between the years 1652 and 1806 relate to the government of the forests of the Western Province of Cape Colony. From these it is evident that extensive forests existed not merely in the vicinity of Cape Town, but also as far up the coast as Saldanha Bay. References to the cutting of yellowwood at Stellenbosch and Swellendam denote the presence of forests of some extent at these places. The Cedarberg was crowned by forests of Clanwilliam cedar. Now our indigenous forests are moisture-loving forests, and the presence of these forests in practically a continuous belt from Cape Town to

George is absolute proof that the rainfall must have been greater and more soaking than at the present time.

Besides referring to the forests, several of these *placaats* between the years 1702 and 1743 prohibit the ruthless cutting of reeds and rushes on the Cape Downs. These would indicate the presence of considerable vleis in those days, and the existence of far wetter conditions than are now to be found at, or in the vicinity of, Cape Town. This belief is further strengthened by certain *placaats* prohibiting the killing of the hippopotamus (1677, 1680, etc.), and of "wild asses" (1742), and governing the trading in ivory. The physical conditions required by these animals are scarcely the conditions to be found to-day, and since the elephant was then to be found right along the coastal belt of South Africa, there is strong presumptive evidence that the area now almost karroo between Swellendam and Mossel Bay was then, at any rate in large part, forest country.

As early as 1687 the detrimental effect of grass-burning was apparently realised, for in that year a *placaat* was issued strictly prohibiting it, and making it punishable with scourging for the first offence, and death for the second.

We next find evidence of vastly different hydrological conditions from those of to-day in quite another direction, namely, in the names given by the early Dutch pioneers to places to which the names would be most inappropriate at present. We have, for instance, names such as *Rhenosterhoek* and *Zeekoe Rivier*, in the middle of the Cape Karroo. Can anyone to-day imagine the country between De Aar and Naauwpoort as a home for the hippopotamus? I think not. Still, the names of such places and rivers as those mentioned prove that at one time these huge water-loving animals abounded there.

Our actual meteorological records are for far too short a period to be of much practical value in determining whether or not there has been any permanent decrease in the rainfall of South Africa. But in the records of his travels in South Africa between the years 1804 and 1809 Lichtenstein, who journeyed through practically all of the then settled South Africa, makes casual mention of natural facts, from which we can judge something of the hydrological conditions of his day. For instance, referring to Matjesfontein, he says:

> What, above all things, makes it remarkable is the excellent quality of the grass in the neighbourhood. Another advantage enjoyed is that it is free from pernicious droughts.

This reference is the more striking because, if I am not mistaken, Matjesfontein was within the area which, during the past season, has suffered so severely from drought.

Again, speaking of Swellendam, Lichtenstein states that "trees of great size are to be found in the gulleys and water-courses." There is at present one demarcated forest (Grootvaders Bosch) at Swellendam, but no one who has travelled over the line from Swellendam to Mossel Bay can imagine trees of a size to call for comment existing in the dry and bare gulleys one sees.

Again, in continuing his journey northwards from Graaff-Reinet, Lichtenstein mentions the "Snow Mountains," and the perennial nature of the streams, which he ascribes to the presence of low marshy hollows filled with aromatic plants.

Dr. J. C. Brown, writing in 1884, states:

> Dr. Moffat tells of the arid region of his missionary labours, that in his settlement at Latakoo, the natives were wont to tell of the floods of ancient times, the incessant showers which clothed the very rocks with verdure, and the giant trees and forests which once studded the brows of the Hamhana Hills and neighbouring plains. They boasted of the Kuruman and other rivers, with their impassable torrents, in which hippopotamus played, while lowing herds walked to their necks in grass, filling their *makukus* with milk, making every heart to sing for joy. Now all that is a thing of the past. I have visited a farm where it may be said they had had no rain for three years.

The above description which the natives gave Dr. Moffat of the country near Kimberley offers a startling contrast with the country as it appears to-day.

Much more of this sort of evidence might be quoted, but I think I have given enough to serve its purpose. If, then, we briefly sum up this evidence, we find:

That the present high forest belt which practically ends at George was a hundred years ago continuous to Cape Town, and certainly a certain distance up the West Coast.

That the great inland basin, the present Karroo, was, more or less, a true grassveld with perennial rivers, in which hippopotomi, etc., lived.

From these facts we conclude:

That the rainfall throughout South Africa has decreased in the last hundred years.

That the character of the rainfall has entirely changed from soft soaking rains to torrential thunderstorms.

Now, before going any further, I would briefly mention a point which was raised in the Press some two years ago, and I think, from the number of letters which were written on it, aroused a good deal of interest. This is the question of whether or not there has been much actual decrease in the quantity of rain precipitated. One correspondent, writing to the *Agricultural Journal* in August, 1914, gaves the figures of the average rainfalls for the past 60 years as recorded at the Royal Observatory, Cape Town, and showed that the rainfall for the ten years 1891-1900 was practically the same as that for the ten years 1851-1860. There is a saying that figures can be made to prove anything, and certainly I think the figures quoted by the correspondent in question are extremely misleading. Firstly, because Cape Town, with its unique geographical position, has suffered probably less in the actual decrease of rainfall than any inland portion of South Africa; and secondly, and this is of the utmost importance, because the figures given give only the actual quantities of rain precipitated, and give no indication whatsoever as to the manner of its precipitation. And the manner of its precipitation is of perhaps greater moment to the, future welfare of South Africa than even the actual decrease in quantity of precipitated moisture. This question of the manner of precipitation I will refer to later.

To refer again to the first conclusion reached, namely, that the rainfall throughout South Africa has decreased, it may be fitting to explain a little further how one arrives at this. To do so I would again refer to the evidence which proves that at one time a more or less continuous belt of forest existed from George to Cape Town. Our indigenous high forests require a rainfall of between 30 and 40 inches per annum. Many places between George and Worcester to-day do not enjoy a rainfall of more than two-thirds of this. But at one time they must have done so, not merely because we can prove that forests existed there, but also because the forests in the first instance spread there. Our indigenous forests are an offshoot of the great equatorial forest belt, and were not in the first instance indigenous to the present South Africa. They slowly advanced down the East Coast along the Cape coastal belt, displacing an older flora—a flora to which the heaths, sugar-bushes and cedars still to be found in the Western Province belonged. And as this advance of the indigenous forests was continued until they reached the Cape Peninsula—and we still find patches of them even in the gulleys of Table Mountain—the conditions all along the coastal belt must have been such as allowed them to spread —not only a rainfall of at least 30 inches, but also a sufficiently damp and cool condition of the soil to allow the seed to germinate. But now the forests are dying out—the individual trees are perishing, the forest streams are becoming more and more liable to flood and less and less sure in the perennial character of their flow. No surer indication could be obtained of the decrease of our rainfall.

Throughout South Africa we can obtain from the older inhabitants—English, Dutch, or native—endless statements of how the rainfall has decreased. But without proof one can value this no more than one would value hearsay evidence in law—the more so as we almost invariably find, when we enquire into these statements that they have their origin not so much in the decrease in rainfall as in the change in the character of the rainfall, and the consequences of this change. This brings me to my next point, and, as I said before, it is one equally important with the actual decrease of rainfall.

The economic importance of rainfall to a country lies not in the actual amount of moisture precipitated, but in the amount of moisture which, when precipitated, the ground is able to absorb and again yield up to the plant life growing on the surface. For, as all animal life on the land is dependent in the first instance on plant-life—directly or indirectly—for food, so this plant-life is again dependent on the producing power of the earth, and this in large part is the outcome of the presence of absence of moisture. What, then, is it which governs the absorption of moisture, apart from the actual texture of the ground, which is unchangeable for any particular place? The governing factors are twofold: firstly, there is the manner of precipitation of the moisture; and secondly, the condition of the ground surface.

Manner of Precipitation.—No detailed explanation is necessary to make it clear that infinitely more soakage takes place and more good is done to the vegetation of the country by the precipitation of, say, one inch of rainfall in the form of soft showers and mists than by the precipitation of the same amount in one torrential downpour.

Condition of Ground Surface.—The more obstruction there is to the flow off of precipitated moisture the more soakage takes place.

Now the one point of primary importance in connection with these two facts which must be grasped is the interaction of them on one another. It is this interaction which has been responsible for the desiccation of South Africa, for the disastrous droughts and floods we have had such a striking example of this year, and for the decrease in the power of production of the whole country. We may say that in the interaction of the manner of precipitation on the ground surface and the ground surface on the manner of precipitation is wrapped up the whole problem of the future destiny of South Africa, so I would now propose to deal with them.

If a current of air laden with moisture—a sea-breeze, for instance—meets a land surface, the question of whether or not the moisture shall be precipitated depends on the temperature of the land surface met. If this land surface is cooler than the vapour-laden air, it causes the density of the air to increase, the air becomes saturated, and precipitation takes place. If, on the other hand, the temperature of the ground surface is higher than that of the air, it causes the aid to expand, rise and carry with it the moisture it brought. This explains the enormous influence forests exert on the rainfall of a country. Now, since the indigenous forests of South Africa slowly spread westward —and it must have taken thousands of years for this extension to have taken place in—we must presume that the relation between the ground-covering and rainfall remained in a state of equilibrium. But as soon as man interfered with the ground-covering, the rainfall began to change.

The original inhabitants of South Africa, the Hottentot tribes, were a nomadic race, their whole interest being in their herds and in hunting. Thus they were not intentional destroyers of either forest or grass, although their carelessness in lighting fires at their camps undoubtedly was the cause of much grass-burning. The Bantu races coming from the North-East, on the other hand, were agriculturists, and speedily found that old forest land yielded the richest crops, and that veld burned in winter yielded green spring grass. They began the systematic destruction of the forests and the ruination of the grass velds by the burning of the grass. The early Dutch and English settlers followed both practices. The grass throughout South Africa was, and is, ruthlessly burned, the forests were worked, cut out, and ruined. Thousands of acres of what was originally forest is now bare veld; great areas of what are called forests are to-day merely scrub with scarcely a timber tree left; and, finally, the areas which are still true forest have almost invariably been so worked that they are drained in all directions by slip-paths; they are rapidly drying, and as a result the old timber trees are dying from the top down, and there is little or no regrowth. These forests have been called retrogressive; to a certain extent they are, but it must unfortunately be owned that the retrogression is a result of the part man has played in the moulding of the destinies of these forests, and is not due, as some people would say, to any natural phenomenon. The result has been a slow, perhaps scarcely perceptible but nevertheless insistent, change in the character of the precipitated moisture.

The burning of the grass was the first of the two great causes of desiccation to take place. The effect of this burning was the gradual killing out of the more tender "sweet" grasses. This, of course, meant that instead of the grass offering a continued impediment to the run-off of moisture, a way was left between the tufts of grass for the precipitated moisture to rush downhill. This resulted in less soakage taking place, and the temperature of the ground rising. Successive fires destroyed more and more of the grass; what had been at first a mere passage for water to run to waste gradually deepened into a donga; sheep and native paths and disused roads resulted in further donga formation, and year by year the soakage became less, and the percentage of the precipitated moisture running to waste more. Bereft of the cooling effect of the moisture which had previously soaked in, and with its surface exposed, through the killing off of the grass, to the full rays of the sun, the temperature of the grass-lands rose, with the effect that vapour-laden breezes were repelled instead of attracted. With the cutting and working of the forests, the same result was achieved. Every slip-path for timber acted as a drain, carrying away moisture which should have remained in the spongy humus of the forest floor. Every tree felled let in light, which helped to decompose the humus. Our indigenous forest trees require the soil to constantly have a certain amount of moisture, but with these artificial conditions the requisite amount soon became absent, and the trees began to die or to become what is commonly called *stompkop*—that is, to have the topmost branches dead but the lower branches still living. The result was the rise in temperature of the forests. As a result, again, the influence of these forests on the vapour-laden breezes diminished, and with the repellent heat rising from the grasslands, and the forests not exercising their full share in cooling, the precipitation of moisture in the ordinary way—from cloud condensation—became more and more uncommon. But this did not necessarily lead to the diminishing of the average annual rainfall—it merely changed the manner in which it took place. For as these conditions repelled the precipitation of moisture in soft showers, they brought about those conditions which resulted in thunderstorms, and with the thunderstorms often torrential precipitation. This led to further erosion, and, since the period over which the rain was spread was lessened, to further running to waste of the water, to further flooding, and to less soakage. This has been going on, gradually, slowly but very surely, for a considerable period, and the result has been the entire changing of the condition of the water-supply of South Africa, and the conversion of a considerable portion into semi-desert or karroo. So, although the average rainfall for a period of years fifty years ago may be practically the same as the average rainfall for the same period of years now, the result of the two rainfalls may be, and is, vastly different. We have only to look at the desiccation which has taken place in all parts of South Africa to see how our utilisable water-supply has diminished. We have, thoughout the Karroo and Free State, rivers which to-day are rivers only in name—may of them in the dry season but a series of pools. Advocate Eugene N. Marais, writing in the *Agricultural Journal*, in 1914, of the portion of the Transvaal known as the Waterberg, gives some striking illustrations of the desiccation which has taken place in that district. He states: "The two rivers, *Magalakwen* (the Stronghold of the Crocodile) and *Palala* (the Impossible), bearing in their native names proof of their former greatness, are to-day mere ribbands of sand winding through desolate sand-dunes to the Limpopo." And again: "In the north of the district there is a tract of four thousand square miles in extent, in which there is no single drop of water running or stagnant above the surface of the ground." And this in a district in which the same writer states:—

> There was a time within the memory of white men when every kloof and donga was the bed of a perennial stream of crystal water, and the district generally was so marshy and "vals" as often to render a passage by ox-wagon a hazardous undertaking. In those days was its present name bestowed on the district (*i.e.*, the name "Waterberg"), a name that to-day seems to have originated in the bitter irony of some disappointed voortrekker.

Vivid though the picture is, it is by no means a unique picture. On every hand we see the same thing—one-time perennial streams converted into dry dongas, except just after a torrential downpour, when they are raging torrents. With this conversion comes the conversion of the veld and the spread of Karroo conditions. Not only has the great interior basin of South Africa been converted into a semi-desert, but the boundaries of the Karroo are constantly increasing.

Mr. E. R. Bradfield, one of the oldest hydrological observers in South Africa, records an area of some 800 acres in the Stormberg area of the Cape Province which was, not so many years ago, most valuable agricultural ground, now completely gutted by erosion and the grass veld practically converted to Karroo. The same gentleman makes mention of another feature of desiccation in the formation of sand-dunes in the neighbourhood of Molteno. These dunes now cover some 700 morgen of ground, and new dunes are forming in what less than fifty years ago was heavily grassed land. This is merely the first step of semi-desert conditions to that area.

Everything, then, tends to prove the modification of South Africa's rainfall. And as a result of this modification there rises before us a vision of the aftermath to the prosperity of the country in the future—some glimpse of what this aftermath must materialise as is afforded by the desiccation of most of the older civilised countries of the world. We look to Arabia, to the Mediterranean countries of Africa, and to Mexico, all in their day renowned for their productiveness, and what do we see? The loss in every direction of the very power of production. The need of irrigation, and of more and more irrigation, in a country once intersected in all directions by perennial rivers, once without fear of drought or without need of artificial watering, is the best answer to that question.

Since, then, through human agency, the rainfall of South Africa has been so modified as to threaten the whole future of the country, we, the people of South Africa to-day, have to ask ourselves if we can reverse the process, and cause both an increase to take place in the quantity of moisture precipitated and the manner of precipitation to change, so that, instead of thunderstorms and torrential downpours, we may have more and more soaking showers and mists. The influence of the numerous wattle plantations on the rainfall of Natal prove that even in the course of a few years we can influence the rainfall. I do not mean to extol the wattle as an ideal tree for hydrological purposes: I do not consider it as such, but at the present time it is the only actual example we have in this country. The ways in which we can influence the rainfall are, firstly, by artificial afforestation, especially of the mountain areas, and by the strict conservation of our indigenous forests; and, secondly, by cooling the ground surface of the grass velds. These two means again interact on one another, and must, to some extent, be taken in conjunction.

Afforestation.—Tree-planting for commercial purposes, has been going on in South Africa for the last thirty or forty years. A great deal has been done by the Forest Department, but unfortunately, a Government department is always to some extent hampered by political considerations, and while our legislators have recognised the value of a home-grown timber supply to the Union, they have not recognised the influence that afforestation has on climate. Consequently little or nothing has been done, either departmentally or by private enterprise, to combine the growing of timber with the influencing of the climate. It is essential in a country in which the water-supply is yearly decreasing, and the perennial nature of our streams more and more uncertain, that the species planted should be such as exercise a maximum cooling effect on the ground, transpire a minimum of moisture, and provide humus which, acting like a sponge, shall absorb and hold precipitated moisture, and so give the moisture a chance to soak in gradually, and thus render our streams yearly of a more perennial character.

Cooling the Grass Velds.—The ways in which we can influence the grass velds are too numerous for one to consider in detail. But, since the first great factor in the destruction of the grass velds was the burning of grass, so the first way in which we can assist in the improvement of the veld is by the entire prohibition of burning. Once that is done, the sweet grasses have an opportunity of reasserting themselves, and the density of the grass-covering of the ground at once increases. As it increases, there is more shade given to the ground, and more impediment to the flow-off of water. The soakage increases, and with it the permanent humidity of the ground, and the temperature of the ground is lowered.

Apart from the question of grass-burning, undoubtedly one of the most potent factors in the recovery of our water-supply lies in closer settlement. Closer settlement means the more intensive working of the ground, means more ground will be broken up, and more soakage of moisture and less evaporation will take place. It means irrigation, and irrigation means that, instead of water running to waste in a narrow stream channel, it will be spread over a large area, and exercise an enormous influence in cooling the ground. It means that the veld must be made to carry more beasts per acre than it does at present, and to do this means the formation of artificial pastures. It means that South Africa will realise the latent possibilities within herself, and to do justice to them will give this great subject of natural water conservation the attention it deserves.

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Plaatje, Solomon T.—"*Sechuana Proverbs, with literal translations and their European equivalents.*" London: Kegan Paul, Trench, Trübner & Co., 1916.

AN IRRIGATION SETTLEMENT.

By Rev. Bernard P. J. Marchand, B.A.

(*Plates 3-6 and one text figure.*)

I propose to give an account of an irrigation scheme which was undertaken with the view of settling poor families on the land:—

Locality.—The settlement is situated at Kakamas, on the banks of the Orange River, in the Kenhardt and Gordonia districts, about 50 miles west of Upington, and 55 miles north-west of Kenhardt. The source of the water supply is, of course, the Orange River, which bears almost right through the year a large quantity of silt, varying in colour according to the particular region where rain has fallen. The Orange River is fed by the supply from the Drakensberg, near Wakkerstroom, and all the tributaries of the Vaal River, and also by the Orange River proper, which has its source in the Drakensberg, Basutoland, and is augmented by its tributaries in the Orange Free State and the Cape Province.

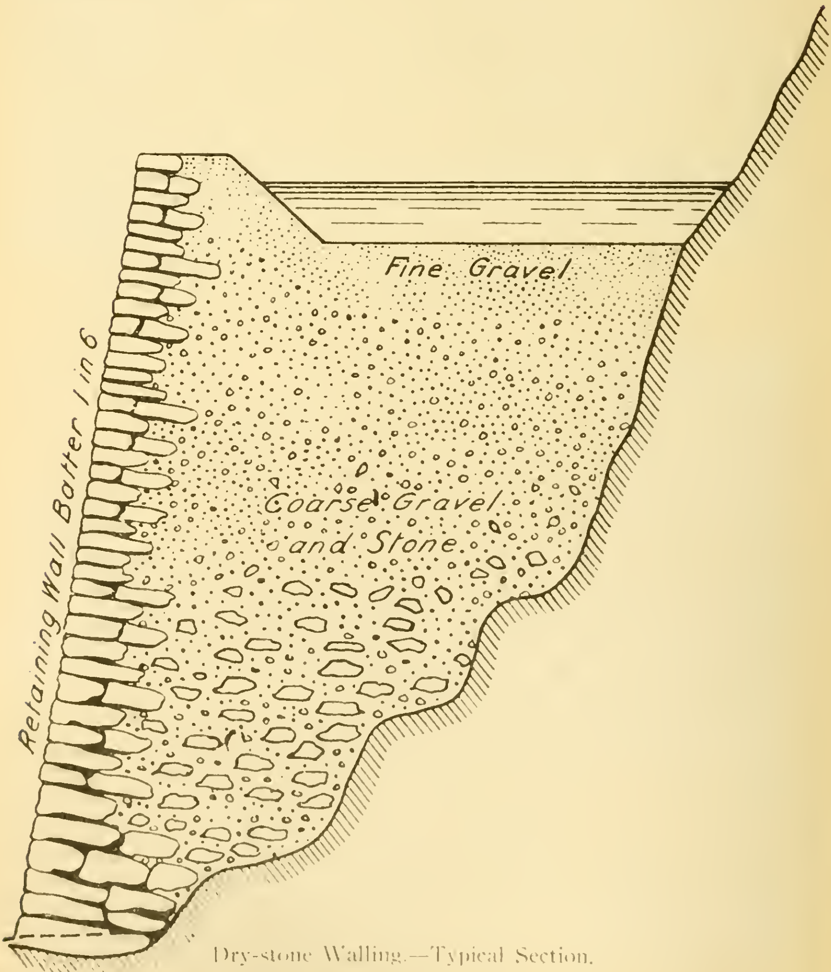
The banks of the river are in most places covered with heavy deposits of silt, in some cases a couple of miles away from the main stream. The nature of the soil is therefore very largely alluvial in the immediate neighbourhood of the river; beyond this one finds a red, stony, sandy, quartzite surface, on which very little vegetation usually grows, but which has been found excellent for citrus culture. In this is also found the rocky formation, known locally as *tsgom*, which is really a decomposed gneiss. This *tsgom* is largely the source of *brack*, along the banks of the Orange River. The rainfall is negligible in those parts, and has no value from an irrigation point of view.

Irrigation Canals.—In 1897, the Cape Parliament granted to the Dutch Reformed Church two farms on the banks of the Orange River, Kakamas, and Soetap, on condition that the land be reserved for the purpose of a settlement for poor families, but to revert to the Government in case the project proved a failure, five years being allowed for taking out a water-furrow from the Orange River and settling the people on the land. In 1898 the work was taken in hand by the Rev. C. Schröder, a missionary of the Dutch Reformed Church at Upington, and one of the founders of that township.

At a spot called Neus, where the Orange River drops 30 feet over a reef, the intake was formed, and a year later the first portion of the canal, about 10 miles long, 10 feet broad, with an average depth of about two feet, was finished. This canal was extended for six miles in 1906, and further after that, so that it now measures about 25 miles altogether, enclosing between its channel and the river about 1,200 morgen. At the same point another canal was begun on the north side of the Orange River in 1908. For the first mile the drop in the river is over 40 feet. There are very few lengths of the Orange River from a point 70 miles above Prieska to the Great Waterfall

(Aughiabies), which have a concentrated fall as great as this. The north furrow—12 feet broad—had for its main objective Paarden Island, which is one of the largest of the so-called Orange River Islands, measuring about 1,800 morgen of the richest alluvial deposit, of which about 800 to 900 are now under irrigation. The whole extent of the land brought under irrigation at Kakamas, north and south of the Orange, is about 2,500 morgen. The best description of the work from an irrigation engineer's point of view will be found in the reports to the Cape Parliament by Mr. F. E. Kanthack, Director of Irrigation, in 1907 and 1911. The following is extracted from the 1911 report, pages 1-4:—

The head regulator is a simple low masonry wall with a drop gate, and is submerged during flood.



Dry-stone Walling.—Typical Section.
Scale: 1 in = 6¼ ft.

(1) Canal in Drystone Walling.

(2) Drystone Aqueduct: on Old Tramrails. Corrugated Iron Centering.

REV. B. P. J. MARCHAND.—AN IRRIGATION SETTLEMENT.

(3) Kakamas Furrow in Drystone Walling.

(4) Downstream Portal of Tunnel No. 2.

Before describing the furrow itself in detail, I must first describe the two leading features of the work to which the success of the whole is largely due, namely, the drystone walling and the tilting escapes. Both are cheap and effective methods of overcoming the two difficulties of steep krantz work and cross drainage which have made so many schemes impossible on account of the great expense in overcoming them in any other way.

The attached sketch shows in section a typical example of drystone walling. In building these walls, three leading points have to be kept in view:—

(*a*) During the early stages of the use of the wall, it has to act like a filter bed, arresting the passage of all fine material and only allowing clear water to pass through.
(*b*) The fine material has to be arrested in such a way as to form eventually as permanent a water-tight channel as possible.
(*c*) The structure must be such that crabs and rodents cannot easily cause a breach.

The most important preliminary operation is to clear the rock of all fine river silt, especially near the outer toe of the pitching. Nothing is more certain to cause a breach than the neglect of this precaution. Once a small stream starts in the silt, it soon enlarges itself till a hole is formed sufficiently large for the internal gravel and packing to pass, after which the collapse is rapid. The silt also forms an easy passage for crabs, and they do not waste much time in finding it out and starting the small destructive stream.

The pitching is heavy and has to be exceptionally well done. The gravel is obtained by blasting from the surface rock, which is decomposed gneiss, and locally called ts'gom. This provides an excellent gravel for the purpose. It is clean and coarse, and the particles being of varied size, the interstices are never very large. The finer gravel is reserved for the last foot, and this is carried up to within an inch of bottom construction level. This point should be carefully noted. In most works, where the silting process is used, it is customary to leave the channel about a foot lower and wider than is necessary to carry full supply, this extra area being subsequently filled automatically by silt. The method at Kakamas is, however, more suitable where the wall is entirely made of such porous material. The silt cannot settle as a layer on the bottom, but is carried by the water through the gravel until it settles in some of the numerous pockets where the velocity of the water is checked. For the first few weeks after the muddy water is let into the channel, water oozes out gently in many places below the wall, where reeds and other growths rapidly spring up. After a couple of months, however, this growth lies dead and dry below the wall, owing to lack of moisture—so rapidly and effectually does the structure become water-tight. The water-tight area is not confined to the immediate bottom of the furrow, but extends throughout the structure wherever the muddy water reached, and it is exceedingly difficult for crabs or other animals to make a way through it, and, even if they succeed, they do not wreck the structure, the process of filtering going on again lower down in the gravel until the hole is automatically repaired.

The tilting escapes are simple vertical wooden shutters 12ft. wide by about 2ft. 3in. deep, pivoted on a horizontal axis, which is set at a little less than one-third of the height from the bottom. They are put in at bed level of the furrow where the formation is hard, and, when the water in the furrow rises to above full supply, they tilt automatically and lie horizontal, the water escaping under and over them. It is interesting to note that when Mr. Lutz first made these sluices on the south furrow, he found the correct position of the horizontal axis by experiment and not by calculation.

There are thirty of these tilting escapes in the seventeen miles of the north furrow, and half of these are in the first five miles. What a large part they play in passing the side drainage waters can be seen when it is stated that, apart from overflow walls, there are only six aqueducts under which the waters of the bigger dongas are carried.

Except for the head regulator, there is not a single gate *across* the furrow, which I consider to be a defect which should be remedied.

The first couple of miles of the furrow are through river silt, and Mr. Lutz employed the "spoeling" or sluicing method of excavation considerably in this length.

The first aqueduct is at 1¾ miles, and there is a slight deviation here from the original official alignment to keep the excavation out of rock.

Rock excavation begins at 2½ miles and the second and widest aqueduct on the furrow is at the bend at 2¾ miles. The typical drystone section (with pitching on both sides) continues right up to the slight masonry abutment. Zinc plates carry the gravel and slight masonry side walls, and the plates are supported by a framework of bent trolley rails. This is the only aqueduct of this type.

The river channel becomes very narrow at 2¾ miles, so that, in spite of the big fall in the river above, the furrow is not completely out of the reach of floods till the third mile. At 3¼ miles the canal meets a high level branch of the river which is parallel to and high above the narrow and deep Neus Gorge, but cut off from it by a ridge of granite rocks. The original idea was to make the furrow along the rock face of this channel on the side farthest away from the river, but when examining the alignment I approved of Mr. Lutz's suggestion to build an earth dam faced with drystone work at the lower end of this high level channel, and turn the furrow into the tank thus formed, which is fifty yards long. This tank forms a good silting reach, and has already almost completely silted up, with the furrow running down the centre. When the silting operations are complete the furrow will be straightened and trimmed up. By this means, about half a mile of difficult furrow-making was saved. Small gaps in the river side of the sluit have been filled up by masonry overflow walls, and these leak rather badly. The third aqueduct is at 3½ miles, which is of drystone construction on corrugated iron centerings.

Lower down the heaviest walling and rock-work in the whole furrow is met with. The walling is 25 feet high in one place, and two very difficult lengths have been blasted out of rock.

At five miles the first tunnel is reached. It is 100 yards long, has a fall of 1 foot, and is 6 feet high by 5 feet wire. Below the tunnel is a long masonry overflow wall, with two tilting escapes, and the last aqueduct of the usual type is at 5¼ miles. Heavy walling follows up to the cutting for the second tunnel, which is 208 yards long, has 18in. fall, and is of the same section as the first, 5 feet by 6 feet. This brings us to the sixth mile, which completes the most difficult length of the furrow. From there to the Paarden Island syphon there is nothing exceptional in the work, which consists of cutting, drywalling, and tilting escapes, though there are very few places where the work can be called easy, the cutting sometimes reaching 10 feet in depth through rock.

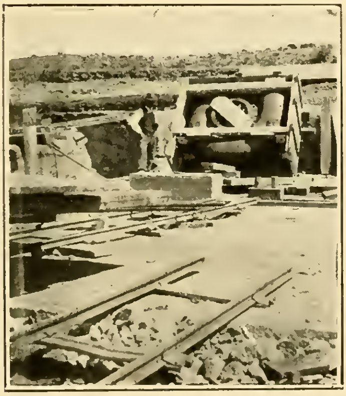
A 22-feet fall is given over rock a little beyond the thirteenth mile, and the furrow enters Krantzkop (not belonging to the Commission) about a quarter mile lower. A slight deviation had to be made just within Krantzkop to avoid the shop there. A length of walling serves instead of a cutting through a leegte, and a 27-inch pipe through the wall under the furrow passes the side drainage instead of the usual tilting escape.

The mainland furrow ends at 17 miles, and the water is carried over to Paarden Island in a 27-inch pipe 1,360 feet long, having 5 feet fall from end to end. The pipe is made of very thin (about 3-16in.) galvanised steel, and was sent out in 4ft. sheets, bent to shape and punched, but not rivetted, so that several sheets could be nested, thereby saving space and ocean freight. The pipes cost £460 in Port Elizabeth, and transport to site cost about the same. The riveting was done cold on the spot, and the pipe was laid

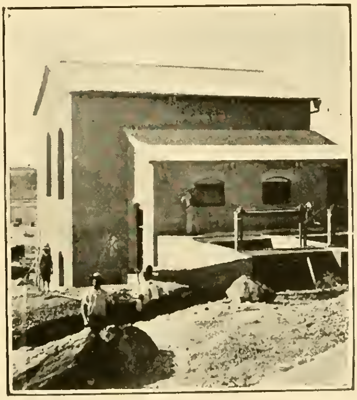
(5) Cutting in Granite.

(6) Second Section of Paarden Island Syphon.

(7) Outfall of Paarden Island Syphon.



(8) Turbine.



(9) Power Station on the north furrow.

through the river in a trench in rock, without concrete setting, being merely packed over with stones. The furrow on the island has been finished for about four miles, and is still in course of construction. The furrow is mostly in fine soil, but the surface of the land in the island is very uneven, and a number of hollows have to be crossed by simple earthen banks, the drystone walling method being impossible, as there is no hard bottom. The fall of the furrow on the island has been flattened to 1 in 3,000, on account of the fineness of the soil. A vertical fall of four feet has been constructed at a little short of three miles from the syphon.

Produce.—The chief crops raised at Kakamas include wheat, lucerne, fruit. In 1915 about 50,000 bushels were harvested; one to two million pounds of lucerne hay; while there has been an enormous development in citrus culture. The Trades Commissioner, Mr. C. Chiappini, told the settlers that some of their land was, from the point of view of citrus culture, worth up to £500 per morgen. A certain number of ostriches are kept on the lucerne lands, while a beginning has been made with sheep under the same conditions.

History.—The history of this settlement dates definitely from the year 1897, when the Cape Parliament granted the original two farms, which, it may be mentioned in passing, were not worth more at the time to the Cape Exchequer than perhaps £20 per annum. The general question of poor whitism had been discussed long before that. As long ago as the year 1886, the Dutch Reformed Synod had its attention drawn to the matter. At its meeting in 1894 a committee was appointed to suggest remedies, and to carry out the idea of a labour colony or, more properly, a land settlement for poor white families. The Rev. Mr. Schröder, a missionary of the Dutch Reformed Church at Upington, and one of the founders of that township, as already noted, was asked to give his services in view of a settlement on the Orange River at Kakamas. He and I visited the spot in 1898, and we came to the conclusion that the project was feasible, and that a furrow could be taken out at the Neus Falls. At the same time, I acquired from private owners four farms on the north side of the river immediately opposite Kakamas and Soetap on the southern bank. The property to-day belonging to the settlement includes about 113,000 morgen, of which, as already stated, about 2,500 are under irrigation.

The object of the settlement being to reclaim poor white families, certain regulations were framed as fundamental to its attainment. The rule laid down that no settler would be admitted who did not take his share of work in the building of the canal was rigidly adhered to, with the result that the whole of the southern furrow was carried out by white labour. The future colonist had to matriculate in hard work before he could enter on the tenure of an allotment. These allotments vary from five to eight morgen in size, the general average being six. Then there are regulations binding the settler to cultivate his allotment, keep it free of weeds, eliminate brack as much as possible, and pay an annual rent. The tenure is for life or good conduct. The number of holdings to-day amounts to about 400, and the settlement has a population of 3,000. When I visited the place for the first time in 1898, there were a couple of traders at the Kakamas Drift, holding short-notice trading licences on Government land. The whole country was bare and uncultivated, the nearest farm-steading being about 15 miles away. The colonists came from different parts of the Cape Province, but chiefly from the North-West, and were mostly bywoners or people who had lost their all through drought. The principles laid down for the redemption of these people were intensive and personal cultivation of the soil, educational agencies, industrial instruction. Let me give a description of what has been attained thus far.

Many of the colonists have built very good brick houses, have farmed their plots with success, have fenced these into lucerne fields, vineyards, orchards, and wheat lands. The failures can be put down as under 10 per cent. There is an air of general prosperity and independence in the whole place, and very little of so-called "poor whitism" remains. One particularly successful colonist made a clear profit last year of about £300 off his six morgen of land. The chief difficulty that had to be encountered was to eradicate the trekking propensity, and the love of ranch-farming. There is a large and very nearly self-supporting congregation of some 1,200 members, to whom two clergymen minister. There are seven schools with an average roll-call of 700 children, and 20 teachers. There is a class of 20 pupil-teachers. Of the teachers, 10 were locally trained and took their elementary teachers' Government certificate. Of the pupils, 150 are above standard V. The need for providing for the children of the colonists, who cannot be allowed to squat on their parents' allotments, has raised the industrial question. An effort is being made to get the Government to establish at Kakamas an Agricultural School for the teaching of profitable intensive farming, poultry rearing, pig and sheep raising, fruit culture, on the lines of the Government Agricultural Schools at Grootfontein, Potchefstroom, and Cedara, but on a basis that will involve comparatively little expense beyond the salaries of the instructors. The means are to hand on the spot, both in the human element and the soil. The Provincial Government has made arrangements for carpentering and smiths' work. There is, however, an opportunity for development on a large scale in the matter of leather and boot manufacture. And here I may fitly introduce the spade-work that has been done in this direction. As noted in Mr. Kanthack's report of 1911, at the thirteenth mile on the northern furrow a 22-foot fall has been given. This potential has been utilised for the erection of a double turbine developing up to 150 horse-power. A visit to Switzerland in 1910 convinced me that we have made far too little use of the existing water-power in South Africa for industrial purposes. The electricity developed by these turbines is carried by wire on pillars across the Orange River to the southern side, where the chief buildings, shops, etc., are situated. A transformer house was built to reduce the high tension current, and the power is applied to drive the machinery of the flour mill, closely situated to it. This mill has this year ground some 8,000 muids of wheat. It uses, however, only 25 horse-power, leaving some 50 to 75 horse-power available for industrial purposes. The times have, however, for the last three years, been so unfavourable for raising cheap capital, that nothing has been done in starting the leather industry, as projected. It is hoped that at an early date there will be an Industrial School also for girls.

The total capitalisation of the scheme stands to-day at £140,000.

	£
Canals	86,000
Buildings, schools, etc.	8,608
Turbine and Hydro-Electric Flour Mill.. ...	13,280
Ostriches	1,800
Paarden Island development.	10,000
Shop and Capital	15,000
Pontoons and Threshing Machines	3,600
Advances	2,600

The Poor Whites.—When the scheme was first started certain regulations were drawn up, already mentioned, and I look upon these as the chief reason for the success of the undertaking as far as it has gone.

One fundamental regulation, already referred to, was that only those who were willing to work for 3s. a day at the construction of the canal would receive consideration when the land was allotted. As a result, the canal on the south side of the river was the work of white men. And it was well done, notwithstanding that the men—most of them, were quite unaccustomed to such labour. The problem of poor whitism is, to my mind, quite capable of solution, if the right methods are adopted. It is entirely a matter of training: the environment in which these people grow up is the one thing that militates against an easy solution. Our idea was to gather them together, bring them under the immediate influence of the church and the school, and awaken in them a sense of their possibilities. I had had seven years' experience of the Knysna woodcutter, and found him easily receptive to the influence of the schoolmaster. What we have to guard against is the dropping of these people into the ranks of the criminal class. We have much for them to do, given the opportunity. It has been said that we have not done much to make this country self-supporting and independent. Why not marshal the great army of people that crowd into the towns—some, alas, to become illicit liquor touts—into an army of industrial workers? And this will be all the more feasible if we can combine a settlement on the land with industrial training. In our school system room will have to be found for institutions of that nature.

In order to safeguard our settlers from the speculator, we started our own shops, of which we have five, with a working capital of about £15,000. These shops act as a sort of exchange, as payment of the rent is accepted in the way of produce.

In dealing with poor whitism or any problem of that nature, the chief desideratum in those who seek its solution is, faith in the salvability of every human being. It is only when we start from this point that we can inspire confidence and self-respect and hope into the man who has lost all.

Effects of Lime on Insoluble Soil Potash.—Messrs. L. J. Briggs and J. F. Breazeale give an account in the *Journal of Agricultural Research** of experiments with orthoclase and pegmatite, and also with soils of granite type, in all of which they failed to detect any increase in the solubility of the potassium on treatment with various proportions of calcium hydroxide or sulphate. In some cases the presence of calcium sulphate in solution actually depressed the solubility of the potassium, proportionately to increase of the concentration of the calcium sulphate. Similar results were arrived at by determining the amounts of potash taken up by wheat seedlings grown in the respective solutions. The availability to plants of the potash in soils derived from orthoclase-bearing rocks is therefore not likely to be increased by the application of lime or gypsum.

Potash from Banana Stalks.—New or dormant sources of potash continue to be investigated from time to time. In the *Journal of Industrial and Engineering Chemistry*† H. E. Billings and A. W. Christie record experimental work recently carried out by them for estimating the possibilities of recovering potash from the thousands of banana stalks weekly cast away as refuse in every large American city. They found the dried banana stalks to contain as much potash as Kainit, and to compare favourably with dried kelp as a filler for commercial fertilisers. When charred and leached, one ton of the fresh stalks yields 27 lbs. of water soluble salts, containing 90 per cent. of potassium carbonate. The chopped-up stalks may be heated on a grating in a tall cylindrical heater, at the top of which it is constantly fed in, while the ash is drawn off below, extracted with water and the resulting liquor evaporated. This method of recovery lends itself readily to small scale manufacture.

*8 [1] (1917).
†9 (1917) [2], 153-4.

NOTE ON THE OCCURRENCE OF A PEDAL NOSE IN THE MALE OF A TRAP-DOOR SPIDER (*STASIMOPUS*)

By John Hewitt, B.A.

It has long been known that spiders are sensitive to odours of various kinds. This can be verified in most species by the simple experiment of holding a scented rod near to the spider, away from her line of vision and without actually touching her, when the creature will shew an appropriate response according to the nature of the scent employed: she may either approach the rod with apparent pleasure, or more often may withdraw therefrom with more or less distinct signs of dissatisfaction.

The position of the organ of smell is not known. Some writers have supposed that the olfactory sense resides in the palps, and others seem to have suspected the cheliceræ; however, it was clearly shewn by the Peckhams (**1**) that spiders bereft of their palps can still smell perfectly well. The most recent writer on the subject, Dr. N. E. M'Indoo (**2**) after summarising all the previously published data relating thereto, and submitting the results of his own experiments, concludes that the olfactory sense is subserved by the lyriform organs which occur in all spiders on most of the joints of the legs and of the palps, and often also on the cheliceræ, spinners, sternum and carapace. These lyriform organs certainly have the essential structure of a sense organ, and in one species (a *Lycosa*), M'Indoo shews that, on carefully varnishing the surface of all the lyriform organs with vaseline, the spider's sensitiveness to odours becomes very greatly reduced.

So far as I can ascertain, no one has hitherto observed any well-defined localisation of the olfactory sense in spiders. There is a hint of it, perhaps, in a paper, which I have not seen, by McCook, who apparently interprets the experiments of the Peckhams as indicating that the olfactory sense organs are distributed more or less over the entire surface of the body, especially at the tips of the feet and at the apex of the abdomen. Recently I have had the opportunity of experimenting with some adult males of a common trapdoor spider, *Stasimopus* sp., kindly collected for me at Alicedale by Mr. Frank Cruden during the months of April and May. I may mention that the males of trapdoor spiders are very rare in collections, and nothing has been written on their habits; yet the fact that these creatures are structurally amongst the most primitive of living spiders should lend a special interest to the study of their behaviour in life, particularly in connection with courtship and mating, which, in many two lunged spiders, is extraordinarily complex.

The specimens examined were of moderately large size, and when at rest their long slender legs were often extended away from the body, which was very convenient when experimenting on the localisation of sense organs. They were comparatively sluggish creatures, remaining quite motionless for long periods, though when disturbed they would run away with considerable speed, never making any attempt to bite. In testing their olfactory powers, a pair of ladies' hatpins was employed, one of them, as a control being brought near to the spider at the point which it was desired to test, when, on finding no response, the other, bearing a droplet of odoriferous liquid on its pointed end, was brought forwards in a similar way, due care being taken to avoid actual contact with the skin or hairs of the creature. The results were very striking. Every time the scented pin was brought near to the tip of a leg, within a few seconds that leg was raised or withdrawn; sometimes the creature as a whole moved away. So far as I could judge, the soft skin of the abdomen and the middle joints of the leg were not receptive to the stimulus, and, indeed, no part of the body except the tips of the legs was found to be sensitive; it seemed impracticable, however, to test the sensitiveness of the sternum. The scents employed were the oils of cloves, eucalyptus and citronella, also ammonia solution. The citronella oil proved most effective, clove oil least so. Of the four pairs of legs, the first and second pairs were clearly most sensitive, judging from the time involved in the reaction, whilst the fourth pair was least sensitive. All the odours employed were repellent in their action.

One morning, choosing a strong specimen, I cut off the end of the first leg of the right side, at about the midpoint of the metatarsus (penultimate joint); by evening the creature seemed fairly active, and all his legs responded in turn to the citronella test except only the injured one, from which no response whatever was obtained. The experiment was subsequently repeated with another specimen, but still with no response in the injured leg. When the amputation was made at the midpoint of the tarsus (end-joint), a definite though feeble response to a scented needle was obtained on the following day, shewing that the olfactory organ is not confined to the distal half of the tarsus.

Similar tests were made with adult females of the same species, also taken at Alicedale, and Mr. Cruden independently experimented with other female specimens. Curiously enough, they appeared to be altogether insensitive to the odours employed.

As yet I am unable to say with certainty what structures are concerned with this olfactory sense on the feet of the male *Stasimopus*. Microscopical examination suggests two possibilities. The olfactory organ may lie in the hairs of the scopula, a term employed for the pad of fine hairs found on the lower and lateral surfaces of the tarsi and the terminal portion of the metatarsi. These hairs, when examined under a high power, are seen to be essentially different from the several kinds of hairs which clothe the other segments of the leg and of the abdomen; the latter are all finely pointed, their tips being solid and strongly chitinous; the scopular hairs, on the other hand, are truncated or even funnel-shaped at the tips, where apparently the central portion of the hair opens freely to the exterior. Now, though it is difficult to see how the impact of olfactory particles on the solid chitinous tips of an ordinary hair can be sufficient for an olfactory sensation, yet it seems quite possible that such particles on a scopular hair may be brought into direct contact with living material or with liquid exudate from living cells, in which case chemical changes may result in the setting up of afferent olfactory impulses. Further investigations on the minute structure of scopular hairs and their relationship with the subjacent cells and the nervous system will be required before this explanation can be established.

It may be noted that the scopula is quite absent in females, which, as we have seen, are devoid of an olfactory sense; yet, on the other hand, it is well established that an olfactory sense is present in many spiders which have no trace of a scopula. The tarsi of the female are relatively much shorter than those of males; moreover, the tarsus of the first leg of the male is distinctly swollen and more strongly scopulate than that of the fourth leg, which is not swollen.

The alternative possibility which would connect the olfactory sense with lyriform organs or related structures does not seem adequately supported by the facts of distribution of such organs. These organs are present on each joint of the legs, except the tarsi, in both male and female, being apparently equally well developed in the two sexes. The organs at the apex of the femur are larger and more complex than those at the apex of the metatarsus, yet I could trace no sensitiveness to olfactory stimuli in the neighbourhood of the femora. However, in addition to the typical lyriform organs, there are to be found on the legs of *Stasimopus* a great number of minute pores. These pores seem to be smaller than the simple slits distinguished by Dr. M'Indoo in the various species he examined. They are perhaps comparable with the olfactory pores of insects as described and figured by that author in the honey bee and other hymenoptera. I have found such pores also in *Moggridgea coegensis* Purcell and in *Hermacha bicolor* Pocock, but in the latter case they are very easily confused with the exposed sockets of broken hairs. In *Stasimopus*, however, the pores cannot possibly be confused with hair sockets, for they are considerably smaller than the pits of neighbouring hairs. They occur abundantly, for example, in the midst of the spinous areas of the tibia and metatarsus of a female leg, where fine hairs do not occur. The distribution of these pores is very general, and they are as abundant in females as in males. They occur on all the joints of the legs and are not specially accumulated on the tarsi and metatarsi. Indeed, the total number of pores on either of these segments is distinctly less than that found on the femur.

It is interesting to speculate on the purpose of this olfactory sense which presumably does not originate in the feet of a male until the final moult which ushers in the adult stage. The mature male appears to have no appetite for food. I have repeatedly offered him flies and grubs, but all in vain; he is, moreover, more amiable than the females, never shewing fight when irritated, and some ten or twelve specimens lived together amicably for more than a fortnight in a small box. It is likely, therefore, that the sense of smell is not required in a search for food.

Their existence in the adult stage is indeed but brief. During April and May they were abundant at Alicedale, but during June Mr. Cruden repeatedly searched for males on my behalf without finding a single specimen.

In all probability their sole function in life is that of breeding, and it is conceivable that the olfactory sense is useful in helping to discover the female. In his search for a mate the sense of sight will not help him much as the female always remains well concealed within her nest. I have not yet been able to observe the mating habits, but have noticed his agitated behaviour in the presence of the adult females.

A few female specimens were kept for a week or two in a small box half filled with dry, loose earth, on the surface of which they slowly crawled about for a time, and eventually settled down half-buried in such depressions as they could find. On dropping an adult male into this box at some little distance from any of the females, he soon exhibited a peculiar attitude, different from any he had previously displayed either in response to pinching or to strong doses of citronella. Standing on his three hinder pairs of legs, he raised his body high in the air, threw out his forelegs horizontally forwards like feelers, and withdrew the palps backwards over the carapace, the palpal tibiæ being directed horizontally. Thus he remained almost motionless except that the forelegs were slowly waved around and now and then were tapped deliberately on the ground. The most marked feature of this courting attitude is the withdrawal of the palps which ordinarily are held in front when walking or running. In this position the creature remained for several minutes.

The late Dr. T. H. Montgomery, who has written extensively on the courtship behaviour of various two-lunged spiders, considers this attitude to be a modification of that normally exhibited as a result of alarm. This view seems to me a very reasonable one. On one occasion a male was taken from his box and dropped on a thick tablecloth, the surface of which presented numerous loose, projecting fibres; for a very short time he also took up the characteristic courting attitude, though there were no females in the vicinity.

Unfortunately the females at my disposal betrayed no amatory emotions in response to the persistent courtship of the males. Occasionally, during his peregrinations a male happened to touch a female, when she at once showed her fangs, and he discreetly withdrew.

If the female be situated four or five inches away from the courting male when first introduced to her box, he may slowly wend his way towards her, holding his palps forwards in the air. One receives the impression that he does not see her, but is guided more or less accurately to her neighbourhood through stimuli received on his first pair of legs. Still, on several occasions the very erratic movements of the male led me to doubt if he was guided to any appreciable extent by odours emitted from the female. Presumably this would be determined largely by the sexual condition of the female which, of course, cannot be ascertained by external examination. The behaviour of the male always seemed to indicate his knowledge of the presence of the female, but not of the precise direction in which she was to be found.

To throw light on this point I removed several females from their box, placing them on a small cardboard tray some distance away, and after a while dropped therein four adult males quite near to but not actually touching the females. None of these males made the slightest attempt to court the females nor did they shew any signs of alarm or emotion. On the other hand, whenever a male was dropped into the untenanted box which had formerly contained the females, he at once took up a courting attitude. The females were removed from their box one Thursday, and on the following Sunday males which were placed therein commenced to court immediately. In all probability this sensitiveness is not alfactory, but is connected with the presence of web spun by the female over the surface of the ground. Females kept in a box in which they do not burrow will crawl about, slowly trailing after them a loose bundle of very fine silky threads of uniform thickness, and thus the serface of the ground becomes sparsely covered with delicate silk.

The paired tarsal claws of the male differ from those of the female in being pronouncedly pectinate, and during life are held widely separated. A courting male, whilst slowly waving his first pair of legs upwards and downwards, may often scratch strongly on the ground with the claws of his first two pairs of legs, so strongly that on hard ground the sound is clearly audible to an observer. Thinking it possible that these tarsal claws might be intimately concerned in the perception of the female web, I carefully cut off, or at all events seriously broke up all the claws on all the legs of three specimens without injuring the tarsi. On the following night I introduced these specimens to the box formerly occupied by females, with the result that two of them promptly took up the characteristic courting attitude.

I may add that males when walking or running do not emit threads of silk; no trace of web was found on the surface of the ground, where twelve males had resided for several weeks. However, during courtship, when slowly approaching the female, a male was observed to be trailing a cord of silk from his spinners.

Males shew no inclination to build a trapdoor, but if placed in a hole in the ground they will line its sides with very fine silk, and may completely cover themselves in with a delicate web.

Though I was unable to observe the further stages of mating in this species, a few additional points can be supplied from observations on *Acanthodon kentanicus* Purcell, another trapdoor spider. The material came from East London, and I am again indebted to Mr. F. Cruden for it. Last year, on July 13th, I placed a female *Acanthodon* in a tumbler containing stiff earth, in which a hole of convenient size had been bored. During the night the spider lined this tube with web and constructed a perfect trapdoor at the top. On July 16th I dropped an adult male *Acanthodon* on to the earth near the female lid. For ten minutes he merely made repeated efforts to scrample up the sides of the tumbler. Then suddenly he took up the characteristic courting attitude, much as I have described for *Stasimopus*, though the palps were held at higher elevation, the palpal femur being drawn backwards and the tibia directed horizontally. Meanwhile, he was tapping repeatedly and rapidly on the ground with his forelegs. Now and then he commenced to scratch the earth with the forelegs and fangs, but this did not continue long, and he resumed the rapid tapping near to and upon the lid of the female nest. After a few minutes this lid was slowly raised and the female appeared, but did not actually come out of the nest. At first she shewed fight, and he temporarily retired, but on courageously tapping her with the tips of his long forelegs she soon became quiet and allowed him to approach quite closely. During copulation, which only lasted three or four minutes, and took place at the mouth of the tube, the female was almost vertically arranged, her legs and palps drawn backwards, and not holding the open lid: the male had his first pair of legs stretched over her head region, the tarsi and metatarsi pressing between her chelicera and palps. Afterwards he withdrew his legs, she re-entered her retreat, and the lid closed. He then remained quiet for a long time, but slowly cleaned the spine of his bulbal organ and the tarsi and metatarsi of his forelegs by drawing them between the fangs several times. Unfortunately, the process of sperm induction was not seen.

It is clear that the female is only aware of his presence when she feels the tapping on her lid, and as likely as not, judging from her menacing attitude, she does not recognise him as a mate, or, at all events, as a desirable mate; he first has to calm her ruffled feelings, and perhaps arouse her sexual desires by tapping repeatedly on her body and legs.

Another male and female of this species were allowed to meet on an open tray. His behaviour was much as I have described already, but for a long time she took not the slightest notice of his attentions. Nevertheless, he continued even when when she had withdrawn to some distance. When she allowed him to approach, he patted her legs and abdomen slowly and repeatedly with his two forelegs; then they copulated, facing each other, she raised upwards on her abdomen and hindlegs, and he approaching her beneath, at first with incessant patting, but eventually his leg movements ceased. The movements of the male palps I was unable to follow.

The ordinary ambulatory movements of the male of this species are fairly slow; the body is carried close to the ground, the palps down, and the legs wide-spreading, feeling his way at every step.

As I happened to have the male of another species of *Acanthodon* I allowed him to walk near to and to touch two adult females of *kentanicus*: he merely shewed ordinary symptoms of alarm without any indication of courting attitude.

Experiments with the males of *Stasimopus* and nesting females were unsuccessful. The male in such case took up the courting attitude previously described for this species and scratched on and near to the trapdoor, but there was no definite tapping, and the female did not respond in any way. No doubt mating will nominally take place at night, when both sexes of *Stasimopus* are comparatively active.

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CLOUDS ON MARS.—A recent issue of *Nature* contains a summary of a report on the planet Mars by Prof. W. H. Pickering, in the course of which it is stated that during its last opposition the planet was scarcely ever seen without clouds, although a few years ago it was claimed by some observers that clouds are never or rarely seen on Mars. Prof. Pickering says that the clouds always lie over the so-called desert regions of the planet, apparently being precipitated as soon as the fertile regions are reached.

THE ENTRENCHMENT OF INDUSTRY.

By Hon. Charles G. Smith.

There are unmistakable signs of a changed attitude on the part of the public of South Africa towards colonial industries. The traditional prejudice against the local article has been converted into a feeling of tolerance, and even in certain cases to one of mild encouragement. The lessons of the war have proved to us our unhappy dependence upon outside sources for the bulk of our supplies, and with the full realisation of our industrial weakness, and the ever-growing penalty we pay for it in the high cost of imported goods and rapidly advancing freights, the public will be compelled to make up its mind whether it is or is not worth while to put some enthusiasm into the question of fostering manufactures and trade within the Union. Not the least of the problems which will engage the attention of Parliament is the one of making South Africa far more self-supporting than she is at present. One shudders at the disastrous consequences to this sub-continent if our sea communications had been interrupted for any prolonged period. The patriotic stimulus that the war has given us must not be allowed to die away with the final sound of the guns. While the youthful vigour of the nation is away fighting the battle of Empire, it is for us who remain so to contrive that no shock shall be given to the national welfare, and that our economic system shall be adjusted on such lines as will ensure expanding prosperity to fully re-absorb in peaceful occupations those who have sacrificed home life and material prospects in order to keep the flag flying. We have had the experience of thousands of able-bodied, acclimatised young men leaving our shores because we lacked employment to keep them here, and the conditions of land settlement offered no attractions. No one will dispute that the great need of South Africa is a stream of vigorous white settlers to revivify the sluggish pools and backwashes of the population. If, then, we allow one single man now wearing uniform to go beyond the seas through lack of employment in South Africa on conclusion of hostilities, we shall not only have disgraced our patriotism, but we shall have set the seal upon our economic decay.

It will not do to wait until the men return and are disbanded. A definite policy must be decided upon, and the machinery for its accomplishment prepared and set in motion, so that the transition from military to civil life may take place without delay and without hardship or loss to the men. Those who have suffered serious disablement by wounds or sickness on active service have done their life's work, and are entitled to a pension on such a scale as will permit them to live in full comfort. Whatever is done in the way of teaching them those occupations which their disabled condition permits them to take up should be entirely supplementary, and they should not be dependent on their exertions whatsoever for a livelihood.

The first duty is with the State, but individual employers, firms, and companies are under definite obligations to take back their employees. For the men whose billets are not secured the problem may present some difficulties. The staffs of some concerns are more elastic than others, and the nature of the business, too, is an important factor. It is to be expected, and the public should see to it, that employers fulfil their obligations to returned soldiers previously in their service, and public opinion must force upon the Government the necessity of making provision in time for men to go on the land under suitable conditions affording prospects of comfort and success for them and their families.

No more suitable time could be chosen for a deep study of the questions which so vitally affect our destiny as a nation. Wealth destruction is taking place on a scale of appalling magnitude, and the reckoning has yet to come. To a perilous extent we are as a nation living on capital and borrowings—not on our current income—and the only means of restoring the balance is greater productiveness, the fullest employment of skilled labour and natural resources in the creation of new wealth.

The obstacles that have so long stood in the path of South African progress must be examined anew, and if the engineering skill of Parliament shrinks at the task of removing them, we must dynamite them out of the way by the explosive force of an aroused, enlightened and courageous public opinion.

I shall leave to others the task of stating how best the land problems may be solved, and shall seek to indicate the lines on which the development of our industries should proceed. And here I will make a declaration of my fiscal faith. I am a Protectionist by conviction, by interest, and by saturation with the experiences of a long and varied business career, confirming year by year more positively and completely that Protection is the best and the only sure road along which South Africa can travel towards permanent prosperity and the fulfilment of her aspirations as a nation.

Free Trade, as understood and practised in Britain, is the most dangerous doctrine of the twentieth century. It is the platform of the flatulent demagogue, and is the main cause of the present devastating war, the buttress of the Liberal party in England, and the hope of Germany. Britain is the dumping-ground of all Protectionist countries. Free Trade and low wages have brought about the practical extinction of the agricultural classes by their diversion to cities and towns, and, if this policy is persisted in, will assuredly put the British under the sway of their present enemies, and the present neutral nations; and even our present allies will impose upon us their industrial superiority, unless Britain and her Colonies permit only practical statesmen to rule instead of theoretical and insincere politicians.

Internal development of industries has enabled Germany to defy the Allied armies for two years. Germany, by her far-seeing policy of industrial development on scientific lines, has

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been able to sustain her armies and population for two years, despite the fact of our glorious navy imposing a blockade of unprecedented length, and latterly, owing to the insistent demand of the public, a more rigid blockade and practical severance by sea of all communications. How could Germany have accomplished such marvels without a carefully considered industrial policy? The United Kingdom has been at the mercy of Free Trade politicians for years. The rich have become richer and the poor poorer. The cry is still Free Trade and more children —in other words, free imports, the increased power of wealth and more children to be trained for labour at low wages. It is an obvious fact that Britain would have been brought to utter collapse by six months' entire blockade. There appears nothing for it but the complete abandonment of Cobden's shibboleths, so dear to the average politician. Industrial development must succeed the policy of control by politicians. One only needs to look at the extraordinary prosperity of America, and in fact all tariff controlled countries, for examples of how best to encourage national development. Where is Free Trade leading England to? Do the powers that be expect the birth-rate to increase without some means of providing for the existence of the population? What object is there in raising the population of a country if all the food necessary for their existence has to be imported? Is it not an obvious fact that with any increase of population poverty must ensue? If the United Kingdom has too large a population for the internal resources to provide food for, then the excess population must be deported, or cities will become larger, millions of people will be condemned to exist under the most unfavourable conditions, and the only progress that can be expected will be the progressive increase of riches among those who exploit the population for their own benefit. In other words, under Free Trade the doctrine of

> God bless the squire and his relations,
> And keep us in our proper stations,

has full power and effect.

We are familiar with the risks and difficulties attendant upon efforts to establish local industries. Various commissions have sat and made their recommendations, but we still await a tariff that will provide security under which industrialists may embark their capital with reasonable prospects of permanent success.

Hitherto there has been a timid policy of moderation. Politicians are saturated with the idea of making concessions to the opposing party or parties in order to keep themselves in power. Moderation is enjoined upon the public in all things. One might as well continue the application, and suggest only a moderate bombardment of the enemies' trenches, or expect people to be moderately honest, or women moderately virtuous. The average man and woman are tired to death of political and social platitudes. Only a vigorous policy will satisfy us. Natal, and doubtless the other States of the Union, might as well have been entirely free of all political representation for all the good the general public have derived from the efforts of Parliament. Under parliamentary rules and party government, measures are submitted to such a pruning and emasculation under the policy of conciliation that their original character is lost and their effectiveness destroyed. Free Traders have a sop administered to them. Protectionists are occasionally placated, rebels are cheerfully forgiven, and the policy of conciliation and compromise satisfies no one. In future elections, if the country is to have any peace and progress, the electors will have to exact from political candidates definite adhesion to views and principles laid down by the various organisations that will undoubtedly be in existence after the war, and unless candidates adhere rigidly to their pledges on the hustings they must be compelled to resign. We have had an instance of the efficacy of political organisation amongst our Dutch fellow colonists, and it behoves every voter in South Africa to belong to some political organisation by which he can make sure that his vote has its true and abiding value. It is time that the cheated elector, promise-crammed and defrauded by successive Parliaments, should stand up and count himself something more than a cipher in the business of politics. As things are with him now—in spite of his ballot-box and his adult franchise—he is a mere pawn that Parliaments play with; a shuttlecock they toss with in sport. It is a lamentable thing to say, but so true that it demands frequent restatement, that a politician's pledge or a Ministerial promise is of no more value than a German signature to an international treaty. There is a very sacred and solemn duty devolving upon all who would rescue our parliamentary life from the level to which it has drifted. The leaders who regularly give promises to catch votes, and who break those promises Parliament after Parliament in order to evade irksome duties, should be met with the stern displeasure of an indignant people. Cannot the people so rise above mere party as to form a League of Truth, the members of which would sternly punish every Government in turn which proves false to its pledges?

South Africa has been a favourite dumping-ground for the surplus goods of other nations, whose internal markets are secured by high tariff walls. In open competition with such goods produced by the worst-paid labour of any and every country, it is impossible for our infant industries to find their feet. An adequate protection is therefore essential to the birth and development of South African industries, the number of which can be extended very considerably under sympathetic treatment.

It has been estimated that our, say, 1,300,000 whites in South Africa as a body of consumers, are equal in spending power to nearly 2,000,000 Australians, the rates of pay being so much higher in South Africa. Our market, therefore, is equal to, and probably better than, the market of 3,000,000 Australians. Based upon this calculation, there should be ample room in South Africa for 7,000 factories employing quite 150,000 persons, of whom (the minimum wage being in force) at least one half would be white, or nearly treble the number of whites the whole mining industry directly employs. The fact must not be overlooked that, as manufacturing enterprise developed, new demands would be made upon the labour market. And the local market broadens by the increased wants of the growing population. The employees in one class of factory become consumers of the articles made in another class of factory. And the prosperity of the factories and of their employees naturally reacts upon the activities of every branch of commercial and industrial life.

The existence of a sufficiently wide market being demonstrated, an enlightened industrial policy affording security for capital would open up factories giving full employment to a much larger population; the spending power of the nation would be increased, and the foundations laid of a permanently prosperous national life.

Proceeding collaterally with the development of industries, legislation requires to be enacted to secure to the worker the full measure of reward for his work. National prosperity means the prosperity of the people comprising the nation—not the drones, but the workers—and any state of affairs that fails to promote the essential welfare of the whole body of workers must be regarded as unsatisfactory. The old doctrine of the greatest good to the greatest number must be extended to secure the fullest opportunities of material progress for all who contribute to the sum of the nation's wealth. The worker's interests must not be left unguarded. He also must be entrenched. The whole trend of modern industrial legislation is an effort to restrict the pernicious operation of the old so-called immutable laws of supply and demand venerated by the Free Traders, whose cardinal principle is cheap labour as the basis of competition. As a writer has well said:—

> Unrestricted competition in industry of the needy and helpless produces a standard of *animal*, not *human* life.

The worker thus occupies very much the same position as do industries under Free Trade—they are ground down to starvation point. The case of the worker is admirably expressed by Mr. Justice Higgins in the Australian Arbitration Court. In the course of his judgment in an industrial dispute he said:—

> The employer needs no court to enable him to reduce wages—he has simply to refuse to give employment at wages which he thinks to be too high. It ought to be frankly admitted that as a rule the economic position of the employee is too weak for him to hold his own in the unequal contest. He is unable to insist on a "fair thing." The power of the employer to withhold bread is a much more effective weapon than the power of the employee to refuse to labour. Freedom of contract in such circumstances is surely misnamed; it should rather be called despotism in contract; and this Court is empowered to fix a minimum wage as a check on the despotic power. The worker is in the same position in principle as Esau when he surrendered his birthright for a square meal, or as a traveller when he had to give up his money to a highwayman for the privilege of life. Admitting all this, yet an employer often falls back on an economic theory as to the law of demand and supply—a theory responsible for much industrial friction, and at the root of many industrial disputes. He thinks that all this regulation of wages is a mistake—a defiance of natural laws. He treats the so-called "law" as being, in matters of wages, etc., more inexorable and inevitable in its play than even the law of gravitation—as not being subject, as laws of nature are, to counter action, to control to

direction. One may dam up a river, or even change its course, but one cannot (it is said) raise wages above its unregulated price, above the level of a sum which a man will accept rather than be starved.

What, then, is Labour's share? Labour is the greatest factor in all produce, but we have not yet devised an effective scheme of apportionment. What we have so far arrived at is —what ought never to have been forgotten as it was—that the labourer is worthy of his hire. A man should command a living wage. It has taken a long time to wring that admission out of the employing class, but the "living wage" is now one of the accepted axioms of the age. However, that settles little or nothing, unless we go further. What is a "living wage"? The same wage which was a living one three years ago is so no longer. The war has brought about a considerable increase in the cost of living, but the question is, have wages gone up proportionately? That is the question that needs to be solved before we can get rid of the uncanny thing called industrial unrest, and so far there has not been devised a scientific method of determining the bearing on wages of the rise in prices. In various businesses a larger ratio of profit is now being earned (though some have suffered a set-back) through the operation of increased prices on account of the war, and, in the absence of any compulsion, those reaping such excess profits should give serious consideration to the claims of their employees to a fair share in the form of increased wages so as to counterbalance the higher cost of living—that is, after suitable provision has been made to safeguard the business from the prospect of diminished profits in the future from the same cause.

The public are very prone to look askance at high rates of profit, and have a suspicion that the law ought to intervene. But profit is exactly what we all need. It is the life-blood of industrial progress, of scientific research, of educational advance. Even if the consumer had to pay more for everything in order to sustain the profits of productive industries, he would get much more in return than he gave. Except in the case of articles for which there is a very limited demand, a slight increase in the selling price will make all the difference between an undertaking which merely "carries on" and one which is able continuously to develop, to spend money on improvements in its works and in the conditions of its workpeople, to organise research, to test and exploit new inventions, and to push its enterprise in fresh directions.

Most of the accusations brought against the British manufacturer may be traced to the meagreness or uncertainty of his profits. The usual indictment is that he is slow to take up new machinery or new processes; that he neglects research; that he is indifferent to the value of high technical education; and that he allows American or German competitors to outstrip him in the vigour and scope of their selling organisations. Each of the counts in this indictment may be true; but in each case the defence is that nothing can be done by any firm which does not enjoy a secure and profitable market. Public opinion in Great Britain has encouraged competition in price to the widest limits, with the result that profits have been reduced to the narrowest limits. The one abiding concern of the Government, local authorities and private buyers, has been to force prices down to the lowest possible point short of driving the manufacturer to give up the business in despair. What matters as long as the prices are low? The average English and South African buyer cares nothing for the quality of goods or the wages of the producers. At the same time they expect the British or Colonial manufacturer to be as progressive on a 5 per cent. margin as the American or German manufacturer is on a 10 or 15 per cent. margin. They expect him cheerfully to scrap plant with many years of useful life, to spend money continually on reorganising his factories, to make increasing concessions to his workpeople, to endow research which may bring only a distant reward in cash, to employ a staff of experts in devising new processes which involve fresh capital and fresh speculation, and to lavish money on commercial development in all parts of the world. In a word, they expect the manufacturer to spend money, while they conspire to prevent him making it. Investigations require a large and speculative outlay of money, and the American and German industries, with their entrenched markets and other advantages, were the only ones who could afford it.

Money is the sinews of trade. Theoretically, everyone admits the truth of this summary statement; everyone agrees that it is obvious. The time has now come to act upon it. There must be an end to the worship of the lowest possible price at all costs. No industrial progress can occur—no founding of new industries, no renewal of old enterprises, no capture of Germany's trade—if the Government, the labour leader, and the consumer in general do not realise that the fair price for commodities must allow a margin for the cost of research, development, education, and the other constructive enterprises which are now demanded of the manufacturer. And in addition to these arguments for the communal benefits of ample profits, we have the simple economic fact that out of dividends come the resources which later appear as capital. "No profits, no capital," is another obvious truth which is again and again flouted in practice.

There has been too great a tendency in the past in South Africa to subordinate all considerations to the one of the lowest possible price. The low grade mines have encouraged it, and received substantial benefits in the form of remission of revenue, which has consequently to fall on other shoulders. The importers and merchants have raised it as a fetish to be worshipped unquestioningly, declaring in their self-interested blindness that South Africa could never be anything but a *mining, pastoral and agricultural country*, and that those interests were best served by a policy of Free Trade. That is precisely what was said by the same class of people in Australia, but every single State in the Commonwealth has seen through their specious arguments, and has permanently adopted Protection, with the result that Australia has developed her manufactures to an astonishing degree. Her need was, as ours is to-day, more population, but she could not attract settlers unless she had employment to offer them. She realised that foreign manufacturers were growing fat on the working up of the raw products she shipped overseas, to be sold again to her in altered form loaded up with heavy cost of double transport and high profits. Why could she not do the work herself, and build herself up as a nation, affording employment to her own people, attracting other skilled workers, and enriching the State coffers? That was the Commonwealth's task, and it is the one that confronts South Africa to-day. Too long have we been content to see the golden treasures from our mines leave these shores. That rich stream should pulse through the arteries of a vigorous internal industrial system. Unless we realise our position we shall bleed to death. The stores of gold which Nature has bountifully provided to give us a start as a nation will be all squandered long before we have reached the stage of being self-supporting. We must make a strong effort to keep the money circulating more and more in South Africa, and divert it from the purchase of luxuries abroad towards the establishment of manufactures and industries which will ensure for us lasting national prosperity. Is this opportunity to be utilised, or is the merchant, who laughs at technical education and the laborious work both of mind and body which manufacturing entails, to have it all his own way, and this country, after the exhaustion of its mineral wealth, to sink back into primitive conditions, with the submergence or absorption of the white race by the black? If history demonstrates anything, it is that manufactures bring wealth, and that a State whose prosperity is built merely upon mining and distribution, unbacked by agriculture and manufactures, is bound in time to be tripped up and left with no resources.

A favourite argument, levelled by the Free Traders, is that Protection leads to the formation of trusts which artificially raise prices. Once upon a time this objection would have been immediately fatal. The mere mention of the word "trust" was enough to reduce the most lively economic reformer to impotence. Even yet the word has some power over those who do not look below the surface of things. But the war has taught us to face the realities of trade, and one of these realities is that combinations of some sort are inevitable in modern industry. They exist everywhere. They control almost every commodity in general use: coal, iron and steel, meat, grain, transport services, typewriters, oils, chemicals of various kinds—a long and miscellaneous catalogue. What we want to guard against is that we should not be placed at the mercy of trusts domiciled abroad. Those which may grow up in our own midst we have the power of controlling. If the Government have reason to think that the profits of a ring of manufacturers are excessive, they have a weapon ready at hand—they can impose an Excise which will divert the excess profits into the Treasurer's hands.

There would be much more effective work done in Parliament if lawyers were replaced to a very considerable extent by industrialists and manufacturers. Let us have a little less law —or jaw—and more products. People will have few grievances to air in the courts if national prosperity prevails. That is the best solution for racial unrest. A Parliament so constituted would see at once the necessity for reviving the portfolio of Minister of Commerce and Industries, and establishing his department on a thoroughly live and effective basis, to ensure national support of industries, the compilation of statistics, and the gathering and dissemination of data.

We want the farmer to realise that his interests are inseparably bound up with those of the manufacturer. Industries and manufactures will bring population, will give fullest employment to those who are here, will open up careers for the younger generation, and will yield a nearer and more profitable market for the farmer's produce. One of the most serious handicaps to the farmer in this country is the great distance his produce and stock have to travel before they reach the few widely scattered markets.

Close attention must be paid to the organisation of our markets and the standardisation of our products. It is to be hoped that we shall not see a repetition of the timidity of the colliery proprietors in selling coal at absurd prices for the benefit of shipowners earning vast war profits.

When industries attain national recognition, perhaps our Government will consider they deserve financial assistance similar to that afforded to agriculturists by the Land Bank. Otherwise influence should be brought to bear on the joint-stock banks, who make handsome profits out of South Africa, to adopt a more generous, sympathetic and enlightened attitude towards local manufactures. Let them appoint representatives to make a special study of opportunities for industrial outlets and expansion.

Then, so that our lawyer friends may not lack employment and brew mischief, they might be usefully occupied in codifying the Company laws, and providing safeguards for the investing public from the machinations of the bogus company promoter; and at the same time directors and shareholders might be educated up to a wider sense of their duties and responsibilities, we then might see the industrial highway strewn with less of the wreckage of once promising ventures.

A gratifying feature of certain local industries is the development of by-products, and operations in this direction promise to be considerably extended in the near future. These by-products are most valuable adjuncts and buttresses to the primary industries. To technical education I look with the fullest confidence to assist in preserving and expanding, not only local industries, but local brains, the most precious—with national character—of all our assets. Here again let Protection prevail

—let us train our own young men and women to qualify for and secure the appointments which are their natural heritage.

These somewhat disjointed references to a subject of gravest importance are intended merely to be suggestive and to arouse interest and discussion.

I admit that in this short paper I have not propounded any original ideas. The views expressed have been mainly gathered from other sources and from current literature. The world undoubtedly is undergoing a marvellous change. The poor cannot always remain poor. Millions of people are born in poverty and remain in poverty the whole of their natural lives. Would it not be better to breed a nation of virile men and women fit to work and entitled to enjoy and be secured in the possession of the full results of their labour? A little imagination would soon bring us to a reasonable estimate of what the probabilities would be under such conditions, and, rightly or wrongly, I believe that conditions of life can only be improved by work and an adequate return for the labour expended. Internal development, therefore—the entrenchment of our industries established and to be established—is the only hope of salvation of our Motherland and the Colonies.

JAPAN'S POTASH OUTPUT.—The annual consumption of potassium chloride in Japan is about 4,000 tons. The bulk of this, before the war, was supplied by Germany. At that time there was only one company in Japan, which produced about 300 tons per annum. Since the outbreak of war many new potassium-making companies have been established in Japan, and according to official statistics, the present yearly rate of output exceeds 3,500 tons. During the last eight months enough has been produced for Japan's own consumption, and in two months half a million pounds' weight has been exported, mainly to China, Sourabaya, and Vladivostock.

SOUTH AFRICAN PALÆONTOLOGY.—Attention is drawn in a recent issue of *Nature* to the progress that is being made in the knowledge of dinosaurs in South Africa. In 1915 a report by Mr. S. H. Haughton was made on bones found in the Forest Sandstone twenty-five miles from Bulawayo. They resembled Thecodontosaurus and Gyposaurus from the Cave Sandstone of the Cape Province and the Orange Free State. A month later Dr. A. W. Rogers contributed to the Royal Society of South Africa a paper on "The Occurrence of Dinosaurs in Bushmanland." The remains were found in the ancient infilling of a valley cut in gneiss, and Dr. Rogers concluded that the present valley was initiated in Mesozoic times. Mr. Haughton referred the bones and a tooth to a new genus, Kangnasaurus, intermediate between the Upper Jurassic Camptosaurus and the Upper Cretaceous Mochlodon. It is thus probable that the alluvial deposit is of Cretaceous age.

HENRY HAROLD WELCH PEARSON,

M.A., Sc.D., F.R.S.

The lamented death of Professor Pearson at the comparatively early age of 46, is being realised by us more and more as a great blow to botanical science in South Africa. His varied activities outside the sphere of Botany have been recognised by others more qualified than the present writer to speak of them, but Dr. Pearson was pre-eminently an enthusiast in his chosen profession. He was, however, in no sense a narrow specialist. He was keenly alive to the possibilities of many somewhat widely divergent lines of enquiry. In his own researches he showed this by not confining his attention to any single field. He also possessed that happy faculty of inspiring enthusiasm in others, and it was in this connection that his breadth of view and varied interest was most apparent.

After a distinguished career at Cambridge—he obtained a first-class in both parts of the Natural Sciences Tripos (1896-97), and in 1899 won the Walsingham medal—Pearson added to his experience and gained a knowledge of wider Botany by visiting Ceylon as Frank Smart Travelling Student. In Ceylon he made a thorough investigation of the vegetation of the patanas. He returned to Cambridge in 1898, and was elected Curator of the University Herbarium. A year later he went to Kew, where he remained until 1902, when he received his appointment as Harry Bolus Professor of Botany in the South African College.

Pearson's first published work (1898) was a paper on the anatomy of the seedling of the Cycad *Bowenia*, but his attention for the first few years of his career was directed chiefly towards Systematic Botany. He wrote the section on the Verbenaceæ for the "Flora Capensis" in 1901. After coming to South Africa he established his reputation as a plant morphologist, his most important work being on *Welwitschia* and *Gnetum*. He demonstrated the nature of the "endosperm," which he proposed to call a trophophyte, and cleared up many points regarding the degree of affinity between the Gnetales and the Angiosperms. This and similar work was continued up to the time of his death, and the MS. of a book on the Gnetales has been left almost complete. I remember, in the course of conversation, Dr. Pearson once mentioned to me that some of his friends in England, who are leading botanists, were of the opinion that he ought to confine his attention entirely to this branch of the subject. But this was not Pearson's view. He realised that while many problems in connection with the botany of South Africa could equally well be solved in England, there were others that could only be dealt with by a botanist resident in this country, and he thought, and thought rightly, that it was his duty to devote attention to the latter.

He therefore commenced his botanical expeditions to Namaqualand, South-West Africa, and Angola, assisted by funds from the Percy Sladen Trust. He endured great hardships, and it is not too much to say, perhaps, that these helped

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to shorten his life, so that in a very real sense he sacrificed himself to Science. His collections have been most valuable, but it is one of the saddest things connected with Pearson's career that he was not able to reap the full reward. Some of the ecological notes which he made during recent visits to South-West Africa were particularly important and interesting, while Systematic Botany was enriched by the addition of many new species. He never lost sight of the claims of Economic Botany, and was on the outlook for new fodder plants, useful succulents, sand-binders, etc. In such papers as "Travels of a Botanist in South-West Africa" and "Le Vaillant's Grotto at Heerenlogement" Pearson showed that his interests were not confined to botany, but he was, as Professor Seward has remarked in an obituary notice in *Nature*, "an explorer of the best type."

All this work was being done by Pearson during the time when his teaching work must have been heavy. Of the enthusiasm which he inspired in his pupils I have already spoken. Even to mention the successes gained by them here and overseas would make this article much too long. One would imagine that Pearson would have been content with the accomplishing of all that has been outlined above, but he himself latterly looked perhaps upon the establishment of a National Botanic Gardens at Kirstenbosch—which he had warmly advocated in his Presidential address to Section C of the Association in 1910—as outweighing in importance everything else. It is not too much to say that no one but Pearson could have done what has been done in this direction. He was faced with countless difficulties: he knew how to overcome them. He knew that Kirstenbosch could be made a great national asset: he convinced others of this, and he proceeded to show how it could be done. In a year or two he had accomplished wonders, but he was not spared to complete the work. It is for all those who have the interests of Science at heart to see that it is completed.

Less than a year before he died he was elected a Fellow of the Royal Society, a well-deserved recognition of his services to Science: he appreciated the honour all the more because, through him, Science in South Africa had been rewarded.

As to his personal qualities, no one who knew him could fail to appreciate his charm of manner: he was direct and truthful, generous to his fellow botanists, and he understood thoroughly the value of co-operation. The country has been fortunate in possessing the services of such a man, who in a short time had accomplished so much; unfortunate in losing him at such an early age, with the promise of so much of value to come.

The following is a list of Professor Pearson's published works:—

(1) *Gnetales*:

1. "Some observations on *Welwitschia mirabilis*." *Phil. Trans. Roy. Soc.*, Series B. **198**, pp. 265-304, pls., 18-22 (1906).

2. "The Living *Welwitschia*." *Nature* (1907).
3. "Further observation on *Welwitschia*." *Phil. Trans. Roy. Soc.* Series B, **200**, 331-402, pls. 22-30 (1909).
4. "On the embryo of *Welwitschia*." *Annals of Botany*, **24**, 759-766, pl. 64 (1910).
5. "On the Microsporangium and Microspore of *Gnetum*, with some notes on the structure of the inflorescence. *Annals of Botany*, **26**, 603-620, pl. lx, figs. 1-6 (1912).
6. "A note on the inflorescence and flower of *Gnetum*" (Percy Sladen Memorial Expeditions in S.W. Africa, Report No. 75 (in part)). *Annals of Bolus Herbarium*, **1**, 152-172, pls. 24-26 (1914).
7. "Notes on the morphology of certain structures concerned in reproduction in the genus *Gnetum*." *Trans. Linn. Soc.*, Ser. 2., Bot., **8**, 311-332, pl. 31-32 (1915).
8. "On the morphology of the female flower of *Gnetum*." *Proc. Roy Soc. of S. Africa* (in the Press).

(2) *Travels and Plant Geography*:

9. "The Botany of the Ceylon Patanas." *Journ. Linn. Soc.*, **34**, 300-365, pl. 7 (1899).
10. "Some notes on a Journey from Walfish Bay to Windhuk." *Kew Bulletin*, **21**, 339-360, map and plates 1 and 2 (1907).
11. "Percy Sladen Memorial Expedition in South-West Africa, 1908-9." *Nature*, **81**, 466-7 and 499-500, maps and photos (1909).
12. "Travels of a Botanist in South-West Africa." *Journ. Roy. Geog Soc.* (1910).
13. "Itinerary of the Percy Sladen Memorial Expedition to the Orange River, 1910-11." (Report No. 7.) *Ann. S.A. Museum*, **9**, 21-29 (1912).
14. "Le Vaillant's Grotto at Heerenlogement" (Percy Sladen Memorial Expeditions in S.W. Africa, Report No. 17). *Geog. Journ.*, **39**, 40-47. Map and 3 illus. (1912).
15. "Introduction to the Flora of the Great Karasberg." *Ann. Bolus Herb.*, **1**, 1-8 (1914).

(3) *Systematic Botany*:

16. "*Vitex mooiensis*." Hooker's *Icones*, fourth series, **8**, plate 2705 (1901).
17. "*Pentaphragma albiflorum*," Hooker's *Icones*, fourth series, **8**, plate 2706 (1901).
18. "Verbenaceæ." *Flora Capensis*, **5**, [1], 180-226 (1901).
19. "South African Verbenaceæ." *Trans. S.A. Phil. Soc.*, **15**, 175-182 (1905).
20. "Thymelæaceæ." Flora of Tropical Africa, **6** [1], 212-255 (1910).
21. "On the collections of dried plants obtained in South-West Africa by the Percy Sladen Memorial Expeditions, 1908-1911" (Report No. 5). *Ann. S.A. Museum*, **9**, 1-19, map (1911).
22. In collaboration with other authors: "List of plants collected in Percy Sladen Memorial Expeditions, 1908-9, 1910-11." *Ann. S.A Museum* (1912, 1913, 1915).

(4) *Botanic Gardens*:

23. "A National Botanic Garden" (Presidential Address to Sect. C. of S.A.A.A.S.). *Rept. S.A. Assn. for Adv. of Science*, Capetown (1910), 37-54.
24. "A State Botanic Garden." *The State of South Africa* (1911).

(5) *Various Botanical Papers*:

25. "Anatomy of the seedling of *Bowenia spectabilis* Hook., f." *Annals of Botany*, **12**, 475-490, pl. 27-28 (1898).

26. "Plants and their food." *Knowledge* (1900).
27. "On some species of *Dischidia*, with double pitchers." *Journ. Linn. Soc.*, **35**, 375-390, pl. 9 (1902).
28. "The double pitchers of *Dischidia Shelfordii*." *Annals of Botany*, **17**, 617-618 (1903).
29. "The Teaching of Botany." *Report of S.A. Assoc. for Adv. of Sc.* Capetown (1903).
30. "Notes on South African Cycads." *Trans. S.A. Phil. Soc.*, **16**, 341-354, pl. vi-viii, fig. 1 (1906).
31. "On the Rooibloem (*Isona* or Witchweed)." Dept. of Agric. of Union of S. Africa. Bull. No. 30, pp. 1-7 (1912).
32. "The problem of the Witchweed." Dept. of Agric. of Union of S. Africa. Bull. No. 40, pp. 34 (1913).
33. "Observations on the internal temperatures of *Euphorbia virosa* and *Aloe dichotoma*." *Annals Bolus Herb.*, **1**, 41-66 (photos and charts) (1914).
34. "Communication on the experimental use of plants for fixing moving sand." *Proc. S.A. Soc. of Civil Engineers*, 268-270 (1915).

J. W. Bews.

Early Man.—Dr. A. Smith Woodward, F.R.S., F.L.S., Past-President of the Geological Society, contributes to the *Geological Magazine** a short discussion and criticism of some of the theories put forward in relation to more recent European discoveries of Palæolithic man. The writer begins by protesting against the false appearance of knowledge which, he declares, Prof. Osborn, in his book "Men of the old Stone Age—their Environment, Life, and Art" provides for the unwary reader who does not understand geology, by assigning dates to the successive episodes which he recognises in his attempted correlation of all the discoveries referred to. There is no real scientific basis, Dr. Smith Woodward says, for any of the statements made by Prof. Osborn in asserting that "Heidelberg man is nearly twice as ancient as the Piltdown man, while *Pithecanthropus* (Trinil Race) is four times as ancient," and that the Piltdown man is "four times as ancient as the final type of Neanderthal man belonging to the Mousterian industrial stage." *Pithecanthropus*, Dr. Woodward has reason to suspect, was really a gigantic and precocious gibbon. Prof. Osborn supposes that *Homo heidelbergensis* is next in antiquity to *Pithecanthropus*, while *Eoanthropus dawsoni* (Piltdown man) flourished much later. Dr. Woodward declares himself unable to appreciate the reason for this supposition, and remarks that such an opinion can only be founded on negative evidence. All the mammalian remains found in the Piltdown gravel, he avers, are so fragmentary in condition, and several are so obviously derived from an older stratum, that they are insufficient to date *Eoanthropus* with exactness. The unravelling of the story of early man, Dr. Woodward says in his concluding paragraph, is indeed a continual struggle with the fragmentary evidence of casual discoveries, and much of it still consists in the balancing of probabilities.

* 4 [1] (1917, 1-4).

SOME NOTES ON RHODESIAN NATIVE POISONS.

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

The discovery of poison by primitive man was probably accidental. The death of a person by snake bite, or by eating poisonous fruit or berries, would naturally suggest to man that certain animals and plants were dangerous, and therefore to be avoided. Indeed, so far as some of the natives of South Africa are concerned, this seems to have been the case, as the following tale related by the Zulus shows.

"The first woman that Unkulunkulu produced had a child before any of the other women. Another woman who saw her with the child was jealous, hated her, and wished to poison her. She looked about her for some plant that was poisonous; she saw the Amabele, which at that time was not cultivated, but grew wild like grass. She plucked the seeds and gave them to the woman. She watched, expecting to see her die; but she did not die as she hoped, but instead of that grew quite fat and nice. At length she asked the woman if the Amabele was nice, and she replied, 'Quite nice.' And from that time the women cultivated Amabele, and it became an article of food." There is also a somewhat similar tale regarding the discovery and use of pumpkins, which relates that a woman troubled with the incessant crying of her child, gave him pumpkins, thinking they were poison, and that he would die; but he got quite fat on them.

Mankind thus discovered poisonous and other plants by trial. But to take the further step of using such plants for medicinal or other purposes, involves a much larger mental process, and probably a very much longer time.

The natives of South Africa have quite an extensive knowledge of poisons, both animal and vegetable, but principally the latter, and make various uses of them, but mostly for the following purposes: (*a*) For war and the chase; (*b*) religious and judicial; (*c*) criminal and medicinal.

The employment of poisons for warfare and hunting is largely confined to the various Bushmen tribes. It is said that the Korannas and some Bechuana tribes obtained their knowledge of poisoned arrows from the Bushmen, but I have never known any of the Bechuana tribes to use bows and arrows either for hunting or warfare, though in olden times they may have done so. The Bushmen regularly employed poison of a potent and deadly character to smear their arrows with. The arrows are made of reed, and the points of hard wood, usually tipped with stone or bone. They were quite separate. The shaft was about 18 inches in length, and the point about 4 inches. Some points I have seen seemed to me to be made of "mopane" (*Copaifera mopane*). The point was sometimes stuck in the hollow shaft, which was bound round with gut to prevent splitting, but generally it was fixed firmly with a sort of wax, or tied with sinew. The poison was smeared over the point pretty thickly and allowed to dry. Any I have seen was chocolate coloured, or nearly black. The composition of the poison, so far as I can learn, was pretty much as follows: (*a*) Snake poison, usually cobra or viper; (*b*) the juices of certain plants such as *Euphorbia*, probably *striata*, *Acocanthera venenata*. The poison bags of the snake were extracted, dried and pounded into dust, and mixed either with *Euphorbia* or *Acocanthera* to make it set. It was boiled repeatedly until it obtained the required degree of consistency, usually that of very thick jelly, and of the colour of chocolate. When smeared on the arrows it adheres firmly and soon dries. I once asked a Masurwa Bushman if he ever used Mamba poison, but the way in which he answered the question left no doubt in my mind that he considered this snake much too aggressive and deadly to interfere with. I have been informed that other ingredients and juices are mixed with the poison, such as *Amaryllis disticha*, poisonous spiders and caterpillars; but I am unable to vouch for the accuracy of this statement. Some Bushmen have told me that they never used snake poison, but only the juices of plants, some of which have already been mentioned. The effects of the poison on animals and man seems to be pretty much the same as snake poison. The Bushmen that I have had any relations with most emphatically disclaim any immunity from their own poison or from snake bite, nor do they seem to have any specific for it, in spite of what is popularly reported to the contrary. The other natives often say that the Bushmen have wonderful cures for snake bite, but I never heard any of these people themselves make any such claim. Of course, it is possible that a Bushman once bitten by a snake, and recovering, might attain a certain degree of immunity, but I have not met with any individuals I have known a Basuto catch puff adders readily enough, but he did not seem to ascribe his dexterity, in this respect, to any immunity from the bite of the snake. In war the arrows of the Bushmen were greatly feared by their enemies, and the slightest scratch was usually fatal. Hence although relentlessly persecuted and killed off whenever possible, they were held in wholesome respect by their neighbours.

The Bushmen occasionally use a species of *Euphorbia* to poison pools and pans for game, and where their enemies might drink, but the practice never was extensive. The plants were mashed and thrown into the water till the pool became impregnated with the poison. The poison did not affect the meat.

The use of poisonous plants for religious and medicinal purposes is common to all natives of South Africa, Bushmen and Bantu. The war doctors often give the armies various decoctions to make them invulnerable to bullets and spears, or to make them victorious in battle. Some of the ingredients of these war medicines are poisonous, such as *Phytolacca abyssinica*, *stricta*, and so on. *Cannabis sativa* is also used to make the warriors mad, if any particularly dangerous expedition is to be undertaken. Decoctions of these plants, sometimes compounded with ants, bits of feathers, the fangs and teeth of carnivora, were either given to the soldiers to drink or were sprinkled over them before they went into battle. Sickness of a more or less violent character was the result. Various plants, some of them poisonous, are used for sacrificial or purificatory purposes. Sickness or purging usually follows from drinking a decoction made from them. However, they are rather nasty than poisonous. It is a curious fact that natives consider the more unpleasant tasted a medicine is, the more potent is must be. Native doctors are well aware of this, and made use of the knowledge accordingly. For ordinary diseases, such as malaria, blackwater fever, blood poisoning, anthrax, dysentery, the native doctors use such plants as *Cannabis sativa, Solanum nigrum, Lippia asperifolia, Crotalaria burkeana, Bauhinia reticulata, Cassia fistula, Pterocarpus angolensis*, and *Anacampseros rhodesica*. This last plant is used for blackwater fever, and for the manufacture of intoxicating drinks, and has been forbidden by law. All these plants are more or less poisonous, but the doctors seem to prescribe them without serious consequences. They know that misadventure means loss of reputation, and they are correspondingly careful. There is no doubt of their success in curing dysentery and blackwater fever. *Ricinus communis, Datura stramonium* and *Euphorbia abyssinica*, and other plants not identified, are used for wounds and sores. Some of these plants are also used for snake bite, but the results do not appear to be satisfactory. In the case of a chief who was bitten by a cobra two years ago, I know that several such remedies were tried without avail; the patient dying within twenty-four hours of being bitten.

The witch doctors had in the old days a far larger and richer field for their operations, in the custom of smelling out, the detection of criminals, and the ordeal by poison. Their energies are now much curtailed by law, for the profession of witch-finding is now forbidden. In the old days the witch doctor was a power in the land, and every man, woman and child cowered with fear before him. No person knew when his or her turn might come to be denounced for bewitching something or somebody. "To breathe the word wizard was to unsheathe a sword which mercilessly divided husband and wife, parent and child, banishes the unhappy victim from human society, and places him beyond the pale of tribal law."* This is a very fair description of the blight of witchcraft which hung over the natives like a black cloud. Innumerable acts, perfectly harmless in themselves, could be construed as witchcraft. It was a terrible engine of oppression, cruelty and revenge. The witch doctors were not necessarily cruel or vindictive in themselves, but they knew only too well that their power in the country depended on their playing up to the chiefs. The witch doctors were credited with being able to turn themselves into various animals at will, such as baboons, dogs, bucks or snakes, hence various parts of these

* F. W. Posselt: "Social Conditions of the Natives of Mashonaland." *Proceedings of Rhodesia Scientific Association*, **12** [3], 130.

animals formed part of their stock in trade. I have often been told by natives that they saw wizards at night, and when I inquired what he was like, was informed that he was like a buck or other animal. This shows how deeply rooted the belief is among the natives. Of course there is a great difference in the minds of the natives between witch-finders and witches, though the former are, to our ways of thinking, the real villains. To kill a nocturnal wizard is justifiable, no matter where found. I have heard it stated that they used to go about perfectly naked with their bodies smeared with fat, so that if captured they could not be held fast, and thus were enabled to escape more readily. Witch doctors are most expert eavesdroppers, and do frequently wander about at night for this and other purposes. Natives are very much afraid of the dark, more especially in lonely places, and usually, when travelling, make a great noise to frighten away the witches, and keep up their spirits, so that if a man wanders about by himself at night, there is something uncanny about him, and he is after no good. These nocturnal visits of the witch doctors were often connected with secret poisoning. The terror inspired by such a visit is almost unbelievable. The *modus operandi* in some cases was as follows. The doctor by night tied a bunch of his herbs, which might or might not be poisonous, over the door of the person's hut, or buried them in the earth just before the door. In the morning when the owner saw the bundle, he was inspired with the greatest terror. To pass over the freshly-dug earth or under the bundle was enough to cause certain death. Sometimes he even sickened and died of sheer fright, or took his own life. He was absolutely convinced that his destruction was certain. There was no use in resisting. Often his family was involved in his ruin. If not actually killed they were driven from the district and lost all their property. Why, because they were suspected of being witches.

Wholesale poisoning does not seem to have been practised among these people, as we read of in other places, such as what happened in the West Indies in the time of Pere Labat, who relates that the whole slave population of an estate in Martinique had been poisoned by an Obeah, or witch doctor, who made use of the juices of poisonous plants that grew in the island, and so skilfully was the matter accomplished that the guilt was never brought home to the criminal, until he confessed at the point of death. This was in 1712.

Occasional poisoning seems not to have been uncommon in the old days. Sometimes this was done by the witch doctors to gratify motives of personal spite, or at the bidding of the chiefs who wanted to rid themselves of unwelcome subjects, who might possibly become too powerful. A man who had a grudge against another would go to the witch doctor or herbalist, and obtain from him some poison which he would mix unobserved with the victim's food or drink. Persons suspected of witchcraft were sometimes quietly poisoned without the formality of smelling out.

Two young girls, some years ago, suddenly and mysteriously died at a village, some distance from Bulawayo. They showed signs of poisoning, and the evidence was not sufficiently strong to fix the guilt upon anyone in particular, although suspicion rested on the chief. I heard afterwards that the poison used was *Strophanthus* in such cases, but this may have been merely a guess hazarded by my informant. The people of the place had no doubt the girls were poisoned. Self-destruction by means of poison was not unknown. It is said that Lobengula took his life by poison when he was pursued by the Chartered Company's forces. He always, it seemed, carried about with him a small phial of poison slung round his neck. He took some of this poison, and then laid down and quietly died. Another part of the witch doctor's duty was the detection of criminals. The doctor was often called in by the chief to assist him in such a case. The fact is, the witch doctor was the power behind the throne, not only in name but in reality. The accused person was occasionally obliged to undergo the poison ordeal, or he could demand it. Sometimes it meant the only chance of escape from an ignominious and unjust death. The risk was great, but to the defendant it was worth taking. The prisoner was given an extract of *Datura* or *Elæodendron*, which produced severe vomiting or purging. If he became rapidly unconscious and died without vomiting, he was held to have been guilty, and the medicine was said to have been very good, and the doctor possessed of great skill, whereas if he showed any of the usual signs of the poison he was acquitted, so that in both cases his prospects were not bright, as sometimes the effects of the poison remained for months. In some parts of Africa the poison ordeal was much more largely used than in Rhodesia, as, for example, in Barotseland, Nyasaland and the Congo. Sometimes the doctor would be in collusion with the accused, and for a consideration would give him a weak decoction of the poison, or even give him an antidote immediately afterwards. But I think unless the defendant was a very big man socially, such a thing did not happen often. If the chief wanted to get rid of a man, no matter what his social standing was, he stood a poor chance. We may look upon the poison ordeal as a sort of rough and ready means of dispensing justice. Undoubtedly it was liable to the gravest abuses, and could be used as an efficient means of revenge or murder. The ordeal probably arose out of some such idea as that of distinguishing between the innocent and the guilty. Savages have little inclination to weigh the niceties of legal evidence, and something that brings a quick result appeals forcibly to them.

There are several other poisonous plants used for various purposes, but so far they have not been identified. This is a promising field of inquiry, and much remains to be learnt concerning native poisons and their antidotes. The native doctors say they have antidotes for all their poisons, and their word is implicitly believed by the people. They could not, however, tell me, or rather would not tell me, much about the action of these antidotes, neither could they impart much information as to how they discovered them. I think many of their discoveries in the realm of toxicology have been purely accidental, and I presume that the same applies to antidotes also. A highy qualified medical practitioner is required to take up this branch of inquiry, and do it thoroughly; one with plenty of time and means at his disposal. Much of value would be learnt, not only to the profession but to the public generally.

VARIABILITY OF URANUS.—A series of photometric observations undertaken by Mr. L. Campbell with reference to the light of the planet Uranus is recorded in *Harvard College Observatory Circular*, No. 200 (1917). The measurements showed that the light of the planet varies by about .15 magnitude in a period of .451 of a day. This period agrees with the period found for the *rotation* of Uranus by the late Prof. Lowell and Dr. Slipher by means of the spectroscope, so that the two periods were arrived at entirely independently. The conclusion is, therefore, that the variation in light is due to unequal brightness of different portions of the planet, and further photometric measurements will be able to show whether the variations in brightness are permanent.

A RED AURORA.—The *Journal of the Royal Astronomical Society of Canada** has a description of a brilliant red aurora seen in British Columbia on the morning of the 4th January. It was first noticed at 4.45 a.m., and at 6 a.m. the sky was still covered by the aurora, but over half of it was a brilliant red. The corona towards the east and south-east was red for about a third of the way down to the horizon, but towards the south, south-west, west, and north-west it was red all the way down, giving the snow and everything else the appearance of being red. That part of the aurora which was not red was tinged with colour, the waves of red, white, and mixed colours sweeping across the sky, and circling round in a most wonderful manner, and with a most beautiful effect. In the United Kingdom the aurora was seen on the evening of January 4, at widely distant stations.† The Rev. W. F. A. Ellison, F.R.A.S., who observed it near Waterford, described it as a particularly magnificent display. From Edinburgh it was also observed as a fine exhibition, extending along a considerable range of the northern horizon, and at Bristol it was conspicuous in spite of the unusual brilliancy of the almost full moon. At Radcliffe Observatory, Oxford, a very fine display was noted at 10.15 p.m., simultaneously with the appearance of a brilliant fireball, which ran rapidly downwards from the direction of the moon, and burst. with a blue colour, about 12 degrees below Jupiter, and emitted a light distinctly more intense than that of the moon.

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* 11 (1917) [3] 124. † *Nature*, 98 (1917) 397.

BIRD LIFE IN THE MIDLANDS OF NATAL.

By James King.

A good many years ago I was induced to buy a book, entitled "The Earth, as Modified by Human Action," by George P. Marsh, an American author. All through it is a work full of interest, and replete with many astounding facts, which must appeal to even the casual reader, and go far to shew that great changes, not only in a phyhical sense, but also to the habits and distribution of the fauna and flora of the world, is due to human action. The writer proposes in this short paper to confine its scope to a short study of bird life in the midlands of this Province, on observations extending over half a century. Natal is somewhat unique in some things, and among others in having a climate which varies in less than 100 miles from the subtropical coast to the almost British climate of the midlands as far as temperature is concerned. These varied conditions are not confined to climate alone, but in the one case wood and thick jungle; in the other, open or alpine country, with timber here and there in the kloofs, and on the hills, heavy forest in some localities, but still, between the two, a clear interval of open country. Under such conditions, birds whose habitat was in the warmer and timber-protected parts of the Province, would not readily become denizens of the colder and opener parts of the country unless the country itself had undergone some change in its physical conditions. This, to my mind, has been brought about by the gradual connecting up of one part of the country with the other by tree-planting round homesteads, and more especially by wattle plantations. This subject will be treated under two heads, *viz.*, the appearance and the disappearance of birds within certain localities from causes which, in the opinion of the writer, have been brought about by human action, either directly or indirectly.

1. *Game Birds—Bustards.*—At one time several kinds of these birds were found in considerable numbers, especially the "Stanley Bustard." *Neotis caffra* and *Heterotetrax vigorsi* (Korhaan) both have practically disappeared, and as they are preserved birds, this cannot well be attributed to the work of the sportsman, but probably to the grazing down of the open country, exposing the eggs and young birds to the ravages of other birds of predatory habits, and also to the country being more timbered than it used to be, as all birds of this species affect the open country. The same causes have undoubtedly much to do with a gradual decline in the numbers of the redwing partridge (*Francolinus levallianti*), quite apart from the action of the sportsman, also the crowned plover (*Stepanilyx coronatus*). From the same causes guinea fowl (*Nimida coronata*), from being unknown in the early days in this district, has become quite numerous, and probably the most so of any of the game birds

of Natal. This is easily traceable to the increase of tree-planting and connecting up of the thorn country—their original habitat—with the high lands by means of the extensive wattle plantations. This increase of cover has also to do with the appreciable increase of the red-necked bush partridges (*Pternestes nudicollis*).

Pigeons.—Of late years there has been a rather notable disappearance of the blue-rock pigeon (*Columba phœnota*); whether this is the consequence of a preference to the open country or to some other cause, the writer is not prepared to say, but the fact still remains that these birds, which at one time were in large flocks, are now rarely seen. On the other hand, at least three of the other kinds of Columbidæ, notably the "black pigeon" (*Columba Arquatrix*), has much increased of late years, as at one time they were a rare bird locally, and essentially belonged to the coast and the more wooded parts of the Colony. These remarks also apply to the Senegal turtle-dove (*Turtur Senegalensis*), the small coloured turtle-dove, *Turtur Capicola*, and the beautiful little long-tailed dove, *Œna Capensis*, all of which were at one time denizens of the warmer and more-wooded coast and thorn country.

Herons and Cranes.—The common heron (*Ardea Cinerea*), has certainly become more plentiful since some of the up-country rivers have been stocked with trout, as formerly it was a very uncommon bird in these parts. Its destructiveness to the young fish is well known. Only a short time ago a gentleman told me that on shooting one of these birds he took a number of small trout from its crop. On the other hand, the Great Wattled Crane (*Bugeranus Carunculatus*), which at one time was quite a common bird, is now rarely seen: this is probably caused by swamps being largely dried and drained for agricultural purposes. A similar scarcity is to be noted of the beautiful crowned crane (*Balearica Crepopelargus*), from probably the same reason.

Rooks and Crows.—The lessening of the numbers of the common rook (*Heterocorax Capensis*) is difficult to account for, unless it be that some introduced plant or weed, of which there are many, is fatal to them as food; this is, of course, only a conjecture. The white-necked raven (*Corvultur Albicollis*) has almost, if not quite, disappeared, and in "Natal Bush Birds" (Woodward), this seems to be coincident with the rinderpest, in which opinion I agree, this being a carrion-eating bird. And there has certainly been a very marked lessening in the numbers of the common vulture (*Gyps Kolbi*) since the prevalence of East Coast Fever among cattle.

Cape Starling (*Spreo bicolor*).—This bird, which is now to be met with in thousands in the Midlands, at one time was almost, if not entirely to be met with in the thorn country or its environs. Originally I think it lived on ticks or kindred insects, and it was not until cattle in the higher districts of Natal became more numerous and tick-infected that this bird took up its habitat in the upper midlands, and since its almost phenomenal increase in numbers it has become less an insect-eater and more fond of small fruits, and occasionally attacks turnips, cabbages, etc., making holes in them and doing serious damage. One very noxious weed is being spread to an alarming extent by them. This is an exotic, I think, of Indian origin, generally known as the "inkberry" (the botanic name I do not know), but the birds I mention feed on the berries at a certain time of the year, resulting in a spread of this weed over the whole country. It has a strong herbaceous stem, sometimes 6 feet high, with a tough fibrous root, often strong enough to defy a strong disc plough. This bird is of the starling tribe, and it is rather remarkable that its original congener, *Amydrus morio*, which used to be seen in large numbers, is now seldom to be met with.

Of aquatic birds, the appearance of the cormorant, an essentially sea bird, in the fish-stocked rivers of the uplands, often 120 miles from the sea, is to be specially noted. I cannot quite place this bird, but am of opinion it is either *Palacrocorax Capensis* or *P. Africanus;* they have come for the same reason as the heron, and causing havoc with the young trout, some of these birds have been shot on the Upper Mooi River with their crops full of young fish. Spur-winged goose (*Plectopterus gambensis*): This bird in the early days was rarely seen, but since cultivation became more common on the banks of the larger rivers, they have made their appearance, sometimes in large flocks, doing much damage to mealie crops. Change of habit has been noticed in some of the afore-mentioned birds, a condition that often results in birds becoming a nuisance from a previously harmless character. One of them, the large ground hornbill, generally known as the turkey buzzard (*Bucorax Caffer*) is another instance, with its well-known change to predatory habits from living on snakes and lizards and similar prey, to the destruction of young game birds of all kinds, even in raiding farmyards in search of young chickens. A neighbour, on going round the farmyard in the early morning, was just in time to see the last of a brood of turkey chicks being devoured by some of these marauders. Snakes and other reptiles are lessening in numbers, and the bird takes to feeding on something else.

Of the smaller birds that have taken up their habitat in the upper midlands of late may be mentioned three kinds of shrikes, *viz.*: *Buchanga Assimilis*, *Grancalus Colsius*, and *Laniarius Sulphurepectus*, all of which at one time were unknown in this district. Of birds of prey, some have almost, if not quite, disappeared, notably some of the larger kinds, two of which deserves mention, *viz.*: Batleur's eagle (*Helotarsus ecaudatus*) and the crowned hawke eagle (*Spizætus Coronatus*). The former lived almost entirely on mice and other small vermin, the grazing down of the pasture lands reducing the numbers of mice and rats. The latter has probably been reduced by the shot-gun, as it was destructive to poultry and young game. How far-reaching the consequences of "human action" may be, can hardly be discounted without going more deeply into the question, but sufficient has been said to prove that changes of a not insignificant character are being carried out by the agency of birds, which in their turn have either been extirpated or propagated by human action, especially on the one hand by lessening the destruction of noxious insects, and on the other by the spreading of some of the worst weeds the farmer has to contend with,* and I cannot conclude this paper without putting forward a strong plea for the preservation of such birds especially known as insect destroyers, as well as adding beauty and interest to the country. We hardly know as yet what far-reaching consequences may follow on what is sometimes a thoughtless disturbance of the "balance" of Nature, and which not infrequently has an adverse effect on the welfare of the human race—surely a strong reason against the indiscriminate destruction of the feathered denizens of the country.

NOTE.—For the technical names of the birds mentioned I am indebted to "Natal Bush Birds" (Woodward).

SPECTRUM OF THE SOLAR CORONA.— In the Report of the Council of the Royal Astronomical Society, made to the 97th Annual General Meeting of the Society, it is stated that the discovery of a new red line in the coronal spectrum during the eclipse of August 21, 1914, has led to an important extension of Nicholson's theory of the spectrum of the solar corona. It was first noted by Carrasco that this new line, $\lambda 6374$, was a member of the same cube root series as the green line $\lambda 5303$, and Nicholson has deduced therefrom that the atom of the element coronium is a simple-ring system with nucleus $7e$. When it has eight electrons, or a single negative charge, it emits the lines 6374, 5303, 4566, 4359, 3642, 3534. The neutral and positively charged atoms yield lines which are outside the range of observation. All the remaining known lines of the corona have previously been assigned by Nicholson to protofluorine.

*The foregoing remark leads the writer to the conclusion that the change of habitat in the birds mentioned (environment) has more to do with it than climate, and following on the premises, that these changes often lead to others, which, in some cases it must be admitted, may be brought about by ordinary migration. Some time ago I noticed that a naturalist, in examining the feet of a grouse (*Lagopus Scoticus*), found a dozen or more seeds of plants adhering to its feathered feet in nodules of clay, and round my own homestead, among the ornamental trees, nearly every known tree in the adjoining bush is represented by the upspringing of young plants. I have also noticed that of recent years the large mimosa, generally known as the "camel thorn," is spreading into the midlands; specimens may now be seen as far up as Lion's River and Dargle Road stations—a tree that was quite unknown in these parts, the seed of which must have been carried by birds from the thorn country.

OUR NATIVE BIRDS: THEIR VALUE TO MAN.

By F. W. FitzSimons, F.Z.S., F.R.M.S.

In the economy of nature, birds take a very considerable part. Throughout all forms of life, from the humble creatures which are mere spots of transparent jelly, upwards all along the line to the highly evolved subhuman animals, nature guards against undue increase by so ordering things that those forms of life which increase most rapidly have the largest number of enemies.

Man fondly nurses the erroneous belief that he is the dominant animal upon earth. True, he has acquired a considerable measure of power and dominance, and persecutes and slays the lower animal life around him in a most unreasoning manner. Knowing no better, he destroys friend and foe alike.

The real lords and masters of the world are the insects. With his many inventions, man wages a constant warfare upon the Insect Army, which is seeking to drive him from the face of the earth. The numerous allies which the Creator has provided to aid him in his struggle for life are doing most of the fighting, however. Man's puny attacks would do about as much damage to the insect enemy as shooting into a flight of migratory locusts with a single rifle.

Insects breed with astonishing rapidity, and when from any cause, their natural enemies are diminished in numbers, they increase and become a plague.

Over 300,000 species of insects are already known, and new kinds are being discovered every day. These vast uncountable hordes live upon vegetable and animal life. If we had the power to exterminate all the natural enemies of insects, and exercised that power to the full, then, within a period of five years, the insects would have swept the entire world bare of vegetable life —yes, as bare as the Sahara Desert. Every living creature is dependent, either directly or indirectly, on plant life, and the world would, without it, become a barren, uninhabitable waste. Man is indeed a provokingly unreasoning animal, for he, as a general rule, does not avail himself as he should of the knowledge of men of science. To bring about many of the reforms for the protection and general betterment of the individual and the race, it is usually necessary to employ compulsion in the form of legislation. Until the education of the children takes a more practical turn, the human race will continue to blunder on and evolve to higher intellectual and spiritual planes at an exasperatingly slow pace.

Insects have hosts of enemies other than our feathered allies, but if we exterminated the native birds, the human population of South Africa would, in a few years, be reduced to a condition of starvation.

The fecundity of many species of insects is staggering to the imagination of even an astronomer. For instance, one Hop

Aphis, if allowed to breed unchecked, would develop 13 generations in a single year, and at the end of the 12th generation would have bred an army of ten sextillions of aphides.

Forbush has worked it out, and says if this uncountable army was marshalled in line 10 to the inch, it would extend as far as the great star Sirius, which is so far away that if a man could travel at the rate of light, which is 184,000 miles per second, the journey from the earth would take him 8.6 years.

Kirtland, too, has carefully worked out the rate of breeding of the Gypsy Moth, and states that if a pair of these moths and their progeny were allowed to breed unchecked for eight years, they would strip the entire United States of America of vegetation.

A Colorado Beetle, or Potato Bug, would, if unchecked, multiply in one season to the number of 60,000,000. It can thus be realized by even the dullest intellect, that at this rate of multiplication the Colorado Beetle would very quickly exterminate the potato plant.

The Migratory locust, for instance, if allowed to lay its eggs and breed unchecked, would in a few years make farming an impossibility. Aye! it would sweep the entire country of vegetation and convert it into a barren, useless desert.

The tick is another insect scourge. It is parasitic, and feeds on the blood of animals. It reduces the condition of stock animals more or less seriously, and is an active agent in carrying disease germs from one animal to another.

The female tick lays from 2,000 to 18,000 eggs, according to the species.

If all our tick-eating birds were destroyed and dipping suspended, these terrible pests would kill off every stock animal in the country. On taking up my residence in a house at Port Elizabeth surrounded by large grounds and gardens, I was amazed to find the place a paradise of insect life. The flowers and vegetables which I planted were completely eaten off before reaching maturity. Prior to my tenancy the house was uninhabited for two years, and boys had been in the habit of roaming at will about the premises with catapults and air-guns, murdering any and every bird they could find. Others searched the bushes for nests, intent on robbing them of their contents. The place became a sanctuary for birds on my advent, and within a year the insect army of occupation was annihilated.

Insects not only breed with astounding and disconcerting rapidity, but their powers of eating are, if anything, still more amazing. A caterpillar will eat two or three times its own weight of vegetation every day. This, on first thoughts, does not seem so very astonishing, but if applied, for instance, to a horse, it would mean the animal would require a ton of food every 24 hours to satisfy its hunger and provide for its growth. A man weighing 150lbs., eating twice his own weight of food, would need a daily ration of 300lbs.

The appetite of the vegetation-eating caterpillar is, however, dwarfed into comparative nothingness by the colossal eating powers of some of the carnivorous larvæ. One of them, for instance, will devour 200 times its original weight in 24 hours.

If a caterpillar eats an ounce of vegetation a day, one can well imagine what a quantity of produce the offspring of a few moths or butterflies would devour in a season, if every egg was allowed to hatch and the caterpillars permitted to live their allotted span of life. The actual bulk of vegetation devoured is not the only mischief wrought by insects. Hosts of species of insects pass the first or larval stage of their lives underground, and feed on the roots, and consequently destroy the life of the young plant.

Man with all his weapons of defence could not withstand the onslaught of the insect hosts a single year without the aid of the allies which he ignorantly persecutes, in the front rank of which are the birds. Yet, strange to say, man, who claims by reason of his mental superiority to be the lord of the earth, is either directly or indirectly destroying the creatures which the All-wise Creator has provided to help him in his struggle for food and life against the most formidable of his enemies—the insects and their near relations which, although not true insects in a scientific sense, are popularly grouped as such.

Man, who claims to be guided by an educated intellect, deliberately attacks his allies instead of acting in co-operation with, and safeguarding them in every way in his power. Lack of the right kind of knowledge is undoubtedly the tap root of the evil. Boys and girls leave school knowing little or nothing at all about the Natural History of the country in which they dwell. A few pick up some knowledge of the ways and habits of the lower forms of life, but the vast majority go forth to persecute and slay the creatures which are striving to make the lot of man a brighter and happier one; nay, more, which are making it possible for him to live and enjoy the fruits of his toil. In his orchard and garden, man can, to a limited extent, keep the insects in check with various insecticides which are, after all, unnatural and expensive, and often dangerous Even with these aids, he is frequently overwhelmed. When his crops, his pasturage, and his forests are invaded by ravening hordes of insects, his offensive collapses and his defences are demolished. He sits in his home, curses, blames Providence, the Government, or thinks the visitation a Divine punishment for his sins. In this latter surmise he is not far wrong, for it truly is a chastisement for his sins and those of his neighbours in allowing his friends and allies, the native birds, to be done to death, or driven to seek less dangerous hunting grounds.

Insects are attacked by parasites, diseases and fungi, and some kinds prey upon others, but all these natural checks, with the fight put up by man, are altogether and entirely inadequate to prevent insects from developing into uncountable ravening hosts and sweeping all vegetable life from the face of the earth.

Insects are preyed upon by some small mammals, by lizards, toads, and other reptiles, but their arch-enemy—the foe which keeps them in check— is our feathered ally, the bird. Destroy the birds and all the other foes of insects could not prevent them from carrying all before them by sheer force of numbers.

Why are birds indispensable allies in our desperate efforts to stem the advance of the insect Huns? Because the food of the vast majority consists of insects, and the seed-eating species, with but few exceptions, feed their young solely on an insect diet.

Is it then a matter for wonder that outraged nature scourges us so severely? We deserve it surely! There are sins of omission and commission—both are equally far-reaching in their results.

We are hypnotised by the belief that it is necessary to have our children's mind filled with what might be termed "the ballast of the ages," in order that they may seemingly possess some little veneer of hot-house so-called culture. There is no time left in the children's lives, or no desire on the part of the parents to have them taught those things which are necessary for them to develop into useful and progressive citizens of the State, and to enable them to pilot their way through life with the minimum of mishaps and disasters. To study nature is to study the works of God. It is eminently practical in every sense of the word, and is also a powerful factor in the awakening of the moral and spiritual nature of man.

Why have so many of the human race degenerated into mere money-making machines, with intervals of leisure for the gratification of their animal passions and desires? Chiefly because their minds have never been awakened to a realisation of the fairyland around them opened up by a study of Natural History.

What is sport to man is often death or persecution to some creature which, more likely than not, is a valuable ally, but he knows it not. Since the invention of the gun, man has been engaged upon the deliberate and wanton upsetting of the balance of nature. He ventures where angels fear to tread, not because of his bravery, but by reason of his want of knowledge. Knowing no better, he allows his children indiscriminately to maim and kill the wild birds and rob their nests. He hands down to them erroneous, mischievous and harmful beliefs in regard to the sub-human inhabitants of veld, mountain, forest and stream, which results in the persecution of the creatures which are helping him in his battle for life.

For instance, it is popularly believed that the harmless little Geko Lizard is venomous. The result is, this highly useful insect-eater is killed at sight. So much for the wisdom of man.

Conversing with a lady school teacher from an up-country dorp, I expressed regret at the profound ignorance of Colonial children on the ways and habits of the wild creatures of this country. She admitted the fact, but was eager to inform me she encouraged the boys in the school to learn Natural History. "One boy," she declared, "had made a wonderful collection of birds' skulls." "How did he procure the skulls," I queried. "He went on excursions and killed the birds with a shot-gun," she replied. "Other boys," she declared with pride, "collected birds' eggs, and had really lovely collections." "I suppose they always took the entire clutch of eggs every time," I asked. "Yes! oh yes! They were so eager, you know, and so jealous lest their rivals should get more eggs than they." I left her presence thinking it would be much to the advantage of South Africa's people if she and those of her kind who deliberately encouraged the wanton destruction of bird-life were chloroformed.

In South Africa there are about 921 species and sub-species of birds. Of this great host, not more than a dozen species can be said to be harmful to man without sufficient redeeming qualities from an economic point of view to justify their preservation. There are some which, when judged from a broad standpoint, are beneficial to man as a whole, but which are a pest to individuals such as fruit-growers and stock farmers.

The Colies or Muis Vogels, and the Bulbuls, for instance, are foes to the fruit farmers, and the larger birds of prey can expect no mercy from stock and poultry farmers.

When any creature is destroyed which acts as a check on another, the inevitable result is a multiplication of the latter. The destruction of a pair of breeding starlings, for instance, which involves the death of 4 to 6 nestling birds, means an increase of a minimum of 30,000 caterpillars and grubs within six weeks. These caterpillars soon reach the adult condition, change into chrysalises, and emerge as moths, butterflies and beetles. Each of the females lays thousands of eggs, which bring forth a vast and destructive army of larvæ, and from the 30,000 caterpillars and grubs there will arise in a few short months an uncountable host. All because of the thoughtless or wanton destruction of a pair of breeding insectivorous birds.

Many years ago the English Press gave colour to the erroneous and stupid belief that owls were birds of ill omen, and that they were destroyers of chickens and useful birds. The superstitious and credulous farmers, believing these false statements, mercilessly persecuted the owls, and the survivors retreated to the wilds. The following season loud and bitter were the complaints about the damage done to the crops and young poultry by rats and mice. The second season proved still worse, and many a farmer was utterly ruined.

James Buckland, whose life's work has been largely devoted to spreading knowledge in regard to the economic value of birds, relates several instances of the serious consequences attendant on the indiscriminate destruction of wild birds, which are briefly as follows:—

In the Island of Bourbon the people, impelled by erroneous beliefs and superstition, set a price on the Martin's head. The birds were nearly annihilated, and as a consequence, grasshoppers overspread the island, and the people were frantic with fear lest they should perish. It was, indeed, fortunate for those foolish people that the Martin was not quite beyond recall. Every encouragement was given these birds, and swift fell the punishment on anyone who persecuted them. The Martins, finding an abundant food supply, increased rapidly in numbers, and the devastating hordes of grasshoppers were destroyed.

In the year 1861 the harvests of France were very poor, and the Minister for Agriculture appointed a Commission to investigate the cause of this alarming diminution in the crops throughout the country. The Commission attributed the unusually poor return to the ravages of insects. It seems the birds which had been keeping the insects in check, had been shot, snared and trapped throughout the country in such numbers that the survivors were unable to maintain the balance of nature, and the insects multiplied and overspread the land to scourge man for his ignorance and folly. This Commission reported that they could suggest no other remedy against the ravages of the insects than for prompt and energetic legislation to prevent the destruction of birds.

For some years prior to 1877 the farmers of Nebraska were in the habit of poisoning the Blackbirds during the spring and autumn around the cornfields, because they believed this bird was damaging the crops, particularly the wheat. Large numbers of Prairie Chicken, Quail, Plover, and various other species of eminently useful birds were destroyed at the same time, by eating the poisoned grain.

Again outraged nature arose and smote those unreasoning farmers in the form of countless hosts of locusts which swept the land bare of crops and pasturage. "As ye sow, so shall ye reap."

In the year 1815, in the region of Ekaterinburg, in Russian Siberia, two species of cut-worms, and about ten species of locusts devastated the countryside, and the farmers were in despair, for there was famine throughout the land. The local Society of Natural Sciences carefully investigated the cause, and declared it to be due to the almost complete destruction of the native birds which had been killed and their plumage sent abroad to gratify the vanity of so-called civilized women.

The tick is a living ever-present nightmare to the farmer. Knowing its disease-carrying propensities, he never can tell when it may infect his flocks and herds with a disease that will destroy, perchance, the majority of them. The tick is the most formidable enemy with which the stock farmer has to contend.

With but few exceptions, the ground birds feed more or less on ticks. Some species of birds, such as the Tick Birds (*Buphaga*) take them direct from the cattle, but the majority feed upon them on the herbage and ground. When a female tick has gorged herself with blood she drops from her host and crawls away to seek a suitable place in which to deposit her eggs. These blood-gorged ticks are eagerly sought after by birds which frequent the grazing grounds of cattle to seek for them. Every female tick so destroyed means the destruction of thousands of eggs. For instance, a quail, partridge, guinea fowl, lark, rail, starling, or any one of the many tick-devouring birds, in a single season is capable of killing vast swarms of ticks directly or indirectly.

I have found as many as 50 gorged female ticks in the crop of a single cattle egret (*Bubulcus ibis*). Taking the minimum number of eggs laid by one of these ticks at 2,000, we have the tremendous total of 100,000. In the crop of a quail, eight of these mature female ticks were found. This, multiplied by 2,000, makes a total of 16,000 ticks accounted for by one bird in a day; or during the course of the spring and summer the colossal number of three million ticks would have been accounted for by one quail.

Twelve Crowned Lapwings (*Stephanibyx coronatus*), or Kiewitjes, as they are popularly termed, were shot during December on a cattle-frequented veld. Nine of these contained an average of 5 blue female ticks distended with blood or eggs. Again, taking the minimum number of eggs laid by each tick at 2,000, we have a total of 10,000 ticks accounted for by each of the five birds in one day. In three months these birds, eating female ticks at the rate of five per day, would account for a million. If these had survived, and taking half their number to be females, the following season they would have totalled something like 6,000,000,000.

In French West Africa the unrestricted shooting and trapping of the guinea fowl has resulted in epidemics of germ diseases amongst the native tribes, and the destruction of crops by beetles, cut worms, grubs, and locusts.

The wholesale destruction of native birds is followed by disaster to man as surely as day follows night. Man idly, wilfully or ignorantly brings about the cause, and he suffers the effect to the full. To-day he has men of science who are capable of guiding and teaching him how to avoid most of the set-backs he gets in his journey through life, but he heeds them not.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, October 14th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*The prospects of the carbonisation of coal, with by-product recovery, as a South African industry*": S. B. **Bilbrough.** After a brief enumeration of the primary and by-products obtained from coal by means of gas producers, coke ovens, and town gasworks, the author discussed the prospects of coal carbonisation as applied to South African coals. The prospects of obtaining ammonium sulphate on a large scale in the production of power gas were dealt with exhaustively. It was pointed out that South Africa possesses one of the cheapest coals in the world at the pit's mouth, and that this fact, coupled with the abundance of the coal, the geographical situation of the country relatively to the large demands of India and the East, and the richness of South African coal in nitrogen, should combine to make an ammonium sulphate industry in South Africa highly promising. The author also discussed the production of coal-tar in connection with gas works, and pointed to the large market in South Africa for road composition.

Saturday, Novemer 11th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Note on bolted timber joints*": W. **Alexander.** In the case of a tension joint, consisting of a middle piece of timber and two side pieces, the distribution of the transverse pressure of the wood on the bolt was briefly discussed, and formulæ were obtained (1) for the thicknesses of the side and middle pieces and the diameter of the bolt, and (2) for the strength of the bolt per joint.

Saturday, December 9th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Boiler house operation and maintenance; with special reference to the Rand Power Companies' Plant*": T. G. **Otley.** and V. **Pickles.** The methods of boiler house operation and maintenance adopted at Brakpan, Simmerpan, Rosherville, and Vereeniging were described, and the results of efficiency tests were set out.

Saturday, January 13th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Recent developments of the Whiting hoist as applied to deep winding*": B. **Gray.** and J. **Whitehouse.** Experiments and developments carried out at the Village Deep Mine in winding with Whiting Hoists were described, and an account was given of the winding plant originally employed, and of the steps which led up to the conditions at present existing. The possibilities of applying the improved system in the future to deep winding were discussed.

Saturday, February 10th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*The deterioration of Curtis Rateau Turbine blading*": A. **Fenwick.** The author supplied information and placed on a record data summarising his experience, with regard to the behaviour of certain materials used in turbine blading, gained during the last six years in operating and maintaining the turbine plant of the Rand Power Companies. All necessary particulars regarding the design of this plant were included.

South African Institute of Electrical Engineers.—Thursday, November 16th: Professor W. Buchanan, M.I.E.E., President, in the chair.—"*Electrical system of the Rand Power Companies, with special reference to methods of operation and experience*": B. **Price.** The lay-out and characteristics of the electrical portion of one of the largest power schemes of the present day was described, and commented on, in the light of experience gained on that scheme by the author during a period of seven years.

Thursday, December 21st: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*Some notes on efficiencies and costs of steam and electric winding plant*": H. W. **Clayden.** The relative efficiencies and power cost of three winders—two electric and one steam—working on mines under the control of the General Mining and Finance Corporation were dealt with. It appeared that, for surface winding, given the same capital cost for installation, and the present ruling high power rate on a low-load factor, steam is the cheaper power with a load factor below 35 per cent., and electricity above 35 per cent. From figures obtained on hoists on the group of mines the above conclusion appears to hold good for hoists up to 800 h.p.—"*Comparison of Ward-Leonard and Three-Phase Winding Systems*": S. E. T. **Ewing.** The conclusions reached by the author were that for shaft-sinking either type is equally effective on all points at approximately equal capital cost; that for rock-winding from one level, the capital cost is lower in the case of the alternating current system, and both systems afford equal safety and ease in handling; where even running is secured by means of tail ropes, relative economy depends on the frequency of winding, but in absence of tail ropes and for rock-winding from several levels, for raising and lowering men, lowering supplies, and dead slow winding the three phase winder in each case involves lower capital cost, but the Ward-Leonard is more economical and easier to handle.

Thursday, February 22nd: W. H. Perrow, M.I.E.E., President, in the chair.—Presidential address: W. H. **Perrow.** The early history of the induction coil was reviewed, its subsequent development traced, the construction and operation of the modern type of apparatus referred to, and some of its applications recounted.

Geological Society of South Africa.—Monday, December 18th: P. A. Wagner, B.Sc., Ing.D., President, in the chair.—"*Graphite-bearing xenoliths from the Jagersfontein Diamond Mine*:" Dr. P. A. **Wagner.** Nodular xenoliths of the cognate type, presenting in their mineralogical composition an extremely wide range of variety, are rather abundant in the blue-ground and Kimberlite of the Jagersfontein Mine. Among them nodules containing graphite seem to be by no means uncommon. Two specimens were described by the author, the contained graphite being identical in physical properties with the graphite found in a garnet-pyroxene nodule from the Premier Mine, described by the author in 1911.—"*The alteration of the dolomite at the Northern limeworks, near Potgietersrust*": Prof. R. B. **Young.** The rock quarried at the limeworks belongs to the Dolomite Series, and is normally a magnesian limestone, containing approximately 52 per cent. of calcium carbonate, while the rock quarried contains more than 90 per cent. The changes which the rock had undergone were indicated, and an explanation of its abnormal composition was offered.

Monday, January 29th: P. A. Wagner, B.Sc., Ing.D., President, in the chair.—"*Some problems in South African Geology*": (Presidential address) Dr. P. A. **Wagner.** Four problems, which have, in the past, greatly exercised the minds of South African geologists, were discussed in the light of the latest investigations. These were: (1) The problem of the auriferous conglomerates of the Witwatersrand, (2) The genesis of the diamond; (3) Is the diamond susceptible of alteration under the influence of the agencies operative or specially active at or near the earth's surface? (4) The salt pan on the farm Zoutpan, No. 467, north-northwest of Pretoria.

South African Association of Analytical Chemists.—Thursday, February 15th.—J. McCrae, Ph.D., F.I.C., Vice-President, in the chair.—"*Blast furnace possibilities in South Africa*": R. V. **Crake.** The author instituted a comparison between the materials used in Scotland for the manufacture of pig-iron with those available in South Africa, and arrived at the conclusion that with certain adaptations it was possible to start a blast furnace industry, and that the time is opportune.—"*Non-routine steel analysis*": W. O. **Andrews.** A review of various methods of steel analysis useful in laboratories where such analyses are only occasionally required.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, February 17th: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*New Applications of Thymolphthalein and Naptholphthalein, including Rapid Methods of Analysing Limestone and Ammonium Salts*": Dr. J. **Moir.** Three analytical methods were described: (*a*) A rapid method of analysing limestone by titration. The acid equivalent of the CaO and MgO together are first determined, and the CaO subsequently found by subtracting the MgO, whose determination is based on the fact that magnesium hydrate, when coagulated by boiling, ceases to affect thymolphthalein, although it still colours phenolphthalein. (*b*) New method of determining ammonium salts by titration. By this method ammonium may be determined in its neutral salts when present in explosives, fertilisers, etc., without distillation. The solution is titrated with sodium hydrate in presence of thymolphthalein, which turns blue when the equivalent of the ammonia present has been added, the indicator remaining unaffected by the ammonia set free. (*c*) Determination of true neutrality in waters by means of mixed indicators. The mixture recommended comprises methyl red and α-naphtholophthalein. This mixture will detect 1 part of H_2SO_4 and 2 parts of $Ca(OH)_2$ in 1,000,000 parts of water.

GAME AND GAME PRESERVATION IN ZULULAND.

By F. Vaughan-Kirby, F.Z.S.

It is proposed in this paper to deal with the above subject in concrete form, and in its relation solely to the game of Zululand rather than to view it in the abstract, and to endeavour to set forth the conditions obtaining at the present time in that portion of the Natal Province which is perhaps the only place in the world where actual large game may be encountered within fifty miles of a rail-head, distant only twelve hours' journey from a large and thriving coast port.

With this object in view, but few remarks will be introduced upon what is termed the sentimental aspect of the question; a brief summary of the laws which have been passed from time to time to regulate the destruction of game since the inception of the work of preservation will be presented, to be followed by a short description of the Zululand Game Reserves.

The tsetse-fly borne disease known as Nagana, will, of necessity, be touched upon, but entirely from the view-point of the ordinary lay observer.

It will be impossible to cover all the above ground without introducing contentious matter and perhaps treading upon someone's toes. But it will be my endeavour to deal with the former in a fair and non-controversial manner, while as regards the latter I will try to tread as lightly as possible.

As a keen student and lover of wild life, it is my earnest desire that a *modus vivendi* should be established between the supporters of game preservation and those *bona-fide* settlers whose position has been the cause of the principles upheld by the former having entered the realms of somewhat bitter controversy.

The subject of game preservation is one which, over and over again, has been dealt with by able and sympathetic writers, men whose earnestness of purpose and sincerity cannot be called into question, and who, in the face of continued and often unreasoning opposition, and not a little ignorant abuse, have loyally upheld their convictions.

They have contended that it is a duty which those of the present generation owe to their successors that they hand down to them for their pleasure and enjoyment some, at least, of the many beautiful forms of animal life, the contemplation and study of which has brightened the lives of thousands in the past and present, and has no greatly enriched the stores of scientific knowledge.

Arrayed in opposition are two classes of residents, having little or nothing in common otherwise, the one consisting of those whose honesty of purpose can no more be doubted than that of those whom they oppose, who have no real desire to see game exterminated, and who only hesitate to cease their opposition because of their doubts as to what may be the economic results of preservation.

The other is very differently constituted, people whose motives are almost entirely personal and selfish, and those who speak and act through ignorance, an ignorance which frequently displays itself in loud self-assertiveness.

The former class have hitherto evinced a praiseworthy desire to arrive at a mutually satisfactory understanding with the powers that be on the basis of the preservation of game in such manner that it shall not constitute a menace to their domestic animals.

During the last fifteen years much useful work has been accomplished by the champions of protection, particularly in the Transvaal, and some check has been placed upon the wholesale and cruel slaughter of wild game.

Nevertheless, it has to be admitted that, as regards Natal at any rate, we stand, as it were, at a parting of the ways, and that the cause of protection never stood in more urgent need of thoughtful, unprejudiced, but withal strenuous support than at the present moment.

Few people, it may be asserted, realise how sure, though gradual, has been the disappearance of the wild fauna of the sub-continent during the past fifty years. Even those whose experience only carries them back a dozen years, and whose knowledge is concerned with but a limited portion of the country, cannot be blind to the existence of this process of extermination, while those who have wandered afar during the past twenty-five years, and who remember the amazing wealth of animal life of which the country boasted even in those days, stand aghast at the dismal tragedy which is daily being enacted.

The former can no more grasp the reality of the profusion of wild game as it existed twenty-five years ago than the latter, in their earlier days, could realise that its extermination would ever be as nearly complete, relatively, as it is now.

The humane man, and more particularly the true lover of nature, can but feel infinite regret for the purposeless waste of life which has been going on ceaselessly during the last two generations, and which has deprived the Continent as a whole, and the southern portion in particular, of one of its grandest assets, and of one of its most valuable educational media.

And if it is persisted in the writer can already see, in imagination, a country which once boasted the possession of an apparently inexhaustible wealth of faunal life become a void and lifeless waste.

There is no unprejudiced person but will admit that while this country possesses scenic beauties in its mountain regions, and in many of its tropical parts, the vastly greater portion of its land surface is dull and uninteresting, and that where it is otherwise, it is almost solely due to the presence of animal and bird life. Under that spell the most desert regions become charmed and quickened into beauty, and keen interest and pleasure supplant dullness and monotony in the heart of the beholder.

The writer cannot but believe that if the attention of the thinking and observant public in this country could be seriously directed to this subject—if the certain results of inaction, indifference, neglect, and, worse still, of opposition to the principles of game protection could be brought home to them, a large majority would surely rouse themselves to find that *modus vivendi* by which the hateful conditions above suggested might be staved off at a minimum risk to themselves and their interests.

That the Government of Natal has not been backward in falling into line with other Administrations both within and without the Union a glance at the history of game preservation in this Province will make sufficiently clear; and I am enabled through the courtesy of the present Administration, and the personal assistance rendered by Mr. John M. Herschensohn, to present such a brief view.

Fifty years ago the first Game Law in Natal was enacted, and was known as No. 10 of 1866, which fixed a close season for game birds and crane (species not mentioned) from September 15th in one year to April 15th in the year following. Twelve species of game animals (including hares) were provided with a close season between the 15th August and the 30th November in each year. Eland, Hartebeeste, Ostrich, Secretary-bird, and "Turkey buzzard" (Ground Hornbill) were declared Royal Game. Provision was made for the protection of growing crops, and a penalty imposed for contravention of the Law.

Eighteen years later this Law was repealed and re-enacted by 23 of 1884, by which the close season for birds was fixed at from the 15th August to the 30th April, and for the game animals at from 30th June to the 31st December.

Wild duck were added to the Schedule of game birds, and "rabbits" and bluebuck (Blue bush-duiker *C. monticola*) to that of the game animals, while buffalo, "kwagga," zebra, and reedbuck were omitted therefrom.

Hippopotami, reedbuck, springbuck, and blesbuck were added to the Schedule of Royal Game.

Law 28 of 1890 introduced a provision prohibiting the killing of game at all times by means of traps, snares, pit-falls, etc., and the penalty for contravention of the Ordinance was increased.

Rooi Rhebuck, bushbuck females, and "red bushbuck" (Red bush-duiker, *C. natalensis*) were included amongst the Royal Game.

Law No. 16 of 1891 repealed all previous laws and re-enacted them with certain amendments, amongst others permitting the destruction of game birds by means of sticks, and requiring the permission of the Governor to enable owners and occupiers (to whom the concession was restricted) to shoot

Schedule C Game, presumably upon their own properties. Provision was made fixing the minimum penalty for contravention at a fine of £2, and the maximum £20 as before.

Pauw, crane, and korhaan were removed from Schedule A to Schedule C, Royal Game, and "rabbits" were omitted from the game animals.

It should be noted that the foregoing Law was based upon the report of a Committee "appointed for the purpose of considering the Game Laws in force in this Colony, and of advising the Government of the alterations, if any, which were desirable." Every effort would appear to have been made with a view to obtaining the fullest information possible, in order to assist the Committee in framing their recommendations.

The most important of these latter were that the close season for all game be from the 16th August to the 30th April, both days inclusive; that the taking of game by any manner of traps be declared illegal, and that heavy penalties be laid down.

The signatories to these recommendations were Colonel J. G. Dartnell, C.M.G., H. Binns, Esq., M.L.C., and T. K. Murray, Esq., M.L.C.

A subsequent Act passed in 1894, amended Law 16, 1891, by limiting the Governor's permission to destroy Royal Game to the open season only, and by adding wild duck and geese to Schedule A.

Further, Bushbuck females were removed to Schedule B, Steenbuck to Schedule C (Royal Game), and the Ground Hornbill was excluded altogether.

Game matters in Zululand appear to have first come under legislative control in 1890, when, under the provisions of Proclamation 3, the close season was fixed as from the 1st August to the 31st March for Schedule A game, *i.e.*, all the game birds with the exception of pauw and wild duck, these two latter birds being placed in Schedule B with a close season provided from the 1st October to the 31st March.

Schedule C game comprised "rabbits," hares, and all the smaller antelopes with the exception of the Klipspringer, which was placed in Schedule D (Royal Game), together with Reedbuck, Blesbuck, Springbuck, all the larger antelopes, Buffalo, Rhinoceri, Hippopotami, "Kwagga," Zebra, Ostrich, Secretary-bird, and the Ground Hornbill, which still appeared under the inexplicable name of "turkey buzzard."

The occurrence of the words "waterbuck and piva" and of "kwagga and zebra" in juxtaposition upon the list of game reads very quaintly.

The special permission of the Governor or of the Resident Commissioner was necessary before Royal Game could be shot.

The penalty for contraventions was fixed at a maximum of £10, except in the case of the elephant, for destroying which the penalty was from £50 to £100.

Proclamation 5 of 1893 repealed and re-enacted the above, the close season for Schedule A game being altered to the 1st

September to the 31st March, while provision was made for the forfeiture of game trophies illegally obtained.

The oribi was removed from Schedule C to D, and rhinoceros, water buck, wildebeest, "kwagga," zebra, kudu, and reedbuck were removed to Schedule C.

Zululand Proclamation No. 5 of 1895 amended the above by deleting rhinoceros and waterbuck from Schedule C, the former being included in a section of the Proclamation referring to the elephant, which practically gave absolute protection, while the latter was again placed in Schedule D.

Zululand Proclamation No. 2 of 1897 repealed and re-enacted the above, the Livingstone's Suni (Zululand sub-species) being added to Schedule C.

Hippopotamus and Black Rhinoceros were placed in a separate Schedule E, and a licence requiring the payment of £10 for each animal was demanded, not more than two of each species being allowed to any one applicant, and a maximum penalty of £25 for contravention in respect of either of these animals was fixed.

Section 14 of this Proclamation provided for the first establishment in Zululand of Game Reserves, although these did not then become Reserves in the true sense of the word, as shooting was permitted therein upon permit, the charge for which was fixed at £10 per month or any less period, while provision was made for the surrendering to the Government of a portion of the trophies.

For hunting in these Reserves without a permit a maximum penalty of £10, and a minimum of £5 was provided for.

Four such Reserves were established, under Zululand Government Notice 16, 1897, to which reference will be made later.

Section 18 of the above Proclamation provided for permission being granted to natives to kill certain game, out of season, when found damaging crops, and in times of scarcity.

Act No. 8, 1904, consolidated the Game Laws of Natal and Zululand, repealing the previous Natal enactments, and Zululand Proclamation No. 2, 1897.

The outstanding provisions incorporated therein were—

(1) The close season in Zululand was made uniform with that in Natal.

(2) The destruction of all but the smallest game with a shot-gun was prohibited.

(3) The employment of natives to hunt game, except in the capacity of beaters, was prohibited.

(4) The penalties were increased all round, and the minimum penalty of £2 was done away with, while Stamp Duties were imposed in respect of Schedule D game, and in the case of Schedule E game, even the Governor was deprived of the right to issue permits for these.

Act No. 8, 1904, was repealed and re-enacted by our present Ordinance.

Referring again to the establishment of Game Reserves in

Zululand, it would appear that insufficient consideration was given at the time to the effect which such Reserves might have upon the economic conditions of the country. This I think will be sufficiently evident if we glance for a moment at the areas in question.

One Reserve, "Umdhletshe, No. 1," included portions of the present Shooting Areas Nos. 6 and 10, together with a large portion of Native Reserve No. 12, now apportioned to the Mdhletshe and Mandhlagazi tribes. This Reserve was abolished in 1897, under Government Notice No. 192.

Another Reserve, known as the "Hluhluwe Valley, No. 2," included, in addition to the area now styled the Hluhluwe Reserve, that portion of Native Reserve No. 3 and of Crown Lands which now forms the southern portion of Special Shooting Area No. 7.

The "St. Lucia Reserve, No. 3," included the present Dukuduku Reserve, together with a tract of country about equal in area to the latter.

"Umfolozi Reserve, No. 4," had identically the same boundaries as the present Umfolozi Reserve.

Subsequently a fifth Reserve was added and notified under Government Notice No. 93 of 1905 in the *Natal Government Gazette*, and was known as "Reserve No. 5."

This included practically all that portion of the Hlabisa Division, which did not fall within the boundaries of the Mdhletshe and Hluhluwe Valley Reserves, with the exception of the extreme south-eastern area, thus including considerable portions of main transport roads.

This latter Reserve was abolished at the same time and under the same Government Notice as No. 1 Reserve.

Government Notice No. 322 of 1907 provided for the extension of Umfolozi Game Reserve No. 4, with its southern boundary along the line of the Imvamanzi Stream and the Sangoyana Range.

The areas thus included in Game Reserves as above described were at least four times as large as those now set apart for the purpose, in view of which it is not difficult to understand why provision was made for a limited amount of shooting therein, although this concession deprived them of one of the most essential characteristics of Game Reserves, namely, that their occupants shall be free from disturbance.

It may be assumed that these Reserves were originally set aside upon the suggestion of the Resident Commissioner, and the action was, at any rate as far as the Natal Parliament is concerned, fully endorsed, no complaint against these Reserves being made at the time.

Between the years 1907 and 1911, the southern boundary of the Hluhluwe Reserve (*i.e.*, the area originally styled "Hluhluwe Valley Reserve No. 2") was defined as starting from the highest point of the Zankomfi to that of the Mtolo, and thence to the Maxatshwa, thus necessitating a slight alteration of the eastern boundary-line, which now ran from the last-named point to the original one on the Mzinene River.

During the same period the Dukuduku Reserve was limited to its present boundaries, as was also the Umfolozi Reserve.

It should be mentioned that at the time of the establishment of the first four Reserves above mentioned the shooting on permit to which reference has been made was allowed only in Nos. 1 and 2, none whatever being permitted in 3 and 4.

I am not certain of the reason for the abolition of Reserves Nos. 1 and 5, but have understood that this land was intended to be divided up for European occupation.

During the year 1911 a Game Conservator was appointed for Zululand, with a staff of native Game-guards to assist him; the headquarters of this official were esablished at Nongoma, this place having been selected for the purpose by reason of its being in telegraphic and telephonic communication with all the magistrates in Zululand.

In 1912 it was considered advisable to add another Game Reserve to the three already existing, and this was done under the Provisions of Section 8 of Act No. 8 of 1906, as amended by Section 81 of the South Africa Act, 1909, whereby the present Mkuzi Game Reserve was established. This is situated on the south bank of the Mkuzi River, in the Ubombo Division, with Native Reserve No. 2, as its south-western boundary and the Msunduzi River on the south-east.

The object sought to be obtained by the establishment of this Reserve was the inclusion of certain species of game not found in either of the others, *viz.*, Impala, Inyala, Red Bush-Duiker, and a local sub-species of Livingstone's Suni.

It may be mentioned that the area thus included was practically uninhabited, and that the game therein had for a considerable period been partially protected by the Magistrate at Ubombo, in whose Division it is situated, and whose "mufti" Reserve is the name by which it was known.

A brief reference to the leading characteristics of the present four Zululand Game Reserves may be of interest, as serving to show that they supply the needs of all the different classes of game which are to be found in the country.

The Mkuzi Reserve, in extent about 62,000 acres, consists for the most part of rolling country formed by the foot-hills on the northern slopes of the south-eastern extremity of the Ubombo Range; these fall away gradually towards the Mkuzi River, within a few miles of which the ground again rises slightly and forms an extensive plateau. On the eastern side the country slopes steadily towards the Mlambomudi River ("Soma" on the maps), along the banks of which it is very flat and unusually open for thorn-country.

Buffalo used to be fairly plentiful in this Reserve, in the neighbourhood of the Delakufa, where the bush is thick and dense reed-beds clothe the river banks. By 1911 their numbers were reduced to two, both large bulls, and these died, as far as is known, natural deaths during 1912. The unusually massive head of one is, I believe, now in the Natal Museum.

There is a troop of about forty Impala in this Reserve; these, at one time, were in the habit of crossing the Mkuzi freely, and could be as often seen on the north bank as on the south, but the great amount of shooting that is done on the former side has taught these wary animals that safety lies to the south in the Game Reserve.

Kudu are more or less resident therein, though after the manner of their kind, are given to frequent wandering.

Wildebeesten (Brindled Gnu, *C. taurinus*) are fairly plentiful, as are all species of the smaller antelopes which are represented in Zululand, with the exception of the Blue bush-duiker.

Mountain Reedbuck are found on the foot-hills, and in the dense bush along the Mkuzi the beautiful Inyala (*T. angasi*) is plentiful. In certain places in this bush, principally about the Delakufa, a form of Bush-buck is found having straw-coloured tips to its horns, similar to its congener the Inyala. They are decidedly scarce, but a few are found on the opposite bank of the river, and again a few in the Mtshazi Bush on the Pongolo.

Lions are mainly visitors in the Reserve, coming across usually from the north bank, though recently I have had reason to think that a few are resident. Leopards occur but rarely, though they are very common on the other side of the river, outside the Reserve.

The Hluhluwe Reserve is in many respects the "pick of the bunch," mainly on account of the very great diversity of land surface and climate of which it boasts. It may be described as a central valley containing but little flat ground, being broken up into ravines and kloofs throughout its greater area, and rising on all sides to considerable mountain ranges. The northern and north-western portions are very hilly and rough, and covered for the most part with dense bush, amounting in places to actual forest, of which the Pongwe is the largest and most dense.

This Reserve is the true home of the buffalo, where, in the safe retreat afforded by the above-mentioned bush, it breeds freely. In the more or less open thorn country outside the main bush, herds of from twenty to forty individuals may often be seen grazing in the early mornings and late evenings.

The Prehensile-lipped rhinoceros, or as it is familiarly styled, the "Black Rhino," is also thoroughly at home here, and along the margins of the two fine streams which water the central portions of the Reserve, the Amanzibomvu and Amanzimnyama, this uncouth, pre historic-looking creature is very commonly met with.

The Impala, Inyala, and Suni are not represented here, nor until recently were either Wildebeesten or Zebra. The shooting outside, however, has resulted in a fair troop of each of the latter species taking up its abode in this safe retreat, where they are doing well.

A scheme of acclimatisation in connection with this Reserve was favourably considered by the Administration a short time back, the object of which was to introduce certain other game into the country. Eland, the Cape or Red Hartebeest, Sable and Roan Antelope, and Sassaby (*Alcelaphus lunatus*) were the species indicated, all of which would without doubt thrive here.

The idea has been temporarily abandoned, after it had actually gone so far as the selection of the site, the Amanzila Valley, in the western portion of the Reserve, having been chosen for the purpose.

Unfortunately there are several natives living within the boundaries of this fine Reserve, who—together with those living actually upon them, and others in very close proximity outside—give constant trouble.

The area of this Reserve is about 40,000 acres; it is the only one of the four into which wheeled transport can be taken, without encountering almost insuperable obstacles, there being a track, which with the expenditure of a little time and labour, might be made available for wagon transport, leading to the Amanzila Valley from the Inhlwati-Makowe main road.

One of the greatest advantages possessed by the Umfolozi Game Reserve is that it is of no use for any other purpose, the climate therein being very deadly.

It consists for the most part of low, flat thorn country, the only elevated portions being the Dengeza, Impila and Amantiyane Hills, and a slightly raised plateau in the eastern portion.

Except along its northern and southern boundaries, formed by the Black and White Umfolozi Rivers respectively, it is poorly watered, save during the summer months, when practically the whole of it becomes a quagmire.

Game is not exceedingly abundant therein if we except Wildebeesten and Zebra, though wart-hog are surprisingly numerous. Small game is generally scarce, though in the bush along the rivers, Bush-buck abound, and Duiker and Steenbuck are plentiful in the eastern section.

The fact that small game are thus generally scarce has been put forward by those who should know better, as proof of the overwhelming numbers of vermin; this is most misleading, the actual reason for their scarcity, as is the case in the Ubombo thorn veld, being that the physical conditions of the country are unsuitable.

Buffalo and Prehensile-lipped Rhinoceros are fairly numerous, but it is as the home of the Square-mouthed Rhinoceros, commonly known as the "White Rhino," that this Reserve may be considered as one of the most valuable in Africa. Nowhere else on the Continent, save in an area on the Blue Nile, can this weird creature be seen at the present day.

It is exceedingly difficult to compute their numbers even approximately, but I consider that there are between thirty and forty adult animals actually resident in the Reserve, as well as a useful number of calves. Some of them occasionally cross to the south of the White Umfolozi, and it is true that at any time a number of these animals may be encountered there, outside the Reserve, some, at least, of which are probably resident outside. This fact led to the extension of the Game Reserve to the boundaries provided for under Government Notice No. 322 of 1907, previously referred to, but owing to complications which subsequently arose in connection with the occurrence of Nagana, last year it has reverted temporarily to its old boundaries between the Umfolozi Rivers.

The area of this reduced Game Reserve is approximately 75,000 acres.

The Dukuduku Reserve, lying between the lower reaches of the Umfolozi River and the sea, and to the north of Native Reserve No. 4, merits but little notice; it is a sandy waste of low bush country, and contains little game beyond Waterbuck, Bushbuck and Red Bush-Duiker.

Bush-pigs are very numerous, and until quite recently it was more or less the headquarters of *the* Zululand Elephant, a magnificent bull, which in February of this year was done to death by a native, for which scandalous deed he was mulcted in a fine of £50 *or six months' imprisonment!*

It was nearly a month after the event that the animal's death became known, by which time, of course, the hide was useless, and even the skeleton had been partially damaged. Steps were at once taken to recover as much of the latter as possible, and with the kind assistance of some of the neighbouring planters the Game Conservator was enabled to carry out this work.

Reference has already been made to trouble which has from time to time been caused by the proximity of natives' kraals to the Reserve borders, and the presence of others actually within the boundaries.

These constitute, in my opinion, a serious menace to the well-being of these Reserves, especially in view of the fact that practically all the natives possess dogs, some of which have actually been shot when in pursuit of game therein. Moreover, twice during the last two years one of the Reserves, the Hluhluwe, has been burnt out almost from one end to the other, with the result that much game has been driven outside, and on the first occasion a young rhinoceros was burned to death.

It may also be recorded that on one of these occasions the natives who fired the grass and who were charged with the offence in the local Court, were acquitted!

It cannot be too urgently insisted that a Game Reserve, if it is to fulfil its functions properly, must be an actual *sanctuary* within which the animals must be assured of absolute immunity, not alone from harm, *i.e.*, bodily harm, but also from all disturbing elements of whatever nature.

Of the latter, an advancing wall of fire, five miles in length, leaping along through four feet high grass, may certainly be considered a type.

The confidence which may be established in wild animals is little short of surprising, but it requires time, and unbroken quiet. That such confidence was becoming acquired between the years 1911 and 1914, was evidenced by the fact that the writer has on several occasions seen from his guard-hut on the Kwankwa both reedbuck and bushbuck grazing in the middle of the day within fifty yards of the hut, and entirely disregarding the native guards who were sitting round their fires eating and talking.

Only in a locality in which they considered their safety assured would the wary bushbuck so far forget his customary caution as to venture on a prolonged midday meal.

Deliberate poaching in the Game Reserves is almost a thing of the past as regards Europeans, although last year, when the Nagana panic was at its height, and the whole country south of the White Umfolozi was thrown open to indiscriminate slaughter, several parties entered the Reserve from that side and destroyed game. The natives, however, continue to poach whenever they get the opportunity, especially those living near the Reserve boundaries; and it is quite impossible, with the comparatively small force of guards at the disposal of the Game Conservator, to prevent this.

Zululand is a large tract of country to patrol with less than twenty men, and it is fairly certain that if *all* parts were patrolled (as they should be), each individual area would be visited about once every two years. The only plan, therefore, to adopt is to station guards at certain spots where the greatest danger threatens, making occasional changes as circumstances suggest.

The question of the occurrence of vermin in Zululand is one which has given rise to a great amount of inconsequent chatter, and the time-worn shibboleth, "vermin is bred in the Game Reserves," is raked up whenever the occasion seems to warrant it. It is an old tale, long ago worn to shreds in the Transvaal, where the Game Warden clearly showed its absurdity.

It still passes muster here amongst a certain class, mainly consisting of those who merely talk for talking's sake, and who the while, know nothing whatever about the subject.

Let us for a moment consider the matter dispassionately, and ask ourselves (1) what reason can be given why vermin should show a partiality for the Reserves as breeding grounds, and (2) is the statement that they do so borne out by facts?

(1) Two reasons are commonly advanced for their partiality to the Reserves, *viz.*, on account of the small risk of disturbance therein, and because they can there obtain plenty of food. As to the first of these, it is certain that outside the Reserves there are just as many quiet, undisturbed spots as inside, and moreover, those species of vermin which "lair down" in holes of the ground (and amongst these is to be reckoned the hunting dog, the greatest criminal of the lot) are by no means particular in this respect.

I know of a spot where, until last year, two litters of wild dogs were brought forth regularly each year, and upon three occasions the litters were destroyed by the Game-guards; a constantly-used wagon-road passed within 80 yards of the place.

In recent years lions have occasionally bred in the Umfolozi Game Reserve, but their chosen breeding ground is the Ubombo thornveld, in which, with the exception of Hlabisa, more shooting is done than in all the other divisions put together.

Unfortunately for the food argument, those who make use of it are constantly telling us that the food supply is becoming exhausted in the Game Reserves, and that all the small game is killed off by the vermin; it is therefore difficult to understand why, if that is the case, vermin should continue to show any partiality for such places.

The fact of the matter is, and this also answers the second query propounded, that it is a case of any stick being good enough to beat a dog with. My records show that for each littering down place of wild dogs found in the Reserves, we have found seven outside. And in any case, even were these figures reversed, it would have very little signification, because these animals are the most pronounced wanderers of all the mammal fauna of Zululand, never remaining more than two or three days at a time in one locality. True, when the period of parturition arrives, the bitches are compelled to remain longer in one spot, but when it is over they quickly rejoin the pack.

The following figures may be of interest: During the year 1913, twenty-one wild dogs were killed by the Game Conservator and his staff; during 1914, the number killed amounted to fifty-two, and in 1915 to sixteen; giving a total of 89. Of this number, 17 were killed in Game Reserves, and the remainder outside.

During the past three years a further record has been kept at the office of the Game Conservator of the localities (confined to the Divisions of Mahlabatini, Hlabisa, Ndwandwe, Ubombo and Ingwavuma) in which wild dogs have been seen, local natives having given considerable assistance in the matter. The data are still insufficient to enable a definite statement to be made upon the subject, but already much has been learned of their movements, which have been recorded upon a large scale map. It would be trespassing too much upon the space allotted to me if I were to set forth the results obtained, even though they are of a most interesting nature.

The Nagana question and its relation to game preservation now claims attention, and it is indeed a thorny one.

I have no definite information as to the period when, and the manner in which the controversy upon this subject first arose, but I find that during the course of the discussion upon Act No. 18 of 1906, whereby the Laws relating to game in Zululand and Natal were consolidated, the Prime Minister (the Hon. C. J. Smythe) referred to the fact that Zebra and Wildebeesten were held to be largely responsible for the spread of the disease.

Since that time apparently the outcry against the game as being the responsible host of the trypanosoma, and against the tsetse-fly as the principal causal agent, has been maintained with fluctuating intensity, according to whether any particular season has been favourable to the occurrence of the fly or otherwise.

It may be noted that this agitation has invariably been directed against "game," a word which is almost universally understood to signify the various species of the Family Bovidæ, together with the single representative of each of the Families Equidæ and Hippopotamidæ, and two species of Rhinocerotidæ.

For this reason I consider that the word "Game" was somewhat ill-chosen by the Veterinary Research Officer in his recent able report upon the occurrence of Nagana in Zululand.

The brief explanation given by him of his use of the word fully suffices for those who *wish* to understand it, but for those who wilfully or ignorantly fail to do this, the constant reiteration of the word "Game" may be, and I know has been, harmful and misleading. At least two species of animals in Zululand which are never looked upon as game, are proven hosts of *T. brucei*; these are the hyæna (presumably *H. crocuta*) and the Bush-pig (*P. chœropotamus*), the latter a great wanderer, and existing in incredibly large numbers in this country.

Another class of vermin, the Hunting Dog (*L. pictus*) has not, as far as I am aware, been yet experimented upon in Zululand.

It must be quite evident, therefore, that to use the word "game" when referring to the responsibility of the mammal fauna generally of the country for the dissemination of Nagana is to play into the hands of those who only wish to hear the final doom pronounced upon those creatures, the sale of whose horns, hides, and meat, may put a few miserable shillings into their pockets.

This point is not brought forward for the purpose of endeavouring to cloak the real issue, indeed there is little doubt but that such an attempt would defeat its own ends. But seeing how strenuous is the opposition in some quarters to game preservation, it is as well that it be made perfectly clear to what extent that opposition is justified.

It will be conceded that unanimity of opinion is a very desirable asset for an opposition to possess, but it is one which we find deplorably lacking in those who are "up against" protection. The advocates of indiscriminate slaughter comprehensively blame all the game, and wish to see a clean sweep made thereof, but that is so manifestly absurd a proposition as to be unworthy of comment.

The moderates of the party are far less bloodthirsty; but there is much diversity of opinion amongst them as to where the blame should be apportioned. To take two instances by way of illustration: A recent Magistrate in Zululand, very keen upon shooting, used to practically stake his reputation upon the culpability of the Black Rhinoceros, which he stoutly maintained is the *fons et origo* of all the trouble.

Another, a very old resident, who is not lacking in self-assertion, has made certain statements in letters addressed to Government officials. In one he has made it quite clear that he considers the kudu mainly responsible, while presumably exonerating the zebra, for he writes "zebra and donkeys quite take to each other. I have had zebra stay all day with my donkeys . . . I had two donkeys go off with zebra for miles." In another letter he writes: "The fly are harmless where there are no kudu for them to suck from." Further, after eulogising the zebra as a transport animal, he adds: "They are not affected by the fly," a remark which, by the way, has little bearing upon the point at issue! These are definite statements, almost amounting to dogmatism, yet their value may be assessed from the conclusions arrived at by the Veterinary Research Officer after his work in Zululand. He placed the kudu first upon his list of dangerous and suspected game, while the *zebra* came next, and the bush-pig (which is "vermin") is third. The above-mentioned resident has always asserted that the waterbuck is blameless, but we find it upon the black list of the Veterinary Research Officer, though whether justly so I am inclined to doubt.

All this goes to confirm the old saying, "*quot homines, tot sententiæ*," and at least it should satisfy one section of the opposition, seeing that amongst the diverse opinions expressed, scarcely any one of the game animals escapes condemnation.

The rinderpest plague of some years ago has furnished the opposition with a good deal of material for apparently plausible argument, if positive assertion may be so called.

The Veterinary Research Officer throws very little light upon its relation to the mysterious partial disappearance of the tsetse-fly, with which it certainly synchronised, not only in Natal but in the Transvaal also. It is commonly asserted that the fly died off because their food supply failed through the destruction of buffalo and kudu by the plague, but I do not think that argument will bear investigation.

To be of any value it would have to be shown that not *only* two sources of food supply failed, but that there was an appreciable diminution of *all* sources. But we know that this was not the case, and that on the contrary, it being well established that the fly feeds on all warm-blooded mammals, there could have been but a comparatively small percentage of the supply cut off.

Zebra, the second on the black list, were immune from the disease; and wildebeesten, fourth on the same list, suffered but very slightly, if at all; consequently these were still left in great numbers, as well as very many bushbuck.

The presence of these species alone would have furnished ample food supply for the fly, to say nothing of such bush-pig, buffalo, and kudu as certainly remained. Unfortunately for Zululand game, the after results of the plague were not so satisfactory as in the Transvaal, where the fly never occurred again, at least, not in the Game Reserves.

I lean to the opinion that possibly a certain proportion of the existing fly was killed by absorbing the virus-laden juices from the dead carcases of animals killed by the plague, and the diminution in their numbers thus caused may perhaps have been accentuated by existing climatic conditions, which were overlooked at the time, or not considered in relation to the bionomics of the tsetse-fly.

The Administration of Natal has for a long time past concerned itself with considering how best to minimise the risk to domestic animals resulting from the spread of Nagana, and in 1913 Mr. C. E. Gray, Principal Veterinary Surgeon (Union) visited Zululand in company with Veterinary Surgeons Power and Ewing, with the object of reporting upon the existing conditions.

A number of recommendations were appended to his report, the most important of which were (1) the destruction of all infected domestic animals; (2) the outlawing of all small game along the road-sides; (3) clearing the dense undergrowth for a distance of 400 yards from the roads at the suspected points; (4) that the natives should be compelled to exercise greater care in herding their stock, and be encouraged to keep the bush cleared in the vicinity of the places where their cattle water.

As a result, Nos. 2 and 3 were adopted early in the year 1914, and in addition to abolishing the close season in the suspected areas with respect to small game, a Proclamation was issued under which reedbuck and kudu of both sexes were also outlawed. No. 1 recommendation was discarded, but I consider it unfortunate that in place of the destruction of infected stock a policy of immediate segregation was not adopted.

I am unable to say whether anything was done with regard to (4), but it is certain that if any instructions were issued to that end they fell upon deaf ears.

In the same year, 1914, an expedition set out from Pretoria, styled the Bacteriological Research Expedition; but though much game was destroyed, our knowledge upon the subject of the relation between tsetse-fly and game was but little advanced thereby.

In June, 1915, a deputation from the sugar-planters in the Lower Umfolozi Division was sent to Pietermaritzburg, and was accorded an interview with His Honour the Administrator, the Game Conservator (Zululand) being requested to attend.

The result of the interview was that the whole of the country south of the White Umfolozi, including that portion which had recently been added to the Umfolozi Game Reserve, and lying between the White Umfolozi and the line Imvamanzi-Sangoyana, was thrown open to shooting upon the ordinary Game Licences (£1), the only restriction imposed being that neither Klipspringers nor Rhinoceros might be shot.

Further, it was enacted that under the provisions of Proclamation No. 8, 1915, all Schedule A game (to which both sexes of Reedbuck, Waterbuck, Kudu, Wildebeest, Buffalo, and Zebra were now added) might be shot upon the £1 Ordinary Game

Licence within an area of three miles on either side of the Somkeli-Hlabisa-Nongoma, and the Somkeli-Umduna-Ubombo roads.

Proclamation No. 10, 1915, added to the above the main road Mahlabatini-Nongoma-Ubombo, and the branch road from the Mbhekamtetwa over the Msunduzi River to Banganomo.

Natives were given permission to destroy any of Schedule A game over their grazing areas.

The worst feature about it was that whilst this legislation was enacting, preparations were already nearly completed for the visit to Zululand of the Veterinary Research Officer, Mr. D. T. Mitchell, who was to work there in connection with the occurrence of Nagana. This officer therefore entered the country, and had to prosecute his researches under abnormal conditions, caused by the scattering of the game outside its usual haunts.

Of all or even an appreciable part of all that occurred when these areas were given over to practically free shooting, I prefer to say very little, as the details were too horrible. That people calling themselves human beings could ever have been so lacking in all humane feeling was indeed a revelation to me. There were but few, very few, brilliant exceptions—men who were sportsmen and not butchers, and who scorned to emulate the deeds of the rabble.

For the rest, well, they laid themselves out to slaughter, and for ever earned the contempt of all true sportsmen. It was indeed a "reign of terror" for the beautiful and defenceless creatures which have been placed upon this earth for man's use, not abuse; for his enjoyment, not for the exercise of his spirit of blood-lust.

And, after all, the game is not to blame, the blame lies at the door of the causal agent, the tsetse-fly.

The Proclamations above referred to were revoked with effect from the 1st May, 1916, under Proclamation 7, 1916, which authorised the destruction of the different species of game supposed to be responsible for the spread of Nagana in all areas of Zululand, with the exception of Game Reserves and certain Special Shooting Areas which were defined in Provincial Notices Nos. 74 and 103, 1916.

At the same time Proclamation No. 8, 1916, declared Mountain Reedbuck (*C. fulvorufula*) to be Royal Game, as also Klipspringers.

The definition of the Special Shooting Areas was based upon that portion of the Veterinary Research Officer's report which records his conclusions in respect of certain areas, mainly around the Game Reserves, where he considers that Nagana is endemic.

Within these Special Areas game could be shot upon payment of reduced fees, while outside, in the Open Areas, Permits costing £2 each for the open season, or £5 for the whole year, were alone required. The Open Areas, it may be remarked, embraced practically the whole of the Zululand Native Reserves, while most of the Crown Lands fell into the Special Areas.

The objects sought to be attained by the establishment of the latter were, first, to include within their limits areas in which, owing to the presence of water and dense bush, and the proximity of the Game Reserves, Nagana might be considered to be, as the Veterinary Research Officer expressed it, endemic; and secondly, to provide buffer areas where possible, round the Game Reserves, which would tend to prevent persons who had only the £2 licences from trespassing in the Reserves, as was done by both Europeans and natives during the latter portion of 1915 and the opening months of 1916.

It was expected, and hitherto the results have justified that expectation, that many more Open Area Licences would be required than for Special Areas, with the result that in the former game would quickly be diminished in numbers, while those which escaped would be urged towards the Special Areas, and thence, by the holders of licences for those Areas, into the Game Reserves.

The success or failure of this scheme depends entirely upon whether the pressure is exerted from behind or in front, *i.e.*, from the Open or the Special Areas. If from the former, success is, I believe, assured; but if the pressure slackens in the Open Areas, and is exerted from the direction of the Game Reserves and Special Areas, failure will certainly result.

It might be contended that in the latter case there is as much chance of the game flying towards the Game Reserves as to the Open Areas, but I consider that most unlikely in consideration of the relatively vast size of the latter. And even if it were to go in the direction of the Reserves, these are no small that they would be quickly crossed and the game would again find itself under fire.

And, obviously, if the object be to keep the game in the Reserves, or as close thereto as possible, at no time should the pressure come from that direction.

The Native Affairs Department is, of course, fully justified in doing all it can in the interests of the natives, that is its *raison d'être;* but it seems that if the question be considered in a sane, common-sense manner, it will become apparent that to permit the natives to harry the game all the year round, *especially* upon the immediate borders of the Reserves, is not in consonance with their best interests.

In the first place, these localities, being near the Game Reserves, are considered by the Research Officer to be amongst those in which Nagana is endemic, and to permit natives, particularly such as own stock, to continue to live therein, merely because they wish to, does not seem to be a course of action conducing to their interests.

It is very similar to permitting a child to continue playing with a box of matches in the middle of a straw-yard, merely because he wishes to do so. Moreover, during the close season, owing to the rains and length of the grass and other cover, there will be a distinct diminution in the amount of shooting done in the Open Areas, that is to say, the pressure from behind will slacken. Continued harrying of the game on the Reserve borders.

and throughout the Special Areas, can therefore only result in driving a large number back into the Open Areas.

It must be borne in mind that in his heart the native does not believe in the harmfulness of the tsetse-fly.

I desire particularly to emphasise this statement, because a great deal of twaddle has been said and written to the contrary.

The inherent belief amongst them is that deaths amongst cattle, etc., in game country is that they are caused by the game grazing over the same ground as the cattle, these latter thus being compelled to swallow some of the game saliva (" *amat'enyamazana* " as they put it). It is true that nowadays many natives, if asked the cause of such fatalities, will say that it is the fly, because they hear Europeans say so, but *they do not believe it*, hence they fail to understand that there is any difference between a fly area and another, and would as soon live in the one as the other.

Another cogent reason for their choice of these out-of-the-way places is that they think they run less risk of detection when indulging in their poaching and trapping proclivities.

There is yet another very important point in connection with natives living in fly-areas. Mr. Mitchell has stated in his report that on the borders of the Game Reserves, " the native kraals which are found have, in practically every instance, lost their cattle from Nagana. In spite of the knowledge that the area is a deadly one for stock, the natives, however, usually prefer to remain."

Elsewhere, when considering the " spread of Nagana," he states: " Wandering game must be held as most responsible for the spread of the disease, but domestic animals suffering from Nagana also constitute a grave danger when in the vicinity of a tsetse-fly area."

Quite recently some correspondence passed between the Administration and the Native Affairs Department upon the subject of natives being permitted to destroy game elsewhere than upon their own grazing areas, and the latter urged, in support of the concession, that owing to Nagana having encroached so much on Native Reserves, the natives are forced to change their grazing grounds constantly in order to find land not infected with Nagana.

I ask any unprejudiced person to place this statement side by side with that of the Veterinary Research Officer above quoted, and then to say whether it is in the interests of the natives to permit them to live with stock in endemic centres of Nagana, and then to move their infected cattle about in their ward at their own sweet will.

If it is agreed that these Special Areas are " endemic centres," then it would be only an act of justice to the natives living therein, and owning stock there, to save them, as it were, against their will, and not to permit them to remain and constitute themselves a " grave danger " to the community at large by indiscriminate moving about the country with infected animals.

And if it is against their interests to be permitted to remain hugging the Reserve boundaries, what can be said concerning those who are—and for several years past have actually been living *in* the Game Reserves?

I would like, with all deference, both in the interests of game protection and that of the natives, to urge that the matter be taken up in a frankly conciliatory spirit between the Departments, each being prepared to grant concessions where such are necessary, reasonable, and possible, because I believe that the action would be justified by results.

That infected stock in Nagana areas is a source of "grave danger" has been conclusively shown, and there should be a way of counteracting that danger, that way, it appears to me, being by the segregation of infected stock. The carelessness displayed in the natives' herding arrangements is another source of danger, and is due, I believe, to the peoples' inability to realise that the game, apart from a transmitting agent, is harmless.

I have repeatedly seen troops of cattle grazing on warm, windless summer mornings in the thick scrub and bush by the Mkuzi Drift, where they had been taken to water, while the herd-boys who were responsible for them were half-a-mile away up on the hill-side, playing games.

As there were certainly infected cattle amongst the herds, and all the conditions were favourable for the fly, it is not difficult to understand that the results of such carelessness would probably be disastrous.

It is generally admitted that the conditions which obtain in respect of the relationship between tsetse-fly and game vary greatly in widely-separated localities.

A remark made by Mr. Mitchell in his report tends to confirm this when considered in the light of the experiences of others.

He says: "The association between game and tsetse-fly is a very close one, and so far it has not been possible to procure fly, except in areas where game were numerous. In such cases the tsetse-fly has been found in practically all instances." It must be presumed that the word "game" is to be understood in the general sense as explained in that report.

In 1896-7, in company with my friend, Capt. (now Col.) Harrison, of the Indian Staff Corps, I was elephant-hunting in the Mozambique Province, and during one portion of our travels we marched from Chirimani across the Lualwa and Lukugu Rivers to Kuruwe, thence through Lukosi across the beautiful Liuli River to Marari, and back to Chirimani by a different route. The distance covered was approximately 534 miles, and on the slightly shorter outward journey we encountered great quantities of game of all sorts, with the exception of elephants, of which, however, we saw spoor on the Liuli.

On the return trip (268 miles), we had the utmost difficulty in providing food for our carriers, as we did not see twenty head of game on the journey, and were constantly compelled to keep the shot-guns going to supply any sort of bird which offered a shot, in order to get meat.

Yet on the outward journey we saw no tsetse, notwithstanding the large amount of game encountered, though in the sand veld and low, scrubby thorn-bush passed though on our return there were thousands of tsetse, and a small terrier dog belonging to my friend was bitten and died on the 12th day of the return journey.

Major Stevenson Hamilton, late Warden, Transvaal Game Reserves, had an almost similar experience a few years later, when with Mr. C. F. Maugham, H.B.M. Consul at Delagoa Bay, he marched through the Mozambique Province along a route some distance to the north of the route taken by me.

Both in his work on the Game of Africa, and also in the Bulletin of Entomological Research, 1911, July, pp. 111-118, he has remarked upon the prevalence of the tsetse in the almost complete absence of game. Mr. Maugham has personally expressed himself to me upon the same subject in like terms, but in this instance I believe there was not, as in our case, any recorded proof of the infectivity of the fly.

I must dismiss very briefly the question of the supposed occurrence of another form of trypanosomal disease in Zululand, known as "Munca." I have always considered it to be a different form to that of Nagana, and most natives clearly distinguish between the two, while some say the word merely indicates the same disease.

It is pathogenic to domestic stock, though apparently in a less degree than Nagana.

Mr. Mitchell, who describes it as a "chronic form of Nagana," puts forward a very interesting suggestion, *viz.*, that possibly this milder form may be Nagana reduced in virulence by passage through the smaller antelopes.

Upon the subject of the possibility of Sleeping Sickness being introduced by the tsetse-fly into Zululand, I would merely point out that, as far as I am aware, *Glossina palpalis,* which transmits the human trypanosome, is not found in the country. Neither, I believe, is *morsitans,* although the bush in the Ubombo Low Country, of a xerophilous nature, would seem to be suitable to their habits.

In conclusion, the report to which so many references have been made, carries us a step further on the way to complete knowledge of the association between game and the tsetse-fly in Zululand, and though to my mind, it is not altogether convincing, partly on account of the echo I catch here and there of time-worn Zululand platitudes, and also on account of its being inconclusive in respect of some important points, this latter is doubtless due to the insufficient time at the Officer's disposal, in which to have completed his work.

But it has at least cleared the air somewhat, and has given the Administration a basis upon which to work.

Possibly with regard to game protection, Mr. Mitchell's conclusions upon the subject of endemic centres of Nagana are of the utmost importance. They make it clear that we are brought face to face with two alternatives—that of *completely* "wiping out" all mammalian life, *including that of domestic stock*, within these centres, or of frankly recognising the impossibility of doing this, and thereupon setting to work to devise means whereby the spread of the disease from these centres may be prevented.

I venture to think the latter is the obvious and only reasonable alternative to adopt, but in order to succeed, there must be complete mutual understanding established between the Government Departments concerned.

I have endeavoured to show that it is contrary to the interests of the natives, just as it is to those of game protection, to permit them to live, with stock which is being constantly moved about, in these endemic centres of Nagana. And as there seems no lack of space for them elsewhere, I must believe that if the Native Affairs Department were willing to help in regard to these centres, there would be no insuperable difficulty in carrying out such measures.

We must not accustom ourselves to look at one side of the question only, while ignoring the other, to think solely of the present and leave the future for others. The dance is pleasant, but the piper expects his pay afterwards, and who will pay him?

What will be said when the gradual extermination of game brings the fly to the doors of kraals and other habitations, seeking from domestic stock some of the sustenance they are denied by the scarcity of game, and later still, when virtual extermination is accomplished, and nothing remains but domestic stock for their food supply? Domestic animals, in gradually increasing numbers, themselves constitute almost as serious a factor in the spread of Nagana as do the wild animals, and it would be a grave error to delude ourselves with the idea that when the game is destroyed the fly will vanish.

There is abundant evidence to the contrary, just as there is evidence that wild game can live unassociated with the tsetse-fly. The Transvaal Game Reserves furnish such proof.

I cannot think that the various interests concerned are necessarily antagonistic, but to prevent their becoming so, the party that stands solely for selfish and sordid material gain, the curse of the present age, must be silenced, or if that is impossible, it must be ignored.

Even if the theory of the sole culpability of the game were ever proved, which is about as likely as a final victory for the Huns in the great Continental struggle, still the difficulty would admit of some other solution than that of the wholesale destruction of Africa's wild game.

The voices of those who love Nature's handiwork, the students of her every mood, who are in genuine sympathy with her children of plain and forest, who contend that these are not ours to do with just what we will, but that they constitute an inheritance to be handed down to *our* children and to theirs again—these voices have an equal right to be heard with those of others.

As Dr. G. D. Maynard, F.R.C.S.E., of the South African Institute for Medical Research, has so aptly put it, " It is easy to propose remedies entailing the adoption of measures of economic importance, but inhabitants who have to reap the aftermath will demand expert opinion and a reasonable probability of success before deciding to carry out such recommendations." I ask for whole-hearted support in the up-hill task which lies before those who seek to preserve to the sub-Continent the most striking and by far the most beautiful of its characteristics.

PHYSICAL CONDITIONS ON MARS.—The British Astronomical Association has recently published, as volume 20, part 4, of its *Memoirs*, the tenth report of the section for the observation of Mars. It is assumed that the mean temperature of Mars must be above the melting point of ice, and almost comparable with that of the earth. The atmosphere of the planet is extremely transparent: its absorbing power for light is feeble, and it has no reflective power. Hence stars must be visible in the Martian firmament in broad daylight. On a small scale Mars has its trade and anti-trade winds; and white clouds, probably analogous to, but much less frequent or dense than our own, float in its skies: their height above the planet's surface is comparable with that of our own clouds. The presence of snow at the poles necessitates the existence of water on Mars, which would appear grey, greenish or black, according to the nature and depth of the bottom. The lawn-green areas are probably due to vegetation, and the vast ruddy expanses have the colour of sandy deserts, in which there are many dusky irregularities, apparently corresponding to our valleys. Change in outline of the greenish marks may be accounted for by growth and decay of vegetation, and the yellow clouds which veil, often for months together, extensive regions of the planet, are probably due to sand dust raised from the desert regions. Mars may therefore still be inhabited, but it has certainly reached the stage of decrepitude in planetary life.

PHOSPHATE SCARCITY.—Consequent upon the difficulty of obtaining phosphatic fertilisers, the President of the Board of Agriculture and Fisheries of the United Kingdom has appealed to farmers to cease applying phosphates to meadows and pastures during the present season, and to reserve all available supplies for other crops, particularly root crops and potatoes. In view of the short supplies, it is advised that only three-fourths of the usual dressings of these phosphatic fertilisers should be applied in the case of lands of uniform quality, and where land in good condition can be given full dressings of farmyard manure the omission of artificial phosphatic manures is suggested.

BANTU METHODS OF DIVINATION: A COMPARATIVE STUDY.

By Rev. Noel Roberts.

(*Plates* 8-10 *and two text figures.*)

DIVINATION is the professed power of acquiring knowledge by occult means. It is based on the assumption that the whole of Nature is united by a subtle bond, corresponding in many ways to the ether postulated by Science. This bond is of such a nature that the diviner believes that his instruments will record actions far or near, present, past or future, in much the same way as the seismograph, the photographic plate, or the barometer indicate or record disturbances, incidents or changes in the physical world.

Broadly speaking, divination is of two kinds[1] :—

1. *SUPERNORMAL PERCEPTION* by means of visions in trance or in dreams.
2. The use of *ARTIFICIAL AIDS*, such as twigs, bones, etc.

The present paper is confined to the consideration of the second class only.

Before I describe the methods of artificial divination practised in the tribes that have come under my observation, it will be necessary to review the relation of divination to magic and totemism, for without a clear understanding of these relations it would be impossible to follow the lines of thought governing the interpretation of the "bones" or other "aids." The former relation is a very close one, for divination is really a branch of *MAGIC*.

Now, magic is to the savage what science is to the *savant*, namely, systematized knowledge founded on the records of observation. The savage studies the track of the animal he hunts, and a close inspection of the footprints and other signs, coupled with his knowledge of the habits of the animal, enable him to make fairly accurate predictions concerning the animal itself. He will tell you whether it is old or young, male or female, wounded or unhurt, and a host of other things which would amaze a novice in the art. He works precisely on the same lines as the man of science who, for instance, after a careful study of the pedigree and character of the parents, can predict the proportion of red or white offspring they will produce.

Predictions of science and of magic are based on the observation of relationships which exist, or appear to exist, between pairs of objects. Thus, for example, the relation between

[1]In practice, however, these two classes are largely interdependent, for the interpretation of "artificial aids" frequently depends on the state or condition of the seer, and the prophetic trance is often induced by artificial means.

the hoof of an animal and its imprint on the ground is observed. The hoof of the ox is cloven; that of the horse is not. The imprint of either corresponds in outline and in general character to the hoof that formed it. If the hoof be maimed or broken, a corresponding trace of that injury will be observed in the "spoor." Thus far, the conclusions of the savage are legitimate, and strictly scientific. But when it is assumed that this relationship *continues indefinitely*, a false premise is introduced, and the subsequent argument is fallacious.

This is precisely what is done in magic, for the laws of magic assume that whatever has once formed part of a body, or has been in contact with it, *continues to form part of it*, or to be *en rapport* with it.[2]

A native tracker, believing in this extended relationship, will point at the "spoor" with his thumb face downwards, in order, as he says, "to hold the spoor down," and he believes that by this action he retards the flight of his quarry. He will even go further at times, and drive a peg into the footprint, in the belief that by so doing the animal will be maimed.[3]

The rules of magic go still further, for they assert that this *rapport* may be induced between the representation of an object in the form of an image or symbol and the object itself. "Thus the North American Indians, we are told, believe that by drawing the figure of a person in sand, ashes or clay, or by considering any object as his body, and then pricking it with a sharp stick, or doing it any other injury, they inflict a corresponding injury on the person represented."[4]

Sympathetic magic, therefore, gives us a key to the interpretation of the Bantu witch-doctor's "bones" and other aids to divination, for every bone, or other object, used as an "autoscope"[5] is believed to be *en rapport* with some person, place or object, with which it was at one time in contact, or which it is supposed to represent. The rules by which these objects are chosen may be found in the study of *TOTEMISM*.

Totemism may be broadly defined as a generic system of classification found in primitive communities in many parts of the world, in which a class, family, or tribe is represented by an animal or other natural object. The system may be described as follows: Man is communal and gregarious by nature. He lives in communities, and hunts or makes war in organized bands. Such a band will arrange a code of signals by means of which combined action may be possible at any given moment. Among savage hunters, as a rule, such a signal will take the form of an imitation of the cry of some wild animal or bird, well-known in the neighbourhood, in order that it may not arouse the suspicions of the quarry. This idea is still further developed in warfare, and a tribal password is arranged, and,

[2] *Vide* "Encyclopædia Britannica," 11th edition, article "*Magic*."
[3] *Cf.* Frazer, "The Magic Art," 1, 208-212.
[4] Frazer, "The Magic Art," 1, 55.
[5] Sir W. F. Barrett, "Psychical Research," 28.

for the same reason given above, the cry or the gesture of a common animal is frequently chosen for the purpose.[6] In many cases these sounds or gestures would become the permanent signals or passwords of the tribe, and men would be known as "Owl" men, "Jackal" men, etc., because they belonged to the section or clan which was distinguished by the call or gesture of that animal or bird.

Among all primitive people who practise magic, however, we find the belief that a *rapport* exists between the *name* of a thing and the thing itself—in fact, a man and his name are often regarded as identical.[7] In the same way the identity of a *community* with a synonymous object may be postulated. Thus, for example (arguing on the law that things which are equal to the same thing are equal to one another), if a man and a bird are each called by the specific name "Owl," they must belong to the same species.

If this confusion of thought really exists, we should expect to find, as a natural corollary, that the killing of an owl by a man called "Owl" would be regarded as equivalent to the murder of a man of his own tribe. This is what we actually find.

Almost every Bantu tribe is distinguished by the name of an animal or other natural object, and that animal or object is regarded as *taboo* to all members of the tribe which bears its name.

This identity of man and totem is expressed not only by vocal imitation of the animal, but also by gestures of a more or less conventional type, which are supposed to represent the characteristic movements of that animal. These gestures are woven into the ceremonial dances, so that the tribal origin of a man may be ascertained by noting his actions during the dance. If a South African native wishes to find out what tribe another native belongs to, he will ask, "What dance do you dance?"[8] and the reply will be, "Owl," "Jackal," "Baboon," etc., according to the totem of his tribe.

If the foregoing principles of magic and totemism be borne in mind, there should be no difficulty in following the interpretation of the "bones" and other "artificial aids" used in Bantu divination.

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[6] *Cf.* the adoption of this principle by Baden-Powell in the organization of Boy Scout "Patrols."

[7] *Cf.* Andrew Lang: "Probably the whole Aryan Family at one time believed not only that the name was part of the man, but that it was that part of him which is termed the Soul . . . but, if the name is the soul of the bearer, and if the Totem also is the Soul, then the name, and the Soul, and the Totem of a man, are all one" ("The Secret of the Totem," p. 116, etc.). See also Frazer, "Taboo and the Perils of the Soul," p. 318 *ff*.

[8] Stow, "Native Races of South Africa," 411.

The system which is most widely known is that of

ASTRAGALOMANCY.

In this system the witch-doctor provides himself with a set of *astragali* or huckle-bones of various animals. These bones are convenient in shape and size, and they are still used in Russia, Italy, and other countries for playing various games. In South Africa the Boers call them "dol-ossen," or toy oxen, and this word has been retained in the phrase "dol-ossen gooi," which is equivalent to the English "Consult the oracle."

As a rule the set contains the astragali of the totem animals of the neighbouring tribes. In the case of larger animals some other bone or part of the body is used to replace the huckle-bone. Thus in the case of the lion, one of the phalanges is usually chosen, and parts of the carapace of different species of tortoise are commonly seen. A set in my possession contains a fretted bone ornament which was called "tlo" (*i.e.*, elephant), as it was supposed to be made of ivory, but in practice I was told that it represented "the white man," because it had been obtained from a European trader (Plate 8, Sekukuni set). From what we know of magic and totemism, it is clear that each bone or object in the set represents the animal of which it once formed part, and hence the *tribe of which that animal is totem;* and in the case of the "tlo" we have a good example of "contagious" magic, since it stands for the white man, with whom, at one time, it had been in contact.

The oracle is consulted in the following manner:—

1. Certain roots are chewed by the diviner.
2. The astragali are gathered up between the palms of the two hands.
3. The diviner blows or spits upon them, and utters a short incantation or formula calling upon the "bones" to reveal the answer to the question given.
4. The "bones" are then cast upon the ground before the squatting seer, and an answer gleaned from the position they assume.

It will be seen that the sides of each huckle-bone can be distinguished, as they differ in contour and general shape. The different aspects are named in accordance with the rules of magic. Thus, for example, if the huckle-bone of one of the *Bovidæ* be examined, it will be seen that two of the sides project towards one end rather more than the other; and if it be held against the light with these projecting sides uppermost, a rough likeness to the silhouette of an animal's head with ears erect will be obtained. This end, therefore, is regarded as the "head" of the "bone." In like manner the convex and concave faces are called the "back" and "belly" respectively.

When the "bones" are thrown, they may fall with the "head" facing either towards or away from the operator, and with one or other of these faces uppermost. In reading the

Rev. N Roberts.—Bantu Divination.

signs these positions are supposed to correspond to the positions of the objects they represent, and therefore to indicate the *condition* of the "principal" of each object. For, just as an animal is usually seen upon its feet when alive and well, it lies upon its side when asleep or sick, while a dead body is often found upon its back with feet uppermost, so the object in the diviner's set, being *en rapport* with its "principal," is expected to assume the same attitude taken up by its "principal" at the time.

The various positions assumed by the "bones" may be generally classified as follows:—

1. *Anterior position*: head facing away from the operator = "lost," "strayed," etc., generally *negative* character.
2. *Posterior position*: head facing towards the operator = "will be found," etc., generally *affirmative* character.
3. *Dorsal aspect*: back uppermost, indicates "health," etc., and, by a grouping of ideas, "success," "prosperity," etc.
4. *Ventral aspect*: belly uppermost, representing "death," "failure," etc.
5. *Right pectoral aspect*: right side uppermost.
6. *Left pectoral aspect*: left side uppermost.

   Either pectoral aspect may represent "sleep," "sickness," "uncertainty," and hence "try again."[9]

R. H. Nassau[10] records the same custom in the Congo: "After the ceremony, an elderly man or woman who has been a twin is called upon to split the kola nuts in order to find out whether the children will live or die. This is their way of asking the god or goddess to answer their requests (and it is singular that this throwing of kolas may be done repeatedly until the reply is favourable to the inquirer)."

In addition to the above positions, the *direction* of a lost object may be indicated by the direction in which a given bone faces. Thus the astragalus of a goat pointing directly at the huckle-bone of a pig would be conclusive evidence in the eyes of many natives that a lost goat had been stolen by a man of the pig totem. Sometimes a bone is included in the set, whose sole function is that of a "pointer."

Once these general principles are grasped, their application is left in a large measure to the ingenuity of the witch-doctor, but throughout the system we see the influence of imitative and contagious magic. Hence if the three carapacial plates of tor-

[9] If a reply be unfavourable, or not what the querent desires, he will often repeat the process indefinitely till he gets the desired answer. To our "Western" minds this is a proof of charlatanism. I imagine, however, that the Bantu witch-doctor regards the interaction of his "bones," and the objects they represent, as a mutually reflex one. Not only does the principal affect its vicar, but the latter acts reflectively on the former. Hence if the representative of a lost goat can be persuaded to fall in such a way as to indicate its recovery, the result is more than a mere prophecy—it is a magical act which will assist in the restoration.

[10] "Fetichism in W. Africa," 207.

toise (Plate 8, Sekukuni and Malaboch) should fall in the *anterior position* with the *dorsal aspect* when the diviner seeks information regarding the weather, the interpretation would be, "It is going to rain," because, to quote a native proverb, "*The tortoise only walks when it rains.*"

The use of *astragali* in divination can be traced back into the dim ages of the past, and indeed, they appear to be the earliest form of "autoscope"[11] known. According to Cicero, the Corcyraeans presented to the temple at Dodona "a metal basin with a statue of a man placed over it, in the hand of which was a brazen scourge of three thongs, from which small bones (ἀστράγαλοι) were suspended, which, being moved by the wind, struck against the basin," and thus produced sounds "of prophetic import."[12]

Angelo Mosso refers to the system as follows:—

"In the articulation of the foot there is a cuboid bone termed astragalus, used by the ancients for play like dice, and also for the purpose of divination. Fig. 30 shows some astragali of oxen and sheep from the excavations of Phæstos. I found some at Canatella, near Girgenti,[13] in a cultus site, and this is important, for astragali were used in the neolithic period, and are connected with the primitive Italic religion, which accounts for their being discovered in great numbers near the Lapis Niger in the excavations of the Roman Forum."[14]

These quotations, taken from a large number of records, ancient and modern, should suffice to show that there is more than a passing interest to be gained from a closer study of this primitive method of divination.

It is well known that dice used for play owe their origin to huckle-bones. Their evolution from astragali took place very early in history, and probably coincided with some advance in civilization and culture. There are several sets of dice from early Egyptian tombs in the British Museum, and some of these are identical in form and marking with the pattern in use in our own day.[15]

Side by side with the transition from the use of natural bones to artificially-formed cubes of ivory in the games of the ancients there appears to have been a similar development in the substitution of

IVORY TABLETS

for purposes of divination. This system of divination is described by Ennemoser under the title of *Cleromancy*, as

a kind of divination performed by the throwing of dice or little bones, and observing the points or marks turned up.

and he goes on to say that

[11] Autoscope = instrument by which the inspirations of the seer are automatically recorded or brought to light. *Cf.*, Sir W. F. Barrett, "Psychical Research," 28.

[12] Cicero, "De Divinatione," 34, 76, quoted in Smith's "Dictionary of Greek and Latin Antiquities," 3rd ed., **2**, 279.

[13] "Monumenti antichi," **18**, 88.

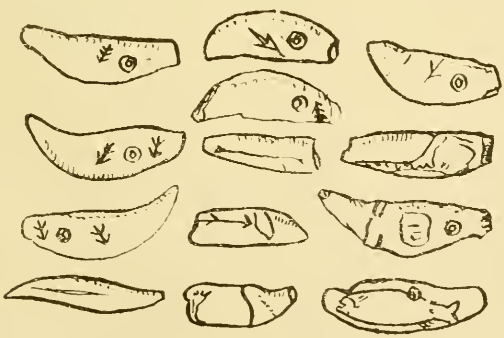
[14] A. Mosso, "Dawn of Medit. Civil," 67.

[15] *Cf.* "Harmsworth Encyclopædia," **3**, 1894; in which specimens are figured.

at Bura, a city of Achaiah, there was a celebrated temple of Hercules, where such as consulted the oracle, after praying to the idol, threw four dice, the points of which, being well scanned by the priest, he was supposed to draw an answer from them.[16]

Ivory Tablets from a Libyan Tomb.
(*Vide* Petrie, "Naqada and Ballas"; Churchward, "Signs and Symbols of Primordial Man.")

A still older relic may be found in the so-called "votive tablets" discovered by Professor Petrie in the Lybian tombs of Naqada,[17] which in all probability were used for the same purpose; and if the bear's teeth found in the Cave of Duruthy, in the South-



Bear's Teeth from the Cave of Duruthy.
(From S. Reinach, "Repertoire de l'Art Quaternaire," p. 179)

West of France, which are marked by differential symbols,[18] may be taken as evidence, the history of cleromancy goes right back into the quaternary period.

[16] H. Ennemoser, "History of Magic" (Eng. transl. by W. Howitt, in Bohn's Scientific Library, 2, 454.

[17] Petrie, "Naqada and Ballas"; De Morgan, "Recherches sur les Origines de l'Egypte"; G. Sergi, "The Mediterranean Race," 97. Churchward, "Signs and Symbols of Primordial Man," 179.

[18] *Cf.* S. Reinach, "Répertoire de l'Art Quaternaire," 179.

This practice has survived among the Bantu, and was described by Bent in almost the same words as Ennemoser: "On the evening of a new moon they will seat themselves in a circle, and the village doctor will go round tossing each man's set of *dolosses* in the air, and by the way they turn up he will divine the fortune of the individual for the month that is to come."[19] Mr. H. W. Garbutt, in a most interesting paper read before the Rhodesian Scientific Society in 1909,[20] showed the widespread use of tablets for divination in the country north of the Limpopo, and the following description by Dr. Theal proves the existence of a similar practice along the East Coast:

> The tribes of the interior were more superstitious than those of the coast, as they were guided in nearly all their actions by the position in which some pieces of bone or wood of the character of dice fell when they were cast upon the ground. . . . On each tablet a different pattern was carved, and each had a signification different from that of the others. Sometimes, instead of tablets, pieces of bone or of ivory carved in various shapes were used, in the manufacture of which a great deal of patient labour was expended. The usual number employed was five, but more were sometimes found in a set. If an ox strayed, the *daula*[21] was thrown to ascertain in what direction it had strayed; if a hunt was to take place, it was consulted to indicate in what quarter game was most likely to be found—in short, it was resorted to in every case of doubt. Each individual carried with him a set of these mystic articles strung on a thong, to be used whenever required. This superstitious practice, just as it was described more than three hundred years ago by the friar Dos Santos, is still prevalent and firmly believed in.[22]

H. A. Dryden[23] describes "four curious-looking pieces of ivory, three triangular in shape, the fourth rather long and pointed at either end," which "were flat, and had a sort of pattern rudely worked upon them," which were used by the Masarwa diviners, and in Plate 8 I figure a set in my own collection used by the Ovambo, still further west.

In the Northern Transvaal, ivory tablets resembling those of the Makalanga and Mashona are used by the chiefs and their indunas, but, as far as I am aware, only in conjunction with one or more astragali. These tablets are usually four in number, and are cut from the tusks of the wild boar. The individual pieces in a set are similar in size and shape, but are differentiated by symbols incised on one surface, the female sex being expressed by a "V"-shaped nick at one end. Those used by the Malaboch (*vide* Plate 8) are marked with symbols closely akin to those used in Southern Rhodesia, and are called by the following names:—

1. *Kuami*, representing the Chief of the Tribe or Clan.
2. *Tuadima* or *Tsuadima*, his wife.

[19] Theodore Bent, "Ruined Cities of Mashonaland."

[20] H. W. Garbutt, "Proceedings of the Rhodesian Scientific Association," 9, 50, *ff*.

[21] The same word "da-ula" is used in the Northern Transvaal to signify "throw the bones" or "divine." N.R.

[22] Theal, "Dark and Yellow-skinned People of Africa," p. 201.

[23] H. A. Dryden, "Gun and Camera in Southern Africa," p. 285.

3. *Selumi* (a technical term equivalent to "tooth-pattern," which may be translated literally as "the biter").
4. *Lengwana.*

The general rules of interpretation resemble those of astragalomancy, and the various positions are described in detail in a former volume.[24]

A comparative study of the designs on these tablets reveals a striking uniformity in nomenclature, and in many cases patterns from widely separate tribes are of a similar nature. The conventional designs on the Churinga of the Arunta of Central Australia[25] are said to be symbolic representations of the tribal or personal totems of their owners, and it is possible that these Bantu designs may serve the same purpose. At any rate, they are symbols expressing ideas, and bear the same relation to writing as potter's marks,[26] or the incised patterns of ancient divining tablets do to our own alphabet.[27] Their discussion, however, is beyond the scope of this paper, except in so far as they introduce us to another system of divination known and practised by the initiated in certain Bantu tribes, namely:—

Divination by Bowls.

In the course of a witchcraft trial a few years ago in the Northern Transvaal, two curious old bowls were produced as *corpus delicti*, and subsequently confiscated. They are now in the possession of C. A. Wheelwright, Esq., and Major C. Manning respectively (Plates 9 and 10). Each bowl is carved from a solid block of wood, with a fairly wide rim, which is divided into sections, each section being marked by a distinct symbol carved in relief. The bed of the bowl, in like manner, is divided into areas marked by embossed figures. The designs on the rim were said by the owner to represent "all the nations of the earth"—in other words, they are probably conventional symbols representing tribal totems Several of these crude figures will be recognised by students of symbolism and heraldry; *e.g.*, there is a fine example of the crocodile disappearing into the water—an ancient symbol of "night" or "death." One of the tablets forming fart of the complete set is embossed with a battle-axe, another ancient symbol representing "power," hence royalty, or "the Chief." (See photographs, Plates 9 and 10.) A solid cone of a hard, black, wax-like substance rises from the centre of each bowl almost level with the sides, the apices being

[24] Report South African Association for Advance of Science, Kimberley (1914), 367-370.

[25] Spencer and Gillen, "Native Tribes of Central Australia," 146 *ff*. *Cf.* also "Northern Tribes of Central Australia," 729-736.

[26] *Cf.* A. Mosso, "Dawn of Meditt. Civil," 12; Flinders Petrie, "The formation of the Alphabet," etc.

[27] "Formerly," says John Exarch of Bulgaria, who wrote in the ninth century, "the Slavonians had no books, but they read and made divinations by means of pictures and figures cut on wood, being pagans" (Edward Clodd, "The Story of the Alphabet," 215).

crowned by inverted cowrie shells. The bowl was filled with (water?) and a number of seeds, in the one case, and a pair of naviculate wooden buttons, in the other, were cast upon the surface, accompanied, presumably, by appropriate formulæ, and an answer divined from the position they assumed. Each bowl was accompanied by a set of astragali and tablets.

This method of divination finds many parallels in the history of magic. It bears a striking resemblance to the modern practice of divination by tea-leaves, and if "The Golden Wheel" said to have been used by Cagliostro[28] were transferred to a bowl the likeness would be perfect. It also reminds us of "a widespread practice of divination by oil among the ancient Babylonians, of which we have evidence in the reign of Urukagina, King of Lachish (*circa* 2800 B.C.). The procedure consisted in pouring oil upon the surface of water, the different forms taken by the oil on striking the water indicating the course events would take."[29]

The possession of a *pair* of these bowls by a native witch-doctor is explained by the following ceremony, which is performed during the training of a candidate in the art of divination. Two qualified witch-doctors take up positions about half-a-mile apart, and out of sight of one another. Each is provided with a wooden bowl filled with beer. The bones (astragali and tablets) are thrown in the bowl by one of the "doctors," but the position in which they fall cannot be seen, as they are hidden by the beer. The candidate then carries the bowl to the other "doctor," who consults his own tablets (or bowl?), and foretells the position of the set in the bowl of his companion. The accuracy of the Ngaka's forecast is then proved by carefully decanting the beer in the first bowl.

The Corcyræan bowl of Dodona was probably regarded with special veneration, as it combined three different methods of divination—astragali, the bowl, and "sounds of prophetic import." The use of astragali and bowls by Bantu diviners has already been described; it remains, therefore, to notice a method as yet but little known to Europeans, namely, the

"DIKOMANA,"

or divination by drums.

Frobenius[30] describes many interesting customs relating to the use of drums in Africa, but he says nothing about divination. As far as I am aware, the only non-Bantu people who use drums for this purpose are the people of Lapland and the North-East Coast of Russia.[31] Drum divination in those countries is a species of sortilege akin to the Bantu "bowl" system, and in

[28] "Manual of Cartomancy" (Wm. Rider and Son), 89, and Frontispiece.

[29] Hastings, "Encyclopædia of Religion and Ethics," 4, 783.

[30] Leo Frobenius, "The Childhood of Man" (Seeley & Co.).

[31] Tornaus, quoted by Ennemoser, "Hist. of Magic," 2, 98; see also "Encycl. Britt.," 9th ed., 14, 307.

·A·BANTU·DIVINER·

·WHEELWRIGHT'S·BOWL·

·MANNING'S·BOWL·
·OBVERSE·

·MANNING'S·BOWL·
·REVERSE·

this respect has nothing in common with the Bantu drums as far as I am aware, but in other ways they are similar.

The *dikomana*, or war-drums, are essentially instruments of magic, and are not to be confused with the *morupa*, or dancing drums, with which they have no connection. They are invariably "consecrated" by human sacrifice, a custom recorded in the Segananoa proverb: "The man who makes the dikomana will see them with his eyes, but he will never hear them with his ears." They are supposed to be possessed or inhabited by the tribal spirit,[32] and are consequently jealously guarded, and stored in a special hut. They are only used in connection with tribal fertility rites, or for other purposes of magic, and are therefore seldom seen.

The number of drums in a set is *always* five or a multiple of five. Each group is called a herd, individuals being known by the following names:—

1. *Moradu*: the "big cow" of the herd. This is the largest of the set, and is beaten with the fists only. The rest are beaten with sticks.
2. Pau (Po-o).
3. Maditsi.
4. Todiane.
5. Bo-pampane.

Each drum[33] is carved from a solid block of wood, and they appear to have been modelled on the spherical clay pots used by the Basuto. All are provided with projecting handles with the exception of the smallest, which has only one. The mouth of the drum is covered with the undressed skin of an ox, specially sacrificed for the purpose, and kept in position by wooden pegs. The largest drum is only eighteen inches in diameter, and the others diminish in size down to seven inches in the smallest. Numbers 2, 4 and 5 are without ornament of any kind. No. 1 has an embossed rim at the level of the handles, ornamented by a series of curved lines. No. 3 is surrounded by a belt ornamented with a series of patterns, including the "selumi" or "teeth." A smooth white pebble is kept in one of the drums, and part of a femur in another.

The use of the *dikomana* is closely bound up with a curious instrument called *sitlajani*, made of two pieces of grooved ivory bound together, grooves inward, with a thin film of skin between them, after the fashion of the "squeaker" used by "Punch and Judy" showmen.

At the time of some national crisis all men who have been initiated in the dikomana degree are summoned to the Chief's cattle kraal, where a solemn service is conducted. The invocation of the spirits is accompanied by the beating of the drums

[32] At certain times libations of beer are offered by being poured upon the largest drum in the set (Mrs. Franz).

[33] This description is taken from a set said to be over 300 years old, and now in the author's possession.

in a particular way, and these in their turn affect or "inspire" two or more "prophets," who masquerade as spirits, and emit weird cries through their *sitlajani*, which are believed to be the "voice of the gods." These cries are understood by the initiated, but by them alone. In this way the will of the tribal spirits is revealed, and woe betide those who fail to carry out orders received in this way.

Other Methods.

The foregoing notes refer to the methods of divination practised by men. Most natives are able to interpret the signs in sortilege more or less accurately, but as a general rule no one presumes to practice until he has graduated under a recognised professor in the art. In addition to the bones and drums there are simpler methods of divination known and practised by the common folk, and even by women. One of these, the *moseliseli*, is interesting since it is a variation of the custom of "breaking the merry-thought" or "wishing-bone," well known in most English homes.[34] When the traveller approaches a neighbouring kraal, he will take the ends of a forked twig of the moseli-seli tree and pull them apart. If one of the ends break away, it is regarded as an ominous sign, and the intended visit will probably be postponed. If, however, the branch splits evenly, "like the smile on the face of a friend," it is a sure sign that the querent will be received with smiles of welcome.

Omens are frequently consulted, and are gathered from the flight of birds and other incidents in Nature; but as these hardly come within the scope of "artificial aids" to divination, three short examples must suffice as illustrations of the rest.

1. If a *Grey Lourie*[35] is disturbed by herd boys on returning towards the kraal, and it flies off without uttering its usual cry—"Go 'way"—trouble is sure to be awaiting them at home.

2. A flock of *mouse birds*[36] flying over a kraal foreshadows the advent of visitors with beer.

3. The *track of a snake* across the path portends great difficulties on the journey. These can be removed, however, by cutting one's way through it with a spear.

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[34] Now replaced in most homes by the more refined, if more exciting, Christmas cracker. Forked twigs are also used by modern "dowsers."

[35] *Schizoris concolor* (Layard).

[36] *Colius erythromelon* (Vieill).

SOME OBSERVATIONS ON THE OCCURRENCE OF BULBILS ON THE SUBTERRANEAN OR AERIAL ORGANS OF PLANTS.

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

(*Plate* II.)

Vegetative reproduction by means of bulbillæ is known from all classes of higher plants. It is of frequent occurrence among the bryophytes, and several genera of liverworts produce special receptacles for their formation, *e.g.*, the common *Marchantia polymorpha*. Less frequent but not rare are bulbilliferous ferns, *e.g.*, *Asplenium monanthemum* and *A. gemmiferum*, the "mother-fern."

There do not seem to be any bulbilliferous plants among the Gymnosperms—at any rate, not in the South African flora.

The best-known examples of bulbil-bearing Dicotyledons of the British flora are *Dentaria bulbifera* (Cruciferæ) and *Polygonum viviparum* (Polygonaceæ). No bulbilliferous Cruciferæ or Polygonaceæ are known in South Africa. On the other hand, we find a number of species of *Oxalis* bearing bulbillæ, the best-known example being *O. cernua*, which under certain conditions produces large numbers of bulbillæ in its bulbs, as well as in the axils of the leaves. As is usual with such plants, they do not produce any seeds, although they may have flowered profusely. I have found plants of this species with a large number of tiny bulbils, about the size of a cabbage seed, accumulated in the axils of the leaves. They are rich in starch, and eagerly searched for by birds. On one occasion I found the crop of a pigeon almost filled with such bulbillæ.

Of European Monocotyledons the best-known examples are *Lilium bulbiferum* (in the axils of the cauline leaves) and *Allium sativum* (in the inflorescence), and of foreign plants introduced into South Africa, *Fourcroya gigantea* (Amaryllidaceæ) from Central America, which bears numerous large, green bulbils on the ramifications of the inflorescence.

More numerous are such plants in our flora, producing them on the subterranean as well as the aerial organs.

I. On Subterranean Organs.

We need not here consider the formation of several young bulbs by an older one, which process is of general occurrence among Liliaceæ and other orders, and for which the various lilies, the onion, the *Ornithogalum*, etc., are familiar examples. I wish to refer only to cases where the bulbillæ appear in great numbers around or within the principal bulb or corm.

Albuca minor.—Several plants collected at Camps Bay in October, 1915, possessed numerous small bulbils around the parent bulb. Under ordinary circumstances the species readily sets fruit, but when I gathered these two plants, one of which had produced four and the other one five flowers, the first two of each plant had withered without having set fruit (Pl. 11, 3).

Albuca viridiflora.—Of two plants gathered near Mowbray in October, 1915, each one possessed about 20 to 30 small bulbils around the principal bulb. The first flowers had just opened, hence I do not know if they would have produced fruit.

Gladiolus grandis.—Two plants from Frenchhoek enclosed numerous bulbillæ (small cormlets) among the fibrous covers of the main corm. The only flower of each plant was still fresh when gathered. Some other specimens of this species were without bulbils, but some gathered near Capetown possessed them as well.

Gladiolus cuspidatus.—A few plants gathered by Dr. W. F. Purcell neaer Retreat, on the Cape Flats, showed impoverished flowers, but numerous bulbils between the scales of the corm. In this case the abortion of the flowers was evidently due to the attack of a fungus (*Uromyces gladioli*). Leaves and stalks of some plants were so badly infested with this rust that the spike did not contain a single normal flower, and in some cases it possessed no flowers at all. On a few which were in a less injured condition the flowers were of normal size, but none had set seeds. Dr. Purcell informed me that in some years he had not been able to find a single well-developed flower owing to the ravages of this fungus.

Antholyza revoluta.—Several plants gathered at Camps Bay in July, 1916, possessed a large number of small bulbillæ among the old scales of the corm, quite similar to those of *Gladiolus grandis.**

Moræa viscaria (yellow variety).—From Cape Flats, October, 1915.—Numerous bulbils on the corm. The nearly allied *M. bituminosa*, gathered in the same locality, showed no bulbillæ.

II. Bulbils on the Aerial Organs.

Ornithogalum thyrsoides.—Groups of small green bulbils formed on the underside of a leaf. Flowers apparently normal, but no seeds formed.

Watsonia iridifolia.—In a patch of plants gathered near Hopefield (Cape Province) all stems bore bulbils (cormlets) in the axils of the cauline sheaths. Some of these plants were transferred to the author's garden at Capetown. They flower every year, but do not produce any fruit, although sun-birds often visit them. All produce little cormlets of medium size in the axils of the cauline bracts.†

Homeria miniata.—Frequent on the Cape Flats, near Capetown. Numerous bulbils on the corm and at the nodes of the stem. Flowers numerous, but seed-vessels apparently always empty (Pl. 11, 4).

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* See illustration of such a corm on Plate 50 of "The Flora of South Africa. (4.)

† See illustration in "Flora of South Africa," (4, 132.)

1 *Me.as, hœrula graminea* (L. fil.) Ker.

2. *Micranthus plantagineus* × *fistulosus* Marl.

3. *Albuca minor L.* 4 *Homeria miniata* Sweet.

R. Marloth.—Bulbils on Organs of Plants.

Homeria collina and *H. aurantiaca* in similar localities are without bulbils, and bear seeds well.

Moræa ramosa.—Numerous small bulbils on the corm, and a few large ones at the nodes of the stem.

Hesperantha bulbifera.—" Leaves 4, grass-like, linear, above a foot long, furnished with bulbillæ in the axils."* The plants had been collected by P. MacOwan on the Boschberg, near Somerset East.

Melasphærula graminea.—A frequent spring flower among shrubs near Capetown (Dutch name " baardmannetje "). In some localities always with a few large bulbils (cormlets) along the stem (Plate 11, 1).

Micranthus plantagineus.—Mostly with a few larger bulbils on the lower nodes. Flowers all fertile.

Micranthus fistulosus.—No bubils, neither on the corm nor in the empty bracts of the spike (the lower portion of the distichous spike is always formed of bracts without flowers, 20 to 30 on each side).

There is a plant named by Baker, *M. plantagineus*, var. *junceus*†, which bears bulbils in the otherwise empty bracts of *M. fistulosus*. This plant is, however, in our opinion, not a variety of *M. plantagineus*, but a hybrid of the two species (the only two), and its name is consequently to be *M. plantagineus* × *fistulosus* (Pl. 11, 2).

The following statement will show the intermediate nature of this plant:—

Micranthus plantagineus.—A few bulbils at the lower nodes. Lowest leaf (radical) lanceolate, acuminate, prominent midrib and thickened margin, the two cauline leaves shorter, also lanceolate, acuminate, strongly ribbed. Spike long, all bracts floriferous, the flowers dark blue; all flowers fertile.

M. fistulosus.—No bulbils. Lowest leaf (radical) fistulose, with a blunt but mucronate apex, the walls of the hollow leaf membranaceous, often brown at flowering time, the two upper leaves fistulose, acute, much shorter. Flowering portion of spike short, the lower bracts (30 to 50) empty; flowers pale blue, all fertile.

M. plantagineus × *fistulosus.*—No bulbils on lower part of stem. Lowest leaf (radical) terete, wiry, very elongate, hollow, striate like those of *M. plantagineus*, the two upper leaves shorter, otherwise similar. Inflorescence a simple spike or branched, the upper part flower-bearing, the lower part without flowers, but in each bract two or more bulbils; some bulbils also in the axils of the floriferous bracts. No seeds formed.

Summary.

From the foregoing observations it is obvious that there is a considerable number of bulbilliferous plants in the flora of

* Baker in " Flora Cap.," (6, 65.)
† " Flora Capensis," (6, 97).

South Africa. It is further seen that in most cases, *viz.*, 9 out of 12 species, the absence of fruit or seeds has been actually observed, while in the other three cases this was probable. The question naturally arises, is the formation of the bulbils the cause of the barrenness, or is the barrenness the cause of the appearance of the bulbils? In most cases experimental investigation could probably decide the question; but two of the above cases give some indication of the primary cause, *viz.*, that of *Micranthus plantagineus* × *fistulosus* and *Gladiolus cuspidatus.*

The *Micranthus* is a hybrid, and as it is known that hybrids are usually sterile, the formation of bulbils in the axils of the bracts of the spike is apparently caused by the barrenness, the materials required in fertile plants for the formation of the seeds being utilised for the production of the bulbils of the seedless hybrid.

The evidence afforded by *Gladiolus cuspidatus* is even stronger, for the barrenness of these plants is obviously caused by the rust, and the formation of the bulbils must be considered as a secondary process, which enables this species to propagate itself even in localities where the fungus attacks it regularly. In other localities, and also in gardens, *G. cuspidatus* often remains quite healthy, and produces perfect flowers, but I have not been able to ascertain whether these plants are fertile and whether they bear bulbils or not.

I have no doubt that more such cases will be found in our flora if more attention be paid to the subject; hence collectors of plants could much assist in the matter if they would record their observations when gathering and drying such specimens.

List of South African Species Mentioned.

Albuca minor L.
A. viridiflora Jacq.
Antholyza revoluta Burm.
Asplenium gemmiferum Schr.
Gladiolus cuspidatus Jacq.
G. grandis Thunb.
Hesperantha bulbifera Baker
Homeria miniata Sweet.
Marchantia polymorpha L.
Melasphærula graminea (L. fil.) Ker
Micranthus fistulosus (Jacq.) Eckl.
M. plantagineus (Ker) Eckl.
M. plantagineus, var. *junceus*, Baker
M. plantagineus × *fistulosus* Marl.
Moræa bituminosa (L. fil.)
M. ramosa (Thunb.) Ker
M. viscaria (L. fil.) Ker
Ornithogalum thyrsoides Jacq.
Oxalis cernua L.
Watsonia iridifolia (Jacq.) Ker
Uromyces Gladioli P. Hennings

A SCHOLASTIC VIEW OF TIME.

By Rev. Sidney Read Welch, B.A., D.D., Ph.D.

The thirteenth century was in some ways one of the most remarkable in the history of human development. From the political and religious standpoint it was a creative epoch, but it also marked the zenith of the evolution of the Scholastic Philosophy, one of the most complete systems which the world has seen.

I wish to draw attention to a minor chapter in that philosophy, its treatment of the vexed question of the nature of time. Two thirteenth-century treatises are extant in Latin, which deal with this subject, and are usually ascribed to the great St. Thomas Aquinas. They hold the most important contribution made from that quarter to the subject.

I propose not only to give an idea of what this teaching was, but also to trace it back to its foundation in Aristotle's works, and forward to its development among the Neo-Scholastics.

Every exponent of the Scholastic theory in its various schools took his stand in Aristotle as far as possible. It is said that they only read him in Latin translations, but with the Greek text before us to-day we note that their grasp of his meaning was wonderfully close.

The Aristotelian teaching, which is mainly contained in the last chapters of the fourth book, *Φυσικῆς Ἀκροάσεως*, may be summarised under three headings. I shall not take them in Aristotle's order, but in one more convenient for the present purpose.

The present moment is the only part of time which actually exists. For us it is the point which takes us to the boundaries of time.* It is the end of the past, the starting-point of the future, and the whole of the present. Hence he also calls it the link of time (*συνέχια χρονου*). We are conscious of time when, standing in the present moment, we become aware that the past is slipping away by moments, which are indivisible, as the Scholastics glossed the text.

The instant constantly moving along the course of time recalls the analogy of the moving point, which by its motion constitutes the line.† If you take any given point in a line, you can see what is before and what after; and so at any given instant, where you happen to be, you can measure "before and after" in time. The one point enables us to gauge distances in motion, the other reveals the existence of a duration in motion,

* *ὅλως πέρας χρόνου ἐστίν* (ch. xiii., n. 1).

† *Καὶ ὁμοίως δὴ τῇ στιγμῇ τὸ φερόμενον, ᾧ τὴν κίνησιν γνωρίζομεν καί τὸ πρότερον ἐν αὐτῇ καὶ τὸ ὕστερον* (ch. xi., n. 8).

which we signify by saying that things happen before a certain instant or after it.

But though it is true that the present moment enables us to divide time into present, past and future, it is also true that the moment establishes the continuity of time.* In the same way it causes us to realise two other properties of time, *viz.*, that it is quantitive and divisible. Now these three qualities are common to extension, motion and time. And since movement follows a line of some sort, since time follows movement, their measurements run parallel to one another.† Hence we measure movement by its extension, and time and motion in terms of one another. And for an instinctive tribute to the truth of the last statement, you need only remember that when you want to measure the flight of time, you look at the progress made by the hands of the clock. These preliminaries elucidate Aristotle's definition of time: "It is the measure of motion in its aspect of duration" (not a literal translation, but a fair paraphrase of his words): *ἀριθμὸς κινήσεως κατὰ τὸ πρότερον καὶ ὕστερον.* Experience teaches us that time disappears where there is no consciousness of movement, yet it is not movement itself; but whenever the mind discovers one thing living or moving before another, it becomes conscious of time.

Upon this foundation of Aristotle the two scholastic treatises mentioned build a fuller and more consistent theory of time. Much of what Aristotle has written is obscure, because of the imperfect way in which his lectures were taken down and preserved; but some of the obscurity is doubtless due to a want of development of the subject. This is fully atoned for by Aquinas in his exposition of the nature of time, which is a model of clarity and straight reasoning.

The monograph "De Tempore" has four chapters, in the first of which it is shewn that time is something real, though not an independent, self-sufficing entity. The second chapter is that which adheres most closely to Aristotle, whilst it puts greater logical sequence into the ideas scattered here and there by the Master. Time is not movement (is the burden of this chapter), but is dependent upon it and a measure of it. The third chapter discusses what things are measured by time and what not—movement first of all, and other things, in as far as they partake of movement or are related to it.

Amongst the realities which are above time, as we know it, come the separated substances and the First Cause of all things. Here Aquinas departs a good deal from the conclusions of Aristotle, but he is at pains to shew that the Scholastic theories of his day are in complete accord with the general and fundamental positions of the Philosopher; whilst time (he holds)

* *Καὶ συνεχής τε δὴ ὁ χρόνος τῷ νῦν καὶ διῄρηται κατὰ τὸ νῦν* (ch. xi., 9).

† *ἀκολουθεῖ γαρ τῷ μὲν μεγέθει ἡ κίνησις, τῇ δε κινήσει ὁ χρόνος, τῷ καὶ ποσὰ καὶ συνεχῆ καὶ διαιρετὰ εἶναι* (ch. xii., 6).

as defined by Aristotle is the proper measure of the duration of all things which are subject to generation and corruption, it cannot be the ἀριθμὸς of existences on a higher level. *Ævum* and eternity are the measures which express (as far as expression is possible in our terms) the duration of separated beings and the First Cause.

Here he carefully distinguishes at least two kinds of eternity—that which is mere time without beginning or end, and that which is "unitas rei æternæ." Elsewhere he contends that the eternity of the created universe is conceivable, and would not amount to a contradiction of its dependence upon a First Cause. The eternity of the latter is totally different in kind, and he describes it in the words of Boethius: "Æternitas est interminabilis vitæ tota simul et perfecta possessio."

The treatise "De Instantibus" carries the discussion a bit further in its five chapters. The second and third chapters pursue the fleeting τὸ νῦν through all its peregrinations, and are the most thorough discussion of the subject that we have anywhere. The other three chapters are most interesting, because they shew how the Scholastics were able to use Greek philosophy in expounding the scientific bearing of many facts of the Christian Revelation.

What Aristotle called the separated substances Christian tradition called Angels. But whereas Aristotle only glanced at these, it was necessary for a Christian philosopher to say a great deal about beings which figure so prominently in the Old and New Testament. Hence the need of expanding the teaching of the Greek, and of applying it to these new facts. I shall now endeavour to shew how he sets about this task in regard to time.

In the separated substances (which the Christian Revelation calls Angels) there is not the material succession* which is the basis of all time measurement with which we are acquainted. But since they can apprehend ideas in succession, there must be some means of measuring this duration of successive acts of their minds.

There is, therefore, a *prius et posterius* in the intellectual acts of separated substances, but it is not continuous, but discrete, if that term can be applied to a series which is not quantitative at all. Hence, whatever be the nature of the "time" which measures the successive operations of the angelic intelligence, it is composed of indivisible units. Let us imagine a number composed of successive units, each of which is indivisible because not quantitative.

A closer comparison with our own time will elucidate this. Time is called a number by Aristotle, because it is the means of enumerating the length of the duration of a motion. But if our time is a continuous quantity always, this is because it measures a material succession which is continuous. But the

* Aquinas, "Opuscula," vol. i., p. 350.

Angels are called separated substances by the philosophers because they are removed from all matter. Hence the measure of duration in their actions is in no sense a material number, whether discrete or continuous. But a multiplicity of succession there must me; and since it does not fit into any of the categories that we are familiar with, it is called a "transcendental multiplicity." This is the only way in which we can describe the time which measures the mental activity of these separated substances.

Hence it also follows that in the mental operations of these immaterial beings there is no such thing as a break measurable by time. In our mental operations such a break must occur when we pass from one subject to another, and may occur when we pause in our thought upon one subject. The second supposition is self evident, and the first becomes clear when we analyse what it means.

Let A be the moment of time when we cease thinking one subject, and B be the moment when we begin to think of the next. They cannot be identical; for we are unable to grasp two different subjects of thought at the same moment. These two points of time are like the points of an unbroken line; for time is flowing on in this unbroken succession during all our thoughts. But between any two points of a line there is a divisible extension, no matter how small it may be conceived to be. This is the necessary transition-time between one subject of thought and another.

There is therefore no break in the successive thoughts of the separated intelligences. With us the break is caused sometimes by the subject matter of our thoughts, which must always leave a gap measurable by our time when we change the subject of our thoughts; sometimes by the cessation from the act of thinking, which pause is likewise computed in terms of continuous time. But in the case of the immaterial substances the indivisible particles of time are not related to any external measure which runs on continuously and registers a break or transition. One particle of that indivisible time may persist whilst much of our time passes; but there can be no proportion between the parts of our time and the parts of the other.* All this transcends our imagination, because we are tied to the *continuum* of our time.

It is clear, however, that all time consists in a certain succession of duration. It depends entirely upon the things which are measured by time whether this succession will be continuous or discrete. There being no trace of material being in the Angels, *ex hypothesi*, even the disgregated particles of their time cannot be numbered or labelled as can the periods of our time.

Now, if the Scholastics stand for anything in this matter, it is for the reality of time. In modern speculation there has been an undoubted tendency to set down the idea of time as one

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* Aquinas, "Opuscula," p. 352.

of our mental delusions. It is therefore interesting to see how the revived Scholasticism of the last few decades has met these new tendencies. Kant, Bradley and Bergson may be taken as names that represent three streams of thought, which tend to shake the empirical view that time counts for something in the realm of reality.

Most of the Kantians will not admit that Emmanuel Kant treats time as a mental delusion. But what is it in his system? When he tells us that it is empirically real and transcendentally ideal, he does not describe what we mean by a real thing. What we think of, in apprehending time, is, he tells us, qualities of an absolute time which does not exist. Time is just the form of our internal perception, which is given us *a priori*, and which therefore does not necessarily arise from our being in touch with reality.

Against this the modern Scholastics have advanced two positions, which appear to safeguard the reality of time, better than Kant's hypotheses, if we are prepared to admit that Kant leaves anything to guard.

First, the data of time arise from experience, and are not given *a priori*. Cardinal Mercier, who was the distinguished leader of the Neo-Scholastics of Louvain forty years before his name became famous as the brave Belgian prelate, holds that Kant's objections only apply to ideal and imaginary time, *i.e.*, to notions that we may form of a possibly unlimited time or of a time limited only by the efforts of our imagination. It does not apply to what we may call physical time.

In fact, he says:

> Supprimez par la penseé tous les movements qui dans la realité forment le cours des événements, de coup le temps réel s'évanouit, mais le temps idéal reste avec le substrat que lui prête l'imagination. En résumé, rien ne demande que les notions d'espace et de temps soient antérieurs à l'expérience; l'analyse montre au contraire que l'observation extérieure et le sens intime en sont la source!

On the other hand, time has its root in the real world. For pure duration, which is a real consequence of real movements, is the foundation of that measurement which we call time. Pure duration is certainly not time, but it is something real which, when measured, gives us time. Certain conditions are required in order that this measurement may be possible; there must be a measuring mind, and the object to be measured must be normally presented. If any of these fail the measurement fails, not for want of a reality, but for want of the normal conditions in which it can be gauged. Is this not true of every real measurement? "Yet measurement, though as such it is an act of the mind, is none the less objectively determined." So says another recent writer* among Scholastics.

Bradley strikes at the reality of time through a destructive criticism of causality. But he also attempts to deal directly with time through duration. His argument is "based on a fallacy.

* Leslie J. Walker, S.J., "Theories of Knowledge," p. 249.

He assumes that causation, though continuous, has no duration, or, in other words, that for a finite cause to produce a finite effect no time is required; whereas, in fact, all causal action is a gradual process which may occupy a considerable period of time." * In some ideal world, or in some actual world more perfect than any of which we know by direct experience, all this may be so.

But in the real world, which is the rough material out of which we hew our speculative knowledge, the case is very different. Duration, and consequently time, are physical conditions of growth and evolution. Geological formations, animal variations, great political developments, are really tied to time for their results. The lapse of time is a real condition which gives the agents at work a necessary aid to their action. Time alone neither makes nor mars; but in many instances we perceive that all the other causes together will not produce a desired effect, if this reality be wanting. Who will doubt to-day that time is a real element of military preparedness?

Bergson is at once the most recent and the most thorough opponent of the reality of time. There is indeed a kind of time, which he asserts to be the very essence of life and the whole meaning of reality. But as this is a metaphor, we need not stop to consider it.

Time, as science conceives it, does not form part of the reality of material things: this is the Bergsonian proposition which really concerns us. It is so startling that one can only look for the reasons that are supposed to support it.

In the first place, Bergson asks us to reject the idea of a *real* time in relation to ordinary unorganised material things because whatever happens to them they remain substantially the same. In other words, time does not affect any substantial change. This is not always true, as we see when the diamond emerges from the ground, produced by many geological adventures in a long time from baser materials.

But even if time never worked a substantial change, that would not demolish its reality; for not all reality is made up of substantial differences. There are minor differences between things which often escape our observation because of the very incompleteness of their being. These are "quæ minimam entitatem habent," according to Aquinas in the very first chapter of his work "De Tempore." Time has a kind of parasitic existence, in so far as it cannot be conceived as standing alone, apart from the things which are measured by time. A partially elusive existence it does lead, and it requires logical reflexion to define its nature. Whilst, therefore, we can admit with Bergson that time does not possess the most substantial kind of being, nor the most obvious, these properties may make time an incomplete reality, but they do not destroy the reality of it.

Again Bergson takes up the parable by admitting that there is something which looks like reality in time, but it is a creature

* Idem, p. 372.

of the imagination. We imagine that things are subject to time, simply because our imagination is.

Let us examine this position. Does not the same experience that enables us to perceive the permanence and identity of our own being under its several phases also enable us to realise that we pass through various states of secondary change? Whilst all our lives we feel the same personality, our changes of experience are often very great at different times. It is not imagination that underlines this duration, partly identical and partly different; it is memory, and memory is most sensitive to the reality of time past.

But a modern Scholastic writer,* who did not write directly against Bergson in this point, has indicated the element of truth in Bergson's contention. "Apprehendit homo per conscientiam memoria adjutam seipsum durantem, proinde suam durationem suum tempus; postea alias durationes per experientiam externam percipit; quibus perceptis, mensuram aliquam communem ex arbitrio eligit. Hac ratione inducitur ad fingendum tempus quoddam universale, essentialiter mensurans ideoque relativum, cujus fundamentum extat in rebus experientia notis."

The concept of a universal time by which all other things are measured may be arbitrary and fluid, as the many methods of measuring time show. But all our measurements are in some way conventional. What is real in time is the fact of a real duration that can be measured, and is measured with mathematical precision.

Hence one may be pardoned for holding that the Scholastics, mediæval and modern, with their master Aristotle, have in this point established a philosophic view of things that has stood long changes of fashion. Time, which eats into so many things, has not consumed their main conclusions, which hold the golden mean between the extreme views, both of which Bergson has succeeded in incorporating into his astonishing system.

Glycerine from Waste Fat.—It was recently officially stated that glycerine is being recovered at the rate of 1,000 tons per annum from the waste fat of the food supplied to the Allied forces on the Western front. This quantity is sufficient to provide propellant explosive charges for about 1,250,000 18-pounder shells. In the earlier stages of the war the meat scraps from the military camps used to be destroyed or disposed of for trifling amounts. All this waste is now utilised by collecting and sorting the table refuse for the above purpose. Special plants for the conversion of waste fat into glycerine have been erected both in England and France, and the glycerine thus manufactured is sold by the War Office to the Ministry of Munitions for £50 per ton instead of the £240 per ton that glycerine imported from the United States would cost.

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* "Creteriologia," by R. Jeanniere, S.J., p. 374.

SIMPLIFIED SPELLING.

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

It might be thought that a paper urging the advantages of simplified spelling would be unnecessary before a scientific association, because the scientific method is the experimental method, and because a belief in evolution as a living principle is inherent in scientists. If this is so, why, then should experiments in spelling not evolve? In spite of grammars and dictionaries, our spoken English is evolving. Why should our spelling suffer because of an alien yoke long since forgotten? (I refer to the influence of the printers from Holland, who settled in England and virtually crystallized our spelling.)

Personally, I don't want to write in a simplified spelling, nor do I want to read in a simplified spelling; but then my learning days are perhaps past. It is not for myself or others who have acquired all the knowledge they ever will that I would advocate the need of simplified spelling. Nor is this advocacy to-day confined to idealists and visionaries. At the Annual Conference of Educational Associations held recently in the University of London, the subject was ably discussed. Professor Gilbert Murray said it was their hope that the English language would be read and spoken as widely as possible over the surface of the world, and one essential obstacle to their aim was that foreigners learning English had practically to learn two languages—one spoken, one written. Language should be written as pronounced. The English language was in a different position from many European languages. In most a watch had been kept over the relation between the written and the spoken word. Scandinavian and German were fundamentally but not minutely and exactly phonetic; Italian and Spanish were exquisitely and beautifully phonetic. Whoever hears an Italian word can spell it. In French, though the sound was not a good guide to the spelling, the spelling was a very safe guide to the sound. Some languages had gone wrong—as, for instance, Russian and Greek; and English is in a bad condition. Practical teachers estimated that English spelling entailed a dead loss of about one year of the pupil's time, which was serious enough, but more serious was the positive harm of giving children a training in unreason. The object of education is to put before the child as far as possible a reasonable world, instead of which the tendency in teaching spelling was to present to the child a thoroughly mad world, and to make the teacher appear capricious.

Sir Frederick Pollock, LL.D., D.C.L., compared the spellings as follows: In the first class he would put Spanish with special distinction, then Italian, then Dutch, although their vowel system was open to some objection; in the second class German fairly consistent but clumsy, then Gaelic and Russian. In the third class French and Greek. As for English, charity might give it a pass degree. It was the pendantry of Latinized printers which gave English spelling its Wardour Street character.

Dr. Macan, Master of University College, Oxford, said if he was a socialist he might go about the country denouncing the present system of spelling as a capitalistic and aristocratic device for keeping the people ignorant and in leading-strings.

Mr. W. W. Steer, President of the National Union of Teachers, said that children had to waste their time in spelling when they ought to be spending it in dealing with facts. It was impossible to give the same time to technical education, when there were these spelling difficulties to be got over.

And so on.

And how do our enemies look at it? A few weeks ago the *Cologne Gazette* found satisfaction in saying that the English had a spelling system so complicated that her educational efficiency was seriously impaired.

If Germany has put her general efficiency to bad uses, that is no reason why other countries should worship the cult of the inefficient.

There are two simplified spelling societies at work, namely, the Simplifyd Spelling Sosyeti of London, and the Simplified Spelling Board of New York

Of these, the English society is the more radical; it is out and out phonetic, whilst the American society relies on slow permeation. And many of us are adopting the spelling "recommended" by the Americans, such as "altho," "draft," "program," etc. The English society has on its board many living authors or authorities on English literature, such as Dr. Gilbert Murray, Lord Bryce, Professor Stanley Jevons, Dr. Mahaffy, Sir William Ramsay, Dr. Michael Sadler, Mr. Wells, and others.

An example of the English society's spelling is as follows:—

> And for children, if such a chainj took plais, wun wood be unaibel tu distingwish the edeukaited from the unedeukaited, or werdz tu that efekt.

The letters *c* and *q* are not used.

The American society recommends as a start the adoption of one hundred specimen words as follows:—

activ	brekfast	curv	dropt
addrest	brest	ded	dum
alfabet	campain	definit	endorst
altho	catalog	deserv	engin
anser	center	det	enuf
ar	cifer	discust	examin
askt	clipt	dout	exprest
bild	confest	draft	fantom
bilding	crost	dred	favorit
bredth	crusht	drest	fixt

fonograf	kild	rime	theater
fotograf	leag	ruf	tho
fulfil	liv	serv	thoro
gard	medicin	servis	thred
gardian	medieval	shal	thru
giv	nativ	shipt	til
hav	notis	slipt	tred
hed	offis	spred	tuch
helpt	orderd	stedfast	tuf
helth	paragraf	stopt	tung
honor	plow	sulfur	washt
iland	practis	surprize	wel
imagin	program	taxt	welth
imprest	relativ	telefone	wil
insted	resolv	telegraf	yung

And this list, neatly printed, will be sent gratis to all enquirers. The address of the society is 1, Madison Avenue, New York.

In my own experience, I have known some very clever men who were bad spellers, and some of them carried tiny pocket dictionaries. I have also known ignorant men who had the facility of eye and memory, who, if they talked vilely, spelt correctly.

Might we urge that our higher educational authorities should permit the use of simplified spelling in Matriculation and other examinations of a similar calibre, in which it is to be hoped the intention is to find out what the student knows of the world and its inhabitants, and with what precision of word he can convey that knowledge. Still better would it be, in this bilingual country, if the Government, in its official English correspondence, adopted the simplified spelling of the American society.

Mr. Bernard Shaw has very justly observed that if we don't alter our spelling we alter our pronunciation so as to bring it into conformity with the spelling. In my own time, I have noticed that many words are changing in this way. I give a few examples:—

Spelt and Now often Pronounced.	Twenty five years ago or with pedants like Myself To-day.
Opposite	Opposit
Infinite	Infinit
Often	Ofen
Wed-nes-day (or Wedensday)	Wensday
Again	Agen
Thank	Thenk
Humour	Umor
Clerk	Clark
Pall Mall	Pellmell

Thus it appears we cannot crystallize both, and the question is which is the better, that the spelling should follow the sound or the sound the spelling—at least, as far as possible?

But some spellings baffle all sound, such as "cough," "enough," "plough," "phthisis," whilst in other words it is becoming pedantic to give the sound values of a third of a century ago, such as "which," now generally pronounced "witch"; white—wite, etc.

My own experience tends to show that it is not the educated Englishman who can impress on the crowd the proper way to pronounce words, but, on the contrary, it is the crowd which forces the educated man to conform to its way of doing so.

In a scientific sense this leads to a mild confusion. The guardians of literature and speech have said in effect, "Speak as we do and spell as we do," and the populace has replied, "No; we will do either, but not both. We see your written word, we do not hear it; we will speak by the written word." This being so, if the guardians of speech consider that their spoken word must be preserved, then they must make their written word conform to it. Things will evolve even if they desire to stand still. Which should it be? In the interests of the rising generation and in the desire to facilitate the use of English all over the world, my vote would be for phonetic spelling.

The argument that the written and spoken languages should agree deserves emphasis when, as in South Africa, English is not the mother tongue of half of the white race nor of the teeming millions of natives. If we who acquired English as our mother tongue believe that its use should become general, let us aid its spread among other peoples by smoothing the road.

GRANTS FOR RESEARCH.—The Royal Society of South Africa invites applicants for grants in aid of Scientific Research in South Africa to send in their application forms, properly filled in, to the Secretary of the Society, Prof. W. A. Jolly, South African College, Cape Town, not later than the 1st August, 1917. Application forms may be obtained from Prof. Jolly.

POTASH FROM FELSPAR.—The problem of preparing soluble potash from felspar has long occupied the attention of chemists, but has not hitherto been made a commercial success. A process has, however, been patented by a Swede, J. Rhodin, who claims to be able to divide the cost of preparing the potash by producing along with it, as a by-product, a marketable white cement. Successful results had been obtained from Swedish felspars, and recently the Rhodin process has been applied to British felspars, from Roche, in Cornwall, and from Loch Eriboll, in Sutherlandshire. From the Roche felspar 75 per cent. of the contained potash was obtained in a soluble form, and 60 per cent. from the Loch Eriboll felspar. The cement produced at the same time is described in the February issue of the *Journal of the Board of Agriculture* as being a true hydraulic cement, satisfactory in colour, but much lower in tensile strength than Portland cement.

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AN ACCOUNT OF THE NATAL FUNGI COLLECTED BY J. MEDLEY WOOD.

By Averil Maud Bottomley, B.A.

The late Dr. Medley Wood's fungi amounted to some 550 mounted specimens. All, with very few exceptions, were found in Natal between the years 1875 and 1915, and by far the larger number were collected at Inanda about 1881, before he took charge of the Botanic Gardens, Durban.

The collection of these plants was thus primarily merely a hobby; for this reason, and taking into consideration his inadequate equipment and lack of reference books, it is greatly to his credit that there are so few omissions in his earlier collections.

Until recently the collection was left untouched; the specimens were retained in paper capsules firmly glued to sheets of mounting paper. No attempt was made to classify them beyond keeping those which are usually parasitic on living plants from the others. Dr. M. Wood deprecated the fact that lack of time prevented his remounting the specimens, because he feared that the above arrangement would lead to different species getting mixed when examined, the value of type specimens thus being destroyed. Now, however, in accordance with his wish, they have been remounted and classified, and, in order to make the collection of as much use as possible, it has been thoroughly revised; modern names have been substituted for obsolete, undetermined specimens have as far as possible been determined, and the whole has been incorporated with the Mycological Herbarium, Pretoria.

The above collection has been selected from several sets of specimens, *viz.*, his "Cryptogamia Austr. Africana—Herb. J. M. Wood," divided into 27 folios, each folio consisting of a single sheet of 18 mounted specimens; the set entitled "Ex. Herb. Woodianum, Colonial Herb—South African Plants," and miscellaneous specimens, many of whose numbers are prefixed by an A, his earlier distinguishing mark for the Cryptogams in general. The same specimen was often duplicated in the different sets, but is, of course, only quoted once.

In the list prepared below, the fungi have been arranged according to Engler and Prantl's system of classification. There are 100 genera, representing fairly well all the groups of Fungi except the Fungi Imperfecti, of which there are only eight genera. The majority of the specimens, however, belong to the Uredineæ and the Agaricaceæ. Of the 34 new species described by Cooke in publications of Grevillea, 30 belong to the former group alone. Among genera of particular interest might be mentioned *Rodwaya* Syd., formerly known as *Campbellia* Cke. and Mass., one of the Polyporaceæ. Apparently only two species of this genus have been recorded so far, one, *R. infundibuli-*

formis, from Australia, and the second, *R. africana*, collected by J. M. Wood in the Botanic Gardens, Durban. Another genus of interest is *Woodiella* Syd. and Sacc., named after its discoverer, belonging to the Patellariaceæ of the group Pezizineæ. Found in Durban on leaves of *Pavetta obovata*, it seems peculiar to Natal. With regard to new or interesting species collected by Dr. Medley Wood, there are too many for individual mention, so it will suffice to draw attention to just a few by enumerating the following:—

Neobaraclaya natalensis, *Femsjonia natalensis*, *Diorchidium Woodii*, *Hemileia Woodii*, etc.

MYXOMYCETES.

Myxogasteres.

Arcyria punicea Pers.
1. On decayed branches *Ricinus communis*. (322).
Ceratium hypnoides A. & T.
2. On decaying stumps. Inanda, February, 1881. (521).
3. *Hemiarcyria clavata* (Pers.) Rost. (529).
Physarum cinereum Fr.
4. On grass. (429).
Stemonitis fusca (Roth.) Rost
5. On Wood. (206).
Trichia turbinata Fries.
6. On rotting wood. (463).

PHYCOMYCETES.

OOMYCETES.

Cystopus cubicus Sw.
7. On leaves *Hewittea bicolor*. Inanda, January, 1881. (467).

ASCOMYCETES.

PEZIZINEÆ.

Pezizaceæ.

8. *Peziza aluticolor* Berk.
Peziza (Tapesia) *natalensis* Cke.
9. On decaying trunk of tree. (476).
Peziza nilgherrensis Cke.
10. On bark. Inanda, February, 1881. (549).
11. *Phillipsia domingensis* B. (411).

Helotiaceæ.

Helotium capensis C.
12. On decaying wood. Inandi, February, 1881. (520).
13. On bark. Inandi, January, 1881. (531).

PATELLARIACEÆ.

Woodiella natalensis Sat. & Syd.

14. On *Pavetta obovata*. Inanda, 25/5 97. (6451).

PHACIDIINEÆ.

PHACIDIACEÆ.

Phacidium repandum Fr.

15. On *Rubia cordifolia*. Inanda, June, 1881. (597).

16. *Rhytisma eugeniacearum*. (599).

Rhytisma porrigo Cke.

17. On leaves. Inanda, August, 1881. (660).

PYRENOMYCETINEÆ.

PERISPORIALES.

PERISPORIACEÆ.

Antennaria Robinsonii B & M.

18. On leaves host undetermined. Inanda, July. 1886. (636).

Balladyna? sp.

19. On Randia? Umgeni, 16/7/15.

20. On host undetermined, Mayville, 22/7/15.

Dimerosporium Acokantheræ P. Henn.

21. On *Acokanthera spectabilis*. Near Durban. 25/5/07. (6450).

22. On tree unknown. Near Durban, 17/5/99. (6461)

Meliola amphitricha Fr.

23. On leaves *Plectranthus* sp. Inanda. (22).

24. On *Plectranthus ciliatus* (604).

25. On host undetermined. (620).

26. On *Burchellia capensis*. Inanda, August, 1881. (653).

27. On *Gardenia globosa*. Umgeni, 16/7/15.

Meliola bifida Cke.

28. On *Osyridocarpus natalensis*. Springfield, 14/7/15.

Meliola Bosciæ Doidge.

29. On *Nebuhria pedunculosa*. Umgeni, 16/7/15.

Meliola capensis (K. & C.) Theiss.

30. On *Hippobromus alatus*. Umgeni, 16/7/15.

31. On *Hippobromus alatus*. Near Durban, 1897.

32. On *Hippobromus alatus*. Inanda. (57).

Meliola falcata Syd.

33. On *Plectronia* sp. Springfield, 14/7/15.

34. On host undetermined, Mayville, 22/7/15.

Meliola inermis K. & C.

35. On *Buddleia* sp. Inanda, June, 1881. (570).

Meliola Mitchellæ Cke.

36. On *Acridocarpus natalitius*. Inanda, May, 1881. (575).

37. On host undetermined. (637).

Meliola polytricha K & C.

38. On host undetermined. Inanda. (222).
39. On leaves *Oxyris compressa.* (448).

Meliola Rhois P. Henn.

40. On *Rhus.* sp. Mayville, 22/7/15.

Meliola sapindacearum Speg.

41. On *Dovyalis rhamnoides.* (6454).
42. On leaves host undetermined. (6457).

Meliola trisepta B. var.

43. On *Rubus rigidus.* Inanda, June, 1881. (566).

Meliola Woodiana Sacc.

44. On host undetermined. (6467).

Meliola sp.

45. On host undetermined. Near Durban, 28/5/99. (6456).
46. On *Euclea natalensis.* Near Durban, 25/5/97. (6447).
47. On host undetermined. Mayville, 22/7/15.
48. On host undetermined. Springfield, 14/7/15.

Parodiella perisporioides (Berk. & Curt) Speg.

49. On *Vigna marginata.* Inanda (115).

Parodiella Schimperi. P. Henn.

50. On *Rhynchosia* sp. Near Durban, 25/5/97. (6455).
51. On *Rhynchosia* sp. (6445).

MICROTHYRIACEÆ.

Asterina diplocarpa Cke.

52. On *Sida rhombifolia.* Inanda, June, 1881. (601).

Asterina ditricha K. & C.

53. On *Celastrus.* 1876. (3).

Asterina fimbriata K. & C.

54. On *Hypoestes aristata.* Inanda, 1881. (608).

Asterina Grewiæ Cke.

55. On host undetermined. (639).

Asterina MacOwaniana K. & C.

56. On *Celastrus buxifolius.* (6450).
57. On *Celastrus buxifolius.* Near Durban, 25/5/94. (6452).

Asterina myriadæ Cke.

58. On host undetermined. (641).

Asterina phæostroma Cke.

59. On *Kraussia lanceolata* (652).
60. On *Pavetta natalensis.* Inanda, September, 1881. (606).

Asterina similis Cke.

61. On *Sida rhombifolia.* Inanda, April, 1881. (5[illegible]).

Asterina stylospora Cke.

62. On *Sponia guineensis.* Inanda. (564).
63. On *Trema bracteolata.* (A564).

Asterina tenuis Wint.

64. On *Kraussia coriacea.* (6452).
65. On host undetermined. (6458).

Asterina toruligena Cke.

66. On host undetermined. (635).

67. On host undetermined. Near Durban, May, 1881. (559).

Asterina sp.

68. On *Jasminum multipartum* Springfield, 14/7/15.
69. On *Heteropyxis natalensis*. Springfield, 14/7/15.
70. On one of the *Celastrineæ*. Umgeni, 16/7/15.
71. On *Cryptocarya Woodii*. Mayville, 22/7/15.
72. On *Trimeria alnifolia*. Mayville, 22/7/15.

Asteronia fimbriata D. & C.

73. On host undetermined. (608).

Asteronia sp.

74. On *Dicleptera heterostegia*. Mayville, 22/7/15.

Seynesia Balansæ Speg., var. *Africana* Sacc. n.v.

75. On *Rubus rigidus*. (6464).

Hypocreales.

Hypocrea lycogalæ K. & C.

76. On host undetermined. (399).

Hypocrea sp.

77. On bark. Inanda, January, 1881. (547).

Nectria coccinea Fr.

78. On decaying trunk. Inanda, February, 1881. (517).

Sphærostilbe pseudotricha Schy.

79. On fallen trunk of tree. Inanda, January, 1881. (488).

Dothideales.

Dothidea circinata K. & C.

80. On host undetermined. (49).

Dothidea crotonis C.

81. On *Croton sylvaticus*. (466).
82. On *Croton sylvaticus*. Inanda, January, 1881. (406).

Dothidea graminis P.

83. On grass. (221).
84. On grass. Inanda, May, 1881. (569).

Dothidea lucens Cke.

85. On host undetermined. Inanda, May, 1881. (581).

Dothidea perisporoides Bernk.

86. On *Desmodium setigerum*. Inanda, June, 1881. (541).
87. On *Eriosema cordatum*. Inanda, May, 1881. (664).
88. On *Eriosema salignum*. (471).
89. On *Vigna marginata*. Inanda. (115).

Dothidea puncta Cke.

90. On *Dalbergia armata*. Inanda, June, 1881. (605).
91. On host undetermined (607).

Dothidea repens Corda.

92. On *Ficus* sp. Inanda, April. (543).
93. On host undetermined. Inanda. (228).

Dothidea scabies K. & C.

94. On host undetermined. Noodsberg. (48).
95. On host undetermined. (50).

Dothidea Strelitziæ Cke.
96. On *Sterlitzia augusta*. Inanda, May, 1881. (580).
Dothidea viventis Cke.
97. On *Albizzia fastigiata*. Inanda, May, 1881. (583).
Phyllachora Crotonis (Cke.) Sacc. Grev. X 28-9.
98. On *Croton sylvaticum*. Inanda, 12/1/81. (A466).
Phyllachora gentilis Speg.
99. On *Eugenia capensis*. Near Durban, 14/5/97. (6462).

SPHÆRIALES.

Chætomiaceæ.

Ascotricha chartarum B. & B.
100. On host undetermined. (542).

Sphæriaceæ.

Melanopsamma parasitica Sacc.
101. On host undetermined. Inanda. (6467).
Sphæria applanata Fr.
102. On *Pinus* sp. (4103).
Sphæria Collinsii Sch.
103. On *Amelanchier canadensis*. (4102).
Sphæria Coryli Botsch.
104. On *Corylus* sp. (4101).
Sphæria filicinum Fries.
105. On *Pteris aquilina*. (4100).
106. *Sphæria fimbriata*. (4097).
Sphæria fusca Pers.
107. On host undetermined. (4098).
Sphæria trifolii Pers.
108. On host undetermined. (4099).
Sphæria sp.
109. On host undetermined. Inanda. (83).
Sphærella myrsines K. & C.
110. On leaves *Myrsine africana*. Niginya. 14/10/07. (11235).

Ceratostomataceæ.

Ceratostoma sp.
111. On leaves host undetermined. Durban. (558).

Coryneliaceæ.

Corynelia uberata Fr.
112. On leaves *Podocarpus elongata*. (3203).

Mycosphærellaceæ.

Stigmatea Rhynchosiæ K. & Cke.
113. On host undetermined. Inanda, 1877. (55).
114. On *Dioscorea* sp. Noodsberg. (A54).

Pleosporaceæ.

Physalospora chænostoma Sacc.
115. On *Maesa rufescens*. (86).

Valsaceæ.

Valsa stellulata Fr.
116. On dry sticks. Natal, 1884. (574).

Diatrypaceæ.

Microstoma quercinum.
117. On *Quercus* sp. Inanda. (59).

Xylariaceæ.

Hypoxylon rubiginosum Fr.
118. On bark. Inanda, February, 1881. (523).
Poronia punctata Fries.
119. On horse dung. Inanda. (404).
Xylaria hypoxylon Fr.
120. On tree trunk. Inanda (342).
121. On tree trunk. Inanda. (402).
Xylaria nigripes (Kl.) Sacc.
122. On grass. Durban, April, 1914. (12600).
Xylaria rhopaloides M.
123. Inanda. (346).
124. *Xylaria* sp. (324).

BASIDIOMYCETES.

Ustilagineæ.

Ustilago Sacchari. Rabh.
125. On *Saccharum officinarum*. Umhlanga, July, 1881. (650).
Ustilago Vaillantia Tul.
126. On flowers. *Scilla Kraussia*. Inanda, September, 1881. (649).
Ustilago sp.
127. On *Cyperus* sp. Durban, 1884. (A823).
128. On *Chloris compressa*. Natal, 1884. (821).
Graphiola Phoenicis Poir.
129. On *Phœnix reclinata*. Inanda, March, 1881. (554).

UREDINALES.

Melampsoraceæ.

Coleosporium Hedyotis K. & C.
130. On leaves *Hedyotis amatymbica*. Inanda. (60).
Coleosporium ochraceum Fell.=MacOwan, 1112.
131. On leaves *Agrimonia Eupatoria* (432).
Coleosporium? sp.
132. On host undetermined. Umhlanga, July. (624).
133. On *Vernonia* cf. *hirsuta*. Inanda, 10/6/81. (A622).

Melampsora hypericorum (D.C.) Schrot.
134. On *Hypericum æthiopicum*. Inanda, September, 1881. (646).
135. On host undetermined. (610).
Melampsora stratosa. Grev. X., p. 28-9.
136. On *Croton sylvaticus*. Inanda, 12/1/81. (A466).

PUCCINIACEÆ.

Æcidium acanthacearum Cke.
137. On *Calophanes Burkei*. Grev., X., 124. Inanda, September, 1881. (2685).
138. On *Justicia* sp. (603).
139. On host undetermined. (645).
Æcidium albilabrum Kalch.
140. On leaves *Kraussia floribunda*. (11344).
141. On leaves *Kraussia floribunda*. (2786).
142. On leaves *Kraussia floribunda*. (A233).
Æcidium aroideum Cke.
143. On leaves *Stylochiton natalense*. Inanda. (114).
Æcidium asperifolium L.K.
144. On *Cynoglossum micranthum*. Inanda, 17/9/81. (643).
Æcidium bicolor Sacc.
145. On leaves *Maba natalensis*. Near Durban, 14/5/97. (6460).
Æcidium Brachypodii.
146. On host undetermined. (590).
Æcidium Cardiospermi Cke. Grev., X. 124.
147. On leaves *Cardiospermum microcarpum*. (2673).
148. On leaves *Cardiospermum microcarpum*. (537).
Æcidium Crini K. & C. Grev., X., 124, XI. 126.
149. On leaves *Crinum Moorei*. (2667).
150. On leaves *Crinum capense*. Inanda. (68).
Æcidium crypticum K. & C.
151. On leaves *Gerbera discolor*. (11955).
152. On leaves *Gerbera* sp. (66).
Æcidium Cussoniæ K. & C.
153. On leaves *Cussonia* sp. Inanda. (88).
Æcidium Dissotidis Cke.
154. On leaves *Dissotis incana*. Grev., X., 124. (223).
155. On leaves *Dissotis princeps* (470).
Æcidium Dolichi Cke.
156. On *Dolichos axillaris*. Inanda, July, 1881. (640).
157. On *Dolichos* sp. Inanda. (40).
Æcidium flustra Bernh.
158. On *Aster* (Diplopappus) *asper*, September, 1881. (2681).
159. On *Aster asper*. (648).
Æcidium Macowanianum Thum.
160. On *Conyza incisa*. Inanda, 1877. (18).

161. On *Conyza pinnatilobata.* (456).
162. On *Conyza pinnatilobata.* (2669).

Æcidium Ocimi P. Henn.

163. On *Ocimum obovatum.* Inanda. (46).

Æcidium ornamentale K.

164. On legumes *Acacia horrida.* Ladybrand, February, 1895. (5629).
165. On host undetermined (A682).

Æcidium Osyridocarpi Mass.

166. On *Osyridocarpus natalensis.* Tabamhlope, 14/10/07, and September, 1907. (10527).

Æcidium Oxalidis Kalch., n. sp.

167. On *Oxalis purpurata.* (453).

Æcidium Phaseolorum D. C.

168. On *Desmodium scalpe.* June, 1881. (613).

Æcidium Plectroniæ Cke.

169. On *Plectronia Gueinzii.* Grev., X., 124. (2743).
170. On *Plectronia Gueinzii* (577).
171. On host undetermined (573).

Æcidium Plectranthi Cke.

172. On *Plectranthus* sp. (2768).
173. On host undetermined. (505).

Æcidium of *Pleoravenelia* MacOw.

174. On *Acacia horrida.* Ladysmith, February, 1895. (5629).

Æcidium Royenæ C. & M

175. On *Royena pallens.* Near Durban, 13/9/88. (4078).

Æcidium scrophulariæ D. C.

176. On *Chænostoma scrophulariæ.* 3/5/81. (2762).
177. On *Chænostoma floribundum.* (562).

Æcidium Senecionis Desv.

178. On host undetermined. (642).

Æcidium Stobææ K. & C.

179. On *Stobæa* sp. (63).
180. On *Berkheya* sp. (651).

Æcidium Tabernæmontanæ Cke.

181. On leaves and petioles *Tabernaemontana ventricosa.* (469).
182. On leaves and petioles *Tabernaemontana ventricosa.* (2776).

Æcidium Thunbergiæ Cke.

183. On leaves *Thunbergia natalensis* (468).

Æcidium Tragiae Cke.

184. On *Tragia* sp. (628).

Æcidium Valerianae D. C.

185. On *Valeriana capensis* (443).

Æcidium Vangueriæ Cke.

186. On *Vangueria infausta.* Durban. (11799).
187. On *Vangueria infausta.* (527).
188. On *Vangueria infausta.* Near Durban. 14/5/97. (6463).

189. On *Vangueria infausta.* Inanda, March. 1881. Grev., X., 124 (2671).
190. On *Vangueria latifolia.* 1906.

Æcidium Vignæ Cke.

191. On *Vigna marginata.* Inanda, 1881. (407).

Æcidium Withaniæ Thum.

192. On *Withania somnifera* (447)

Æcidium sp.

193. On *Gomphostigma scoparoides.* Bushman's River Valley, 21/10/07. (10565).
194. On *Helichrysum quinquenerve.* 7/10/81. (A662).
195. On *Helichrysum* sp. (73).
196. On *Kraussia floribunda.* Near Jee's, May, 1876. (21).
197. On *Ocimum gratissimum.* Botanical Gardens, Durban, 5/3/09. (11234).
198. On *Ocimum obovatum* June, 1881. (368).
199. *On Pelargonium aconitiphyllum.* Inanda. (81).
200. On *Senecio tamoides.* Winkle Spruit, 28/5/15.
201. On *Senecio* sp. Inanda (11348).
202. On *Tragia* sp. Greytown, 15/4/94. (11353).
203. On *Vangueria latifolia.* Inanda, January. (A540).

Cæoma nervesequina Thum. n. sp.

204. On fronds *Pellæa hastata* (441).

Cæoma Ricini.

205. On *Ricinus communis.* Inanda. (33).

Diorchidium Woodii. K. & C.

206. On leaves *Millettia caffre.* Grev., XI., 26. Durban, Tongaat, near Umzinyati Falls. 1880. (A70).

Hemileia vastatrix B. & B.

207. On *Coffea* sp. Riet Valley Estate. Natal.
208. On *Coffea Maragogipe* var. Botanical Gardens, Durban. 30/4/97. (6466)
209. On *Coffea Maragogipe* var. Botanical Gardens, Durban, February, 1906.

Hemileia Woodii K. & Cke.

210. On *Vangueria infausta.* Grev., X., p. 22. Inanda, March, 1881. (28).
211. On *Vangueria infausta* Natal, March, 1898.
212. On *Vangueria infausta.* Isedumbini, 26/4/99. (A107).
213. On *Vangueria latifolia* (A540).

Phragmidium longissimum. Thum.

214. On *Rubus rigidus.* Inanda. (34).

Phragmidium mucronatum Fr.

215. On *Rosa* sp. Durban, 1882. (A686).

Puccinia africana Cke.

216. On *Spilanthes africana.* Inanda. (200).

Puccinia arundinaceæ Hdw.

217. On *Phragmites communis.* (444).

Puccinia brachypodii. Fckl.
218. On grass. Inanda, June, 1881. (590).
Puccinia bullata (Pers.) Wint.
219. On *Peucedanum capense.* Inanda, August. (A623).
Puccinia carbonacea K. & C.
220. On host undetermined. Near Jee's, May, 1876. (23).
221. On host undetermined. (111).
Puccinia Cerasi (Bereng) Cast.
222. On host undetermined. itafamasi. (45).
Puccinia compositarum Schlecht.
223. On host undetermined. (37).
Puccinia cucurbitacearum.
224. On *Momordica cordifolia* Inanda. (141).
Puccinia discoidearum Lk.
225. On *Artemisia afra.* Inanda, August, 1881 (625).
Puccinia exhauriens Thum. n. sp.
226. On *Jasminum tortuosi.* Boschberg, October, 1875. (454).
Puccinia Galopinæ Cke.
227. On *Galopina aspera.* Inanda, June, 1881. (602)
Puccinia (Uredo) *Gladioli* Cast.
228. On *Dierama* (*Sparaxis*) *pendula.*. Inanda, June, 1881. (585)
Puccinia graminis L.
229. On *Phragmites communis.* Umhlanga, July, 1881. (A624).
Puccinia granularis K. & Cke.
230. On *Pelargonium aconitiphyllum.* Inanda, 1877. (A10).
Puccinia Helichrysi K. & C.
231. On *Helichrysum latifolium.* Grev., IX., p. 21. Inanda, June, 1881. (592).
232. On *Helichrysum petiolatum.* (35).
233. On *Helichrysum quinquenerve.* (A551).
234. On host undetermined. (632).
235. On host undetermined. (633).
Puccinia holosericea Cke.
236. On *Ipomæa ficifolia.* 3/5/81. (A560).
237. On *Ipomæa holosericea.* Grev., X., p. 126. Inanda, May, 1881. (560).
Puccinia Ipomææ Cke.
238. On host undetermined. (225).
Puccinia Kraussiana Cke
239. On *Smilax Kraussiana.* Inanda, June, 1881. (611).
Puccinia (*Uredo*) *Lychnoidearum* D. C.
240. On *Dianthus crenatus.* Inanda, June, 1881. (615).
Puccinia Malvacearum Mont.
241. On *Althea rosea.* (455).
242. On *Malva rotundifolia.* Somerset East. (440).
243. On host undetermined. Inanda. (42).

Puccinia Menthæ Pers.

244. On *Mentha sylvestris.* (466).

Puccinia Mesembryantheæ MacOwan.

245. On *Mesembryanthemum micrantha.* Graaff-Reinet.

Puccinia natalensis Diet & Syd. n.sp.

246. On *Lantana salviæfolia.* Umzinyati. (71).

247. On *Lantana salviæfolia.* Zululand, March, 1888. (11351).

248. On *Lantana* sp. Zululand, April, 1888.

Puccinia œdipus Cke.

249. On *Senecio panduriæfolius.* Grev., X., p. 126. Inanda, May, 1881. (561).

250. On leaves and scales *Ornithogalum* sp. Grev., X., p. 21. (659).

Puccinia Pachycarpi. K. & Cke.

251. On *Pachycarpus grandiflora.* Inanda. (36).

Puccinia Pentanisiæ Cke.

252. On *Pentanisia variabilis.* Grev., X., p. 125. Inanda, June, 1881. (567).

253. On *Pentanisia variabilis.* (11343).

254. On host undetermined. (536).

255. On host undetermined. (596).

Puccinia Plectranthi Thum.

256. On *Plectranthus?* sp. Grev., X., p. 126. Inanda, June, 1881. (618).

Puccinia Phyllocladiæ Cke.

257. On *Asparagus falcatus* Grev., X., p. 125. Inanda. (630).

Puccinia Popowiæ Cke.

258. On *Popowia caffra.* Grev., X., p. 126. Inanda, June, 1881. (614).

Puccinia Printziæ Thum., n. sp.

259. On *Printzia Huttoni.* (442).

Puccinia purpurea Cke.

260. On *Zea Mais.* Inanda. (229).

Puccinia Rhynchosiæ K. & Cke.

261. On *Rhynchosia adenodes.* Inanda. (29).

Puccinia Salviæ Ung.

262. On host undetermined. Inanda. (27).

Puccinia Scorodoniæ DC.

263. On *Lippia asperifolia.* Inanda. (538).

Puccinia Stobeæ K. & C.

264. On *Berkheya* sp. Inanda, June, 1881. (616).

265. On *Stobæa membranacea.* (438).

266. On host undetermined. (67).

267. On host undetermined. (80).

Puccinia striæformis Wasta.

268. On host undetermined. (113).

Puccinia Tabernæmontanæ Cke.
269. On host undetermined. (612).
Puccinia Thunbergiæ C.
270. On *Thunbergia natalensis.* Grev., X., p. 125. Inanda, May, 1881. (576).
Puccinia Tragiæ Cke.
271. On *Tragia* sp. Inanda, July, 1881. (631).
Puccinia Trochomeriæ.
272. On *Trochomeria sagittata.* Inanda, June. 1881. (594).
Puccinia (Trichobasis) *Vernoniæ* Cke.
273. On *Vernonia angulifolia.* Grev., X., p. 126. (3204).
274. On *Vernonia hirsuta.* Inanda, 10/6/81. (A622).
Puccinia sp.
275. On *Lantana salvæfolia.* Inanda. (71).
276. On *Lantana salvæfolia,* Inanda. (85).
277. On *Lantana salvæfolia.* Zululand, April, 1888. (11351).
278. On *Pentanisia variabilis.* (11343).
279. On host undetermined (Verbenaceæ). (72).
280. On host undetermined (Liliaceæ). Inanda, June 22nd. (630).
281. On host undetermined. Inanda, 21/8/79. (A629).
Ravenelia glabra. K. & C.
282. On legumes, *Calpurnia sylvatica.* Somerset East. (503).
Ravenelia minina Cke.
283. On *Albizzia fastigiata.* Grev., X., p. 128. Inanda, May, 1881. (571).
Ravenelia stricta B. & Br.
284. On leaves *Calpurnia sylvatica.* (445).
Ravenelia Tephrosiæ Kalch.
285. On *Tephrosia macropoda.* Inanda. (25).
Trichobasis cichoracearum Cke.=*Puccinia Hieracii* (Schum) Mart.
286. On *Bidens pilosa.* Inanda. (230).
Trichobasis Hypæstis Cke.=*Uredo hypæstis* Cke.
287. On *Hypæstes aristata.* (589).
Trichobasis Labiatarum Lev.=*Puccinia Menthæ.* Pers.
288. On *Leonotis ovata.* (578).
Trichobasis Phaseolorum DeBy.
289. On *Phaseolus* sp. (504).
Trichobasis Rhynchosiæ K. & Cke.
290. On *Rhynchosia orthodamon.* (565).
291. On *Rhynchosia orthodamon.* Inanda, May, 1881. (579).
292. On *Flemingia congesta.* (553).
293. On *Eriosema cordatum.* (556).
294. On host undetermined. (617).

Trichobasis Rhynchosiæ K. & C. var *eriosemæ*.
295. On host undetermined. (528).
Trichobasis rubigo-vera. Lev.=*Puccinia Rubigo-vera* Wint.
296. On *Avena sativa.* (452).
Trichobasis Stachydis D. C.
297. On *Stachys nigricans.* (654).
Trichobasis umbellatarum D. C.=*Puccinia Apii* Desm.
298. On *Peucedanum capense.* (623).
Trichobasis vernoniæ Cke.
299. On *Vernonia corymbosa.* Inanda, April, 1881. (546).
300. On *Vernonia* sp. (626).
301. On *Vernonia* sp. (584).
302. On *Vernonia hirsuta.* (622).
Trichobasis sp.
303. On *Hypæstes* sp. 10/6/81. (A589).
Uredo Alliorum D.C.
304. On *Scilla Kraussii.* Inanda, September. 1881. (655).
Uredo Aloes Cke. n. sp.
305. On *Aloe Saponaria.* Grev., XX., 1891-92, p. 16. Near Greytown. April, 1891. (4511).
Uredo appendiculatus (Br.) Link.
306. On *Phaseolus* sp. (89).
Uredo balsamodendri Cke.
307. On *Balsamea* sp. Gardens. Durban, June. 1882. (A689).
Uredo caricini Schl. (*Uredo* form of *Puccinia striola* Link.)
308. On *Cyperus tenuiflorus.* (450).
Uredo cf *Puccinia caricini* D. C.
309. On host undetermined. (670).
Uredo celastrineæ Cke. & Mass.
310. On *Salacia alternifolia.* Near Durban, October, 1888. (4028).
311. On *Salacia Kraussi.* Near Durban. September, 1888. (4028).
Uredo Clematidis B.
312. On *Clematis Oweniæ.* Inanda (563).
313. On *Clematis brachiata.* (457).
Uredo Cluytiæ K. & Cke.
314. On *Cluytia pulchella.* Inanda, 3/6/78. (51).
315. On *Cluytia* sp. (32).
Uredo Commelinæ K.
316. On *Commelina madagascarica.* Inanda. (231).
Uredo Cussoniæ Cke. & Mass.
317. On *Cussonia* sp. 12/3/86. (3494).
Uredo Ectadiopsidis Cke.
318. On *Ectadiopsis oblongifolia.* Inanda. June. 1881. Grev., X., p. 128. (600).

Uredo Geranii D. C.
319. On *Geranium ornithopodum*. Inanda. (77).
Uredo Hypoestis Cke.
320. On *Hypoestes antennifera*. 10/6/81. (A589).
Uredo labiatarum.
321. On *Moschosma riparia*. Umlaas, January, 1876. (1).
322. On host undetermined. (47).
Uredo leguminosarum Rabh.
323. On *Faba vulgaris*. (439).
Uredo lucida Thum.
324. On *Rubus rigidus*. Inanda, May, 1881. (582).
Uredo macrospermum Cke.
325. On fronds *Pteris aquilina*. Inanda. (61).
Uredo Maydis D. C.
326. On *Zea Mays*. Inanda, January, 1882. (669).
Uredo Myrsiphylli K. & MacO.
327. On *Asparagus medioloides*. Noodsberg. (219).
Uredo Pamparum Speg.
328. On *Rhynchosia orthodanum*. May, 1881. (A579).
Uredo Phaseolorum DeBy.
329. On *Phaseolus* sp. Inanda. (89).
Uredo Pycnostachidis K.
330. On *Pycnostachys reticulata*. Inanda. (30).
Uredo of *Ravenelia* sp.
331. On host undetermined. (606).
Uredo Rhynchosiæ K.
332. On host undetermined. Inanda. (24).
Uredo scladiopsis.
333. On host undetermined. (600).
Uredo transversalis Thum.
334. On *Tritonia* sp. (458).
335. On *Gladiolus* sp. (591).
336. On host undetermined. (697).
Uredo Vangueriæ Cke.
337. On *Vangueria latifolia*. Inanda, January, 1881. (540).
338. On host undetermined. (8).
Uredo sp.
339. On *Cluytia pulchella*. Inanda. (43).
340. On *Cluytia pulchella*. Inanda. (76).
341. On *Dolichos axillaris*. Zululand, April, 1895. (11352).
342. On *Hypoxis oligotricha*. Clairmont, 26/5/81. (A586).
343. On *Ipomœa? Hewittea bicolor*. 25/3/79. (467).
344. On *Peucedanum capense*. Inanda, 1/8/81. (A623).
345. On host undetermined. 1876. (2)
346. On host undetermined (588).
347. On host undetermined (634).
Uromyces Albucæ K. & C.
348. On *Albuca* sp. Grev., XI., p. 20. Inanda, September, 1881. (647).
349. On *Albuca* sp. Inanda. (69).

Uromyces Bulbinæ K.
350. On *Bulbine latifolia.*, Grev., XI., p. 20. (451).
Uromyces cluytiæ K. & C.
351. On host undetermined. (52).
Uromyces Eriospermi K. & C.
352. On *Eriospermum McKenii.* Grev., XI. Umzinyati, March 1881. (552).
Uromyces Erythrinii, var. *drimiopsoidis.*
353. On *Drimiopsis maculata* (688).
Uromyces Euphorbiæ Cke. & Pecke.
354. On *Euphorbia sanguinea* Durban, 22/4/07. (10362).
355. On *Euphorbia sanguinea* Durban, 14/7/03. (11340).
Uromyces Fiorianus Sacc.
356. On *Peucedanum* sp. Durban, 12/6/14. (12602).
Uromyces Heteromorphæ Cke.
357. On *Hetermorpha arborescens.* (449).
Uromyces Hypoxidis C.
358. On *Hypoxis oligotricha.* Grev., X., p. 127. Clairmont, May, 1881 (586).
Uromyces leguminosarum.
359. On *Crotalaria lanceolata.* Inanda. (199).
Uromyces lugubris Kalch.
360. On host undetermined. Inanda, June, 1877. (15).
Uromyces (Uredo) *Lupini* B. & C.
361. On *Lotononis corymbosa.* Inanda, June, 1881. (595).
Uromyces Melantheræ Cke.
362. On *Melanthera Brownei.* Umhlanga, July, 1881. (A627).
Uromyces Mimusops C.
363. On *Mimusops caffra.* Grev., X., p. 127. Isipingo. (506).
364. On *Mimusops caffra.* Near Durban, 14/5/97 (6459).
Uromyces phaseolorum DeBy.
365. On *Rhynchosia* sp. or *Eriosema* sp. Inanda, June, 1881. (621).
Uromyces Polygoni Pers.
366. On *Polygonum tomentosum.* August, 1881. (A752).
Uromyces Pseudoarthriæ Cke.
367. On *Pseudoarthria* (*Anarthrosyne robusta*). Grev., X., p. 127. Inanda, 9/6/81. (598).
Uromyces Rhynchosiæ Cke.
368. On host undetermined. (557).
Uromyces Thwaitesii R.Br.
369. On *Sida rhombifolia.* Verulam. (106).
Uromyces sp.
370. On *Helichrysum quinquenerve.* (A551).
371. On *Zornia tetraphylla.* Inanda, June, 1881. (593).

AURICULARIALES.

Hirneola Auricula-Judæ (L.) Berk.
372. On wood. (412).

Hirneola nigra. Sw.
373. On wood. (108).
Hirneola vitellina Fr.
374. On wood. (398).
Stilbum connatum K. & C.
375. On old stump. (516).

TREMELLINEÆ.

Exidia cinnabansia B. & C.
376. On *Salix* sp. (4105).
Exidia glandulosa Fr.
377. On *Betula* sp. (4107).
378. On host undetermined. (4106).
Femsjonia natalensis C. & P. Grev., Vol. II.
379. On decayed stem. Inanda, December, 1880. (476).

DACRYOMYCETINEÆ.

Guepinia spathulata Fr.
380. On old stump. (514).

HYMENOMYCETINEÆ.

THELEPHORACEÆ.

Cladoderris Thwaitseii Berk & B.
381. On wood. (239).
382. *Craterellus cornucopioides.* (4108).
Cyphella tabacina C. & Phil.
383. On bark. Inanda, February, 1881. (524).
Solenia minima C. & Phil.
384. On decayed stem *Strelitzia.* Inanda, January, 1881. (482).
Stereum elegans = *Stereum nitidulum* B.
385. On dry wood. Inanda. (396).
Stereum luteo-badium Fr.
386. On wood. Inanda. (163).
Thelephora pedicillata Schuz.
387. On bark. Inanda, February, 1881. (532).

CLAVARIACEÆ.

Clavaria Kunzii Fr.
388. On ground. Inanda. (148).
389. *Lachnocladium semivestitum.* (700).

HYDNACEÆ.

Hydnum ochraceum P.
390. On decaying wood. Inanda, January, 1881. (479).

POLYPORACEÆ-POLYPOREÆ.

Polyporus (Pleuropus) *affinis* Nees.
391. On trunks of trees. (419).
Polyporus biformis Fr
392. On decaying tree. Inanda, January, 1881. (534).

Polyporus corticola Fr.
393. On bark. Inanda. (188).
Polyporus ferruginosus.
394. On *Prunus cerasus.* (4115).
Polyporus (Pleuropus) *flabelliformis.* Klotzsch.
395. On trunks of trees. (422).
Polyporus (Pleuropus) *rhipidius* Berk.
396. On branches. Inanda, 1880. (351).
Polyporus stereoides B. var.
397. On decaying wood. (674).
Polyporus vibescinus Fr. var. *antilysum.*
398. On old stump. (99).
Hexagonia polygramma Mont.
399. On wood. Natal. (201).
Trametes rigidus Fr. resupinate.
400. On fallen tree. (496).
Trametes occidentalis Fr.
401. On tree trunk. Inanda, February, 1881. (535).
Trametes funalis Fr.
402. On bark. (433).

Boletineæ.

Boletus flavidus Fr.
403. On soil. (329).
Boletus sp.
404. On soil. (691).

Agaricaceæ-Cantharelleæ.

Cantharellus capensis B.
405. On ground. (513).
406. *Cantharellus ciborius* Fr. (4100).
Cantharellus leucophlæus.
407. On ground. (675).
408. *Cantharellus crispus.* (4110).

Coprineæ.

Coprinus curtus K.
409. On dung of Rock Rabbit. (526).
Coprinus digitatus Fr.
410. On dung heap. Verulam. (384).
Coprinus ephemerus. Fr.
411. On dung heap. (423).
Coprinus nivens. Fr.
412. On dung heap. Verulam, February, 1879. (384).
413. *Coprinus plicatilis* Curt. (367). (698).
Coprinus punctatus K. & Cke.
414. On ground. (413).
Coprinus truncorum Fr.
415. On dead trunk. (333).
416. *Coprinus* sp. Botanical Gardens, Durban, 29/11/07. (679).

Hygrophoreæ.

Hygrophorus coccineus Fr.
417. On trees in woods. (510).

Schizophylleæ.

Schizophyllum commune Fr.
418. On *Acer* sp. (4104).

Marasmeæ.

419. *Anthracophyllum nigrita* Lev (189).
Lentinus Lecontii Fr.
420. On stumps *Fagus sylvatica*. (4114).
421. *Lentinus strigosus* Fr. (421).
Lentinus zeyheri Berk.
422. On wood. (97).
Marasmius helvolus Berk.
423. On ground in bush. Inanda, March, 1880. (147).
424. *Marasmius oreades*. (4111).
425. *Marasmius petalinus* B. & C. Inanda, 1881. (676).
Marasmius robusta Scop.
426. On twigs. (4112).
427. *Marasmius tener* B. & C. (681).
428. *Marasmius Thwaitesii* Baker & B. (465).
429. *Panus stipticus* Bull. (4116).
430. *Panus torulosus*. (411).
Xerotus caffrorum K.
431-2. On dry wood. (341) (371).

Agariceæ.

Agaricus (Lepiota) *Africanus* Kalch.
433. On ground. (417).
Agaricus (Flammula) *Alnicola* Fr.
434. On dead tree. Inanda, 10/2 81. (512).
Agaricus (Mycena) *argutus* K.
435. On ground. (340).
Agaricus (Psalliota) *arvensis* Schff.
436. On dead wood. (409).
Agaricus (Psilocybe) *atrorufus* Schff.
437. On ground. Inanda, February, 1881. (522).
438. On host unknown. (507).
439. On host unknown. (508).
Agaricus (Pleurotus) *aureo-tomentosus* K.
440. On ground. (103).
441. On host unknown. (348).
442. On host unknown. (416).
Agaricus (Pholiota) *auricellus* Fr.
443. Inanda, March, 1881. (533).
Agaricus (Panæolus) *caliginosus* (Jungh) Gill.
444. On ground. (472).
445. Host unknown. (515).

Agaricus (Hypholoma) *capnolepis* K.
446. On ground. (337).
Agaricus (Mycena) *clavicularis* Fr.
447. On ground. (478).
448. On host unknown. (147).
449. *Agaricus* (Collybia) *contortus* Bull. (461).
Agaricus (Mycena) *corticola* Fr.
450. On wood. (484).
451. Host unknown. Inanda. (550).
452. Host unknown. (492).
Agaricus (Psathyrella) *disseminatus* Fr.
453. On old stump. Inanda, June, 1881. (490).
454. On old stump. Inanda. (400).
Agaricus (Collybia) *dryophilus* Fr.
455. Inanda. (434).
456. On host unknown. (458).
457. *Agaricus* (Lepiota) *dryophyllus* Bull. (349).
458-9. *Agaricus excoriatus* Schff. (331). (690).
Agaricus (Collybia) *extuberans* Fr.
460. On ground. Inanda, January, 1881. (485).
461. *Agaricus* (Collybia) *extuberans* Fr. (354).
462. *Agaricus* (Pholiota) *flammans* Fr. (673).
463. *Agaricus* (Pleurotus) *gilvescens* K. (332).
Agaricus (Mycena) *hiemalis* Fr.
464. On wood. (498).
465. On host unknown. (555).
466. *Agaricus Inandiæ* Cke. (680).
Agaricus leucisus.
467. Inanda. (388).
Agaricus (Pleurotus) *limpidus* Fr.
468. On decaying tree. Inanda, February, 1881. (518).
469. *Agaricus maculentus* Fries, Inanda. (401).
470. *Agaricus* (Tricholoma) *melaleucas*, var. *porphyroleucas* (Fr.) Gill. (495).
Agaricus (Omphalia) *micromeles.*
471. On old wood. (477).
Agaricus (Stropharia) *olivaceo-flavus.*
472. On ground. (502).
Agaricus (Panæolus) *papilionaceus* Fr.
473. Verulam. (385).
474. *Agaricus* (Naucoria) *pediades* Fr. (464).
Agaricus (Pleurotus) *perpusillus* Fr.
475. On trunk of tree. Inanda. (191).
Agaricus (Psathyrella) *pronus* (Fr.) Gill.
476. On ground. (499).
477. On host unknown. (511).
Agaricus (Panæolus) *reparatus* Fr.
478. On dry cow-dung. (460).
479. *Agaricus rhodiophyllus* K. (338).
480. *Agaricus rubricatus* B. & B. (394).
481. *Agaricus* (Omphalia) *rusticus* (Fr.) Gill. (509).

Agaricus (Stropharia) *olivaceo-flavus* K. & MacO.
482. Inanda. Grev., IX., p. 131. (415).
483. On host unknown. (244).
– *Agaricus pleuropus* K. & MacO.
484-7. On hosts unknown. (345). (356). (359). (372).
Agaricus (Entoloma) *sagittaeformis* K. & C.
488-9. On hosts unknown. (344). (357).
Agaricus separatus.
490. Verulam. (376).
Agaricus (Mycena) *sciolus* K. & M.
491. On floor and walls of outhouse. Inanda. (92).
Agaricus (Pleurotus) *septicus.*
492. On trunk of tree. Inanda. (191).
Agaricus sinopicus Fries.
493. Inanda. (395).
Agaricus spadiceo-griseus Sch.
494-5. On hosts unknown. (323). (336).
Agaricus (Psilocybe) *squalens* Fr.
496. Verulam. (383).
Agaricus sublateritius Fr.
497. On root *Conium maculatum.* (4113).
Agaricus (Lepiota) *sulfurellus* Kalch.
498. Inanda. (387).
Agaricus (Psathyrella) *subtilis* Fr.
499. On dung. Verulam. (382).
Agaricus (Psalliota) *sylvaticus* Schff.
500. On ground. Inanada. (480).
501. *Agaricus tædiosus* Kalch. (393).
502. *Agaricus* (Naucoria) *undulosus* Jungh. (370).
Agaricus (Pholiota) *unicolor* Fr.
503. Inanda. (390).
504. *Agaricus* (Tricholoma) *ustalis.* (428).
Agaricus (Collybia) *velutipes* Fr.
505. Inanda, January, 1881. (486).
506. *Agaricus* (Lepiota) *Zeyheri* Berk. (392).
Agaricus sp.
507. In bush. Inanda. (473).
508. On host unknown. (530).

PHALLINEÆ.

Lepturus Woodii (*Anthurus Woodii* Kalch) McOw.
509. On ground. (134).
Kalchbrennera Tuckii (K. & McOwan) Berk.
510. On ground. Durban, November, 1882. (A665).
Phallus (Hymenophallus) *indusiatus* Vent.
511. On ground in thick bush. Inanda, January, 1882. (667).
512. On host unknown. (609).

LYCOPERDINEÆ.

Bovista lilacina M. & B.
513. On soil. Inanda. (408).

Geaster fimbriatus Fr.
514. On ground. Inanda. (489).

PLECTOBASIDINEÆ.

Scleroderma bovista.
515. On ground. Inanda, December, 1880. (369).
Scleroderma pyramidatum K.
516. On soil. (375).
Scleroderma vulgare.
517. On soil. (374).

NIDULARIACEÆ.

Cyathus Poepogii Tul.
518. On ground. Inanda. (334).
Cyathus sulcatus Kalch.
519. On ground. Inanda. (334).

FUNGI IMPERFECTI.

SPHÆROPSIDALES.

Chætomella Artemisæ Cke.
520. On *Artemisia afra.* (572).
Darluca filum.
521. On *Phaseolus* sp. Inanda. (89).
Sphæropsis Mappæ C.
522. On *Mappa capensis.* June 21st. (A619).

MELANCONIALES.

Neobarclaya natalensis Syd.
523. On *Eugenia cordata.* Inanda, 26/5/97. (6446).

HYPHOMYCETES.

Cercospora Leonitidis Cke. n.sp.
524. On *Leonotis Leonurus.* Inanda, 1877. (5).
Epochnium phyllogenum K. & C.
525. On host undetermined. (39).
Fusicladium fuliginosum K. & C.
526. On *Greyia Sutherlandi.* (9).
Isaria sp.
527. Inanda, 1881. (677).

UNDETERMINED FUNGI ON FOLLOWING HOSTS.

528. *Carissa* sp. (95).
529. *Cephalanthus natalensis.* (3920).
530. *Chloris* sp. (A687).
531. *Citrus Medica* v. *Limonum.* Inanda. (41).
532. *Cluytia* sp. (423).
533. *Cluytia* sp. (A32).
534. *Croton sylvaticum.* (A466).
535. *Cryptolepis capensis.* (A672).
536. *Dalbergia armata.* June, 1881. (609).
537. *Dioscorea* sp.

538.	*Euclea natalensis.* Near Durban, 25/5/97.	(6447).
539.	*Euphorbia erubescens.*	(101).
540.	*Hydrocotyle bonariensis.*	(430).
541.	*Ischæmum angustifolium.* Durban, 14/7/03.	(11340).
542.	*Lantana salvifolia.*	(11349).
543.	*Leucas Martinicensis.* March 27th.	(11354).
544.	*Moschosna riparia.*	(11345).
545.	*Ocimum obtusifolium.* April, 1881.	(545).
546.	*Ocimum obovatum.*	(A46).
547.	*Pavetta* sp.	(11347).
548.	*Pavetta lanceolata.* Mayville, 22/7/15.	
549.	*Pellæa hastata.*	(243).
550.	*Polygonum tomentosum.*	(75).
551.	*Prunus persica.* Inanda, 1877.	(7).
552.	*Rhus* sp. Inanda, November.	(A457).
553.	*Rhynchosia orthodanum.* July.	(A579).
554.	*Royena villosa.* Springfield, 14/7/15.	
555.	*Royena pallens.* 13/10/88.	(4078).
556.	*Rosa* sp. Durban, August, 1882.	(A686).
557.	*Salacia Kraussi.* Near Durban, October, 1888.	(4028).
558.	*Salacia* sp.	(696).
559.	*Salacia* sp.	(11341).
560.	*Senecio* (climbing).	(11348).
561.	*Senecio oxyriæfolius?* D. C.	(11350).
562.	*Smilax Kraussiana.*	(100).
563.	*Sponia* sp.	(A564).
564.	*Tragia* sp.	(629).

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, March 10th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Rand Mining Economics: some salient unappreciated issues*": G. A. **Denny.** The paper dealt with some of the fundamental principles governing mining policy on the Witwatersrand gold fields. The author at the outset referred to the vague knowledge available to the mine manager respecting the economic fundamentals of his business, and stated that failing such knowledge the operations of a mine might be prejudicial to its standing, and the conclusions based thereon so radically contrary to its interests as to lead an otherwise sound undertaking to disaster. The causes responsible for this state of affairs were pointed out, and a complete investigation of the fundamentals of mining economics advised. The author proceeded to discuss the methods of calculating the tonnage and value of ore reserves, and made various suggestions respecting those reserves and related economic issues. It was also pointed out that blocks of ore which from the point of view of development were fully opened up were generally wrongly regarded as fully valued. The economics of milling low grade ores were also discussed, and it was asserted that the milling of waste rock generally results in loss and creates an impression of improved work by spurious lowering of working cost per ton, which, as the principal objective, makes for extravagance in capital outlay.

NATIVE EDUCATION IN THE TRANSKEI.

By Rev. John Robert Lewis Kingon, M.A., F.L.S.

Synopsis.

I. The Field Covered.
II. The Origin of Native Education.
III. The System of Native Education.
  1. The Missionary-Superintendent.
  2. The Teaching Staff.
    (*a*) Training in the past.
    (*b*) Teachers' certificates.
    (*c*) Training Institutions.
    (*d*) Quality of teachers.
    (*e*) Social position.
    (*f*) Economic position.
  3. The Schools.
    (*a*) How schools originate.
    (*b*) Granting of sites.
    (*c*) Survey and limitation of sites.
    (*d*) Need for better type of buildings.
    (*e*) Growth in number of schools.
    (*f*) Denominational control of schools.
    (*g*) Distribution of enrolment.
  4. The Inspection of Schools.
    (*a*) Large circuits of Inspectors.
    (*b*) Inspectors do not always know the language.
    (c) Inspectorate inadequate.
IV. The Education now in Process.
  1. Literary.
  2. Industrial.
  3. Agricultural.
V. The Curriculum.
  1. What we are teaching the Natives.
  2. Vernacular as medium—Kafir as a subject.
  3. Religious teaching.
VI. The Attendance.
  1. Number attending school.
  2. Number available.
  3. Reasons for small percentage at school.
  4. Desire for compulsory attendance.
  5. What compulsory attendance would mean.
VII. The Results of Native Education.
  1. Manifest unsoundness of argument against Native Education.
  2. Economic value of Native Education.
  3. Moral value of Native Education.
  4. Some other reasons why Education of Native is essential.
  5. Numerical results.
  6. Remarkable advances made.
  7. Value of "School Natives" to the Administration.
VIII. The Support of the Schools.
  1. Missionary Societies.
  2. Government Grants.
  3. Local Contribution.
  4. Effect of Council System of Education.
IX. The Grading of Schools.
  1. Out-station schools.
  2. Main station schools.
  3. High Schools.

X. Higher Education.
- 1. What is "Higher Education"?
- 2. The Native College.
- 3. Institutions.
- 4. The future of Native Higher Education.

XI. The Future of Native Education.
- 1. As to Administration.
    - (*a*) Missionary Superintendent's position.
    - (*b*) Provincial Council or Union Government control?
- 2. As to possibilities in attendance.
    - (*a*) In Cape Province.
        - (i) By compulsion.
        - (ii) By growth of population.
    - (*b*) In the Union.
- 3. The Expansion of Expense.
    - (*a*) Due to higher grants for teachers.
    - (*b*) Due to larger attendance; hence more teachers.
    - (*c*) Due to grants for more buildings and equipment.

XII. Conclusion.
- 1. The national importance of educating the Native—morally, economically, intellectually.
- 2. The time ripe (not least on account of war) for adoption of a wise and strong policy.
- 3. Education is the foundation of all progress—agricultural, industrial, commercial.
- 4. An appeal for earnest consideration.

I. The Field Covered.

The Education of the Native is a much-discussed subject, and one upon which a variety of opinions has found expression from time to time. Unfortunately, these opinions are not always soundly based, and often tend to produce misconceptions in the public mind, and an atmosphere not conducive to the wise and just handling of the matter, whereas a well-informed view, while keeping certain real difficulties in right perspective, would go a long way in the direction of removing misconceptions, and correcting many hasty generalisations with which we are all too familiar. Coming, as I did a few years ago, from my home in the Western Province, to work in the Transkei, I was conscious of a certain emancipation of view, and adjustment of outlook, as I became familiarised with the situation in the Native Territories, and acquainted with what was actually in process there, and in this paper I propose to make a statement, I might say a survey and review, of the position of Native Education, hoping that it may have a place and a value as a contribution towards the solution of a question which is undoubtedly of supreme concern to our South African nation.

That the time is opportune for an earnest consideration of the whole question of Native Education will be conceded by all. In the first place, the statutory five years having elapsed since Union took place, certain important changes in the administration of education are now pending. Elsewhere we shall deal more fully with this point. In the second place, the passage of the University Bills through Parliament has created a new, and as yet undefined, situation. In the third place, the opening of the South African Native College at Fort Hare, by the Prime Minister, on the 9th of February, 1916, has marked an epoch in the history of Native Education, and appreciably altered the whole position. Finally, in view of the Great War, we all expect a general readjustment of our relationships and responsibilities on the restoration of international equilibrium. To catch the flowing tide, let us be prepared.

As a basis for this consideration, and for the purpose of greater accuracy, I propose to give, in some detail, the actual position not only as it was, but as it is. Further, we have sufficient statistics—which will appear in due course—to show what has been accomplished in the past, and what is being accomplished in the present. What might be accomplished at present, and what we shall have to face, and to accomplish, in the future, will also be stated; and when we have exhausted our statistics, perhaps we shall need to remind ourselves of the volume of results which can neither be expressed in black and white, nor tabulated, for life can never find adequate expression in formulæ and tables.

The field of enquiry covered by this paper lies within the borders of the Transkei. An effort has been made to confine oneself to these limits in order to show what has been done in the worst possible surroundings by Native Education, and to see what education can and does do in purely native communities.

Unfortunately it has not always been possible to disentangle the statistics on the subject, published in Blue Books and elsewhere. Thus, for instance, certain published figures include the natives in the colony proper, and it is not always easy to say precisely what proportion are to be assigned to the Transkei, and what proportion to the Ciskei. Again, in dealing with Ciskeian statistics, we have mission schools and aborigines' schools. As the mission schools are mostly, but not wholly, attended by coloured children, and the aborigines' schools mostly, but not wholly, by native children, and the totals are not differentiated, it is difficult to separate the statistics with accuracy —and this is my reason for not making the attempt. In passing, however, I may say that the Select Committee of 1908 specifically referred to this point, and recommended* not only the abolition of the distinction between mission and aborigines' schools, but also that native and coloured children should be differentiated as soon as practicable in the returns. Much, however, can be statistically established, and our knowledge of the position will crystallize, provided that care is taken to observe whether the figures quoted apply to the Territory, or the Province, or the Union. One other word of caution is necessary in this connection. The extraordinary circumstances brought about by Union and the Great War have hindered the publication of

* Report of Select Committee on Native Education (1905-08), p. xiv.

annual reports, and consequently some statistics are not so complete as they might be.

II. The Origin of Native Education.

The origin of Native Education is directly traceable to the earliest missionaries. As one and another arrived in this country, about one hundred and twenty-six years ago, he was faced with the problem of a growing number of converts who could not read the Word of God. The logical step was to teach them to read, and, the bonds of ignorance and superstition once broken, men eagerly came forward to learn. The first schools were composed for the most part of old, or at least full-grown, men and women, the missionary was the teacher, and the only textbook a classic which holds pride of place in the literature of the world. These schools were often conducted in places widely separated from each other, sometimes by men of highest qualification, sometimes by men whose highest qualification was a life transformed, and as a result they varied in most respects. Nevertheless, they formed the nucleus of a system which later came to be modified by State superintendence and assisted by grants-in-aid.

To-day the whole fabric of Native Education rests upon the missionaries, but neither the missionaries on the one hand, nor the State on the other, are free agents. Perhaps this accounts for such unsatisfactory features as are to be found in the system—it is neither purely missionary nor yet purely State. Some years ago a special report on education was prepared for the Imperial Government, in which we find this clear statement of the actual beginnings:—

> The missionary movement, begun by the Moravians in 1792, had been taken up by the London Missionary Society in 1799, the South African Society about the same time, the Wesleyan Church in 1816, the Glasgow Society in 1821, the Rhenish Society in 1829, the Paris Society in 1829, and the Berlin Society in 1834. It had thus gradually assumed large proportions, and we are consequently not surprised to learn that at the time now reached there were over 50 missionaries at work in the Colony. All of these, with their numerous helpers, interested themselves in the education of the coloured races, no fees being charged, and the training being in most cases similar to that given in the schools attached to Churches in England. In almost every village, we are told, a branch of one or other society existed, by means of which the education of coloured people, both children and adults, was fostered.

As early as 1841, on the suggestion of Sir John Herschel, Government grants had been made available for teachers in these mission schools provided certain requirements were fulfilled, but this was designed in the interests of the white and coloured children rather than for the natives. Perhaps the experience gained as a result of this was largely incidental in leading Sir George Grey, greatest of Governors, to apply a similar system in the Transkei. It is to be noted that the Imperial Government, as a matter of policy, encouraged the education of the natives as a sort of insurance against Kafir wars, and for years he received money direct from the Imperial Government with which to maintain industrial and native schools. The system once established, it needed but an Act of Parliament to bring these aided aborigines' schools under the jurisdiction of the Education Department of the Cape Colony alongside the previously recognised mission schools. The distinction, however, between mission schools and aborigines' schools perpetuated in the Act of 1865 continues even unto our own day. In that year there were no less than 11,737 pupils on the roll of the mission and aborigines' schools; in other words, there were three times as many children in mission schools than in all the white schools put together, and of these more than one-half were coloured, so that Native Education was still in its infancy. At first the main difficulty in the way of Native Education was that of language. It must be remembered, and appreciated, that the first missionaries came upon a new and unknown language, and their first work was to become familiar with the customary pronunciation and usage of words, and to fix upon an alphabet which would give adequate expression to the strange sounds. It is a fact that many "clicks" were either missed or purposely ignored in the process, and so have been, and are being, lost to the language. Perhaps the differences in nationality of the early missionaries, and the impossibility of communication with each other, is responsible for the orthographical differences in our various South African native languages. But it is significant that the various attempts to secure a uniform orthography have not accomplished much, and at this late date probably no change of importance will occur. The fixing of the alphabet was the first step in reducing the native language to writing—and without a written language teaching could not be undertaken. Mr. Bennie has put it on record that

> On the 17th December, 1823, we got our press in order; on the 18th the alphabet was set up; and yesterday we threw off Fifty Copies.

Thus was laid the foundation of Native Education at Ncera on the 19th day of December, 1823. The following year Lovedale was established at Ncera. Until 1865 aborigines' schools were unrecognised, but from that date the Education Department has controlled Native Education, making certain conditions on which Government aid would be available, and yet tacitly recognising the position of the Missionary Superintendent, thankfully accepting his willing service, and interfering as little as possible with him.

III. The System of Native Education.

1. THE MISSIONARY SUPERINTENDENT.

The Missionary Superintendent occupies a position as yet undefined. The Department has little control over him, for his services are given gratuitously. He is the independent agent of the Missionary Society. The whole local control of the schools is under his superintendence, and as many schools are usually under one man, he has much to do to keep them well staffed, and doing efficient work. The Act recognised him without defining his position, maintained a wise silence about his duties in connection with the control and management of the schools, and expected him to provide the necessary buildings and even equipment.

It is his duty to supervise the teachers in their duties, to advise and help them, to examine the schools from time to time, to organise and direct the religious instruction, and in cases of serious trouble he exercises the power of dismissal.

All this work, if thoroughly done, entails a fair amount of correspondence, and much more of time and labour, for most teachers need constant supervision, and the outstations are often some distance away; and when it is remembered that the work in connection with the schools is only a part—and that not the main part—of the missionary's duties, it will be conceded that his time and strength are fully taxed. As much as £1,000 per annum, and more, passes through the hands of some superintendents, in Government and General Council grants, and every penny of this money is paid out in salaries to the teachers, and for all this extra responsibility and work the superintendent neither receives nor desires any remuneration from the State. It is done because the first duty of the missionary is to enlighten, Christianity having everything to gain by the dissemination of knowledge. If men are taught to think aright, even heathen men, then they will live aright; and anything done to lift native thought out of the animal rut, and provide something pure and clean and uplifting to think around and speak about, is to be welcomed. Too often the conversation of the heathen is but a cesspool of immoral thought—from which they need emancipation. This is simply due to the fact that they are ignorant. In the early days their minds were fully occupied by warlike pursuits, or in hunting, and in their leisure hours they would think about these things, and relate the stories to one and another of their friends. To-day there is no outlet in these directions, nor has there been for years, and consequently their thoughts seem to concentrate upon cattle, Kafir beer, and women, especially the more degrading aspects of these subjects. If these same people were better informed on other subjects this deplorable state of things would automatically right itself in large measure—and we look to education to lead to cleaner thinking and better living.

In any case, the more education they get, the more intelligent and sturdy will be the products of missionary effort. For these and other reasons, which need not here be specified, the superintendents are prepared to undertake the burden of Native Education without any monetary return. It is not too much to say that the whole fabric rests upon them, and that the withdrawal of the missionary superintendents would mean the virtual collapse of native education.

To begin with, excluding an almost negligible percentage, almost all the schools are held in church buildings, or school buildings, provided by the missionary superintendent. Usually the people of the location have helped in the work of building, but often the place was erected for church purposes, and by courtesy of the missionary school is held in it during the week, and in any case the site belongs to the church concerned. If the missionary superintendent were superseded, the Government would be faced with the provision of hundreds of new school buildings, and new sites, and a very considerable staff of qualified officials. While officials may be appointed to perform certain work it needs to be pointed out that more than mere labour is required of men who take up this work. Such officials would need to have interest in the work, for its own sake—and interest cannot be bought. The probability then would be that the officials would perform their duties in a purely official way, and quite without the interest essential to the success of the work. And, moreover, the additional expense both in initial outlay and in salaries would be a revelation to the country. It has been calculated that the missionaries are doing work in South Africa, which could not be done departmentally for less than £200,000 per annum.

With these considerations before us, it is well to remind ourselves that sooner or later the question of the management of native schools will arise. Already there is a slight tendency to resent the power of the superintendent on the part of delinquent teachers and those interested in them. Sometimes a teacher is dismissed for immorality—much to the surprise of the heathen community! At other times, schools are made to languish and die, by the withholding of children, so as to get rid of a sound teacher who may be unpopular because he belongs to another tribe; or again, because some influential man hopes to get his son or daughter appointed to the place or even for ecclesiastical reasons.

In order to meet these and other subtleties it is necessary, at the present stage of development, to have men who are free to exercise their judgment without let or hindrance.

In any case, it is difficult to see where suitable native men would be forthcoming who could take their place on any "public authority" created for the purpose. It is sufficient for the superintendent to act discreetly, and not without informal consultation with headmen and people where necessary—and this, I may say, is the usual practice. In suitable and more advanced localities, perhaps, an Advisory Committee might be of some value some day.

2. THE TEACHING STAFF.

The question which gives greatest trouble to the superintendent is the provision of an efficient staff of teachers in his schools. On the character of the teacher depends the character of the school.

(*a*) *Training.*—In the earliest days no pretence was made of training the teachers, the senior scholars being used as needed. But as schools increased the need became more apparent, and an institution was opened at Lovedale.

The first great step towards the training of native teachers was made in 1872 by the wise provision on the part of the Government, for the granting of an Elementary Teachers' Certificate.

The subjects required for this certificate included Arithmetic, English, Geography, Handwriting, and School Management, with Dutch and Kafir as optional subjects.

The establishment of the certificate necessitated training schools, where the pupils could receive instruction in the required subjects, and as a result some of the more important centres were converted at that time into institutions. At these places no fees were charged, at first, the whole expense being borne by Missionary Societies, but the fee system is now fully established. The influence of these Native Training Institutions upon the whole educational system has been very great, and naturally there has been a good deal of action and reaction as between these institutions and the schools. The former produced better teachers for the schools, and these in return produced better material for the next generation of teachers.

The greatest fault to find—and it is a serious fault—is that the whole school system has become stereotyped to produce teachers, and nothing but teachers.

The first five teachers to take the certificate graduated from Lovedale and Grahamstown in 1874; in the following year 37 were successful. The results seem to have varied a good deal from year to year:—

1874	1875	1880	1885	1890	1892	1895	1900
5	37	40	41	76	36	22	37
1905	1907		1911	1912	1913	1914	1915
44	72		191	178	204	267	288

The output of teachers varied in certain consecutive years by as much as 50 per cent., and at the time of the retirement of Sir Langham Dale, in 1892, the numbers had fallen below the level of 1875. The introduction of a new system at this stage, no doubt, is accountable for the low figures which followed during a period of years, but by 1900 the production of teachers once more moved forward. The contrast between the results secured at the end of that year, and those secured at the end of 1915, give a good idea of the remarkable expansion of Native Education during the intervening period. In 1900, 37 teachers were successful. In 1915, 288 graduated—an increase of 678 per cent. But this does not give an adequate idea of the advance actually made, for the teachers' certificate is now taken in three parts, and the 288 represented only the third and final stage. Six hundred and fifty-two candidates passed the first year, and 448 were successful in the second year. Perhaps, however, it would be better for us to tabulate these figures, so as to visualise as far as possible the extraordinary expansion of recent years.

TABLE I.

Passes.	1900	1905	1911	1912	1913	1914	1915
First Year..	—	—	390	510	529	601	652
Second Year	—	—	237	251	369	360	448
Third Year..	37	44	191	178	204	267	288
	—	—	818	939	1,102	1,228	1,388

(*b*) *Teachers' Certificate.*—The three years' course leading up to the teacher's certificate was introduced by the Department in 1894, and led to a thorough reorganisation of the Training Institutions. Up to that time Standard IV had been accepted as admitting to the course, and this continued until five years later, when Standard V was required, and in 1901 the sixth standard was demanded; but as very few natives passed Standard VI in those days, an alternative examination, conducted by the Department, was held at the various native training schools, and this examination was continued until 1904, when the special circumstance which called it forth no longer operated.

Five years later the admission standard in the case of European teachers was raised to the VIIth Standard. Native and coloured candidates were not affected by this regulation, but continued to take the same course, and certificate; the certificates, however, are now known as T. 3 Senior and T. 3 Junior. The senior course is open to all who fulfil the condition of admission, but the possession of T. 3 Senior would not give any monetary advantage to the native holder.

With all this raising of the standards before us, it will be realised that the remarkable advance of Native Education is not only a matter of increased attendance, but also of real attainment; that the number of those who hold the teacher's certificate is considerably increased; and that the certificate itself has much more value than ever before.

Attention has already been drawn to the fact that the standard was in process of being raised all around from 1894 onwards, and that meant that even though the standard of admission to the teachers' course seemed for a time to be stationary, yet in reality it was being raised steadily. Some idea of the value of the T. 3 certificate will be gained when it is said that the first and second years' course is in the main simply a revision of the work of Standards V and VI, together with lessons on the practice of teaching; the third year is a little more advanced, and Woodwork, Drawing, Needlework, Kafir, and Tonic Solfa are optional. Woodwork is compulsory for male candidates, and Nature Study has been recently introduced.

(*c*) *Training Institutions.*—The institutions are all the result of missionary effort, being supported by grants from the Home Churches, and providing the necessary buildings and equipment, and salaries of European missionaries, quite independently of the Government. The United Free Church of Scotland was the first to establish institutions of the kind, but of late the Wesleyans have shown great enterprise in developing along similar lines. The Anglicans and Moravians also have Training Colleges, and altogether there are now thirteen of these centres. Since many students from the Transkei find their way to Lovedale, Healdtown, and other Ciskeian places, all are included in the accompanying (Table II), which gives us an idea at once of the relative sizes of the centres, the total output, and the numerical development which is now proceeding.

(*d*) *Quality of Teachers.*—How much remains to be accomplished will be realised, when it is said that only 34.12 per cent. of the teachers in the aborigines' schools are qualified.

The demand is far greater than the supply, and consequently many students break their courses and take up teaching appointments. There seems also to be an idea abroad that a Standard VI pass is sufficient qualification for assistant teachers, who are to take charge of the sub-standard classes. Indeed, one superintendent told me that it was his duty to economise on behalf of the Government by appointing Standard VI teachers, as in this way the Government would be spared the expense of higher grants.

Fortunately, the Department realises that Standard VI is no qualification at all, and economy of this kind is neither expected nor desired. The best qualified teachers should be provided for the sub-standards in order that the foundation may be well and truly laid.

Two-thirds, then, of the teachers possess only the second year pupil teacher's certificate, or the first year, or Standard VI, and it is in the main from this uncertificated class that most of our troubles arise. Having little to lose they are often careless and incompetent, and sometimes the general laxity is not unconnected with immorality. To give such men charge of a school in which there may well be growing girls is sometimes a real danger, and even constant vigilance does not always prevent the fulfilment of one's fears.

On the other hand, it is a real privilege to help the better type of uncertificated teacher, who is earnestly striving to improve his, or her, qualifications, and in many cases one is amply repaid by any effort made. Enough has been said to indicate that a certain proportion of the teachers do not give satisfaction, but it must not be thought that this proportion is unduly large. It is very easy to run away with an exaggerated view of the actual situation. Probably if the Education Department were to publish a return of all teachers dismissed for immorality it would be found that only a very small percentage was concerned—under 4 per cent. That figure does not give us any true indication of the extent to which immorality prevails. Too much of it remains undiscovered, in the very nature of things.

(*e*) *Social Position.*—It must also be remembered that the social position of the teacher is a peculiar one. In all the location he probably is the best educated man, and he stands alone. If he is fortunate he has one or two companions who have had some schooling, but if they have even achieved Standard VI

TABLE II.

DEVELOPMENT OF TRAINING INSTITUTIONS.

TABLE P.	1874	1880	1890	1895	1900	1907	1912	3rd Q'ter 1913.				4th Q'ter 1914.				1st Q'ter 1916.			
								P.T. I.	P.T. II.	T. III.	Total.	P.T. I.	P.T. II.	T. III.	Total.	P.T. I.	P.T. II.	T. III.	Total.
Bensonvale ...	...	...	3	1	1	3	73	39	33	10	82	50	27	27	104	36	24	24	84
Bythswood ...	...	...	7	1	1	8	120	56	24	9	89	57	29	23	109	96	56	20	172
Buntingville ...	...	...	...	...	...	...	54	27	17	9	53	41	14	5	60	58	36	17	70
Clarkebury ...	...	5	17	1	4	3	51	26	15	9	50	37	16	12	65	28	24	27	79
Emfundisweni ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	46	...	...	46
Emgwali... ...	..	...	2	...	...	12	73	30	27	17	74	29	19	9	57	31	15	6	52
Engcobo... ...	...	...	...	...	...	...	52	26	19	9	54	36	24	15	75	25	19	16	60
Healdtown ...	...	1	9	7	11	15	161	90	43	38	171	78	52	32	162	98	74	49	221
Lovedale ...	2	12	21	10	6	14	180	87	80	26	193	65	70	54	189	87	72	29	188
Mvenyane ...	...	...	...	...	...	.	53	38	23	21	82	35	27	26	88	43	23	32	98
Peelton	...	12	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Shawbury ...	...	..	...	...	1	...	86	50	19	10	79	62	22	17	101	43	23	32	98
Umtata	...	...	4	2	3	6	41	13	7	5	25	26	10	7	43	21	23	11	55
Keiskamma Hoek	...	...	1	...	2	7	121	67	48	24	139	71	45	33	149	55	38	38	131
							1,065	549	355	187	1,091	587	355	260	1,202	687	428	291	1,406

the chances are that they, too, will be teaching. Consequently his companions are not his equals in education, and too often they tend to drag him to their own level. The heathen often are out of sympathy with him, for he is ever before them as an example of what they could and should be—and they know it. In many cases he turns for companionship to the assistant mistress, who works alongside him day by day, who understands his outlook upon life, and who shares the new tastes he has acquired. His position as teacher can be, and often is, an influential one, for even in heathen communities the worth of a truly good man is recognised. Many of the children of the location grow up under his care and guidance, and over these, in after life, he usually retains an influence.

The possibilities are very great, but they are dependent upon the class of teacher available for the schools. If our teachers are poor the influence exerted upon the children and the people will be correspondingly poor, and it is for us to get the best type of man and woman to complete his or her training, and, if need be, to exclude from training those who are unsuitable. Unhappily this selection is not attempted. Every scholar who passes Standard VI is accepted at Training Institutions if he presents himself for entrance, and at no stage in the course is there a weeding out of undesirables. On the completion of the required tests they are regarded as qualified teachers. Not a few men who have completed their training should never have been allowed to qualify.

(*f*) *Economic Position.*—In addition to this, the economic factor should be at work attracting the best men to the teaching profession—but it is not. Qualified teachers are paid only from £36 up to £74 per annum, and consequently many who complete their course prefer to take up positions as clerks, or interpreters, and sometimes even as policemen. It is earnestly to be hoped that some effort will be made, in the near future at least, to put the teaching profession on a level with policemen and clerks, and unskilled labourers on the mines. In these days of economy one does not care to advocate additional expense, but one suggestion may be permitted in view of the importance of the whole question of the payment of teachers. At present the local contribution amounts to 15s. for every pound of Government grant, in case of principal teachers; and 10s. per pound in the case of assistant teachers. This scale, however, might be better applied rather to certificated and uncertificated teachers, so as to encourage the latter to qualify, and in order to prevent the hardship of a certificated assistant drawing a local grant on the lower scale. The suggestion is that the local grant for certificated (and alternatively uncertificated principal) teachers should be on the pound for pound basis. This would appreciably help in raising the standard of teachers' salaries directly, and even indirectly in connection with the good service allowance; and any extra outlay in this direction will tend to produce greater efficiency.

3. THE SCHOOLS.

(*a*) *How Schools Originate*.—Turning from the teachers to the schools we find a similar development, and improvement at least numerically, but before tracing this surprising development it is as well to have some idea how schools originate.

Sometimes the people of a given locality approach the missionary with a request to open a school for their children. The headman, or the chief, may be behind the request, or it may be necessary to get his permission and blessing upon the project. Most headmen welcome a school in their location so that they may bask in the reflected glory, and added dignity. If the attendance keeps up to a certain level the General Council, on the recommendation of a School Inspector, gives a grant of £10 per annum for two years, and a grant of £5 to help in providing furniture for the school hut. At the end of that time, if not before, the school should have a regular attendance of 25 children, and so be drawing a Government grant together with the ordinary General Council grant. Sometimes a private hut is used for the school, or the people may unite to build a hut if there is no existing church hut at hand, but usually the school is held in the church hut.

(*b*) *Granting of Sites*.—Grants of land are made from time to time by the Government, on special application, for church and school purposes. In the unsurveyed districts a "permission to occupy" certificate is given, which is exchangeable on survey of the district for "title." If the land is used for any other purpose it may be taken back by Government, who only grant it on the condition that it is used for mission purposes, and the land cannot be alienated by sale.

(*c*) *Survey and Limitation of Sites*.—The free grant of land is only right and reasonable, but it is disappointing to find that the extent of the grant is no more than half a morgen. At present the vast extent of open veld renders a school playground unnecessary, but the day will come when the available land will be allotted, and our schools hemmed in on all sides. In those days men will wish that a far-seeing policy had been adopted at the time when the country was being surveyed district by district—as at the present—and that a minimum grant of 2½ morgen had been made instead of the paltry half-morgen.

(*d*) *Need for Better Type of Buildings*.—The buildings in which the children spent their school life are often poor huts without even windows, or they may be small buildings made of corrugated iron—"tin abominations," as one exasperated inspector called them! The furniture is rough but reasonably good. In such surroundings what can we expect to make of the children, and is it any wonder that they are only too glad to leave school after a year or two of incarceration? It seems too much like a fairy vision even to suggest a neat building standing in a suitable position on enclosed land with trees giving shelter and shade—a place to which the children delight to go. That day will come only when the authorities make the grants conditional upon necessary improvements of the kind, and provided time were given no real hardship would be experienced from such a condition.

Up to the present we have been so busy coping with the problem of providing accommodation that we have hardly stopped to enquire what kind of buildings was being provided—the day is now come for us to deal with this matter.

(*e*) *Growth in Number of Schools.*—In order to illustrate the growth in the number of schools let us glance for a moment at the available statistics. In Cape Province there were 120 non-European schools in 1854, 837 in 1894, 1,265 in 1904, 1,830 in 1914, and 1,842 in 1916. If we consider the 24 year period of Sir Thomas Muir's *regime*, and taking into account aborigines' schools only, we find that there were 273 in 1892, 770 in 1907, 940 in 1913, and 1,007 in 1916. An examination of the figures will show an increase of 182 per cent. in 15 years to 1907, and of 268.5 per cent. in the 24 year period to date.

In connection with the enrolment for the years 1892, 1907, and 1916, we find that the 15,193 grows to 45,936 at the middle date, representing an increase of 202 per cent., and by 1916 the enrolment is 65,459—an increase of 431 per cent. With these figures before us we are able to get a fair idea of the rate of progress which may reasonably be expected.

(*f*) *Denominational Control of Schools.*—The next point is to show to what extent the various Churches and Missionary Societies control Native Education, and once more it is necessary to resort to the Superintendent-General's Annual Report (1914). How few schools are managed apart from Missionaries may be observed under the heading of "other" in the accompanying Table.

TABLE III.

Denominational Schools.	*(Non-European.)* *Schools.*	*Pupils.*
Wesleyan	672	49,443
Anglican	415	31,667
Presbyterian—		
1. South African Church	151	9,223
2. U.F. Church of Scotland	124	8,986
Independent	109	7,767
Dutch Reformed Church	72	6,290
Moravian	68	5,578
Roman Catholic	40	3,097
Berlin Mission	31	2,595
French Evangelical	26	2,080
Rhenish Mission	17	2,510
London Missionary Society	12	762
Baptist	8	363
South Africa General Mission	6	287
Salvation Army	5	330
Lutheran	1	39
Other	44	4,427
	1,801	135,444

(*g*) *Distribution of Enrolment.*—At a later stage, under the Results of Education, we shall give further details of enrolment, distribution, and classification.

4. THE INSPECTION OF SCHOOLS.

(*a*) *Large Circuits of Inspectors.*—In order to ensure the necessary standard in mission, as in other schools, several Inspectors have been appointed by the Education Department. In 1892 only two Inspectors visited the Transkeian schools, whereas to-day we find eight—and even so, the work expected of these eight Inspectors is unreasonably great. In some cases the circuit is far too large geographically, and in other cases the number of schools must make efficient work exceedingly difficult. One man has 189 schools to inspect, but the average number is as high as 147 schools per Inspector. Another man is expected to inspect all the schools in Bizana, Flagstaff, Libode, Lusikisiki, Mount Ayliff, Ntabankulu, and Port St. Johns.

(*b*) *Lack of Knowledge of the Language.*—Speaking generally, the inspection is conducted in a sympathetic manner, but a serious criticism is to be found in the fact that only two or three Inspectors know the native language. It is admitted that difficulty is experienced in securing men who have the necessary qualifications, together with a knowledge of the language, and very often men are accepted whose vernacular qualification is a minimum. Probably this fact accounts for the tenacious way in which the Education Department has adhered to the use of English in all standard examinations; and it also accounts very largely for the extraordinary idea of insisting upon teaching little native children who have come direct from some heathen native kraal through the medium of English. For years this has gone on in our schools, but now the change is coming; indeed, it has partly come already. As we shall be dealing with this point at a later stage, it is sufficient merely to mention it here, and pass on.

The first matter of importance, then, in connection with the Inspectorate is that those working in native schools should, and must, have a sufficient knowledge of the language, in order that they may inspect children in their own language—not in English—at least up to Standard III.

Since the Mission Schools are tending more and more to take the character of the particular denomination to which they belong a possible solution may be found by permitting the larger churches to appoint their own Inspectors, or, at least, to have the power of nomination, and knowledge of the language surely must be an essential.

(*c*) *Inspectorate Inadequate.*—The general impression amongst Missionary Superintendents seems to be that Inspectors have too many schedules to fill up, and too many schools to visit considering that there is no railway communication, and that in the coast districts great distances have to be travelled on account of the characteristic deep river valleys, which cannot be crossed, necessitating a long, circuitous journey up the ridge until a crossing is possible, and then the journey down the other ridge to the point desired.

An idea of the work required of an Inspector may be realised when we remember that in the school year there are 40 weeks, or 200 days. If a man has 189 schools to attend to how is it possible for him to inspect each of them thoroughly, especially when we recall the length of time required in getting to the schools; and is it any wonder that we have wholesale passings sometimes, and at others wholesale failings?

With excellent men in the Inspectorate the thing is almost a physical impossibility, and should be remedied by the appointment of a larger staff.

IV. The Education now in Process.

Before we enter into questions of curriculum perhaps we should define the position a little more clearly. The education now in process may be defined as—

1. Literary.
2. Industrial.
3. Agricultural.

1. LITERARY.

The literary education provided is outlined in the ordinary curriculum for European schools. In other words, the children from heathen kraals attending our schools are expected to fulfil the same requirements as the European children. At the Butterworth Conference (as between the Superintendent-General of Education and the missionaries) in 1910 it was gravely stated that the policy of the Department was to provide for the natives education "of the same kind and on the same lines" as European children were receiving.

Such a policy presupposes that the European and native children come from the same environment, that the mind of the European child works in the same way as the mind of the native child, and the presuppositions are utterly incorrect. Educationally, then, applying the European curriculum to the native schools is unsound, and the fact that they have done so well even in spite of this handicap is an indication of the earnest purpose in all their searchings after knowledge. It must be understood that slight modifications may be allowed in the curriculum from time to time by a sympathetic Inspector, but, then, all Inspectors do not hold the same idea as regards sympathy, and no educational system should be based on informal assurances, and understandings. The time is come for a thorough enquiry into the environment, requirements, mental capacities and processes of the native mind, and all the other factors in the situation, in order to the devising of a suitable curriculum. Let us first know and understand his manner of thinking so as to learn how best to teach him, and then consider what subjects are to be selected and taught so as to produce the best results—best in the interests of the native himself, and best in the interests of the State.

The greater part of this paper is devoted to Native Education, especially in its literary aspect, and consequently there is no need to traverse ground already made familiar elsewhere. It is sufficient to draw attention to the need for a well-devised syllabus based on the experience of the last 50 years, adapted to the special capacities of the native mind, the environment from which he comes, and the part he is destined to play in the South African State.

2. INDUSTRIAL.

The industrial side of Native Education is, relatively, small. It seems that some difficulty has been experienced in devising suitable courses which could be applied to the native schools, but so far nothing has been done, except in the large Training Institutions, where we find struggling Industrial Departments. The provision of tools for use in the native schools would be an expensive item, teachers who could combine literary with industrial work* are easy to secure; but in any case it is an open question whether it would be wise to introduce such a course into all the schools of the Territories. It is very popular to assert that all natives must have an industrial training; but, then, even fallacies are sometimes popular!

Nevertheless, greater facilities for industrial training should be provided by the Government, and the time is come when this branch of education should be placed on a sound footing, so that those who want it may get it, and those who have little, if any, idea as to what industrial training really is, will see it and possibly desire it. All that the native knows (I speak of the heathen native in red blankets) of education is the village school, and if he does not see industrial training going on there how can he be expected to know about it, and to send his children to be trained?

If the Government were to make reasonable grants available no doubt many missions would provide facilities in this direction, but as things are, the industrial departments of our institutions are usually run at a loss to the mission, and the economic factor is too strong. That, in plain words, is why industrial education is a negligible quantity in native schools to-day.

TABLE IV.

INDUSTRIAL SCHOOLS.

Boys.

	Black-smiths.	Book-binders.	Carpen-ters.	Farmers.	Printers.	Shoe-makers.	Mixed.	No. of Individual Pupils. 1916.	1915.
Blythswood ...	—	—	29	—	—	—	—	29	28
Clarkebury.. ...	—	—	15	—	—	12	—	27	28
Lovedale	4	4	41	1	14	—	16	93	75
Mount Arthur	—	—	11	—	—	—	—	11	12
Osborn..	—	—	15	—	—	—	—	15	16
Umtata..	—	—	14	—	—	—			
Totals	4	4	125	1	14	12	16	—	—

* Certificated male teachers usually possess 3rd year Woodwork Certificate.

Girls.

	Cookery.	House-work.	Laundry.	No. of Individual Pupils. 1916	1915
Blythswood	11	11	11	11	13
Lovedale..	32	36	36	36	54
Totals	43	47	47	47	67

Table IV shows the exact position to date of the extent of industrial education. One is tempted to enquire whether the deplorable condition of industrial education is due to the fact that certain sections of the community fear the competition of native labour, and so facilities are withheld in order that the natives may not be in a position to compete.

So humiliating an attitude surely must be dismissed from our minds, and one prefers to think that the unsuccessful policy is due to the practical difficulties.

3. AGRICULTURAL.

At present the only instruction in all our native school system, which even borders on agricultural education, is the course of Nature study recently introduced into the Training Institutions. If our curriculum were based on the accepted principle of proceeding from the known to the unknown it is difficult to see how we could avoid teaching agriculture in our native schools. The child coming from a heathen home is acquainted with the cattle and goats and sheep and their ways, and has often, if he be a boy, led the oxen when his father was ploughing. The girls, on the other hand, would have helped their mothers in the work of hoeing the lands. Starting them from the cattlefold and the mealie garden much might be taught.

The need for industrial training is great, but the need for agricultural training is greater. The continued increase of the native population dare not be lightly treated, and it is essential that we should teach the native peoples how to get the best results from the limited amount of land available; and a wise dissemination of knowledge in, and through, our schools will accomplish more at slight expense than other costly schemes involving the establishment of agricultural colleges. In any case, the agricultural colleges might well have a place of their own in the scheme of higher education.

In connection with this subject it is interesting to observe that in other parts of the world agriculture is actually included in the school curriculum. In his report on "Agricultural Education in Australia," Dr. C. F. Juritz informs us that, in addition to agricultural high schools in the State of Victoria, the subject is taught in the Primary Schools.

> What everyone interested in the future of South African agriculture should realise in this connection, is that in Victoria no effort is spared to enlist the child's ideas and inclinations on behalf of agricultural pursuits, from the very earliest age possible.

The Victorian Department of Education controls 2,000 primary schools, with their plots and gardens. Of these schools, 700 have regular courses in agriculture and Nature-study, and before leaving the primary school, the pupil is taught the significance of schoolroom and plot experiments of an elementary character, with plants and crops. . . . In order to provide suitable teachers to take agricultural subjects in the primary and secondary schools, courses of lectures on practical agriculture, accompanied by weekly demonstrations of agricultural principles, are given at the Teachers' Training College.

From time to time attention has been drawn to the necessity for including agriculture in the school curriculum here in South Africa, but up to the present nothing has been done in this direction.

That there are difficulties in the way is freely admitted; in fact, they are on no account to be under-estimated. But unless we address ourselves to the problem of overcoming these difficulties we shall be in danger of facing a much greater problem not many years hence.

A course adapted to the exigencies of our climate could be mapped out, providing for practical work in the rainy season, and theory in the cold, dry months of the year. If all the schools could not come into line in this respect, at least the great majority could, and the main difficulties which we would have to face have apparently been already faced elsewhere. In previous papers* I have already emphasised the necessity for introducing this subject into our native schools in the interests of the State, pointing out that both men and women have their part in native agriculture, and so agriculture is specially suitable as a school subject. The compelling factor is to be found in the enormous increase of the native population and the consequent using up of all available land. In a measurably short period we shall be in the midst of serious difficulty unless we inculcate intensive methods of cultivation, and so postpone the crisis, hoping that, in the meantime, economic factors will be at work adjusting the whole situation.

One cannot over-emphasise the importance of this suggestion, and it is to be hoped that serious consideration will be given to the mapping out of a suitable course, the introduction of the subject into our primary schools—especially, though by no means exclusively, our native schools—and the training of teachers in agriculture.

In any case, if in our native education we applied the principle of proceeding from the known to the unknown, we could hardly find a better starting point than is to be found here—the cattlefold and the mealie garden.

V. The Curriculum.

1. WHAT WE TEACH THE NATIVE.

We have already stated that the ordinary curriculum for European schools is employed practically in its entirety in the

* Rept. S.A. Assn. for Adv. of Science. Kimberley (1914), pp.151-164; Pretoria (1915), pp. 178-192.

native schools. The responsibility for this state of affairs must be shared by the missionary body, who have declared from time to time in favour of the development and adaptation of the present system, and that any future changes in Native Education should be of the nature of adjustment within the educational system of the Province. Such a decision is quite reasonable and eminently wise; but the trouble is that little effort has been made to secure these necessary developments and adaptations.

At present, then, we are teaching the natives just what we are teaching the white children. This is a mistake, and we have already expressed ourselves in this sense, and given reasons elsewhere in this paper. There is therefore no need to cover the same ground a second time, though we take this opportunity of emphasising the considerations already given. In particular there is the totally different environment in which the native children live, their totally different outlook, tradition, language, and mentality; also the totally different future which they will need to face when they grow up as compared with the professional or commercial life for which our white children are being prepared; and the fact that they are compelled to assimilate all this through a foreign language. Such a condition of affairs one would imagine would closely affect the reputation of the responsible educational authorities; but here, apparently, the Education Department does not seem to realise that its position is educationally unsound! The glorious doctrine of *laissez faire* seems to be followed with a vengeance.

From the native point of view the position, if rightly viewed, would be regarded as quite unsatisfactory. Why should the natives not be allowed to develop along their own national and natural lines rather than be forced into European moulds, which do not at all suit their genius, and tend rather to handicap them, and turn them out as so many "half-baked cakes."

2. VERNACULAR AS MEDIUM—KAFIR AS SUBJECT.

Perhaps the first change to advocate would be the use of the vernacular as the teaching medium. The letter of the law leaves no room for the use of the vernacular, but various benevolent assurances of an informal nature have encouraged the use as teaching medium of the vernacular up to Standard III. When it is remembered that the little children coming from heathen kraals know nothing of the English language the folly of using that language as medium becomes apparent; and perhaps that accounts for the fact that in practice no exception is taken to the use of Kafir in the lower standards. But the tacit permission is of comparatively recent date. Throughout English is emphasised as medium, probably mistakenly, and the difficulty of securing inspectors conversant with the vernacular no doubt tended to keep up the emphasis of English.

That English should be taught as a subject in the lower standards, and that with some emphasis, is quite right, when we realise that English is to be the medium of instruction in the higher standards. But in my experience of the present system I have observed again and again how an imperfect understanding of the language in which the children were taught led to an imperfect and inaccurate knowledge of the subjects taught through that language. Children came to lose interest in the reading they did not understand, and so in place of learning by understanding they committed large parts of the reading book to memory, and once started off they appeared to read, but really recited the passage; and much of what they did manage to read they did not in the least understand.

Surely it would be far better to allow them to be taught throughout in the vernacular, retaining English as a subject—as an important subject. It is far better to educate the natives soundly rather than to give them a thin coat of English paint; and if English is of such essential importance to them, why is not the other official language of the Union equally important?

The fact is that the languages of the Union might with at least equal propriety be trilingual. With a native population of some seven millions as compared with a white population of one and a quarter millions, the native language should have its rightful place; and surely, if anywhere, its rightful place is in the native schools at least. In all his dealings amongst his own people the native will use his own language—not English—and only a very small percentage of the total population require to talk English after all. Better then, by far, to educate him through his own language, always retaining English as one subject in the curriculum, so that he may benefit to the full, and understand what he is taught. I believe that Native Education will have far greater value, and be sounder in most respects when the hopeless policy of teaching them through a foreign language is abandoned.

Moreover, we are making the extraordinary mistake of not teaching the natives the grammar and structure of their own language! Kafir should, and must, be taught as a separate subject. Many natives do not even understand what they read in their own language because their knowledge and their vocabulary are so limited; nor can they write a letter, which is grammatically correct. It is most important for us to realise that we are making their grammar for them. They had no idea of grammar—they just talked! We have reduced their language to writing, and to order, and to some extent we have mastered the various rules. I believe that a discovery of first importance has been made within recent months regarding one of the points which long has been a problem to investigators: a discovery of such importance as to necessitate the rewriting of the Kafir grammar book. Since there is little value in an education that does not adequately educate, and equip, men for their work in life, I am prepared boldly to advocate readjustment of the curriculum in these three important particulars:—

1. The use of the vernacular at least to Standard IV as medium of teaching.

2. The teaching of English as a major subject.
3. The teaching of Kafir as a major subject.

3. RELIGIOUS TEACHING.

A further point claims our attention in this connection, and that is the place of religious teaching in the curriculum of our native schools. After my experience of native life, and speaking as a South African, I am convinced that the one great obstacle to advance is the moral one Temptation of a sexual nature is the great barrier reef on which Christian teaching and effort is too often broken; and before a native is converted the teaching of the missionary must break through this barrier. And if we dare not leave a large and unenlightened heathen community to practise their evils within our borders, neither do we dare educate them away from their heathen ideas and customs, leaving them free to perpetuate their evils with the impunity which comes with increased knowledge.

It is therefore essential to present the Christian standards of morality as part of the inseparable fabric of true education. And those who have investigated the situation in its several aspects have again and again urged the necessity of Christian teaching in native schools. The authority of Government commissions will hardly be called in question, and at a later stage I propose to give full quotations of the findings of various commissions. I am content here to point out the need for adequate religious instruction in our native schools. So long as present conditions remain this subject will not be seriously treated by the teachers, or the children, and the logical step is for the Education Department to take such steps as may be necessary to place the subject in the school curriculum, and to give practical effect to the pronouncements which hitherto have been made with all seriousness, and quietly left to be overtaken by oblivion.

VI. THE ATTENDANCE.

1. NUMBER ATTENDING SCHOOLS.

The last 23 years have seen a very great development educationally in the Cape Province, and some of the most striking results are to be found in connection with the native schools.

In 1915 it was officially estimated* that the native (and coloured) population in the Territories amounted to 923,916, and as at the second quarter no less than 65,138 children, representing 7 per cent. of the population, attended Government-aided schools. These figures were an increase of 2.2 per cent. on the figures of 1904. For purposes of comparison I should state that out of a white population of 583,868, in 1915, some 103,909 children, representing a percentage of 17.8 per cent. of the white population, were attending school.

* *Education Gazette*, 27 Jan., 1916, p. 709. See also p. 481, *post*.

2. NUMBER AVAILABLE.

Restricting ourselves more particularly to the native population we find, then, that while large numbers of children are attending school yet very many more do not attend. I have worked out a comparative table shewing not only the actual enrolment, but also the number of children available. (See Tables IX and X *post.*) The latter number has been determined on the basis of 25 per cent. of the population. This basis is by no means too high for the purposes of our study, especially since it is applied to a heathen and polygamous community, where one would naturally expect to find large families. It has already been shown that in the census of 1904 it was found that the number of children between the ages of 5 and 14 actually represented 26.1 per cent. of the population.

The actual figures of attendance in the districts which are under General Councils are given in Table X. Certain few of the most backward districts are not yet under the Pondoland General Council, but leaving them out of consideration for the present and confining ourselves to those of which we have exact knowledge, we find an average roll (1915) of 62,835 in an area in which the population amounts to 689,122. If 25 per cent. of the children are of school age then 109,245 children are still available. If it is a problem for us to find accommodation for our present pupils, and grants in aid are secured with difficulty, what will the problem be like if we were called upon to accommodate 1½ times as many more children in our schools?

3. REASONS FOR NON-ATTENDANCE.

At present the natives find their children very useful as servants. The boys are given various duties to perform, such as the herding of the sheep and goats, and the girls assist in the nursing of numerous younger brothers and sisters, as well as in the share of work which usually falls to the womenfolk. In consequence, there is a certain reluctance about sending the children to school. There is also an idea abroad (quite a correct one) that if the girls are sent to school and are educated they will not submit willingly to any arrangement of marriage with some heathen man, and so may refuse to marry a man who could afford to pay her father a substantial dowry for her. Speaking broadly, the natives do not employ servants as we do, and consequently the children are widely used in that capacity, and for that reason large numbers are kept at home.

4. DESIRE FOR COMPULSORY ATTENDANCE.

However, there has been quite an insistent demand of late for compulsory education, and anyone who has attended recent sessions of the Transkeian General Council will know how, year after year, lengthy discussions take place, and unanimous, or nearly unanimous, resolutions are carried on that subject. Hitherto the authorities have frowned upon the suggestion upon the grounds of expense, and not wholly without reason.

5. WHAT COMPULSORY ATTENDANCE WOULD MEAN.

Indeed, the very men who demand most insistently compulsory education, scarcely realise what the granting of their demand would really mean. They would be surprised, indeed, to find themselves without servants and herd boys; and yet that is just what compulsory education would mean.

Looking at it from quite the other point of view, it would mean a very substantial reinforcement of the missionary body at present at work. It would mean finding accommodation, the granting of hundreds of new sites, the building of hundreds of new schools, and the enlargement of existing schools in order to accommodate an enrolment two and a half times as large as the present enrolment.

The teaching staff would need to be doubled, probably, and that would involve considerable developments of the Training Institutions.

The financial question would be a really serious matter, including increased grants for the doubled teaching staff, and the provision of the necessary school equipment, and consequently increased taxation.

But in these days we are living in the midst of a wonderful transformation, and there is no knowing but that we shall still have to face this question, serious though it be. At the very least, it is a possible responsibility, and if it does not come all at once and within the next half-dozen years it will at least come in due time; and the wonderful development of the native schools in recent years seems to indicate that very large additions will continue to be made to existing schools in the near future.

With this vision before our eyes it is only fitting that we should enquire more closely into the actual results of Native Education, and so discover whether we are wise in educating these primitive peoples who dwell within our borders.

VII. The Results of Native Education.

This aspect of our enquiry is one which merits specially careful consideration. There is no doubt that if people gave serious thought to the actual results of Native Education they would not pass those superficial judgments upon the work being done, which, in the aggregate, tend to produce an ill-informed public opinion. It really is absurd for men to continue to make all manner of statements about education spoiling the native, in face of the considered judgments of impartial Government commissions, which always take a strong line in favour of Native Education. It must also be remembered that responsible men meeting together in conferences, and Teachers' Associations, and elsewhere, have time and again declared their judgment in strongest support. All this does not count for naught.

1. ARGUMENT AGAINST NATIVE EDUCATION.

If I may make a bold statement, with all caution, I would say that the argument against the education and advancement of the native on the ground of competition is utterly erroneous and unsound. It is comparable, in some respects, to the old-time argument against the introduction of machinery. We now know that, speaking economically, competition always leads to increased production, and consumption increases with competition, and this, in turn, leads to greater wealth. After a long experience in the industrial world we are now fully prepared to acknowledge that all the riots, which took place in the days when machinery was first introduced, were based on a misconception, and the arguments then used were quite unsound.

2. ECONOMIC VALUE OF NATIVE EDUCATION.

Perhaps, then, the first result of our experience of Native Education is this, that it proves beyond question the unsoundness of the argument against Native Education. Economically, there surely can be no comparison between an ignorant red heathen man in his blanket, whose requirements from the shop, generally speaking, are a blanket and some ochre, and tobacco; and, on the other hand, an educated native needing clothes, tea, sugar, jam, tobacco, tables and chairs, pots, and even other articles of European manufacture. The heathen man staying at home because his requirements are small, the school native going to work because he has acquired tastes for tea and sugar and other things, and must have money to satisfy these tastes.

And so from other points of view we may make the same comparison always to the detriment of the ignorant savage. Applying this argument in the aggregate, how much greater is the force!

3. MORAL VALUE OF NATIVE EDUCATION.

Further, it cannot be to the interests of any State to harbour a primitive people within its borders, indefinitely allowing them to perpetrate and perpetuate unspeakable evils; and our South African nation must be aroused to the situation, and brought face to face with the actual position. I do not propose to speak in this paper of native customs, except to raise the curtain momentarily in order that those who are truly interested in Native Education may see and understand. There is a general impression abroad that the heathen natives live clean lives, that bound by tribal custom men restrict themselves to their wives. Since I made my home in the Territories I have found this to be absolutely incorrect. I learned that the natives have a custom equivalent to the sexual act, and practised almost universally—that practically no heathen girl would not consent, if, indeed, she did not take the initiative. The difficulty which missionaries have to face is this custom of *ukumetsha*, so deeply entrenched in native life and thought that public native opinion thinks nothing of it, and parents take little, if any, care to keep their boys and girls from coming together in this way. Indeed, the girls are often taught by their own mothers how to accomplish their purpose without serious results ensuing. The growing class of school natives, while not wholly free from this custom, represents a very real effort to be free from heathenism; and the larger we can make this class, the better for the white man and his children.

I am further informed, with only very slight exaggeration I fear, that every heathen man has one or more secret consorts other than his wife, and conversely wives are friendly with one or more men other than their husbands. Sometimes there is connivance because the one dare not accuse the other. Amongst school natives there is at least a real attempt in the direction of faithfulness.

With this before us as a serious statement of the position, the argument for educating the native becomes unanswerable. We must choose between keeping within our borders a large and growing population of primitive people, perpetuating evils that every right-minded man should be determined to stamp out; or, on the other hand, putting forth every effort to turn them from animalism to a higher view of life's values; and so long as we do not do our part to right this great wrong they will be an abiding moral menace to the State—a menace that we dare not leave at our doors.

4. OTHER REASONS FOR NATIVE EDUCATION.

I am unwilling to burden this paper with lengthy quotations, but feel that certain paragraphs in Reports of Government Commissions need to be published in their natural context, where they may be correctly correlated. No serious study of the question of Native Education can leave them out of account. These notable findings refer to the results of Native Education, and are in themselves a complete answer to superficial critics.

§ 189. The evidence of the effect of Christian teaching and education on the character of natives is very strong. These unquestionably exercise an enormous influence for good. Administrative action can go but a short way in that direction. It is a universal complaint that the weakening of tribal control is having a disastrous bearing on social and family life. The effect of the introduction of a civilised form of government results necessarily in the discouragement of ceremonies and customs which, though barbaric in European eyes, have important consequences in regard to tribal, paternal, and marital authority, and indirectly on the moral bearing of the community.

In this evolution the Commission is convinced that the restraining and directing influence of the Christian religion and education, if imparted on proper lines, are absolutely essential. There is abundant testimony of the benefit derived from these agencies which should receive the fullest possible encouragement in the interests of the white as well as the black races.—P. 35, Report of the Commission appointed to enquire into Assaults on Women, 1913.

The consensus of opinion expressed before the Commission is to the effect that education, while in a certain number of cases it has had the effect of creating in the natives an aggressive spirit, arising no doubt from an exaggerated sense of individual self-importance, which renders them less docile and less disposed to be contented with the position for which nature or circumstances have fitted them, has had generally a beneficial influence on the natives themselves, and by raising the level of their intelligence, and by increasing their capacity as workers and their earning power, has been an advantage to the community.—§ 328. South African Native Affairs Commission, 1903-05.

Testimony has been given as to the value of education as a concomitant of religious and moral instruction, and as to its economic effect in raising the standard of material comfort, and thus creating wants. Apart from the consideration that there is a moral obligation upon the State to provide for the intellectual development of all classes of its subjects, there appear to be very sound reasons of policy for the adoption of a liberal and sympathetic attitude towards the subject of Native Education. The native, in common with the rest of mankind, does not live by bread alone, and possesses certain mental impulses and aspirations which demand satisfaction. Before the advent of European civilisation, the struggle for existence, the chase, war, tribal politics, all furnished a field for the exercise of faculties which new conditions have condemned to inactivity. No policy can be complete or sound which is limited to political or economical considerations only, and which takes no account of the irrepressible forces within each individual. And it is evident that there is among the people themselves a growing desire for education, which cannot and need not be suppressed. Native witnesses have been strong on this point, and the Native Churches which have seceded from European control have established schools for which they have attempted, in most cases unsuccessfully, to secure Government recognition and financial aid.—§ 329. South African Native Affairs Commission, 1903-5.

The Council assumes without question that the education of the native is to proceed, and proposes to confine itself to the problem of finding the right course. It does not seem to be necessary to enter upon any elaborate justification of this assumption. It seems to the Council to be axiomatic that the native has a right to an opportunity to proceed to such a stage of development, whether moral, intellectual, social, or industrial, as he is capable of; and it seems equally axiomatic that it is a primary duty of those responsible for the government of the country to see that such an opportunity is given to him. Both the right and the duty seem to be beyond controversy.

It is the opinion of the Council, moreover, that on economic grounds merely the case for his proper education can be urged. If education can make his maintenance and development more enduring and stable where he is an occupier of the land, the country will reap indirect advantages from his increased productive power; and it is also equally true that, where he comes in contact with the European as a labourer under supervision, we want the best work possible from him, and, therefore, his education as a condition of advanced efficiency should be proceeded with. Again, the claim he has for educational facilities, as some return for his direct and indirect contributions to revenue cannot be overlooked. The Council therefore takes the case for Native Education to be proved.—pp. 1 and 2. Third Report of Council of Education, Transvaal.

Originally the customs and the manner of life of the South African natives were adapted to the environment; and much may be said in commendation of some of these customs. But the entrance of the white man, and the mere fact of his living in contact with the natives, has changed the whole environment. The question now is: to what extent must we encourage the alteration of the manner of life and customs of the native peoples, so as to adapt these to the new and still changing environment? What kind of education is best for the native peoples and for the State? How should we adapt our educational methods to the special needs, and circumstances, and environment?

There is an advance and a general improvement in the condition and outlook of the people which can never be expressed in figures and percentages, and consequently all this must remain unclassified in our review of the results attained; but there is a growing volume, and quality of work done in our schools, which gives promise of great things in the future, and some idea of the substantial progress made within the last quarter century will be found by referring to the returns of the exports and imports, and by observing the increasing number of native clerks in private and public service, native teachers and ministers, not to mention the steadily growing number of native newspapers, and the growing volume of native literature.

It will be a great day for the native races when the rank and file learn to appreciate the blessings of reading. There is not much "volume" of native literature yet, but it *is* growing.

5. NUMERICAL RESULTS.

Turning to the numerical results of Native Education we find ourselves in a position to classify and tabulate. In the presence of the actual figures one cannot but feel impressed both as regards past attainment, and the challenge of the future. In this year's annual report (1914) the Superintendent-General of Education says:

Never previously has so great an increase in coloured pupils been recorded in any year: and the statistics show that the growth in the Transkei has been much more marked than in mission schools in the Province proper.

	1913.	1914.	Increase.
Province Proper	66,070	70,511	4,441
Transkei...	60,242	67,960	7,718
	126,312	138,471	12,159

The very considerable development recorded is the more gratifying when it is recalled that it is the result of voluntary and disinterested effort on the part of the different religious bodies. In their educational work for coloured and native children the various Churches are carrying out, at a comparatively low cost to the State, work of considerable importance and value to the general community. The missionary bodies are deserving of all praise for the manner in which their schools are conducted, often in the face of considerable financial difficulty.—p. 11.

6. A REMARKABLE ADVANCE.

Table VI is of historic value as showing the state of Native Education in the year 1884 by way of giving contrast to present-day conditions and numbers.

Tables VII and VIII giving details of enrolment as to distribution and classification have an important bearing on the question of the future of Native "Higher Education," and will repay a careful study. In Table VIII three things call for attention. First, the striking increase in numbers; second, the large number of children who now penetrate to the highest standards; third, the abrupt falling off, as at Standard III.

TABLE VI.

From Commission on Native Laws and Customs, 1884.	No.	Children.
Native Training Institutions—		
Day Schools	25	2,321
Kaffir Mission Day Schools	128	6,460
Transkei	106	4,151
Tembuland	42	2,162
East Griqualand	50	2,250
Basutoland	24	1,083
	375	18,427

TABLE VII.

Distribution of Enrolment.	(Non-European.) 1913.	1914.
First Class Public Schools	80	78
Second Class Public Schools	584	620
Third Class Public Schools	1,826	1,848
District Boarding Schools	341	340
Evening Schools	230	210
Training Schools	1,113	1,223
Mission Schools	61,718	66,341
Aborigines' Schools	60,409	67,801
Other Schools	11	10
	126,312	138,471

TABLE VIII.

NON-EUROPEAN SCHOLARS.

	1892.	1907.	July 30. 1911.	At Inspection. 1912.	1913.	1914.	European. 1914.
Sub-Standard A ...	4,759	23,559	58,006	61,396	67,888	72,248	30,285
Standard I	1,521	5,747	11,740	11,928	12,767	13,989	12,117
Standard II	1,273	4,965	10,412	9,950	10,538	11,080	12,018
Standard III... ...	685	3,550	6,988	6,705	7,422	8,200	11,629
Standard IV... ...	157	2,282	3,959	3,769	3,439	3,652	9,307
Standard V	32	1,090	1,732	1,844	1,833	1,828	6,742
Standard VI... ...	5	509	793	785	743	851	4,909
Standard VII.. ...	—	—	8	6	18	38	2,580
Ex-Standard... ...	—	—	—	—	1	17	3,244
Total...	8,432	41,702	93,844	96,383	104,649	111,903	92,831
Pupil Teachers I...	—	482	390	510	529	587	—
Pupil Teachers II..	—	221	237	251	369	355	—
Pupil Teachers III.	35	105	191	178	204	260	—

7. VALUE OF SCHOOL NATIVES TO THE ADMINISTRATION.

Before turning away from the subject, perhaps one other point should be mentioned. With 68,000 children passing through the Transkeian Schools annually, it will be realised that a very considerable class of school natives is in process of creation, and these are of great value to the Administration. Being better informed, they tend to act as a steadying influence upon the old natives, helping to explain new legislation, and easing the situation generally in one way and another. These, then, may be regarded as the main results of Native Education.

A result on which I have not dwelt in this paper is the hypothetical one of competition as between white and black. To my mind the fear of such a competition is a confession of weakness on the part of the white man. The practical importance of the question, however, is such that I prefer to reserve consideration for the present, hoping on some future occasion to enter fully into the whole issue.

VIII. THE SUPPORT OF THE SCHOOLS.

I. MISSIONARY SOCIETIES.

The support of the schools is dependent upon three sources. In the first place the Missionary Superintendent who does the work in an honorary capacity is only able to do so by reason of the fact that his salary is provided by the Church or Society of which he is an agent. In providing the necessary buildings for school purposes he often is supplied with grants towards the building fund from the same source—especially is this so in the case of the Training Institutions in which the Home Churches have sunk thousands of pounds. All this is due to the development of Native Education from the days when the schools were a branch of purely missionary effort, quite unsupported by grants-in-aid; and the financial support still given by the various Missionary Societies is not to be under-estimated. It has been estimated and publicly stated (I quote it not without reserve) that the missionary bodies are doing work in connection with Native Education in South Africa which could not be done by paid agents of the Government at a cost less than £200,000 per annum. If that burden is not upon the Government, it is because it is being faced by the Missionary Societies.

2. GOVERNMENT GRANTS.

In the second place the Government give grants on certain conditions. These grants are paid quarterly to the Missionary Superintendent, who pays the salaries of the teachers; and every penny of this money is paid over to the teachers concerned. Many of the expenses incidental to the work are regarded by the missionaries as personal expenses, so that not only are they not paid, but actually they lose! A fully certificated teacher is paid (from Government sources) £6 per quarter, rising slightly with long experience. Teachers who have passed the second year pupil teachers' examination receive at the rate of £5 per quarter; those who have passed the first year at the rate of £4; and those with only Standard VI qualification at the rate of £3.

After five years' continuous service the good service allowance becomes operative, while grants are made, pound for pound, in the purchase of books and sewing material.

3. LOCAL CONTRIBUTIONS.

In the third place the Transkeian Territories' General Council makes grants, based on the Government grants. Thus all principal teachers receive a grant at the rate of 15s. for every £1 of Government grant, and assistant teachers at the rate of 10s. per £1. This arrangement, as has already been pointed out, is not satisfactory for some fully certificated teachers are not principals, and a large number of uncertificated teachers are principals. Thus certificated assistants are getting less than uncertificated principals, and for that reason it is urged that the higher scale of grant should apply to certification, and not to position, which may mean very little in a small outstation school.

Originally, it was usual for the Government to supply the grants for salaries, and the missionary did the best he could, with or without the assistance of the headman of the location, to raise a further sum to augment the grant. This amount was called the "local contribution." It was, however, found that much of the missionary's time was spent in the effort to rouse the headman to a sense of his duty. In some schools the local contribution was forthcoming; in others only a fraction of the amount was collected. Naturally, this led to a very unsatisfactory condition of affairs since the teacher seldom knew whether he would get his full salary or only a portion thereof.

4. EFFECT OF COUNCIL SYSTEM ON EDUCATION.

The development of the Transkeian Territories' General Council has, however, brought about a considerable change in the condition of affairs. Districts elect to form a District Council under the chairmanship of the Magistrate. This involves that they submit to the imposition of a 10s. rate per adult man, the money thus obtained to be spent on education and public works. Every District Council sends representatives to the General Council. This movement has developed steadily, and 21 districts are now represented on this system, 18 in the Transkeian, and three in the Pondoland General Councils. In consequence, we have an official body with powers to enforce the collection of the general rate, and this body disburses through the Missionary Superintendent, quarter by quarter, the "local contribution." It will at once be seen that such an arrangement is of the greatest possible advantage, for now there is certainty where before there was none, and the missionary is freed from the unpleasantness and labour of chasing an elusive heathen headman, who knew nothing of education and cared still less to be bothered with the none too pleasant duty of urging his people to fulfil their obligations.

In passing, however, it should be mentioned that this extraordinary state of affairs still exists even unto this day in the Colony proper, for there is no machinery in the Ciskei comparable to that in the Transkei. Several efforts have been made to secure some competent authority in the Ciskei with powers to deal with the raising of a rate at least for educational purposes, and it is to be hoped that something will be done along those lines in the near future

The value of this suggestion will be at once seen when we study the accompanying tables relating to the effect of the General Council system on Native Education in the Transkei. For one thing, it has, of course, and quite naturally, attracted the best teachers to the Transkei. In consequence, the standard of work has been much improved, and this improvement is reflected in the better qualified teachers which the Training Institutions are turning out, because they have better material to work on. The Institutions themselves are not only much improved within recent years, their numbers increasing both in point of attendance, and also in the numbers of Institutions. In fact, the whole system of Native Education in the Transkei has been materially improved in most respects, and stands as an illustration and example for all our native territories in the Union.

In order to make the comparison as complete and exact as possible two tables (IX and X) are here given. The first is taken from the minutes of the Commission on Native Education, and the second is compiled from official sources—as are all the tables in this paper.

It will be noted, in the first instance, that in the districts under the jurisdiction of the Council the average percentage attending school is *double* that in non-Council areas. In the second table the first point to be observed is that only four districts are now outside the District Council system. The obvious inference is that the system so manifestly commended itself to the people that they willingly accepted the responsibilities of entrance in order to secure the privileges; and of these, perhaps, the first is education. The four districts which remain without the magic circle are the most backward districts of heathen Pondoland, and their entrance is now only a question of time. How backward these districts really are is revealed by the fact that only 9 per cent. of the children available attend schools, representing an increase of 5.8 per cent. in eleven years!

The average percentage of attendance for all Council areas is 32 per cent.

Alongside these figures it is of value to show the percentages as from certain districts in order to see what number of children may be regarded as available for school attendance. Thus in 1907, in Nqamakwe district, 14.7 per cent. of population were attending school, and 29 per cent. of population were between the ages of 5 and 14 years. This if education became compulsory the school accommodation would need to be doubled, and that in the district possessing, perhaps, the largest school accommodation. So what shall we say of those districts of much smaller percentages? And taking a general average, if between 5 and 14 years of age we have roughly (according to census 44.14 per cent.), 30 per cent. available for school, the percentage would be obviously greater if the age were extended to 16. But taking 30 per cent. as the basis, only 8 per cent. are in school, and the large numbers of schools, teachers, and missionary superintendents would need to be more than trebled. And in the four non-Council districts, where we now accommodate 2.42 per cent., we shall need to prepare for twelve times as many.

Table XI will demonstrate clearly how eminently reasonable is the basis of our calculation.

Table XI. 1911 Census.

A. Under 15 years.	European.	Native.	Coloured.
1. Union	465,459	1,636,031	268,417
2. Cape	219,462	670,868	191,441
B. Proportions per cent. under 15 of persons of each race:—			
1. Union	36.47	40.71	39.58
2. Cape	37.68	44.14	41.38

But hand in hand with the advantages already enumerated has come another effect destined to monopolise much time and thought and diplomacy in the near future. Since the Councils have contributed to the upkeep of the schools they have sought, and are with some insistence seeking, some measure of control in matters scholastic. We need hardly enlarge upon this aspect, inasmuch as we have dealt with it elsewhere in this paper. Nevertheless, the situation is likely to develop as time goes on, and when it does develop it will only be satisfactorily settled in closest co-operation with those who, from the first, have been the prime movers in giving the people education, and at no slight sacrifice now maintain the whole system of Native Education.

IX. The Grading of Schools.

At the present moment, as one surveys the whole system of schools in the Territories, one is impressed with the haphazard way in which schools are allowed to exist. This is largely the result of the conditions which obtained in earlier days, and a little systematising would much enhance the value of the inheritance.

I OUTSTATION SCHOOLS.

Many of the outstation schools are struggling along with one teacher and many children, and the hopeless attempt is being

TABLE IX.

Influence of Glen Grey Act on Education—I (1907).

Territory and District.	Total Population (1904 Census).	Total available, ages 5–14. (1904 Census).	Total Enrolment June 30, 1907.	Percentage of available Total in School.
Transkei—				
Butterworth	18,625	5,143	2,401	47
Idutywa...	27,279	7,619	1,346	18
Kentani	34,048	9,461	2,123	22
Nqamakwe	33,977	9,934	5,003	50
Tsomo	19,869	5,984	2,692	45
Willowvale	42,225	11,563	3,139	27
Tembuland—				
Elliotdale..	29,145	7,169	348	5
Engcobo	59,622	15,973	3,069	19
Mqanduli..	35,318	9,854	1,586	16
Umtata	41,784	11,305	2,494	22
Griqualand East—				
Mount Ayliff	16,738	5,264	861	16
Mount Fletcher	23,992	6,962	1,312	19
Qumbu...	31,160	8,812	3,001	34
Tsolo	31,402	9,265	2,850	31
Umzimkulu	32,574	9,956	2,480	25
Total for Glen Grey Act Districts	477,758	134,264	34,705	26
Tembuland—				
Elliot	6,241	1,523	101	7
St. Marks..	37,145	10,870	1,496	14
Xalanga	14,161	4,208	1,689	40
Griqualand East—				
Maclear	4,829	1,345	239	18
Matatiele	32,627	9,606	1,822	19
Mount Currie...	10,697	2,820	632	22
Mount Frere	32,765	9,271	3,583	39
Pondoland—				
Bizana..	33,022	10,273	281	3
Flagstaff	25,903	7,512	593	8
Libode	24,795	7,550	350	5
Lusikisiki..	42,169	11,830	339	3
Ngqeleni	37,838	10,560	588	6
Ntabankulu	29,336	8,051	663	8
Port St. Johns..	8,681	2,448	95	4
Total for non-Glen Grey Act Districts..	340,200	97,867	12,471	13
Total for whole of the Territories..	81,967	232,131	47,176	20

TABLE X.

INFLUENCE OF GLEN GREY ACT ON EDUCATION—II (1915).

Territory and District.	Estimated Population (1915).	Total available ages 5–14. on 25 % basis.	Total Enrolment June 30, 1915.	Percentage of available Total in School.
Transkei—				
Butterworth	22,500	5,625	2,666	47
Idutywa	32,188	8,047	1,888	23
Kentani	38,040	9,510	2,246	25
Nqamakwe	38,348	9,585	4,241	44
Tsomo..	21,514	5,379	3,173	59
Willowvale.	40,912	10,228	3,799	37
Tembuland—				
Elliot (no longer in Territories)				
Elliotdale..	27,532	6,883	428	6
Engcobo	62,500	15,625	4,025	26
Mqanduli	35,195	8,799	2,099	24
St. Marks	39,536	9,884	3,189	32
Umtata.	45,270	11,318	3,446	30
Xalanga	17,173	4,293	1,636	38
Griqualand East—				
Maclear (no longer in Territories).				
Matatiele..	40,050	10,013	4,243	42
Mount Ayliff	20,370	5,093	1,687	33
Mount Currie..	14,906	3,727	721	19
Mount Fletcher	27,146	6,787	2,695	40
Mount Frere	41,297	10,324	4,799	46
Qumbu	34,900	8,725	4,194	48
Tsolo..	33,586	8,397	3,555	42
Umzimkulu	39,107	9,777	3,553	36
Pondoland—				
Libode	25,895	6,474	867	15
Ngqeleni	36,464	9,116	1,591	18
Port St. Johns..	27,812	6,953	632	9
Total for Glen Grey Act Districts..	762,241	190,560	61,313	32
Pondoland—				
Bizana	49,068	12,267	569	5
Flagstaff	29,290	7,323	1,086	15
Lusikisiki...	45,945	11,486	990	9
Ntabankulu	43,327	10,832	1,120	10
Total for non-Glen Grey Act Districts	167,630	41,908	3,765	9
Total for whole of the Territories	929,871	232,468	65,078	28

made to teach the sub-standards and all the standards up to the fourth. Other main station schools are similarly flooded out with a large sub-standard attendance, and a few scholars in each of the other standards, and we find the principal teacher arranging to teach, say, 12 children in Standards III and IV, while two assistants struggle with 70 children in the lower classes. To obviate this wastage perhaps some wise grading might be arranged whereby the outstation schools would do most of the sub-standard and lower standard work, the children passing on from there to the main station school, which might well teach up to Standard VI.

2. MAIN STATION SCHOOLS.

At present fairly stiff requirements must be fulfilled before Standard VI may be taught in a school, with the result that the sub-standards are flooded with infants in order to secure the necessary attendance of 125. Probably the Department would secure better results by allowing main station schools to teach the higher standards apart from the attendance requirement of 125, so that they may be freed from the encumbrance of sub-standard tuition, and then children would pass naturally from the one school to the other; and in any case there would be no extra expense to the Department.

The whole scheme is simply a matter of arrangement.

3. HIGH SCHOOLS.

We have already shewn elsewhere that there are several high schools for natives, and the opening of the South African Native College is making the establishment of other high schools a necessity. If the grading of schools were seriously taken in hand, a further development would be the establishment of high schools at strategic places so as to serve the needs of groups of districts, and these would serve as stepping stones to the Training Institutions and the Native College. The importance of a well-graded system is too obvious to require further emphasis, and the suggestion here made might well prove to be the solution. Let the main station, and perhaps large outstation schools, teach the higher standards, and confine the small outstation schools to lower standard tuition, drafting the children on in due course to the main station school.

X. HIGHER EDUCATION.

1. DEFINITION OF THE TERM.

In dealing with the "higher education" of the natives we are faced with the initial difficulty of the definition of the term. The South African Native College has been adversely criticised, and some have even gone so far as to say that it is no college, because it is preparing students for matriculation. These same critics would be interested to know that the South African College prepared students for the matriculation examination for many years after the passing of the Act of 1874. In fact, Act

24 of 1874 was called "The Higher Education Act of the Colony of the Cape of Cape Hope," and preparation for matriculation came within its purview. At present, for the native, "higher education" means proceeding to one or other of the Training Institutions for Teachers, or else to the Native College. We have already given some indication of the course for teachers. The first year is in the main a revision of the work of Standard V, and the second year is a revision of the work of Standard VI, and the third year is largely Standard VII work, together with some theory, a little nature study, tonic-solfa, woodwork for male students, and needlework for female students. It will thus be gathered that the requirements are not excessive.

2. THE NATIVE COLLEGE.

The opening of the Native College by the Right Hon. General Louis Botha (Prime Minister and Minister of Native Affairs) took place on the 9th February of this year. Provision has therefore been made for higher education along other lines, and already the natives are availing themselves of the opportunities afforded by the College. But as the corner and capstone of Native Education, the College should be more definitely related to the other institutions. We have recently realised the danger of allowing Colleges to spring up in different parts of the country, and acquiring in the nature of things vested interests, with the result that when one had reached that stage at which it could aspire to University rank, all manner of practical difficulties made their presence felt.

It is to be hoped that a similar situation in connection with our Native Institutions may be avoided.

3. OTHER INSTITUTIONS.

There are now a number of strong institutions in different parts of the country, and perhaps in some quarters there is a feeling that these places are overshadowed by a brilliant younger brother. It is true that the work in these institutions is along other lines, and so does not compete with the College; but why not definitely relate these institutions to the College so that the one may strengthen and help the other?

If a course is to be arranged leading up to the College Diploma, some arrangement might well be arrived at whereby one or two years of the work could be done at a recognised institution, and the remaining minimum of years completed at the College. Such an arrangement would give the institutions a living interest in the College, and the co-operation would be beneficial to all concerned. In time to come most of the existing institutions will take rank as Colleges, if Native Education continues to progress as it has done within the last 20 years, and preparation should be made against that day, in order that the development may take place normally, so that when the time comes the transition may not disturb other institutions.

4. THE FUTURE OF NATIVE HIGHER EDUCATION.

The future of higher education so far as the natives are concerned is hard to foresee, but it must not be thought that they cannot attain to university standard, and it must be remembered that there is in the Union a native population of more than 5,000,000. Very much will depend upon the character of the higher education we place within their reach.

XI. The Future of Education.

1. AS TO ADMINISTRATION.

(*a*) *Missionary Superintendent's Position.*—In view of what has already been shown, it will be interesting to observe the future of the Missionary Superintendent. It is not too much to say that he is the keystone of the arch, and consequently the utmost consideration would be shewn him in bringing about any changes. Not so long ago there was a movement to provide native local Advisory Committees to act with Missionary Superintendents, but as the superintendents act honorarily they could not well be burdened with an unwieldy Advisory Committee, who probably would only add to their labours. A proclamation was issued, but it was stillborn. Probably when a change is made it will be either at the suggestion, or at least with the concurrence, of superintendents.

(*b*) *Provincial or Union Control.*—A more important question which is likely to arise immediately is whether Native Education is to remain under the Provincial Council, or to pass under the control of the Union Government. Clause 85, section iii of the South Africa Act (Union), dealing with the powers of Provincial Councils, reads as follows:

> The Provincial Council may make ordinances in relation to Education other than higher Education, for a period of five years, and thereafter until Parliament otherwise provides.

That period of five years is now at an end, and steps are already being taken for Parliament to exercise its powers. Hitherto these powers have been restricted to legislation connected with higher education, but now it may legislate for education other than higher education—a term which, as we have already mentioned, is not yet defined. The practical question before us to-day, in connection with the administration of Native Education, is whether it will continue to be administered through the Department of Education, or by the Union Department of Native Affairs. The Right Hon. J. X. Merriman is reported to have said in the House that Native Education must be regarded as a native affair, and therefore should come under that Department. But the divorce of Native Education from the Department of Education is not likely to find many supporters in circles most interested. At present the Provincial Administration Commission is making enquiry on this very point. In view of the great advance in the Cape Province within recent years there is some apprehension lest a change should be more of a handicap than a help.

Perhaps a solution might be found by placing Native Education under a Union Department of Education, and possibly making some division in the Department as between the European and native sections. In this way Native Education and native affairs would be under the same ultimate control, for by the Union Act now operative "The control and administration of native affairs" is vested in the Governor-General in Council. The education of natives, however, being treated as education, as before Union, was, under Section 85 (iii), left under the control of the Province. Agriculture, which was taken to include agricultural education, was assigned to the Union Government.

In view of the satisfactory manner in which Native Education is administered by the Provincial Council a change to a Union Department of Education might not be altogether welcome in the Transkei. It almost seems that the *status quo* might well be maintained for many years to come, and in any case is there any need for a change of the kind? Would a Central Department be able to control the whole of white education in the different Provinces of the Union—not to mention the education of the many different native peoples at various stages of development within our borders? Some of us who live amongst the natives are only beginning to understand them and realise their requirements, and it is hard to see how a Union Department of Education could understand, and provide for, the widely divergent needs of peoples like the Zulus, Fingoes, Pondos, Tembus, Baralongs, Batlapins, Swazis—not to mention the Damaras, Hereros, and Ovambos of newly conquered territory, which we hope to see shortly added to the Union. The thing is impossible except by the concession of large local powers. In the multitudes of counsels would Native Education not come to a standstill? There seems, on the whole, no reasonable possibility of getting better work done by over-centralising the administration on the one hand, or making the authority too localised on the other hand. Rather let us maintain intact some form of administration neither too limited nor too accessible, which will more readily understand and deal with the needs of the peoples within its sphere. A local authority of the kind already mentioned might be open to influence, more so than in the case of an authority that is larger, and more distant; and there, for the present, we must let the suggestion rest!

2. AS TO POSSIBILITIES IN ATTENDANCE.

We have already pointed out what has already been actually accomplished. In order to gain a correct perspective of our achievements, and a view of the task which still lies before us, let us now follow out our enquiry along two lines. The first point is to discover what percentage of the children are *not* attending school. The second point is to determine, within reasonable limits, the probable expansion in the population. If we give a faithful consideration to these points we shall be in a better position to face the future of education among our native peoples, and will realise the responsibility resting upon those who are moulding and framing the whole fabric of Native Education, and the importance of making that education sound and adequate.

I am unwilling to cite too many figures, in the course of this paper, and yet the importance of the subject is sufficient warrant for the inclusion of full statistical information. Fortunately, where we have no authoritative figures it is usually possible to compute with some accuracy on a basis that is authoritative. If we desire to know how many children there are between the ages of two and fourteen years, we are reasonably safe in accepting a 25 per cent. basis. In the 1904 Census Report, section 375, we are informed that the proportion of children of school-going age (5-14) to the total population of the Colony is no less than 26.21 per cent. for both sexes.*

Proceeding, then, we may calculate that the available children number one-quarter of the population, and in the accompanying Table XII we give the figures for each district, so as to show in detail which districts are most advanced educationally, and which areas require most attention.

(*a*) *In Cape Province (Transkei)*.—(i) *By Compulsion*.—In the first place, then, on examination of Table XII, we find in the Territories that the average roll amounts to 65,138 children distributed among 1,026 schools and 2,131 teachers. But large as these figures are, we need to remember that 230,979 children are available, and we would require 3½ times the accommodation and 3½ times the teaching staff if education were made compulsory—not to mention the multiplication of the number of missionaries.

(ii) *By Growth of Population*.—Turning our attention to the probable expansion of the population, we are faced with figures unsuited to generalisation. The census returns do not help us very much on account of the fact that they do not cover a uniform area throughout, and in any case the earlier ones are not so reliable as the later ones.

For most purposes we may regard the 1911 census as the most reliable and thorough†—and we cannot generalise on one set of figures. If we desire to work out the approximate rate of increase of the native population, we find the task as yet impossible, and in the next census so great a factor as the East Coast Fever is bound to make its presence known, and disturb the normal rate of increase. The extraordinary series of droughts since 1912 in the Transkei is also a disturbing factor which cannot be regarded as negligible. In consequence we shall not be in a position to know the normal rate of increase of the native races for some time to come, and the accompanying figures must be

* P. xci.

† Even so, in my best judgment, hopelessly inaccurate regarding Transkeian agricultural statistics.

TABLE XII.

THE FUTURE GROWTH OF POPULATION (NATIVE).

	(Census) 1891.	(Census) 1904.	(Estimated) 1915.	Children Available on 25 % basis	Average roll.	No. of Schools	No. of Teachers.	Percentage of Population at School.
Maclear...	2,809	4,829	(No longer included in Territories.)					
Mount Ayliff...	11,815	16,738	20,370	5,092	1,687	27	50	8.3
Mount Currie...	6,153	10,697	14,906	3,726	721	13	29	4.8
Mount Frere	22,793	32,765	41,297	10,324	4,799	69	167	11.6
Qumbu	23,240	31,160	34,900	8,725	4,194	66	134	12
Tsolo	24,043	31,402	33,586	8,396	3,555	53	114	10.6
Umzimkulu..	26,074	32,574	39,107	9,777	3,553	55	114	9.1
Umtata	33,989	41,784	45,270	11,317	3,446	54	112	7.6
Idutywa	25,488	27,279	32,188	8,047	1,888	29	62	5.9
Nqamakwe..	30,260	33,977	38,348	9,587	1,247	51	130	11.1
Tsomo..	16,532	19,869	21,514	5,378	3,173	43	107	14.7
Willowvale	36,330	42,225	40,912	10,228	3,799	54	122	9.3
Matatiele	17,765	32,627	40,050	10,012	4,243	55	141	10.6
Mount Fletcher	13,776	23,992	27,146	6,786	2,695	51	101	9.9
Elliot..	2,301	6,241	(No longer included in Territories.)					
Elliotdale	21,948	29,145	27,532	6,883	428	12	15	1.6
Engcobo	55,163	59,622	62,590	15,625	4,025	59	121	6.4
Mqanduli	28,825	35,318	35,195	8,799	2,099	43	72	6
St. Marks	21,869	37,145	39,536	9,884	3,189	45	99	8.1
Xalanga	10,943	14,161	17,173	4,284	1,636	24	53	9.5
Butterworth	15,091	18,625	22,500	5,625	2,666	26	86	11.8
Kentani	28,834	34,048	38,040	9,510	2,246	42	70	5.9
Ngqeleni	Annexation of Pondoland. 1894.	37,838	36,464	9,116	1,591	40	58	4.4
Libode		24,795	25,895	6,474	867	25	35	3.7
Flagstaff		25,803	29,290	7,322	1,086	19	35	3.7
Ntabankulu		29,336	43,327	10,832	1,120	23	38	2.6
Port St. Johns..		8,681	27,812	6,953	632	17	21	2.3
Lusikisiki		42,169	45,945	11,486	990	20	36	2.2
Bizana..		33,022	49,068	12,267	569	11	19	1.2
Total		806,797	923,916	230,979	65,138	1,026	2,131	7% (average)

examined carefully with a full realisation of the above considerations.

While recognising the fact that a census was taken in the years 1865, 1875, 1891, 1904, and 1911, we also need to remember, as already pointed out, that the area of census has varied from the Cape Colony proper to the whole of the Union. We are thus unable to state finally whether the increase is uniform, or subject to great fluctuations, or rising progressively. We do, however, know that the Bantu population increased from 838,136 in 1891 to 1,424,787 in 1904; that in 13 years there was an increase of 586,651, which means 70 per cent.—but during that period Pondoland was annexed. We also know that in 1911 there was an increase of 95,152 in the seven-year period, and it is apparent that in the ordinary course of nature very substantial increases in the native population are to be expected. In the Transkeian Territories the net increase at 1911 Census was 8.70 per cent.

(*b*) *In the Union of South Africa.*—A further consideration which cannot be neglected in the contemplation of the future is that of the native population in the Union. If the figures relating to the Transkei are large, what shall we say concerning those of British South Africa? If the state of Native Education is so far advanced in the Transkei and yet needs to cope with not less than 3½ times the present numbers attending school, what shall we say of those parts of the Union where Native Education is all but untouched? What manner of task lies before us? What prodigious future to be faced—and what a mighty reservoir of intellectual and economic power to be tapped, and released, in the interests of the South African State?

'Tis only when we allow our thoughts to grapple with the prospect that we realise that Native Education is only in its infancy, and that is why it is so important that we should take the long view, and build on sure foundations. The South African Native College is not a day before its time, and when it becomes the Native University, what a constituency it will have—from the Cape to beyond the Zambesi! And where with a population of 1¼ millions we already have three universities and a fourth in prospect, how many Universities will not the native population in due season support?

Once more it has seemed necessary to leave as little as possible to the imagination in order to avoid the spectre of exaggeration, and accordingly a group of four tables, Nos. XIII, XIV, XV, and XVI, have been arranged so as to show at a glance the largeness of the numbers involved.

TABLE XIII.

BANTU POPULATION IN TERRITORIES.

1879.	1891.	1904.	1911.	1915	Increase 1904-11.	Increase 1911-15.
256,000 (Approximate.)	469,225	834,644 (+ Pondoland)	889,046	923,916 (Official estimate.)	54,402	34,870

TABLE XIV.

CAPE COLONY: POPULATION INCREASE.

Date.	All races.	European.	Bantu.	Mixed.	Increase of Bantu.
1865..	496,381	181,592	100,236	214,553	—
1875..	720,984	236,783	287,639	196,562	187,403
1891..	1,527,224	376,987	838,136	312,101	550,497
1904..	2,409,804	579,741	1,424,787	405,276	586,651
1911..	2,564,965	582,377	1,519,939	462,649	95,152

TABLE XV.

BRITISH SOUTH AFRICA.

Province.	1904. White.	1904. Bantu.		1911. White.	1911. Bantu.
Cape...	579,741	1,424,787	....	582,377	1,519,939
Natal	97,109	904,041	....	98,114	953,398
Transvaal..	300,225	1,030,029	....	420,562	1,219,845
*Swaziland	890	84,601	....	1,083	98,876
O.F.S...	142,679	225,101	....	175,189	325,824
*S. Rhodesia	12,596	593,437	....	23,606	747,471
*Bechuanaland.. ...	1,004	119,772	....	1,692	123,658
*Basutoland	895	347,953	....	1,396	403,111
Total B.S.A... ...	1,116,806	4,729,721		1,304,019	5,392,122

Whichever way we regard the prospects we find ourselves in company with possibilities and results nothing short of stupendous.

So large an inheritance of life cannot be neglected by the State. Dwelling in ignorance and sin we are profoundly convinced that these peoples must be a menace to the State, that the capacities for evil are on no account to be allowed to develop without let or hindrance.

And since every State seeks to develop all its resources in order to secure best results, so we too should realise the untold resources latent in our black population. When the black population is productive the State is obviously going to gain considerably in strength. There need then be no question of the white man being swamped by competition, as one so frequently is led to suppose will be the case. The increase of wealth and activity may certainly mean a readjustment of white labour, it will also mean more openings in the world of commerce and in other directions.

The extent of readjustment no man can forsee, but for many years to come, if not for all time, native tradesmen and qualified men of all kinds will be more than fully occupied supplying the needs of their own race, and the question of competition will, of course, settle itself on economic lines. We have thousands of native teachers at work in Transkeian and other schools, but the question of competing with white teachers never has arisen, and is not in the least likely to arise. Why should we any more anticipate conflict in other branches of effort?

* A few coloured included in Bantu figures.

TABLE XVI.

Territory.	Area of Reserves in sq. miles.	Native Scholars (Estimated.)	Native Population.	Scholars available on 25 % basis	Percentage of Native Population in School.	Public Expenditure on Native Education. £	Amount contributed in Taxation by Domiciled Natives. £
Cape Colony	21,000	60,451	1,424,787	356,197	4.24	47,657*	105,241
Natal	13,892	10,154	904,041	226,010	1.12	7,265	162,193
Transvaal	8,656	11,683	811,753	202,938	1.13	5,000	280,260
Labourers temporarily resident. ...	—	—	133,745	—	—	—	—
Swaziland	—	—	84,531	21,183	—	—	20,688
O.R.C.	128	6,500	235,466	58,866	2.76	1,800	42,803
S. Rhodesia..	38,871	334	570,830	142,707	.05	154	100,806†
Labourers temporarily resident. ...	—	—	20,367	—	—	—	—
Basutoland..	10,293	10,484	347,731	86,933	3.01	7,000	60,528
Bechuanaland	127,630	1,000	119,411	29,853	.83	500	10,566
	220,470	100,606	4,652,662	1,163,165	1.88	—	—

* 1902 Estimates for Native Industrial Institutions and Mission Schools. (Central Administration Expenditure not included.)
† Now doubled.
From Report of S.A. Native Affairs Commission, 1903-05.

Into these questions we must not here enter, but rather let us lay hold of the magnitude of the undertaking as revealed in Table XVI.

If there are, in the Transkei, an immense number of children of school age not attending school, what shall we say of the numbers relating to the whole Union?—and of the expansion of expense in providing for them? Bearing in mind all that is involved in doubling the accommodation we shall appreciate better the difficulty of accommodating all the available native children in the Union, for according to the Native Affairs Commission of 1903-05, 100,606 children were attending school in South Africa.

On calculation (taking the conservative 25 per cent. basis of population) we find 1,153,165 children available. In other words, we shall need to multiply all our present activities eleven times if we are to fulfil our obligations to the full. If this is not a practical issue to-day, it at least indicates what the future holds in store for us, and demonstrates the necessity of placing the finance of the undertaking upon right lines capable of natural expansion with the development of the work.

It also emphasises the importance of a suitable curriculum.

The natives are a conservative people, and a thing once begun along certain lines must continue to follow those lines. Changes are extremely difficult to effect, and when made are liable to create all manner of suspicion in their minds. Any proposed change, for instance, in our present unsuitable curriculum would meet with great opposition on the part of the natives.

Therefore I say let us be careful of the foundations now being laid, for the whole superstructure of future years will depend upon, and take its character from, them.

3. THE EXPANSION OF EXPENSE.

If ever our responsibility to the whole available school community is taken up, the expense of the enterprise would increase very considerably, in fact to such an extent that a system of new taxation would become necessary in General Council areas. Already the amount available from the Council rate for education is just about equal to the burden. But in any case the Council rate is inelastic and produces the same amount, roughly, every year. For this reason it is not satisfactory, and already consideration is being given to other possible schemes that are elastic, so that as the increased development of the Territories brings larger burdens, the revenue will be in a position to bear those larger burdens.

If, then, the present resources are barely sufficient for present needs, we realise what would be required if present grants had to be multiplied. The increase of grants made direct by Government would be proportionate. In this connection it would be interesting to know exactly what revenue is derived from the Territories, and exactly how much is spent in the administration of those same Territories. It is a little problem on which we never seem able to get accurate knowledge! Let us at least take note of the last two colounms of Table XVI.

The expansion of expense would come in three ways:—

(*a*) Higher grants for teachers;
(*b*) Larger attendances, therefore more teachers;
(*c*) Grants for school equipment (perhaps including buildings).

(*a*) *Higher grants for teachers*, as we have seen, is a reform already long overdue, and in any case must be faced soon. The increase will not be confined to the direct increase of salary, it will affect the good service allowances also.

(*b*) *Larger attendances and more teachers.*—The larger attendances necessarily will involve the provision of many more teachers—say, on a very conservative estimate, three times as many teachers as at present, for only 65,138 children out of a possible 230,979 children, now attend school in the Transkei.

If the missionary body is likewise to be increased, the responsibilities of missionary societies will also be proportionately increased.

(*c*) *Grants for more buildings and equipment.*—In the third place the cost of equipment for all these additional children will be very great indeed—so great that it might well become necessary for Government to relieve missionary societies from the expense of new buildings.

All these considerations show how far off we are from making education compulsory; but by no means does the matter end there. What will not come by compulsion may come to a great extent in a voluntary way, and the growth within recent years of the numbers of children attending school is significant of much. Special attention is drawn to this increase. It is well for the point to be realised by all.

Finally the cost of administration, already great, will necessarily be much greater. We appear to be on the eve of a renaissance of learning in the Transkei, if our school returns may be taken as evidence.

This is no place to make an academic pronouncement as to the superiority of the intellectual gifts of the white race—we are here concerned only with the question how to make the best of the material available. We must be alive to the dangers of allowing primitive races to live within our boundaries, perpetuating in their ignorance and even developing under the security of our rule the moral evils of heathen life. As a young man of this great land, and with the experience gained as a missionary living in the midst of our Transkeian natives—perhaps the furthest advanced of all the natives of the Union are found there—and weighing my words carefully so as not to overstate the case, I would say that even to-day the moral evils of native life are unspeakable and widespread. If our intellectual gifts are superior, then the responsibility inevitably rests upon us so to guide and direct these people that ignorance may give place to knowledge, dark superstition to truth, and the filth of heathen customs to purity. No great State can afford to neglect these considerations on the grounds of expense.

XII. Conclusion.

1. THE NATIONAL IMPORTANCE OF EDUCATING THE NATIVE.

Let us now sum up the main conclusions of this paper. First, a wealth of material is available, proving the national importance of educating the native. The plain fact of the matter is that the natives are determined to have education, and will resort to private schools if they canot get encouragement from the authorities. The hands of the clock cannot now be stopped or put back. *Morally*, and *intellectually*, and *economically*, to take the standards of humanity at its best, the national importance of Native Education can hardly be overestimated. We confine ourselves of set purpose to these three realms with which all men are familiar—the moral, the intellectual, and the economic. The necessity for, and importance of, Native Education in these directions is undisputed. Sixty years and more of native education has produced a rich harvest and vindicated for ever the faith of those pioneers who faced all the unpleasantness of espousing an unpopular cause.

2. THE TIME ARRIVED FOR A WISE AND STRONG POLICY.

Second, the time is ripe for the adoption of a wise and strong policy of Native Education. The question is not whether we should encourage the education of the native (it has long ceased to be that), the question is rather what kind of education should be given. A new situation has arisen in South Africa since the consummation of Union. The responsibilities of the white man are, perhaps, all the greater because of the millions of heathen black men who now are subject to one central government; so are the dangers. The great war undoubtedly has profoundly stirred the native mind. These two considerations alone, in addition to the fact that hitherto in the Free State, and Transvaal, and Natal, very little has been done to educate and uplift the native, are sufficient to show that a wise and strong policy of Native Education is an imperative necessity.

3. EDUCATION THE FOUNDATION OF ALL PROGRESS.

Education is the foundation of all progress along the lines of agriculture, industry, and commerce.

Owing to the defective system, education in the Transkei is almost wholly of a literary character, though agricultural education is receiving attention apart from the schools.

Agricultural Education must be developed without delay *in* the schools. Much can be done in this direction if the Department would address themselves seriously to the task. In the adoption of the wise and strong policy already advocated, agricultural education must be given a large place.

Industrial Education is almost at a standstill, owing to the expense of supplying sets of tools to all the schools, and the provision of suitable accommodation. If the grading of schools (an exceedingly difficult and intricate, but not insurmountable task) suggested in this paper were adopted—perhaps also adapted—the difficulty of giving industrial instruction would be largely removed, for only headstation and large outstation schools would teach woodwork.

The present state of Industrial Education in the Transkei is a scandal. A reference to the figures published quarterly by the Education Department will confirm this judgment.

Commercial Education, as far as I know, is possible only at Lovedale. Perhaps in time this branch of learning will be developed in other institutions. For the present I am content to make the point that the development of commerce is dependent upon education. Wants are greatly increased, consequently the trader buys a larger and more varied stock to meet the growing needs of his customers. Also the extension of our credit system is dependent upon it. The growth of banking in the Transkei would form an interesting study on this account; all the more so when we remember the weakness of the native in the direction of getting credit.

Bearing in mind the emphasis that has been laid upon the almost exclusively literary character of the education now given, it is necessary to make the position clear. The point is, not that we should have one whit less of literary, but rather much more of agricultural and industrial education.

4. AN APPEAL FOR CONSIDERATION.

The object of this paper will be gained if in any measure it has made plain the main trials and triumphs of those who labour to educate primitive peoples. The experience of the Transkei should serve as an important and invaluable example and illustration to our Union Government, and lead, let us hope, in the near future, to the application of an enlightened policy in those areas where hitherto the education of the native, by some strange misconception, has not been welcomed. The whole position has been worked out and revealed, in almost too great detail, with a view to the securing of an earnest consideration of the whole situation by those in authority, and the introduction of a liberal and far-seeing policy of Native Education throughout the length and breadth of the Union of South Africa. So only shall the future be made secure.

THERMAL CONDUCTIVITY OF QUARTZITE.

By Prof. Robert A. Lehfeldt, B.A., D.Sc.

In the course of an investigation connected with one of the mines of the Witwatersrand, I had occasion to examine the thermal conductivity of the country rock, a quantity that plays an important part in all questions of heating and ventilation of the mines.

I was supplied, through the kindness of the mine authorities, with two samples of representative quartzite, about 10 cm. square and between 1 and 2 cm. thick, with flat ground and polished faces. An apparatus was constructed, consisting of an electric heater enclosed between thick copper plates, in the centre; the two specimen slabs on each side, and outside them two copper tanks through which cold water was passed. The temperature difference between the faces of the rock was taken by a pair of thermojunctions embedded in narrow grooves cut in the copper plates. The heat flow could be determined (*a*) by the current through the heater, (*b*) by the inlet and outlet temperatures and weight of water used in the tanks. (*a*) will slightly exceed (*b*) on account of loss of heat from the edge of the rock specimens. The mean value in a stationary state, combined with the temperature difference, determines the conductivity.

The experiment is easy and satisfactory: the most essential precaution is to supply the cooling water from a constant level apparatus, and at a constant temperature.

The power used was from 20 to 40 watts; the temperature difference on the two sides of the rock 6° to 12°. The result obtained was

0.0388 watts per degree Cent. per cm. cube.

THE BOSKOP SKULL.—At a meeting of the Manchester Literary and Philosophical Society, held on the 23rd January, Professor G. Elliot Smith discussed an endocranial cast obtained from the fossil human skull, found near Boskop, in the Transvaal, in 1913, and submitted to him for report by Dr. L. Péringuey. Professor Elliot Smith declared that the capacity of the cranial cavity must have been well above 1,800 c.c.—perhaps even as much as 1,900 c.c.—greater than that of the skull of Immanuel Kant, and almost equal to Bismarck's. The features and certain other characteristics of the cast suggested affinities with the Neanderthal race, but the larger size, and in particular the prefrontal bulging, indicated an even closer kinship with Europeans of Aurignacian and later times. One conclusion that emerges from a comparison of such cranial casts is that it is the size of the prefrontal area rather than mere bulk that determines brain superiority.

EXAMINATION OF THE BARK AND SEED OIL OF *TRICHILIA EMETICA*.

By James Sprunt Jamieson, F.I.C., F.C.S.

My object in the investigation of the bark was to study its supposed poisonous properties. Bryant describes it as very poisonous, but the natives inform me that it is very generally used in the form of an aqueous decoction as an emetic. The absence of toxic symptoms on administering it to guinea-pigs upholds the view that it is not poisonous. The yield of oil from the seeds is fairly good, and the probable economic properties of this oil for soap-making is feasible.

The fruit weighs about 20 grams, measures one inch in diameter, and contains four seeds. The testa, on ripening, reddens. The seeds yield about 32 per cent. of their weight of an oil to petroleum ether. Other methods for extraction were at the time unobtainable. At ordinary temperatures the fat is solid, melting at about 30° C. to a brownish oil with very little smell.

About 10 grams of this fat was mixed with mealie meal and administered to a guinea-pig with no toxic effects or symptoms.

The following are the constants of the fat:—

Butyrometer reading at 30° C.	59.5
Specific gravity at 40° C.	.9114
Saponification equivalent	201
Iodine value	67.3
Acid value	.008
Reichert-Meissl value	3.1
Polenske value	3.3
Melting point	30° C.

The volatile fatty acids consist mainly of caproic acid. Judging from the Polenske value, this acid would amount to about the proportion found in a normal butter-fat, *viz.*, 2 to 3 per cent. A quantity weighing 50 grams was saponified with alcoholic potash, the soap dissolved in water, and the unsaponifiable matter extracted with petroleum ether. This yielded only about 2 per cent., which was identified as phytosterol. The soap was then acidified with sulphuric acid, and the free fatty acid extracted with petroleum ether. After washing and getting rid of the solvent, the fatty acids yielded the following constants of fatty acids:—

Melting point	35° C. to 37° C.
Saponification equivalent	181
Iodine value	60.3
Acid value	166
Mean molecular weight	334

The acid was soluble in alcohol, chloroform, and ether, and crystallised in long needles from alcohol. A solution in chloroform had no action on polarised light.

Further investigations on the composition of this acid are in progress, although it appears to be only a glyceride of stearic and oleic acid with small quantities of caproic acid.

The bark of *Trichila emetica*, which is known to the Natal kaffir as the *Umkhulu*, is used as a purgative medicine. A quantity of this bark weighing 800 grams was percolated with hot alcohol. The brown viscous extract contained about 100 grams of extractive matter. This was mixed with water and distilled with steam, but no volatile product was obtained. The liquid was filtered from a small quantity of a brown resinous, sticky mass (A), and then washed with boiling water. On allowing the filtrate to stand for a week, a considerable quantity of a very similar substance was deposited: this was separately filtered off (B). The filtrate (C) was concentrated to a small bulk in a vacuum.

(A) This resin, which amounted to about 20 grams, was dissolved in alcohol and evaporated to dryness with purified sawdust, and then thoroughly extracted with petroleum ether in a Soxhlet apparatus. The ether extract consisted of a sticky brown mass which was dissolved in ether and shaken with animal charcoal for two or three days. This treatment removed hardly any colouring matter. The solution was filtered and then shaken with an aqueous solution of caustic potash. The potash solution was separated, but yielded no acid on acidification. The ether solution was washed with water and evaporated, and the residue boiled with alcoholic potash. The alcohol was then removed, water added, and extracted with ether. The ether was driven off, the residue mixed with potash and fused, dissolved in water and extracted with ether. This, on evaporation, yielded about half a gram of an amorphous substance slightly soluble in water, but no crystals could be obtained from it. It gave with ferric chloride a green solution, which became reddish on addition of sodium carbonate. This is probably protocatechuic acid.

(B) On examination of residue (B), it was found quite as refractory as the resin (A), and yielded nothing crystalline.

(C) The aqueous liquid was concentrated to a bulk of about 100 c.c. and shaken with ether. The ether was allowed to evaporate spontaneously, but nothing was obtained from it. It was also shaken with chloroform, but nothing was obtained.

The aqueous liquid which had been extracted with ether and chloroform was treated with basic lead acetate. This produced a brown precipitate, which was filtered off and then suspended in water and decomposed with sulphuretted hydrogen, filtered, and tested after acidifying with sulphuric acid with the usual alkaloid reagents. These gave negative results.

The filtrate from the basic lead acetate precipitate was freed from lead, and this solution also tested for alkaloids, but none were found, a portion of the filtrate was tested with Fehling's solution, which showed the presence of glucose. It also gave crystals with phenylhydrazine acetate.

A weighed portion was extracted with water, and an estimation of the tanning matter made by means of hide powder. The following results were obtained:—

Total solids	22.32 per cent.
Solids not tannin	15.50 per cent.
Tannin	6.82 per cent.

The purgative action of the bark is probably due to the large quantity of resinous matter. A quantity weighing 20 grams was digested in alcohol, and the resultant extract mixed with food and given to a guinea-pig without fatal result.

Summary.

The substance yielded about 12 per cent. of extractive matter to alcohol, which consisted of a rather refractory resin containing a quantity of protocatechuic acid; the aqueous solution contained small quantities of glucose, but neither alkaloids nor glucosides were found. An aqueous infusion contained 22.32 per cent. total solids, comprising 6.82 per cent. of tannin.

Cosmic Evolution.—According to the *Journal of the British Astronomical Association*, a paper read by Mr. J. H. Jeans before the Royal Astronomical Society, and dealing primarily with spiral nebulæ, leads to some interesting negative results as regards the origin of the solar system. If gas be ejected into a vacuum, it will condense gravitationally only if thrown out with sufficient rapidity and in sufficient amounts. In the first case the outpouring of matter would have to be so rapid that it would take weeks only for a mass equal to that of the earth to be ejected. In the second case, if the matter thrown off from a large nebula of low density is condensed at all, it will condense into masses comparable with that of the Sun: we should not have planets generated, but streams of stars. Thus, if the results to which this paper seems to point, be established, we must conclude that the rotational hypothesis, introduced first to explain the solar system, seems able to explain almost everything except the solar system.

THE CEDARA PLANTATION.

By John Spurgeon Henkel.

The Cedara Plantation having been recently re-surveyed by Mr. S. St. C. Ballenden, the officer in charge, and a description prepared by him of the growing stock, it seemed to the writer that a brief account of the origin and present state of the largest Government Plantation in Natal would not be uninteresting.

The plantation is situated on the south and south-east portion of Section A of the farm "Riet Spruit," purchased by the Natal Government in 1901-2. The whole area was named the Central Experiment Farm, but subsequently came to be called Cedara.

The nearest railway station is that of Cedara, on the Natal main line. From this station the furthest point of the plantation is distant about five miles, and the nearest about two.

The geological formation is that of the Beaufort beds, with numerous intrusions of dolerite. The soil varies considerably, being in parts shaley and shallow, in others a porous red loam, and a stiff black clayey loam in the valleys. It is nowhere as good as the soils on the coastward slopes of the Zwartkop, where trees do so well.

The average elevation is about 4,000 feet, varying from 3,500 to 5,000 feet.

The general aspect varies from north to north-west.

The rainfall, which principally occurs in summer, averages about 30 inches, with 134 wet days. Occasionally snow falls on the higher portions, and in winter frosts occur in the valleys. Hailstorms in the summer months sometimes pass over the area, and occasionally injure the trees.

The configuration is hilly, a large part of the area having a steep slope, which rendered it necessary to prepare the ground by hand.

The action of the Natal Government leading up to the establishment of the plantation appears to date from the year 1900, when, as a result of a discussion in Parliament, steps were taken to collect data in regard to the re-establishment of a Forest Department. In 1901-2 some provision (£1,000) was made for such a Department, and in 1902, on the invitation of the Natal Government, Mr. J. Storr Lister, Conservator of Forests of the Eastern Conservancy of the Cape, visited Natal and submitted a report on the forest areas, and gave suggestions for the establishment of a Forest Department. Mr. Lister visited Cedara in order to determine whether it would be practicable to form a Nursery and Plantation there. He reported favourably, and suggested that about 1,400 acres of the farm be allotted for afforestation, and that the Conservator of Forests have his headquarters at that centre. Various suggestions were given for laying out the plantation and nursery, and the kinds of trees to be grown.

Mr. Lister recommended Mr. T. R. Sim, a Cape Forest officer, for the appointment of Conservator of Forests. Mr. Sim took up his appointment in September, 1902.

In the first Annual Report of the Conservator of Forests, *i.e.*, that for 1902, it was stated that afforestation was one of the primary objects of the Government's present policy. Mr. Sim advised a settled and continuous policy of afforestation in order that all work undertaken may be properly arranged, and was prepared to organise the industry and proceed at whatever rate the Government was able to supply the necessary funds.

The Natal Government, following Mr. Lister's advice, decided to commence operations at Cedara, placing about 1,350 acres available for afforestation; though Mr. Sim pointed out "that the area was mostly, either very steep, or very rocky, and consequently it is both more difficult and more expensive to prepare than more easily ploughable land. The site was selected on account of being the least suitable part of the farm for agricultural operations. Some of the land was so rocky that it was suggested that it be left unplanted. The aspect mostly faces north, and is consequently the opposite to that where natural forests are found, and except in the upper and very rocky part, it is outside the mist belt which occupies the southern and eastern aspects of the same range. Altogether, the site cannot be regarded as a favourable forestal one, except to prove what can be done under rather adverse conditions."

In 1902 active operations were commenced by preparing land and establishing a nursery and engaging a small staff. The avowed object of the afforestation operations was to produce timber for railway sleepers and general technical purposes to replace that which was being imported. It was not the intention of the newly established Department to come in conflict with local and already established industries, but rather to grow the kinds of timber which private enterprise was not, on account of the time element, prepared to invest its capital in.

In 1903 the first trees were planted, and considerable areas sown with Cluster Pine seed, in all about 407 acres having approximately 700,000 trees.

A seed store was established, and tree seeds as well as transplants from the nursery sold to the general public at such rates as to place them within the means of all sections of the community. Gradually the nursery became known, and has been the means of distributing many hundreds of thousands of trees to all parts of Natal.

In addition to the purely forestry work, two *Arboreta* were put down, one having the individual trees widely spaced so as to permit of free and natural development, and the other in crowded groups, so as to demonstrate the relative height growths and supply data as to the value of timber, density of crop, etc., etc.

As the Forest Department controlled all tree-planting operations at Cedara, it fell to its province to lay down the various avenues, shelter and protective belts on the estate, and the skill shown is demonstrated to-day by the beautiful appearance of the whole estate, the estate being considerably enhanced in value both from a scenic as well as a scientific point of view, and students of arboriculture and forestry at the Agricultural College may see many varieties of trees, and can select kinds for planting on their own farms, or advise others as to the right kinds to use.

Afforestation operations were continued yearly, and in 1906 it was reported that there were 1,004 acres planted, and some 100 acres of land prepared for planting during the ensuing year.

One of the objects was to plant as many varieties of trees as possible, in order that their value and suitability to the locality may be thoroughly tested; this object was steadily kept in view, and to-day many interesting studies can be made as to rate of growth, mode of development, etc., of the various kinds. At a later date, when the trees are sufficiently developed, the quality of timber produced by each species will be determined.

Unfortunately, just after the scheme of afforestation was launched, depression set in, and owing to the difficulty of finding adequate funds, the work was considerably curtailed and practically brought to a standstill. In 1907 Mr. Sim was retrenched and his office abolished. The work of the Department was then placed under the control of the Director of Agriculture and Forestry, and continued under his supervision until shortly after the Union of the Colonies came about in 1910.

The young plantation has had to contend against periods of drought, hailstorms, snowstorms and frost, but notwithstanding all these drawbacks continued until 1909 to thrive and give excellent results in regard to growth, etc.

In August, 1909, a calamity befel the plantation. During a violent, hot north-westerly wind, a fire was started by a train travelling north, first at Riet Spruit. But this was successfully extinguished. Subsequently another fire was started near Howick Rail, which swept over the veld and jumped the existing fire-breaks, and practically passed through the whole plantation. Nearly all the Cluster Pine compartments were totally destroyed, and the majority of the Gums were injured to such an extent that they had to be coppiced.

All the reports available indicate that fire-breaks which were considered adequate had been made to meet all ordinary circumstances, but the force of the hurricane was such that breaks 150 yards wide would not have stemmed the onward progress of the fire. At the time it was reported that some 400 acres of the plantation were totally destroyed, and the remainder, principally Eucalypts, Wattles and Blackwoods, with the exception of some of the groups near the College and a few plots scattered about the plantation, were so badly injured that they had to be coppiced. Fortunately, vigorous shoots developed. The re-survey of the plantation showed that, in reality, a larger area had been totally destroyed.

Certain interesting results were observed in regard to the *Acacia melanoxylon* (Blackwood). Whilst Black Wattle and Eucalypts offered little or no resistance to the progress of the fire, some Blackwood planted in a ravine which was a veritable flue and contained four-year-old grass, turned the fire and prevented any considerable penetration along the line.. It seems clear that wherever Blackwood can be successfully grown, it should be used generally for fire protection purposes. At Cedara itself this observed fact was put in practice when replanting operations were commenced, and numerous intersecting belts of Blackwood now traverse the plantation.

In 1910 the staff at Cedara was principally employed in coppicing the injured gums and repairing, as far as this was possible, the damage done by the fire.

In the same year (1st October, 1910) Mr. A. W. Heywood, Conservator of Forests of the Eastern Conservancy, Cape Province, was transferred to the charge of the Natal Conservancy and afforestation operations were recommenced on a larger scale and continued until the outbreak of the European War, when retrenchment of funds only permitted works of maintenance.

With the re-establishment of a Forest Department in 1910 under the Union Administration, it became necessary to define the relative spheres of the Agricultural and Forest Departments at Cedara. An agreement was drawn up in 1912 by which an area of 1281.44 acres were placed entirely under the control of the Forest Department, and the remainder of the estate under the Agricultural Department. Under the arrangement about 131 acres of plantation, consisting of the greater part of the *Arboreta*, ornamental belts, avenues and some black wattle areas fell to the Agricultural Department.

The area of 1281.44 acres which came under the direct control of the Forest Department is in one block.

From time to time stock maps have been prepared of the area planted, but owing to the numerous plots of varying age scattered over the area, it was decided in 1915 to re-survey the plantation and divide it into blocks and compartments. Owing to the numerous small groups the size of the individual compartments was fixed at 10 acres—irregularities of perimeter rendering it necessary for some compartments to be larger and others smaller.

The four blocks were numbered respectively, A, B, C, and D, and contain the following areas:—

Block A	143.26 acres with	18 compartments.
Block B	386.4 acres with	40 compartments.
Block C	409.02 acres with	42 compartments.
Block D	342.76 acres with	37 compartments.
Total	1281.44	137

Careful descriptions on suitable forms were made of each compartment, giving particulars of locality, soil, aspect, species of tree, age, quality and stocking. Each species was separated into a sub-compartment or group. As evidencing the scattered nature of the planting of past years there are in:—

Block A	90 groups.
Block B	193 groups.
Block C	212 groups.
Block D	126 groups.
Total	621

The forms in use provide space for recording the future treatment of each group, and in this way accurate records will be secured in regard to methods of treatment, intermediate and final yields, and costs of the various operations which may be undertaken for the improvement, etc., of the growing stock.

The stocktaking of 1915 yielded the summarised results tabulated on page 504.

Summarising the results still further there are:—

Eucalypts	418.58	acres.
Conifers	347.03	,,
Blackwood	211.89	,,
Poplars	3.75	,,
Black Wattle	104.54	,,
Others	23.74	,,
Indigenous Bush	12.76	,,
	1222.29	
Unplanted Area	159.15	
Total	1281.44	acres

The unplanted area, excepting certain excessively stony patches with practically no soil, and parts required for protecting the Cedara Reservoir, etc., will be planted within the next season or two. The areas under Black Wattle are being converted to timber trees as the crops mature.

Exclusive of the many valuable kinds growing on the area transferred to the Agricultural Department there are approximately 80 varieties of timber trees being tested, and in due course valuable results will be obtained in regard to the suitability or otherwise of each species experimented with.

The woods are being regularly thinned, and with increasing age the whole plantation will become valuable, not only in regard to the timber itself, but also as demonstrating what kinds can be grown successfully and the proper methods of tending each species.

STATE OF PLANTATION IN 1915.

Principal Species	1 year old.	2 years old.	3 years old.	4 years old.	5 years old.	6 years old.	7 years old.	8 years old.	9 years old.	10 years old.	Total Area Acres.	Estimated Volume: Cubic feet.
	Age Classes.											
Eucalypts	94.26	75.22	93.84	79.90	11.39	16.43	—	—	18.53	29.01	418.58	489,718
Conifers—												
Pinus pinaster	2.15	—	—	—	—	—	—	—	141.12	—	143.27	183,456
Pinus longifolia	15.65	—	—	—	12.36	—	—	.5	2.45	—	30.96	13,055
Mexican Pines	14.33	5.84	—	—	—	—	—	—	—	—	20.17	1,168
Other Pines...	.12	2.39	—	—	2.8	—	—	1.9	.40	—	7.61	5,578
Cedrus deodara	—	16.50	15.66	—	—	—	—	—	—	—	32.16	7,998
Cypresses..	47.87	4.15	7.38	6.35	12.99	—	—	.45	1.24	.35	80.78	18,703
Cryptomeria japonica ..	25.98	3.9	—	2.2	—	—	—	—	—	—	32.08	1,465
Acacia melanoxylon.. ...	21.76	47.38	82.48	26.40	15.47	.60	—	6.85	—	10.95	211.89	133,442
Poplars...	3.05	—	—	—	.7	—	—	—	—	—	3.75	525
Other species of Timber Trees	.74	.75	6.03	—	12.26	2.34	—	.85	.06	.71	23.74	15,494
Black Wattle	—	38.42	43.65	8.05	—	.90	—	4.20	9.32	—	104.54	163,018
Totals	225.91	104.55	249.04	122.90	67.97	20.27	—	14.75	173.12	41.02	1,109.53	1,033,620
Indigenous Bush	—	—	—	—	—	—	—	—	—	—	12.76	—
											1,122.29	
Unplanted Area	—	—	—	—	—	—	—	—	—	—	159.15	
											1,281.44	

From the results obtained from time to time, yield tables will be prepared for general use in the plantations, and in localities having more or less similar conditions to those obtaining at Cedara.

The whole plantation is well supplied with roads and bridle paths, rendering all parts of the area accessible. The compartment boundaries have been marked on the ground, and each compartment numbered so that no difficulty is experienced in finding any one of the numerous groups.

In this paper the financial results have not been touched upon, principally because when the plantation was controlled by the Agricultural Department during the years 1907-1910, no separate accounts appear to have been kept of the purely forestry operations. It is hoped, however, on another occasion to give particulars of the costs incurred and the financial prospects of the plantation. Suffice it to say that the Nursery pays for itself, and that such material yielded by thinnings as is saleable, and the yields of mature wattle plantations, are sold at remunerative rates.

In conclusion it may be stated that though Cedara Plantation was the first Government Timber Plantation established in Natal, smaller test plantations have been put down at Empangeni, Port Durnford, Bulwer, Ingwangwane, Ngomi, and experimental plots at nearly all the forest stations in Natal.

A SHORT NOTE ON BRYOPHYTA OF SOUTH AFRICA.

By Thomas Robertson Sim.

(*Précis.*)

In continuation of the statement made a year ago,* the author stated that he had, during the interval, prepared and distributed a check-list of the Bryophyta of South Africa, running to over 1,000 species, and also that the first two parts of his "Handbook of the Bryophyta of South Africa" were now ready. These two parts deal with the whole of the genera of the mosses. The genera of the Hepaticæ and the species of both groups will be dealt with in future parts, and it is expected that the work will consist of about ten parts when complete.

* Rept. S.A. Assn. for Adv. of Sc., Pretoria (1915), 435.

NOTE ON *POLYPORUS LUCIDUS* LEYSS., AND ITS EFFECT ON THE WOOD OF THE WILLOW.

By Paul Andries van der Bijl, M.A., D.Sc., F.L.S.

(*Plates* 12-16 *and Six Text Figures.*)

Introduction.

This fungus was first brought to my notice by Master J. Sellschop, and found to be very plentiful under *Acacia* trees around Pretoria. While hunting for more material of this fungus, Mr. H. F. Cuff came across it on the roots and stem of a large live willow tree.

Subsequently I had the plant from different localities, and it is evidently one of our most common Polyporaceæ.

I have to acknowledge the assistance given by Mr. C. G. Lloyd, of Ohio, in determining and verifying many of my specimens, and am also indebted to Mr. L. O. Overholts, of Pennsylvania.

I have, moreover, to thank those who have favoured me with specimens, and am grateful to Mr. I. B. Pole-Evans, M.A., B.Sc., F.L.S., Chief of the Division of Botany, for letting me have samples of the material forwarded him.

The drawings were kindly made for me by Miss K. A. Lansdell, of the Union Department of Agriculture.

Fungi occurring in South Africa which are either close to or Synonymous with *Polyporus lucidus*.

What is evidently a sessile form of *Polyporus lucidus* has been described by Murrill* under the name *Ganoderma sessile* Murr. (*Polyporus sessilis*), and he gives its distribution as Connecticut to Missouri, Alabama, and Louisiana. Overholts† mentions the following as synonyms of *P. lucidus*:

Boletus lucidus Leyss.;
Ganoderma sessile Mur.;
Ganoderma subperforatum

The fungus *Polyporus fulvellus* Bresadola is evidently only a sessile form of *P. lucidus*; indeed, had we only the fungus from the stem of the willow, and not from the roots also, we would have referred it to this species.

Of *Polyporus sessilis* Mur. (*Ganoderma sessile*) Lloyd‡ says: "As usually applied it is the same as *resinaceus*. We have, however, in the United States, an annual sessile species which we have found on willow. The surface is not so dark nor strongly laccate as the preceding plant, and it is broadly attached, never any intimation of a stipe." I have a single specimen of *Polyporus resinaceus* Boud., kindly named for me by

* Murrill, Wm. A.: "North American Flora," 9 [2], 120.
† Overholts, L. O.: *Ann. Miss. Bot. Gard.*, 1 (March, 1914), 123.
‡ Lloyd, C. G.: "Synopsis of the Section Apus of the Genus Polyporus" (1915), 371.

P. A. van der Byl.—Polyporus Lucidus.

P. A. van der Byl.—Polyporus Lucidus.

Mr. C. G. Lloyd, and this specimen is thicker than *Polyporus lucidus* as usually found in South Africa, and the surface more resinous. I have several specimens of *Polyporus resinosus* Schrad., also named for me by Mr. C. G. Lloyd, and these he regards as but sessile forms of *P. lucidus*. The surface is decidedly resinous. *Polyporus Curtisii* Berk. is close to *P. lucidus*, the only difference being that in the former the surface is more yellowish or almost white.

As stated by Lloyd,* the following description will apply to all the annual *Ganodermus Polyporus* forms: "Pileus sessile, applanate, with a thin, reddish-brown, more or less laccate surface. Context dark burnt umber, varying light. Pores small, round, from 1 to 1½ cms. long, with white or yellow mouths. Spores obovate, truncate at base, 6 — 10 to 8 — 10 × 12 — 14 μ, smooth, varying to strongly punctate. There have been numerous new specimens named, to all of which the above description will apply. The only thing that can be done is to adopt names for the most extreme forms, and then refer the specimens to the nearest one. The spores even in the same specimens vary from smooth to strongly punctate, but the latter are said to be rough."

It is evident that *Polyporus lucidus* is not necessarily stalked, and we must regard the following as close to it, and some certainly synonymous:—

Polyporus resinosus Schrader.
Polyporus resinaceus Boudier.
Polyporus fulvellus Bresadola.
Polyporus sessilis Murrill (*Ganoderma sessile*).
Polyporus Curtisii Berk.

In Saccardo† this fungus figures as *Fomes lucidus*; but I only know it as an annual, and have thus far not come across a specimen with the pores in strata, as is typical of *Fomes*.

Later we hope to deal more fully with the fungi related to *P. lucidus*; in the meantime any specimens will be of material assistance.

Hosts on which *Polyporus lucidus* has been observed.

Polyporus lucidus has been recorded on the following hosts:—

Acacia, sp.; on roots and stem of live *Salix* (willow); base of dry *Ptæroxylon utile* (sneezewood) base of dead *Zizyphus mucronata* (wacht-een-beetje); live *Olea verrucosa* (wild olive). In addition I have a number of specimens from undetermined hosts. *Polyporus resinosus* is common on dead stumps in and around Durban, where I have twice found *Polyporus Curtisii* on dead logs.

An interesting occurrence of this fungus was brought to my notice by Mrs. J. E. Farrar, of Durban, in whose house it was breaking through a concrete floor in three places close to-

* Lloyd, C. G.: *Op. cit.*, 370.
† Saccardo P.: A. Sylloge Fungorum, 6, 157.

gether. The fructifications have thus far reappeared three times after having been broken off. This adds an instance of the longevity of the mycelium of the fungus, and its ability to continue developing sporophores for a considerable time after the death of the host plant. The fungus evidently grew from some tree which was cut down and covered with concrete at the time building was proceeded with, and I am informed that a large tree did grow in the vicinity where the fructifications now continue to reappear.

Unfortunately I could not gather any information on the kind of tree or its condition at the time the house was built, though it is evident that it must have harboured the fungus even at this time, and most probably was well on the way to decay.

Fructification or Sporophore of *Polyporus lucidus*.

Plants variable, annual, sessile, or stipitate (Plates 12-15). Pileus dimidiate or reniform in outline, imbricate or connate at times, flat, or convex above and concave below, 10-25 $\times$ 8-9 $\times$ 8-17 cms., thickest behind; leathery, corky when fresh, becoming corky or woody on drying; upper surface covered with a dark chestnut red or brown varnish, wrinkled or concentrically sulcate, and at times dotted over with irregular tubercles (Plate 15*c*). Context varying whitish to light brown, frequently separating into an upper light-coloured, softer region and a lower darker and firmer region (Plate 12), at times of the same colour and texture throughout; concentrically banded and 2-3 cms. thick.

Stalk absent or present, lateral, irregularly cylindrical, laccate, resembling pileus in colour and substance, 3-5.5 cms. diameter $\times$ 2-6 cms. long. In the specimen of Plate 15*c* the stalk was short, measuring 14 $\times$ 6 cms., and was apparently three fused stalks, as was indicated by the upper surface of the pileus and the incomplete fusion of one stalk. From one of the fused stalks a secondary pileus was growing. In Plate 12 also we have separate pilei. In these cases the hymenium is confluent and the pilei overlap, as is evident in the illustration.

Margin acute, often undulating and turned inwards, rarely truncate. In the specimens taken from the willow stem the pileus was practically white towards the periphery and the margin of the same colour. These were evidently not yet mature. In the specimens the margin showed tawny bands, and on the under surface a sterile region 3-4 mm. wide, yellow, and later becoming brown.

Tubes 1-1.2 cms. long, brown within, 162.5-187.5 μ across, dissepiments narrow, 62-100 μ; mouth circular or angular, 3-4 to the mm., white becoming brown, darken on being bruised.

The hymenium often shows red, varnished patches on which no pores are produced.

In herbarium material the pore mouths were at times observed to change from white to light yellow. Spores (Fig. 1) yellowish brown, varying from smooth to punctate and decidedly

Fig. 1.

Fig. 2.

P. A. van der Byl.—Polyporus Lucidus

P. A. van der Byl.—Polyporus Lucidus

rough, 9.2-11.0, 5.2-7.36 μ, ovoid, truncate at base. The spore has a hyaline membrane or epispore which projects beyond the coloured endospore at the base, and it is the collapse of this empty base which gives the spore the truncate appearance.

A section (Fig. 3) shows that the hyphæ of the laccate cuticle forms an even, compact palisade tissue composed of cells

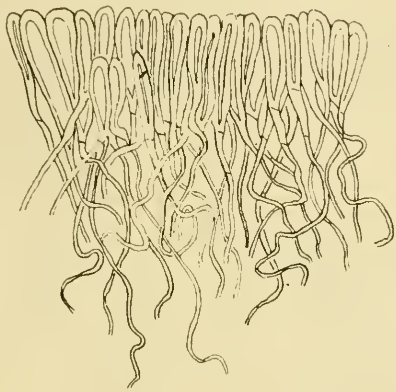

Fig. 3.

growing vertically upwards and becoming swollen at their ends, where they are thicker walled and darker in colour than the ordinary hyphæ of the trama.

The pores appear beneath a layer of downy hyphæ which covers the hymenium. The surface may be perfectly smooth with no indications of pores, but when the outer layer is removed the young pores, often already of some depth, become evident. Fries made use of the development of the pores as one of the characters in distinguishing *Polyporus* from *Polystictus* and *Trametes*. In the former, he held that the pores were preformed (endogenous), and thus at first covered by a smooth contiguous layer, whereas in the latter two genera the pores were supposed to arise successively from the centre outwards and to be open from the beginning (exogenous).

It has since become extremely doubtful whether the development of the pores is of any value in classification, and Miss Ames* writes: "Judging from the forms examined, there is not sufficient difference in the order of development of the pores for it to be used as a character in classification."

I have not had the opportunity of following the complete development of this fungus, which in the very young stage consists of a white-greyish, soft, corky nodule (plate 16*a*), the interior of which is brown and striated and covered by a white rim about .5 mm. thick. Whether the nodule would become hard and pass into a kind of resting condition capable of resuming growth on the return of favourable conditions if growth

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* Ames, A. A.: "Consideration of Structure in Relation to Genera of the Polyporaceæ," *Ann. Mycologici*, **11** (1913), [3], 226.

were arrested I am not at this stage in a position to say, but it is not unlikely.

On the upper surface of the mature sporophore there are usually spores resembling in colour, size, etc., the ordinary spores of the fungus. I have not seen any of these spores attached, and hence can only look upon them as Conidia with a certain amount of doubt.

These conidial spores are also found in *Fomes applanatus* Pers. and other Polyporaceæ.

How the Fungus gains Entrance into its Host.

As often as not the fructifications are formed near the ground (observed in *Acacia, Salix, Zizyphus*), and this would suggest that usually an entrance is obtained near the ground level.

Though there is thus far no direct evidence, it must be held that it is primarily through wounds and abrasions at or near the soil level that the fungus gains entrance, and as is general in fungoid diseases, trees whose vitality has been diminished through external conditions would be more susceptible than young actively growing trees.

It has been observed that usually the affected trees are on low ground, a situation which, owing to the usual presence of moisture, would be a favourable factor for the external growth of the hyphæ of the fungus. As observed on *Salix* and *Acacia* around Pretoria, these trees were in the vicinity of watercourses, though elsewhere I have found the fungus where there was no watercourse in the immediate vicinity.

I would regard the fungus as a *facultative parasite* which is only likely to become established when the ability of the trees to resist its attack is impaired by unfavourable conditions.

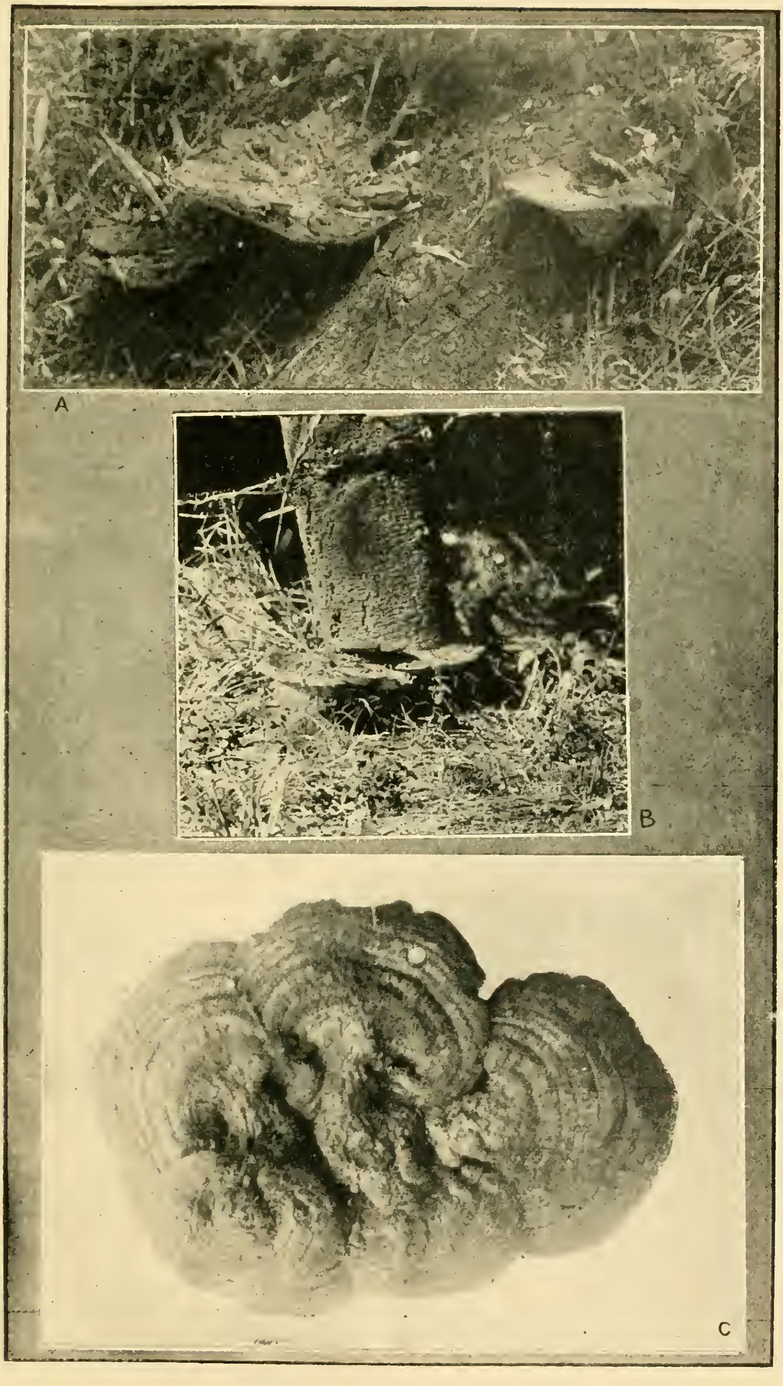
Pathological Anatomy of Willow infected with *Polyporus lucidus*.

It was originally intended to compare the pathological anatomy of *Salix* and *Acacia* infected with this fungus, but owing to difficulties in obtaining material of *Acacia*, I have for the present to limit myself to a description of *Salix*.

Stevens* mentions *Fomes lucidus* as causing cocoanut root rot, but I have not been able to gain access to any work on the fungus either in relation to cocoanut root rot or disease in other trees.

The general naked-eye appearance of the disease is the white mottled spots in the wood. In tangential sections these areas are seen to run at about right angles to the grain of the wood, and also to extend upwards and downwards along the stem, *i.e.*, in the wood elements. Plate 16, *b* and *c*, are photographs of diseased wood of *Salix* and *Acacia* respectively.

* Stevens, F. L.: "The Fungi which cause Plant Diseases," (1913), 433.



P. A. van der Byl.—Polyporus Lucidus.

P. A. van der Byl.—Polyporus Lucidus.

The mycelium of the fungus does not limit itself to these white areas, but is present throughout the intervening tissues. More frequently it is hyalin and very much vacuolated, but brown and firmer hyphæ are also present, and show up particularly well.

The hyphæ are .65-3.68 μ in diameter, less frequently 7.36 μ, are septate and branched, the septa often being close together. Clamp connections, so common in the Polyporaceæ, are of frequent occurrence. Plate 14*a* shows some of the hyphæ from the wood of *Salix*. The tips of the hyphal branches are frequently somewhat swollen.

The wood elements of *Salix* have relatively large lumina. The wood prosenchyma cells have lumina 11-18 μ diameter, and walls 3.68 μ thick; in the vessels the lumina are 36-54 μ diameter. Where vessels adjoin vessels they have bordered pits, but in contact with parenchyma of the medullary rays the pits are simple. The wood prosenchyma cells at times have cross walls and have simple pits. The cells of the medullary rays vary; some are elongated horizontally, others transversely, whereas others, again, are practically square. Their walls are pierced by numerous simple pits.

Unlike the majority of wood-destroying fungi, the mycelium

Fig. 4.

E

of *P. lucidus* has not been observed to bore directly through the cell walls. In both the wood prosenchyma and medullary rays (Figs. 2 and 4) the hyphæ invariably pass through the pits, and in this process often appear to become somewhat constricted.

To stain the hyalin hyphæ I employed methyl violet after first mordanting the sections in tannic acid. With this stain the pits usually showed up particularly well, but the wood elements only took it slightly.

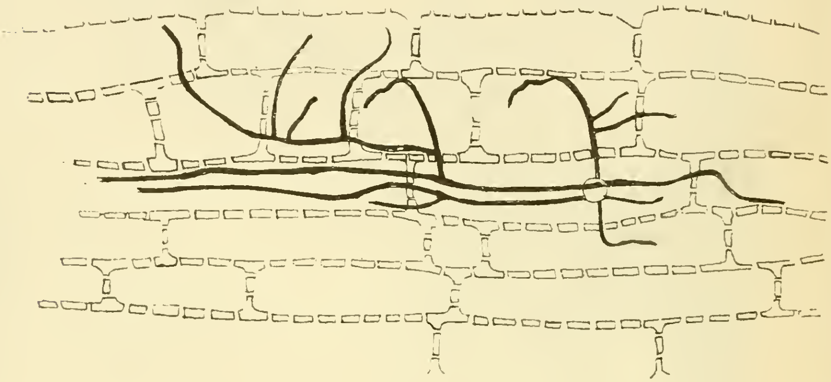


Fig. 5.

In the decaying wood it was noticed that starch was absent from the medullary rays, and since this substance is easily digested, it is probably the first to be utilised by the fungus for its nourishment.

The action of the fungus on the wood can be described as one of digestion. Schulze's solution (chloro-iodide of zinc) clearly shows that the fungus causes the delignification from the walls bordering the lumina, and is followed by the digestion of

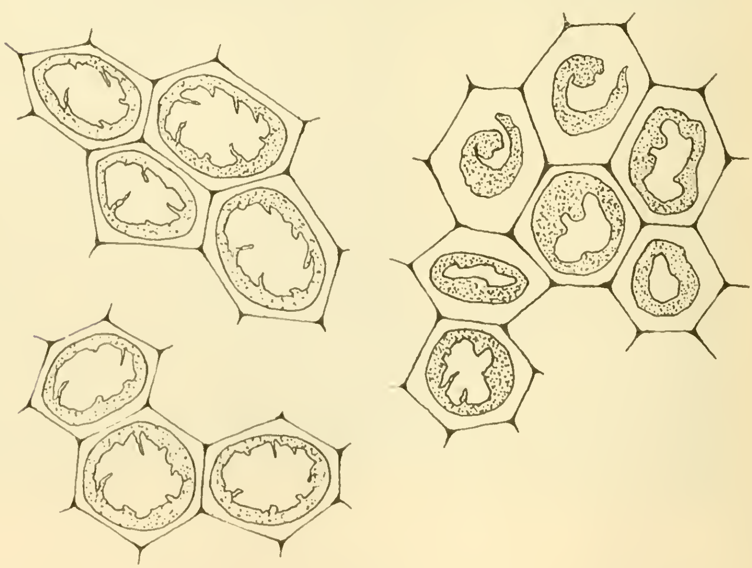


Fig. 6

the now cellulose walls. This digestion is shown in Fig 6, where the walls bordering the lumina of the wood prosenchyma are corroded and cellulose plates project into the lumina. This delignification and absorption result in the cell walls becoming thinner and thinner, though the middle lamellæ are evidently acted upon with some difficulty. When this, too, is delignified and absorbed, the destruction of the cell is complete. I have not observed any delignification in the large vessels.

The action of the fungus on the willow resembles somewhat the destruction of the wood cotton-wood by *Fomes applanatus*, as described by Heald,* but the delignification and digestion would appear to be both slower and more gradual than that caused by the latter fungus.

Though of necessity there must be a certain amount of disorganisation of the wood cells, nevertheless in the material examined I have not noticed any particular tendency on the part of the fungus to form pockets or cavities filled with fungoid hyphæ. The white mottled areas are due to a combination of (*a*) delignification; (*b*) the presence of hyalin which fills the vessels and medullary rays, especially the former.

It is further of interest to note that the medullary rays of the willow are attacked by the solvents of this fungus only at a late stage—in fact, their action on the rays was almost overlooked.

Fate of Attacked Trees.

It was on the willow tree already referred to that I was able somewhat to follow the ultimate fate of attacked trees.

When first observed, this tree had three sporophores on the roots and nine on that side of the stem (Plate 14*b*) on which, higher up, were a few dead branches. On the opposite side there were a few young sporophores on the stem and roots, but this side was to all intents and purposes more active and vigorous, and had more life in it than the first mentioned.

Five months after, when I again happened to visit the place, the tree was nearly dead, and it is probable that by now the fungus has killed it.

There is little doubt that the death of a large number of the *Acacia* trees around Pretoria must be attributed to this fungus. Here, unfortunately, the host was always dead when the sporophores were found, and further investigation was impossible.

Control.

The fungus, which is a facultative parasite, forms sporophores abundantly after the death of its host, and methods of control should be directed towards preventing the spread of the disease. Allowing diseased trees, or dead logs or roots harbouring the fungus, to stand or lie in plantations is a sure means of propagating the fungus, and thus rendering trees

* Heald, F. D.: "A Disease of Cottonwood caused by *Efvingia megaloma* Nebr.," *Agric. Experiment Station Ann. Rep.* (1905), 92.

liable to infection when a favourable opportunity offers itself. All logs or trees affected with this fungus should be immediately burned, and destruction of all sporophores made certain. The instance cited where the fungus was breaking through a concrete floor is definite evidence that the mycelium of the fungus not only remains alive for a considerable time after the death of its host, but that it is capable of forming fructifications afresh should the first be removed. The destruction of all wood harbouring the fungus is thus essential.

From information thus far to hand it would appear that the fungus is not as yet of great economic importance, though considering the different hosts it is capable of attacking and its apparent frequent occurrence in various parts of the Union, it should not be treated too lightly. It is common on *Acacia* sp., and Mr. T. R. Sim once collected the sessile form of *Polyporus sessilis* (Plate 14*a*) on a living *Acacia mollissima*, our cultivated wattle. Proper drainage accompanied by good forest sanitation would go a long way towards preventing this fungus from ever causing very serious trouble.

Summary.

The paper deals with *Polyporus lucidus* Leyss, a fungus very common on native *Acacia*, and its action on the wood of the willow is recorded.

The death of a large number of *Acacia* trees around Pretria is attributed to this fungus, and the fact that it has been found on *Acacia mollissima*, our cultivated wattle, adds to its importance.

The action of the fungus on the wood of the willow is described as one of digestion, which proceeds slowly and gradually.

The fungus is held to be a *facultative parasite*, though there is no doubt that it is capable of attacking, and causing the death of living trees.

Methods of control should aim at the destruction of the sporophores and of all material harbouring the mycelium of the fungus. This is essential, since the mycelium remains active and retains its power of fruiting for years after the host plant is dead. With proper attention and care the fungus should never become serious.

N.B.—Material, either of this fungus or of other Polyporaceæ, will always be welcome, if sent to the author at the Natal Herbarium, Berea, Durban.

Explanation of Illustrations.

Plate 12. Sporophores of *P. lucidus* from an acacia tree.

Plate 13. Sporophores from stem and roots of a living willow tree.

Plate 14*a*. Sporophores from the sessile form *Polyporus sessilis* from living *Acacia mollissima* tree.

Plate 14*b*. Sporophores on trunk of living willow tree.
Plate 15*a*. Sporophores on roots of living willow tree.
Plate 15*b*. Sporophores at base of dead *Acacia* tree.
Plate 15*c*. Sporophore which broke through a concrete floor, and was evidently growing on a decaying stump. Note the indication of the separate pilei and the presence of a secondary pileus on one of them.
Plate 16*a*. Young sporophore on a dead stump.
Plate 16*b*. Diseased wood of willow attacked by this fungus.
Plate 16*c*. Diseased wood of acacia attacked by this fungus.
Fig. 1 ($\times$ 300). Spores of the fungus.
Fig. 2 ($\times$ 300). Mycelium in wood prosenchyma and medullary rays of willow.
Fig. 3 ($\times$ 300). Section through laccate cuticle to show the thick-walled palisade layer.
Fig. 4 ($\times$ 300). Mycelium of the fungus from willow.
Fig. 5 ($\times$ 300). Mycelium of the fungus in medullary ray cells of willow. Note the hyphæ passing through the pits.
Fig. 6 ($\times$ 500). Wood prosenchyma of willow showing the delignification and the digestion of the cellulose. Note the cellulose plates projecting into the lumina of the cells.

GROUND RAINBOWS.—The United States Department of Agriculture *Monthly Weather Review*, **44** [9], 508, reprints from *Science Abstracts* a description of a coloured bow similar to a rainbow, with an intensity equal to that of a good secondary rainbow, which was seen on the ground of a cricket field. The sun was immediately behind the observer, and the bow appeared on the ground, starting from just in front of the observer's feet, and stretching on either side in a sweeping curve away from the sun. The bow was proved to be a hyperbola by pegging out its outline on the ground. It is explained as being due to sunlight refracted twice at the near surfaces, and reflected once at the back surfaces of drops of water that had condensed on gossamer which covered the field. According to this explanation a ground rainbow will form a circle if the sun is in the zenith, an ellipse if the solar elevation is from 42° to 90°, a parabola when the elevation is 42°, and a hyperbola if it is less than 42°.

THE PROGRESS OF THE NATAL SUGAR INDUSTRY FROM ITS INCEPTION IN 1851 UP TO 1915.

By WILLIAM PETRE TUCKER.

Although Sugar Cane was known in ancient times, we do not come across any record of sugar being made from cane at any period previous to 300-600 A.D. The first kind of sugar mentioned was only concentrated juice, called "gur" in India, and is said to have been known in India even in prehistoric times, and a Chinese Emperor, 627-650 A.D., sent people to Behar, in India, in order to learn the art of sugar manufacture, and from that time the art of making sugar out of cane spread rapidly. It was not restricted merely to evaporating the juice to dryness, but the Arabs and Egyptians soon learned how to purify raw sugar and re-crystallization. The Chinese also learnt how to make a light-coloured sugar by drawing off the raw molasses, but the proper art of refining seems to have been brought to China by people from Cairo. Arabs and Chinese introduced sugar cane to the Coast of the Mediterranean, North Coast of Africa, and the Indian Ocean, West Coast of Africa, Madagascar, Siam, and several other countries. In the fourteenth and fifteenth centuries, the countries around the Mediterranean were cane sugar producing countries, the sugar being sold in the form of loaves, square blocks, and powdered, and the industry flourished up to the end of the fifteenth and beginning of the sixteenth centuries. Even in these early days the labour problem influenced the whole production. Sugar cane was introduced by the French into Mauritius and Reunion about the end of the eighteenth century, and from there found its way to Natal.

Turning to the history of the sugar industry of Natal, Byrne's immigrants, introduced between 1848 and 1850, had brought up the population to about 8,000, and it was then with this new life infused into it that the settlement really began its efforts in the work of colonisation. The first Natal Estate was inaugurated by a Mr. Morewood, on the Compensation Flats, on the Umhlali, about 35 miles north of Durban, and the first crop was reaped in 1861; the implements employed in the manufacture were primitive in the extreme, being a pair of wooden rollers, hewn from an old mast, for crushing the cane, and an ordinary Kaffir cooking pot of about three gallons' capacity for boiling the juice; thus was obtained the first sample of indigenous sugar in Natal. It is noteworthy that Mr. Morewood used the plow for breaking up his ground before planting, which, in after years, was to a great extent discarded by Natal planters, no doubt because newly-cleared good bush-land did not require it, and could be holed and planted at once, and probably more than once, with success; now, however, plowing is recognised by all as an essential operation on every well-cultivated property. In these first years, after the experiment at Compensation, the industry made very little headway. Initial mistakes and misdirected energy, through inexperience, were only what was to be expected. It was at first thought that the cane would only grow on flat land, and when they betook themselves to alluvial flats, chiefly on the banks of the rivers, frost would sometimes blight the fields, and floods would wreck mills as well as crops, the three F's, fire, flood and frost, caused much loss. One of the pioneer Estates, that at Springfield, on the banks of the Umgeni, a few miles from Durban, was almost totally destroyed by the great flood of 1856. This river rose 28 feet, and not only submerged the Springfield cane fields, but rushed through the factory to a depth of nine feet, and among other havoc carried the heavy battery of boiling pans clean off the masonry. An amusing incident of this disaster occurred at the height of the flood, when a large elephant was swept past the mill, trumpeting furiously. On the same occasion another factory was similarly destroyed on the banks of the Umhloti. The earlier mills were worked by animal power (oxen) until about 1856, when the steam engine was introduced, and, of course, rapidly superseded primitive methods. Mr. Tom Milner, of Redcliffe Estate, was the first to import steam-driven machinery, with a view to making his factory a central one. In 1858 there were 12 steam sugar mills in Durban County, chiefly in Isipingo and Umgeni flats, and 1,490 acres under cane. In Victoria County there were only four or five mills, but a larger acreage under cultivation; other plantations and one or two mills had also started in less accessible districts near the mouth of the Umkomaas and at Umzinto. In the following years the labour question first came to the front, thousands of capable natives existed in and around the Colony, but could only be got to work by fits and starts, which simply meant ruin to the industry, if it had to depend on native labour.

In the general interests of the Colony, Government gave its sanction for the importation of Indian labour, and Indians were first introduced into Natal in 1860, and up to 1866, 5,600, including women, had been introduced; in that year financial reasons compelled a stoppage of the supply, and it was not again resumed until 1874. The labour question was not the only serious one that the struggling planter had to contend with in the earlier years of the period under notice. The Colony, generally, then passed through a very severe financial crisis, brought about by land speculation and bad seasons, and several succumbed, but the survivors gradually made progress as well as improvement in their work

In 1867 the industry was protected by an import duty.

In 1870-71 a welcome impetus was given to the industry by the great discovery of diamonds in Griqualand West, and the determination of the growers at this time to improve their product may be judged by the fact that whilst in 1870 only three factories possessed a vacuum pan, the number was increased to 12 in 1873.

In the next 15 or 16 years much progress was effected in the development of the industry. Among the influences which favoured its growth, railway extension deserves just mention. The line to Maritzburg was begun in 1876. The completion of the North Coast line to Verulam, in 1879, meant a great deal to the planters in Victoria County. The stoppage of the South Coast line at Isipingo was a handicap to producers in Alexandra and Alfred counties. The introduction, in 1877-78, of the Natal Central Sugar Company's factory at Mount Edgecombe, under the supervision of Mr. Alfred Dumat, from Mauritius, and at about the same time the arrival of a number of planters and artisans from Mauritius, trained to factory work, did much to foster improved methods, as this factory was equipped with a type of machinery entirely new to Natal, which turned out a product marketably as good in the one colony as in the other.

A great fall in the market value of sugar took place all the world over—in 1883-84—and some thought its continuance would mean a permanent blow to the Natal sugar industry, but although the fall was considered established, producers put their shoulders to the wheel of economy and improvement, and a buoyant feeling as to the future prevailed. The labour difficulty cropped up again in this period when railway construction was being pushed; and during the Zulu and Boer wars.

In 1888 a strong feeling prevailed against Indian immigration; the planters took the matter up and held a conference, and proved by the recorded testimony of every important producer that the importation of Indian labour had been and continued to be the mainspring of the Colony's productive power.

Up to 1884 the varieties of cane chiefly in vogue were the Green Natal, Lousier, and Port Mackay. At this date Uba was first introduced into Natal by Mr. Daniel de Pass, of Reunion Estate, about 10 miles from Durban, on the South Coast, and proved so successful that it gradually superseded all the other varieties, and is to-day the cane generally in cultivation throughout the industry. The introduction of the Uba cane, coming as it did when disease was playing havoc with the varieties of canes already mentioned, proved the salvation of the sugar industry. This cane proves a success whenever planted in South Africa, and the industry owes a debt of gratitude to the introducer of Uba. It takes plant-cane two years, and first and second ratoons 18 months to mature, which means three crops from one planting every five years. The yield per acre varies according to soil, seasons, and care bestowed, the average years being 1½ tons sugar per acre, but with better improvements in the factories and cultivation, an increased yield is not uncommon on good lands of between two and three tons. All estates having factories grow their own cane, but there are many growers of cane who get their cane crushed at convenient factories.

In 1891-92 the aggregate crop was about 18,000 tons, about one-third being white sugar, and the remainder yellows and syrup sugars. Most of the factories at this time had double crushing by a pair of mills, and nearly all had vacuum pans for juice and syrup boiling; but a few still had open batteries and Wetzeels. Much of the machinery employed was admittedly out of date, but during the past 24 years vast improvements have been introduced, and though the number of factories has much diminished during this period, cultivation has considerably increased. The crushing season usually runs from June or July to January, and the planting from September to December.

The capital employed in the industry was estimated in 1888 at £830,000 (to-day it is over three millions), and the succeessful flotation in England, in 1892, of Reynolds Bros., Ltd., with a capital of £100,000, is an instance of the outside confidence in the ability cf the industry.

Successful sugar-growing anywhere depends much on climate and rainfall. The Coast climate of Natal, with an average rainfall of 39 inches, and an average temperature of 77°, being warmed by the Mozambique current, making it sub-tropical, has, upon the whole, proved favourable to the production of sugar. As is well known, it is only a coast belt, ranging from about six to twelve miles inland, that contains the conditions suitable for cane growing; besides what is now cultivated, there are still large tracts of land to be found and made available to grow all the sugar South Africa requires, and if the industry continues to expand as it has done in the past ten years, there seems no reason to doubt that the industry will reach the exporting stage in the near future.

The prospects of the sugar industry may be considered satisfactory and hopeful. All those now engaged in the enterprise have had many years' experience of its ups and downs. They know what to expect in the way of seasons, and better than most of their predecessors, the absolute necessity of more careful culture of the raw material, proper scientific selection of land and plants, scientific manuring, labour-saving appliances, mechanical transport and plowing, etc. Factory work is now much better understood than formerly, there being much less guesswork all round and more practical study of the elements of success. The fall in prices which at one time threatened ruin to the industry has, in Natal, as elsewhere, given an impetus to improved methods. It is only by the adoption of the latest modern methods to production of cane, thereby ensuring maximum tonnage and sucrose content, sound engineering practice in the construction of sugar manufacturing plant, and the best methods of manufacturing under chemical control, that the cane-grower will be able in the future to succeed and compete against the required standard of development existing in countries competing in the open markets of the world.

The production of sugar in Natal during the first 40 years of its cultivation reached a total sterling value of £5,000,000, which contributed largely to the prosperity and general spending power of the Colony. In 1898, 29,000 acres were in sugar; in that and the previous year the industry sustained a serious set-back due to the ravages of locusts, the loss being estimated at 8,000 tons of sugar; but thanks to the methods of destruction adopted, the plague was practically exterminated.

Prior to this great visitation of locusts, the only record in Natal occured more than 40 years previously, and remained only a short period. Under the circumstances above described, not to mention other discouragements, a check to the industry might not unnaturally have been looked for—on the contrary, it had the effect of stimulating further improved methods.

The trade amongst the South African States used to be very complicated, as each State had its own import duties and granted different kinds of privileges to different countries. Mozambique sugar, for instance, was exempt from duties on import into the Transvaal, whilst Natal sugar was taxed. This remained in force until a couple of years after the Boer War. In 1906 a Convention was drawn up, in which the British South African Colonies guaranteed each other free trade, whilst sugar from abroad was taxed. The industry from this date onward made steady progress, the production mounting from 35,000 tons in 1907/8 to 102,000 tons in 1914/15. This crop marks an epoch in the history of the industry, the total output reaching for the first time 100,000 tons. The crop in 1915/16 totalled 115,000 tons, so that in nine years the output has more than trebled itself. If this increase is maintained, Natal will soon be an exporting country. The industry is likely to flourish. The factories have been and are being well installed, and up-to-date methods are being applied to cane cultivation, and after the labour problem has been solved, a further expansion of the industry may be looked for, as there is land and labour enough, to judge from the present state of affairs.

The history of the industry and its growth, from the planting of the first cane by Mr. Morewood, on Compensation Flats in 1847, to the existing standard of development, is a story with the elements of romance. One by one the early pioneers of the industry have dropped out of the running, leaving only a few who have followed it from the early beginning, through want of experience and capital. The early pioneers had many failures, but their pluck and dogged perseverance against many odds, of which the present-day planter has no conception, laid the foundation of the present flourishing industry.

British Association.—For the first time since the British Association for the Advancement of Science was founded in 1831 its annual meeting will be intermitted. It has been decided to cancel this year's meeting, which was to have been held at Bournemouth in September. The reasons for this step are mainly the restriction of railway communication and the fact that the buildings in which it was anticipated that the Association would be accommodated are being requisitioned for various national purposes.

VOCATIONAL TRAINING.

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

(*Abstract.*)

The author suggests that pupils from twelve years of age upwards should be required to express their choice of an occupation each year until school-leaving, and that once a year the head teacher should address the pupils on the suitability of their selections. In this way, he thinks, pupils would be brought to reflect carefully on their future careers.

Conference of Scientific Societies.—On the initiative of the Witwatersrand local centre of the South African Association for the Advancement of Science a Conference was held at the Chamber of Mines, Johannesburg, on 10th April, 1917, to discuss and formulate resolutions with reference to:

(*a*) The introduction of the Metric System of Weights and Measures;

(*b*) The introduction of a Decimal Coinage; and

(*c*) The official adoption of Daylight Saving Measures.

The following scientific societies and commercial bodies were represented by delegates present at this Conference:

South African Association for the Advancement of Science, South African Institution of Engineers, South African Institute of Electrical Engineers, Chemical Metallurgical and Mining Society of South Africa, Geological Society of South Africa, Institute of Land Surveyors, Association of Mine Managers, South African Association of Analytical Chemists, Natal Society for Advancement of Science, Biological Society, Pretoria, Rhodesian Scientific Association, Association of Certificated Mechanical Engineers, Pharmaceutical Society, Witwatersrand Agricultural Society, Witwatersrand Central School Board, South African Society of Civil Engineers, Natal Manufacturers' Association, South African Manufacturers' Association, Cape Town, South African National Union, Johannesburg, Central Committee of Industrial Research, Royal Society of South Africa, Cape Institute of Architects, Transvaal Teachers' Association, Johannesburg Municipal Officials, Witwatersrand Council of Education, Transvaal Society of Accountants, Institute of Bankers, Society of Architects, Institute of Architects, Association of Architects, Federation of Master Builders, Transvaal Manufacturers' Association, Association of Chambers of Commerce of South Africa, Transvaal Chamber of Mines.

The Chairman of the Conference, Professor J. Orr, President of the South African Association for the Advancement of Science, in welcoming the delegates, stated that it was fitting that the South African Association for the Advancement of Science should have taken the initiative in this matter, as two of the objects of that Association were (*a*) to promote the intercourse of Societies and individuals interested in Science in different parts of South Africa, and (*b*) to bring about the removal of any disadvantages of a public kind which might impede the progress of that country. The present war had brought before us many new problems, and had also taught us to adopt a less conservative spirit. The time, therefore, seemed opportune to endeavour to bring about certain changes with reference to our systems of Weights and Measures and Coinage, and also to the use of Daylight, which would most inevitably lead to greater progress. He asked Mr. W. Ingham, Past President South African Institution of Engineers, to move Resolution 1:

That the Metric System of Weights and Measures be legalised at as early a date as possible for permissive use until the end of the war, and that its use become compulsory and exclusive after such time as may be found practicable.

After reviewing the history of the present British system of Weights and Measures and of the Metric System, and showing how greatly the Metric System is superior to the British system with reference to the greater facility and simplicity with which all calculations may be made, Mr. Ingham pointed out that the Metric System had already been adopted (up to 1915) by the following countries, having a total population of 477 millions: Argentine Republic, Austria, Belgium, Belgian Congo, Brazil, Bulgaria, Chili, Colombia, Costa Rica, Cuba, Denmark, Finland, France, France (Colonies), Germany, Germany (Colonies), Guatemala, Holland, Holland (Colonies), Honduras, Hungary, Italy, Italy (Colonies), Luxembourg, Malta, Mauritius, Mexico, Nicaragua, Norway, Peru, Philippines, Porto Rico, Portugal, Portugal (Colonies), Roumania, Salvador, Servia, Seychelles, Siam, Spain, Sweden, Switzerland, Uruguay, Venezuela.

British Consuls in foreign countries frequently complain that foreign trade orders are continually being lost by British manufacturers because they persist in sending out catalogues and quotations based upon the Imperial system of weights, measures and coinage. The British Select Committee on Weights and Measures, which reported in July, 1895, after taking evidence from witnesses representing many different interests—official, commercial, manufacturing, educational and professional—decided that the present British system was unsatisfactory and a drawback to commerce. It was stated that one year's school time was lost in teaching our present system, and would be saved by adopting the Metric System. The Committee recommended that the Metric System should be adopted in Great Britain, and was of the opinion that the change could be made without serious opposition or inconvenience.

The South African National Advisory Board for Technical Education, at its sixth meeting at Cape Town on March 1st, 1916, came to the opinion that—

(1) The necessity for school instruction in the use of a non-decimal system of money, weights and measures has resulted in

a quite unreasonable proportion of the time available for education being spent on work which is really non-educational in character, and has prevented a proper development of the school curriculum in the direction of mathematics.

(2) Some relief should be given from the existing conditions wherein the school deals with three systems of weights and measures—the Imperial, the Metric, and the Cape.

(3) The International Metric System has now been taught in our schools for a period sufficiently long to render its daily use quite simple to the greater part of the population.

The Board therefore desired to draw the attention of the Government of South Africa to the desirability of:

(*a*) Making the weights and measures of the Metric System compulsory for use in internal trade and manufacture; and

(*b*) Introducing a decimal system of coinage at an early date.

Mr. C. H. Leake, President of the Johannesburg Chamber of Commerce, in seconding the motion, said that the war had taught us that we needed increased production, and if a method could be introduced that would save time, as the Metric System would undoubtedly save time, then there is everything in favour of it. The advantages of the Metric System so far outweigh the disadvantages that it is difficult to see how anyone could object to it.

Mr. J. Davidson, Assizer to the Johannesburg Municipality, pointed out that the Union Government does not possess a single tangible standard of weights and measures to which it can refer as the "standard unit of weights and measures" from which all other units of weights and measures shall be derived; nor has it, notwithstanding the fact that it is now in its seventh year since Union, defined what standards are to be used throughout the country. The several Provinces which came into the Union have, it is true, some ancient legislation on the subject, but there is no uniformity amongst them. The greatest evil in connection with weights and measures in the Union arises from the fact that up-to-date bye-laws are enforced in the Reef Municipalities and in Pretoria, whilst traders in other towns are at liberty to do as they please. The uniformity which would follow from the introduction of the Metric System would remove a great many anomalies.

After some discussion as to the exact wording of the resolution, it was carried without any dissentient.

Dr. R. A. Lehfeldt, Professor of Economics, South African School of Mines and Technology, proposed Resolution 2:

> That the Government of the Union of South Africa should co-operate with the Home Government and those of the other self-governing Dominions with regard to the decimalisation of coinage.

He said that the only sort of argument that one would have to work against was that the change from the present coinage to decimal coinage would be beyond the capacity of the people. As to arguments in favour of decimal coinage, the first was the advantage in regard to international trade. If one put oneself in the position of a customer who was used to decimal coinage and did not know pounds, shillings, and pence, one would realise that an English trader who offered his goods in terms of pounds, shillings and pence was handicapping himself unnecessarily. The second point is with regard to mercantile convenience: it takes much less time to do commercial arithmetic in the decimal system than under the British system, and the percentage of mistakes is smaller. For example, in working out the price of so many tons, hundredweights, quarters and pounds at so many pounds, shillings and pence per ton, probably a quarter of an hour is the time required; whereas a similar problem could be done in the Metric System in a few seconds. Professor Lehfeldt spoke in favour of the decimal system of coinage as outlined in the draft bill proposed by the London Chamber of Commerce, which retained the pound sterling and made the florin the monetary unit, the florin being divided into one hundred cents.

The motion was seconded by Mr. H. C. Jorissen, President of the Institute of Bankers, who said that the Bankers' Institute was certainly heart and soul in favour of the adoption of a decimal coinage. In 1913, the President of the Bankers' Institute, in his inaugural address, touched very largely on the question of the introduction of the Metric System and a decimal coinage. He said: "I am aware that for a young country as South Africa to adopt a basis of token coinage that differs from that of any other country may appear at first sight a very bold step, and I would like to see the currency in England and all the Colonies on a decimal basis. Still, reforms in the past have invariably been effected gradually, and there is no reason why South Africa should not take the first step towards the establishing of an Imperial Decimal Coinage. The difficulties would, at present, in this country, be quite small, and the adoption of the system in a young and growing country, such as South Africa, would be well repaid. I feel convinced that it is only a question of time when Great Britain and those of her Colonies, which have not already taken the step I indicate, will have to adopt the decimal system in order to stop the present wastage of time. I admit that the change would mean a temporary inconvenience, but if it also means permanent good, then let us use what influence we may have in the hope that the change may be made soon and in our generation."

After some debate on the merits of the decimal coinage scheme, as proposed by the London Chamber of Commerce, the resolution, asking the Union Government to co-operate with the Home Government and those of the other self-governing Dominions, was carried unanimously.

Mr. E. Chappel, Past-President and Vice-President of the Association of Chambers of Commerce of South Africa, proposed Resolution 3:

That in view of the considerable advantages to be gained by a fuller use of daylight, the Government be requested to take into consideration the desirability of advancing the time of the Union one hour for six months of the year, from September 30th until March 31st.

As is, of course, well known, the principal reasons for the introduction of the change of time in Great Britain and France were the increased efficiency gained by the extra hour's work in daylight, and the economy effected by the saving in cost of one hour of artificial light. To these Mr. Chappel added that the facilities thus obtained for an hour's open-air recreation of some sort might also be considered as an additional aid to efficiency during working hours. In view of the triumphant success that the experiment has achieved in Great Britain and France, where it has been universally adopted, there can be no reasonable doubt as to its merits, and as an industrial people it is our duty to do all in our power to bring about the much-needed change. Various suggestions have been made from time to time as to the manner of making this change, but all of them have been rejected in favour of the one proposed by the resolution, *viz.*, altering the clock. Man is very much a creature of habit, and if he has been used to going to his work or to his office at a given time he resents going an hour earlier, although he will go most uncomplainingly an hour earlier in reality as long as it is called the same hour. The real superiority of the proposed method over any other lies in the fact that by altering the clock you do away with the necessity for altering any Laws or Regulations which in any way deal with time, and also you have no need whatever to alter time-tables of any kind whether for railway or other purposes. When this proposal was put before the Government of the Union of South Africa, the only argument that they used in support of their refusal to adopt it was to the effect "that the majority of the white inhabitants of the Union who live in the country districts and villages, and the manual workers who live in towns, regulate their lives more closely in accord with the rising and setting of the sun than do the bulk of the town dwellers, and, as far as the Government are aware, there has been no expression of opinion from them in favour of any alteration in clock time. Under the suggested scheme farmers and others in the country districts would probably regard it as a grievance if during the summer months they were obliged to rise an hour earlier when they wanted to travel by an early morning train or to send or bring produce to market, or to attend to any business in town in the morning." In this argument it will be noted that it is admitted that the country districts already practise the very excellent principle for which we are striving, and therefore it is clear that if our request were granted no great inconvenience would be caused to those who already regulate their lives in conformity therewith.

When in 1892 the clock time was altered by the Government in the Cape Province, and again in 1903 it was altered throughout what is now known as the Union of South Africa, the alterations were made by Government Proclamation only, and no difficulty whatever arose therefrom. it is clear, therefore, that a similar method might be adopted now, thus saving the inconvenience and delay inevitably connected with special legislation.

Mr. H. G. Nitch, representative of the Association of Mine Managers, in seconding the resolution, said that his Association was in favour of the resolution as it stood.

Professor Lehfeldt referred to the arguments, already quoted, which had previously influenced the Government, and thought that they were very strong ones. It was a fact that the majority of the white inhabitants of the Union lived in the country, and to put the clock ahead for them would not cause them any benefit, and the Government might think the change would cause inconvenience. He thought it impolitic to send forward this resolution, on which differences of opinion existed, with the resolutions on the Metric System and Decimal Coinage, on which they were unanimously agreed. He did not think the scheme would suit the inhabitants of Cape Town, where, owing to the geographical position of the town, the clock was already advanced forty-six minutes.

Mr. Chappel pointed out that when the proposal was put before a meeting of the Associated Chambers of Commerce. Cape Town was doubtful at first, but finally agreed to it. The *Cape Times* might be cited as strongly in favour of the new scheme.

The Chairman mentioned the fact that at the annual meeting of the South African Association for the Advancement of Science, held at Maritzburg in July, 1916, this same resolution was proposed by Mr. R. T. A. Innes, Union Astronomer, and was approved of unanimously at a combined meeting of sections, and at a later date confirmed practically unanimously by the Council of the Association, which has many representatives at Cape Town.

After further discussion the resolution was put to the vote, and carried with two dissentients.

Mr. H. Clark, B.Sc., representing the Natal Society for the Advancement of Science, proposed the following resolution:

That in order to make the Metric System and its advantages more generally known in South Africa, the following steps be taken:—

(*a*) That popular lectures be given in the larger towns explaining the system and enumerating its advantages, at which lectures local members of Parliament be asked to preside.

(*b*) That Municipalities be circularised and asked to purchase complete sets of commercial metric weights and measures for inspection.

(*c*) That a booklet, specially written for South African use, be prepared for free circulation or at a nominal figure.

Mr. P. Cazalet, South African Association of Engineers, seconded the resolution, which, he suggested, might take the form of a recommendation to be dealt with by the Council of the South African Association for the Advancement of Science, which had taken the initiative in the Conference.

It was agreed that copies of the resolutions on the Metric System, Decimal Coinage and Daylight Saving be sent to His Excellency the Governor-General, the Prime Minister, the Minister of Mines and the Industries Advisory Board, the High Commissioner for South Africa (London), the British Colonial Secretary, the Decimal Association, London, and the South African Standards Committee.

The Chairman said that an abstract of the proceedings would be sent to each member of the Conference, and he hoped that each Society represented would confirm the resolutions that had been passed. If no reply were received within one month from the date of the Conference, it would be taken for granted that such confirmation was given. The proceedings terminated with a vote of thanks, proposed by Sir T. M. Cullinan, to the Chairman and the members of the South African Association for the Advancement of Science for calling the Conference.

COMET 1917a.—A new comet was discovered by Mr. J. E. Mellish on the 20th March. Its magnitude was 7.5, and it was expected to be visible in the southern hemisphere during May.

GEOLOGY AND THE WAR.—The *Geological Magazine* for February, 1917, contains an abstract of a Presidential address delivered to the Vesey Club by Dr. A. Strahan, Sc.D., LL.D., F.R.S., V.P.G.S., in the course of which the author said that the researches of the stratigraphical geologist, the palæontologist, and the petrographer had received a respectful toleration in England, but were regarded as a luxury, to be abandoned first among luxuries in time of stress. He hoped that it would not be so necessary in the future to urge the claims of science. The Germans, he said, had been active in their application of geology at the front. Two years ago they had begun to make geologists a part of the army organisation. A staff of geologists was created and placed under the direction of a Professor of the University of Greifswald for service on the Western Front. Among the subjects on which geological advice was requisitioned were the laying of field railways, the provision of water, the examination of marsh lands, the finding of road-metal, and the guarding against landslides due to gunfire. The German professor of palæontology, from whom Dr. Strahan quoted, hinted that a much greater use had been made of geological maps than he was at liberty to make known, and recommended that full advantage should now be taken of examining the numerous artificial openings, and of gaining such knowledge of the ground of Germany's neighbours as may be desirable for military purposes, as the coming peace would not be everlasting, and posterity would reproach the present Germany if she neglected so favourable an opportunity of examining present fields of battle, on which the wars of the future would probably also be fought.

THE MEDICINAL SPRINGS OF SOUTH AFRICA.

By Prof. Max Morris Rindl, Ing.D.

In a young country like ours, with such a variety of problems, scientific and otherwise, and such a small population to solve them, progress is necessarily slow. Comparatively few of the problems, it is true, are left entirely untouched, but most of the work is done by individual effort. The medicinal springs of this country constitute a case in point. Many valuable data concerning them are in existence, but no effort has been made to collect and correlate them. Some of the information is recorded, much of it has never found its way into print. The problem is one which commands more than merely scientific interest. It is of practical importance. Most European countries issue big volumes containing all the information about their watering places and health resorts, and these compilations are indispensable to the medical profession. That is far more than we can hope to do for some time to come; but I have attempted at least to make a beginning by putting together all the available facts, incomplete and fragmentary as they are, in a perspicuous form. My object has been a double one, to place on record what has been done, and to stimulate interest by showing what still remains to be done.

Part I.—General.

I am painfully conscious of the incompleteness of my paper. Many of the data herein contined need amplification and corroboration; much of the information will undoubtedly be modified and changed beyond recognition in the course of time. I have included in my list all springs known or reputed to be, or likely to become, of medicinal value. The majority of the springs have a local reputation, and are frequented by the farmers of the surrounding district, but their efficacy remains to be established by impartial medical evidence. The statements of the owners and patients are naturally biassed.

Analyses.—The majority of the analyses are taken from the Annual Reports of the Senior Government Analyst of the Cape Colony. As most of the waters were analysed with a view to ascertaining their fitness as boiler waters, the analytical results are in some respects incomplete. For example, iron and aluminium are usually determined together as oxides, whilst it is desirable to know the amount of ferrous iron separately, particularly in the case of chalybeate springs. Lithium compounds, bromides and iodides, the presence of which, even in minute quantities, seems to have a very marked effect, are usually recorded simply as traces, if at all. Many of the waters have been analysed hundreds of miles from the source of the springs, with the result that the dissolved gases, several of which have pronounced therapeutic properties, have diffused out. Moreover, the dissolved bicarbonates of iron and calcium are likely to be partly or entirely precipitated.

Mineral springs, particularly new ones, occasionally undergo considerable changes, even within comparatively short periods. These changes may be periodical or permanent. A single analysis cannot, therefore, safely be regarded as a criterion. It is desirable to have a series of analyses extending over a term of years until the composition has been proved to remain constant, or the periodicity has been established. An interesting example is the Ehrlich Forest borehole outside Bloemfontein, of the water of which several complete analyses exist. The results show striking differences, although the analyses were carried out within a few months of each other. The lithium chloride content in the last has decreased to the extent of approximately 1/35 of that in the first. In view of such variations future analysts may find the inclusion of the date of each analysis in the tables useful.

As a rule, analytical results in this country are recorded in terms of grains per gallon, and in the series of Tables No. I I have kept the data in the original form. For purposes of comparison I have recalculated them in the usually adopted Continental standard, grams per 100,000 (series of Tables No. II). There is a growing tendency among chemists, although not yet universally adopted, to discard the conventional form of expressing results by combining anions and cations more or less arbitrarily, and to express results instead in terms of ions. Such a system is perfectly legitimate, as the amounts of saline constituents in waters are usually so small that they may be regarded as completely ionised. This method (which has been adopted in calculating the values in series of Tables No. II) does away with the factor of uncertainty at present attaching to all water analyses, inasmuch as the combination of ions is largely a matter of choice.

The value for total solids obtained by actual estimation is usually different from that obtained by addition. It is for that reason that the calculated and determined values are given in different columns.

Most analyses contain the values of iron and aluminium as $Fe_2O_3 + Al_2O_3$. In the calculation for the ionic Tables (Series No. II) these values have been regarded as being pure Al_2O_3 on the one hand, and Fe_2O_3 only on the other. The values for aluminium and iron calculated on this assumption are always recorded in brackets.

Silicic acid is probably present in the uncombined state in most waters. Being an extremely weak acid, it must be regarded as practically undissociated. Nothing is known about its state of hydration (ortho- or meta-silicic acid), and rather than make any arbitrary assumption, I have preferred to leave the values in the form usually given, namely, SiO_2.

From the value of combined carbon dioxide it is impossible to discriminate between carbonate and hydrocarbonate ion. The data necessary for making such a distinction not being available or existent, the course adopted was to regard the combined carbon dioxide as hydrocarbonate ion *only* in all cases where calcium, magnesium, and ferrous iron are present. In the case of the alkaline waters, however, whose predominating constituent is sodium carbonate, the combined carbon dioxide was calculated as carbonate ion.

In many of the analyses under review the values of the alkalies were not determined. After satisfying all the bases, the excess of acids was assigned to the oxides of the alkalies, which are put into reckoning as Na_2O. In such cases, and generally speaking in all cases where there was reason to believe that the values of some of the constituents had been obtained by calculation instead of by actual determination, there could be no object in recalculating the values in terms of ion-equivalents.

Where such tables of ion-equivalents have been made they are appended to the descriptions of the individual springs in Part II of the paper. The values are obtained by dividing the weight of each ion (expressed in grams per 100,000) by its atomic weight (or the sum of the atomic weights), and multiplying by the valency in order to obtain monovalent ions.

In accordance with the generally accepted theory, alkali sulphides are regarded in my calculations as being ionised into sodium (or potassium) on the one hand, and into monovalent SH ions on the other.

Gases.—The operation of collecting the gases escaping from a spring is a difficult one, and cannot be entrusted to a layman. Dissolved gases diffuse out in the course of a few hours. As in most cases the waters were not collected by the analysts themselves, and were transported a considerable distance before being examined, our information about the gaseous constituents is most incomplete. In the case of sulphur springs the values for sulphuretted hydrogen are often not given at all in the original analyses. If recorded, they should be regarded with a certain amount of reserve, unless the estimation was carried out at the site of the spring.

Radioactivity.—It is impossible to express an opinion on this point and to make comparisons, unless quantitative data about the radioactivity are available, expressed in terms of an accepted international standard.

Medicinal Properties.—In the absence of definite expressions of opinion from the medical profession, my information is based on the statements of guide-books of South Africa, on the evidence of patients, and on current beliefs. To what extent such information is credible can be gathered from the fact that practically all our springs are supposed to be specifics for rheumatism and cutaneous diseases, no matter what their composition.

Comparison with European Springs.—The original reports in some cases point out the similarity of the waters examined to well-known European medicinal springs. These statements have been included in the descriptions of the individual springs in

Part II. But it must be borne in mind that the comparison is made solely on the basis of the chemical analysis, whilst the chemical composition is only one of several factors determining the nature and efficacy of a spring. Radioactivity, temperature and altitude should all be taken into consideration, and until we have at our disposal a complete set of data concerning South African springs such comparisons must be regarded merely as tentative. It is for that reason that I have refrained from drawing any parallels.

Classification.—The recognised method of classification is on the basis of the chemical composition. There is a long list of springs of which no analyses exist, and which must consequently be left unclassified, with the exception of those which can be recognised by their smell as containing sulphuretted hydrogen, and which are added to the group of sulphur waters. In many cases my decision in assigning a spring to this or that group will be open to criticism, and in view of the incompleteness of the existing data, no effort has been made to subdivide the groups.

Only three groups are well represented among South African springs, the indifferent, the sulphur, and the chalybeate springs. Each of these groups contain springs which have attained to more than a local reputation, Montagu in the first, Malmesbury in the second, and Caledon in the third group.

Indifferent Springs are defined as such, containing less than 1 gram of dissolved solid constituents, and not more than 1 gram of free carbon dioxide per litre. These waters contain no mineral constituent in sufficient quantity to have a pronounced effect on the system, and their action is probably due to their temperature, which in the case of all South African springs of this group, is well above the average temperature of the atmosphere. Possibly their efficacy may also in some measure be attributable to their radioactivity. I append a list of some of the well-known European springs of the same group for comparison:

Pfäffers	99° F.	Gastein	95-118° F.
Ragatz	95° F.	Wildbad (Würtemberg)	95-101° F.
Teplitz	101-120° F.		

Sulphur Springs.—In this country all springs with the odour of sulphuretted hydrogen are classed as sulphur springs. I am inclined to think that that is not a sufficient criterion. Many well waters in the Karroo contain small amounts of sulphuretted hydrogen (hence so many farms are called "Stinkfontein"), but few of them are, to my knowledge, endowed with medicinal virtues. The majority of the well-known sulphur springs in other parts of the world contain metallic sulphides in addition to sulphuretted hydrogen, and these sulphides are probably far more potent than the small amount of dissolved gas. The only South African sulphur springs reported as containing combined sulphuretted hydrogen (sodium sulphide) are those of Machadodorp, Weltevreden, and the Ehrlich Forest spring near Bloemfontein. In the springs at Matjesfontein, Lochinvar, and Weltevreden the amount of free sulphuretted hydrogen is considerable. All these are practically unknown as medicinal springs. Strange to say, those springs which have attained a reputation as sulphur waters, Aliwal North and Malmesbury, contain only very small amounts of sulphuretted hydrogen.

Hot sulphur springs are, as a rule, less frequent than cold ones. It is, therefore, interesting to note that a large number of our springs have temperatures considerably higher than the average temperature of the atmosphere (Aliwal North, Malmesbury, and Machadodorp), and one of the group of springs constituting the Zongala geyser is just a little below boiling-point. The amount of sodium chloride in the two Isinuka springs is so considerable that they might as well be classed as brine springs, and the amount of sodium sulphate and carbonate they contain would justify their being regarded as sulphated alkaline waters. The action of these compounds on the system is well known, and when once the effect of the spring has been carefully studied it will be easy to classify it according to the constituent which predominates therapeutically. But the only way to study the effect of a spring is to keep a careful medical record of a large number of cases.

Chalybeate Springs owe their curative properties to the iron they contain. Some chalybeate springs also contain sulphuretted hydrogen. The Zwartkops water is of this type, and here again the medical man must act as arbiter in the question of classification. Chalybeate springs are defined as such, containing not less than 0.7 grams of ferrous iron per 100,000. Unfortunately, in many of the analyses iron and aluminium have not been determined separately, but for a rough approximation I am assuming the values given in the column $Fe_2O_3 + Al_2O_3$ to be iron oxide only. The values for ferrous iron in grams per 100,000 would then be:

Balmoral	4.0	Tooverwater Poort . .	0.23
Inungi	5.3	Zwartkops	0.77
Caledon	1.39		
Warmbad (Oudtshoorn)	0.3		

It will be noticed that Warmbad and Tooverwater Poort fall far below the minimum. In commenting on the analysis of the Oudtshoorn spring (Warmbad) in the report for 1908, the Senior Analyst points out that the value is probably low in consequence of the decomposition of ferrous bicarbonate on exposure. The figure for Balmoral is of little value for purposes of comparison in view of my unwarranted assumption regarding the values of iron and aluminium oxides. But in the case of Inungi the iron is calculated from ferrous carbonate, and a spring which contains almost four times as much iron as the famous Caledon water deserves attention, particularly in view of the large amount of calcium and sodium carbonates, which make it partake of the nature both of earthy and alkaline waters. The Balmoral spring differs from the others in containing the iron as sulphate. A noteworthy feature of South African chalybeate springs is that most of them are thermal. Iron springs in other parts of the world are, as a rule, cold.

The South African Salt Springs are not comparable to any of the well-known Central European salt springs. The peculiarity of these is their higher sodium chloride content, and the presence in most of them of appreciable quantities of potassium. Those in which the value of sodium chloride is low usually contain bromine and iodine.

Alkaline Waters contain a minimum of 1 gram of solid constituents per litre, among which the carbonate or hydrocarbonate ions predominate. If this definition were rigidly adhered to, all the springs which I have classified under the above heading would have to be transferred to some other group, as the total of the solid constituents is only about 0.4 of a gram per litre in all cases. But I think I can justify my decision in the matter of classification on the grounds that in all cases (except Msali) sodium carbonate or bicarbonate preponderate to such an extent as to determine the nature of the water. The Msali spring might be regardeed as a sulphated alkaline spring.

Earthy Waters are defined as such containing at least 1 gram of solid constituents per litre, among which the bicarbonates of calcium and magnesium predominate. None of the waters answer entirely to this definition. Wonder Water approaches nearest to it, but it contains less than 0.4 of a gram of dissolved solids per litre. Moreover, it is used almost exclusively as a table water.

The Table Waters are not, strictly speaking, medicinal, inasmuch as they are taken mainly as beverages, and only incidentally on account of any medicinal virtues they may be endowed with. They are usually rich in carbon dioxide, being aerated with the gas before bottling. Judged on the basis of the chemical classification adopted above, they form a heterogeneous group, comprising alkaline waters (Driebad), earthy waters (Wonder Water), and alkaline salt springs (Van Riebeek and Grendel).

Part II.—Description of Individual Springs.

(*The springs are numbered to correspond with the numbers on the map.*)

A. Indifferent Waters.

1. *Brandvlei.*

A most excellent description of this spring is given by Burchell in his book, "Travels in the Interior of Southern Africa" (1811) **1**, from which I take the liberty of quoting:

It forms a shallow pond of about 50 feet across, of the most transparent water, in the middle of which several strong springs bubble up through a bottom of loose white sand, and afterwards, flowing in a very copious stream, become a rivulet, which, for at least a mile and a half, continues so hot that the course along the valley may, at any time of the day, but more particularly in the early morning, be traced by the steam which perpetually arises from it. The pond is sheltered by a clump of white poplars, which thrive perfectly well, although growing at the very edge of the water, and bedewed with the hot steam, which ascends to their highest branches.

Other early travellers give enthusiastic and detailed accounts of the curative powers of the Brandvlei waters.* As Gumprecht's description dates back nearly 70 years, it has little more than historic interest. The spring seems to have fallen into discredit in the course of time. It has now only a local reputation as a cure for rheumatism, and the primitive bath-house that once stood there has been allowed to fall into ruins. The spring is near to the town of Worcester, C.P. It rises from eastward-dipping Table Mountain sandstone, gives a daily yield of 365,000 gallons, and is believed to be slightly radio-active. Its temperature is 145° F. The only European indifferent thermal springs of higher temperature are those of Plombières-les-Bains, Departement Voges, France, with a maximum of 74° C.

2. *Goudini (Rawsonville).*

The Goudini spring is about 12 miles distant from Worcester. Its temperature is 104° F., and it rises through gravels, probably from Table Mountain sandstone. It is believed to be beneficial in cases of rheumatism and cutaneous diseases. There is provision for bathing, and the spring is said to be patronised by a fair number of people.

3. *Olifants River, Clanwilliam.*

These hot baths are situated on a farm (the property of the estate of the late Mr. James McGregor) about 45 miles south of Clanwilliam. Rooms are let to visitors by the late Mr. McGregor's executors, and there are separate bathrooms for the use of white and coloured persons, but no provision for medical treatment exists. The nearest doctors are resident at Clanwilliam and Piquetberg. The latter place is distant about 36 miles from the baths. The spring rises from eastward-dipping Table Mountain sandstone. It has a temperature of 108-110° F. The existence of the spring is recorded by several of the early travellers, and Thunberg seems to have recognised its freedom from dissolved mineral constituents. He reports that it is much like ordinary water, having no unpleasant taste, and being suitable for drinking, cooking, and washing purposes.

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* Gumprecht, "Die Mineralquellen auf dem Festlande von Afrika." Berlin (1851).

4. *Montagu.*

The only one of the springs of this group which has attained to more than a local reputation is that at Montagu. The spring appears to have been known to and frequented by the Hottentots and Bushmen before the advent of the white man, but little was done to make it attractive until it was acquired by the New Cape Central Railway in 1907. The company has erected a bath-house and a comfortable hotel, a glass-covered verandah connecting the two. In addition to the bath-house, which contains eight separate bath-rooms, a swimming-bath has been constructed. Of late radio-active peat baths have been installed, and the erection of an inhalatorium is contemplated. The water is strongly radio-active, and is compared in its composition and nature with the waters of Buxton in Derbyshire, Pfäffers in Switzerland, and Gastein in Austria. As far as its radio-activity is concerned, it is said to be stronger than any of the European springs with the exception of Gastein. Excellent results are recorded in the treatment of sciatica, but the water is also claimed to be a specific for rheumatism, neuralgia, and nervous exhaustion, eczema, acute indigestion, and gravel. The gas, of which an analysis is appended, bubbles freely through the water. Medical treatment is in the hands of Dr. C. H. Muller, of Montagu, and his wife, who is also a Doctor of Medicine. Detailed information can be obtained from a pamphlet issued by the New Cape Central Railway Company. The spring rises from northward-dipping Table Mountain sandstone, and its temperature is 112.3° F. The attached analyses by Prof. Hahn of the peat used at Montagu show it to be very similar to that employed at Franzensbad and Karlsbad.

	Dark. Sample I. Per cent.	Brown. Sample II. Per cent.	Light brown. Sample III. Per cent.
Organic substance	84.81	84.25	85.02
Ash	15.19	15.75	14.98
Ether extract	1.27	1.17	0.95
Sulphur trioxide	9.16	8.85	8.45
Ferric oxide	8.31	7.96	8.38
Humous substance	75.09	71.15	67.83

The gas issuing with the water consists of: Oxygen 10.5 per cent., nitrogen 87.6 per cent., and carbon dioxide 0.6 per cent.

TABLE OF ION-EQUIVALENTS (MONOVALENT IONS).

Cations		Anions.	
K	0.009	Cl	0.037
Na	0.038	SO_4	0.034
Li	0.0002	HCO_3	0.030
Ca	0.031		
Mg	0.022		
Fe	0.001		
Al	0.057		
Total	0.1582	Total	0.101

5. *Barrydale.*

The Warm-Waterberg spring (Barrydale) rises from the east end of an anticline with bent axis in the Table Mountain sandstone. I have not been able to get definite information about its temperature other than that the water is uncomfortably warm to the touch. Medicinally the spring is said to be excellent, but nothing is done to exploit it.

6. *Tarka Bridge.*

On the farm formerly called Driefontein, but now known as Tarka Bridge (District Cradock) there are several warm springs, which appear formerly to have had some little reputation as a cure, but which have now fallen into disuse. Some years ago several boreholes were sunk on the farm, which yield water of constant temperature. In all the boreholes the water comes up accompanied by a large quantity of inflammable gas. In one of the boreholes (temperature 80.4° F.) there is a regular daily variation in the amount of water.*

B. Sulphur Springs.

7. *Aliwal North.*

The springs, which are situated about a mile from the centre of the town, emanate from nearly horizontal sandstones and shales of the Upper Beaufort series, with an average temperature of 95° F. There is a small dyke of dolerite 100 yards below the springs. They issue into a small lake, which is utilised as an open-air swimming-bath. The daily yield, irrespective of the season, is about 1,000,000 gallons. The overflow is carried into the town in a masonry furrow, and is used for irrigation purposes. A bath-house, containing a large swimming-bath and several well-equipped bath-rooms, is situated between the source of the springs and the town. In addition to ordinary baths, provision is made here for electric baths of various kinds. The bath-house is under the control of an experienced masseur. Considerable quantities of gas issue from the eyes of the springs. Whilst this gas is strongly radio-active, the water is only slightly so.

According to Prof. Hahn's analysis, the gas consists of: Oxygen 5.4 per cent.; nitrogen, argon, and helium 94.6 per cent.; sulphuretted hydrogen, trace.

The amount of sulphuretted hydrogen dissolved in the water is astonishingly small, and alkaline sulphides are altogether absent. The amount of free carbon dioxide in solution is 7.4875 grams per 100,000. The municipality has issued an illustrated pamphlet with detailed information about the town and the springs.

* Andrew Young, "A Subterranean Tide in the Karroo," *Trans. Royal Soc. of S. Africa*, 3.(1913), [1], 61-106.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	1.498	Cl	1.705
K	0.016	Br	0.002
Li	0.033	SO_4	0.143
Mg	0.046	HCO_3	0.122
Ca	0.419		
Al	0.081		
Total	2.093	Total	1.972

8. *Malmesbury.*

The Malmesbury spring flows from granite intrusive in the Nama beds, and has a temperature of 94° F. A bathing establishment has been erected in the centre of the town, consisting of 12 rooms with porcelain-tiled baths, and containing a large swimming-bath. In addition to the sulphuretted hydrogen recorded in the tables, the water contains 3.4657 grams of dissolved carbon dioxide per 100,000.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	1.615	Cl	1.612
Mg	0.051	Br	0.002
Ca	0.269	SO_4	0.163
		HCO_3	0.079
Total	1.935	Total	1.856

9. *Fort Beaufort.*

The only information available, in addition to the analytical data given in the tables, is contained in the Report of the Senior Analyst, Cape of Good Hope (1907), 110:—

> The Fort Beaufort spring is close to that town, and in past years, it is said, enjoyed a considerable reputation for its curative properties in chronic ailments, rheumatism particularly.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	0.610	Cl	0.570
K	0.006	SO_4	0.033
Ca	0.054	HCO_3	0.042
Mg	0.017		
Total	0.687	Total	0.645

10. *Isinuka.*

The two Isinuka springs are six miles distant from Port St. John, Pondoland. The spring described as Isinuka I opens out in a small valley between the Isinuka hills. The original opening has been enlarged to form a primitive bath in the limestone 4 feet × 3 feet × 1 foot deep. The water trickles into this from openings in the sides, and there is a continual bubbling of sulphuretted hydrogen through the same openings. The water smells strongly of the gas, and is fairly milky in appearance. The spring described as Isinuka II is about 100 yards distant from the first, and issues from the bank of the Isinuka stream. There was a good flow formerly, but the volume of water has diminished almost to a mere trickle. There is no provision for medical treatment, and the bathing facilities are entirely inadequate. The springs are free of access to all comers, and are used principally by the natives. The water is a powerful purgative and diuretic, and it also has the reputation of being beneficial in both articular and muscular rheumatism. The springs issue close to a fault between the Dwyka conglomerate and the Table Mountain sandstone. There is a deposit of calcareous tufa on the spot. The spring Isinuka I has a temperature of 67°F.

11. *Matjesfontein.*

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	0.521	Cl	0.907
Ca	0.435	SO_4	0.191
Mg	0.500	HCO_3	0.180
Al	0.145		
Total	1.601	Total	1.278

The analysis is taken from the Report of the Senior Government Analyst, Cape of Good Hope, for 1897. All my efforts to obtain positive information about the exact site, etc., proved unavailing. Nobody seems even to be aware of the existence of such a spring. The original report describes the water as being comparable to that of Aix les Bains (Savoy).

12. *Zongala Geyser.*

The Zongala geyser (17° 31′ South Lat., 27° 28′ East Long.), Northern Rhodesia, rises through stratified sandstones, grits and conglomerates. These overlie the aluminous shales of the coal series. The eyes of the springs are surrounded by deposits mainly of crystalline calcite. The similarity in the mineral contents of the two geysers has led to the inference that the Zongala geyser has its origin, like the Goa one, in granite underlying the shales. There are altogether eight springs, one of which ejects water and steam with a hissing noise to a height of 7 feet. The temperature of the hottest spring is 97°C, of the coldest 52°C. The total amount of water in all the springs is 86,000 gallons per day. The water is alkaline in reaction, and contains free sulphuretted hydrogen, but the amount has not been estimated.

13. *Goa Geyser.*

The Goa geyser (16° 39′ South Lat., 27° 20′ East Long.), Northern Rhodesia, rises through granite, and embraces several springs with a maximum temperature of 63°C, and a minimum of 26°C. The springs are surrounded by a deposit of siliceous and partly calcareous pulverulent sinter. The total daily yield of all the springs is 337,000 gallons. Free sulphuretted hydrogen is evolved, but the amount has not been determined. The eyes of the various springs lie in a depression 400-500 yards long and 150-200 yards wide. The owner of the farm on which the spring is situated (Muckle Nuek, near Choma Station), informs me that he only knows of one case of a rheumatic patient having sought and obtained relief at the springs.

Most of the geological data about the two geysers were taken from the paper of D. Ferguson, "The Geysers or Hot Springs of the Zambesi and Kafue Valleys, *Proceedings of the Rhodesia Scientific Association*, vol. iii, 1902.

14. *Koubad.*

On the farm Koubad, on the Pivaan River, District Utrecht or Vryheid, 20 miles north-east of the township of Vryheid, there are two springs, one on the bank of the river with a temperature of 105°F., and a cold one about 300 yards from the river. Both are much frequented during the winter months by the farmers of the surrounding districts. No provision exists either for bathing or for accommodation. In the original report the springs, which are very similar chemically, are compared to those of Uriage, Aix-la-Chapelle and Bagnolles, and it is suggested that by aeration with carbon dioxide the water might become a useful table water of the character of Giesshubler Sauerbrunn. The gas emanating from the hot spring was found to consist of:

	Per cent.
Carbon dioxide	7.39
Oxygen	0.65
Nitrogen	91.96

Tables of Ion Equivalents.

Hot Spring (Analysis by Smitz du Mont).

Cations.		Anions.	
Na	0.285	Cl	0.108
K	0.015	SO_4	0.045
Mg	0.005	CO_3	0.153
Fe	0.0005		
Al	0.015		
Total	0.3205	Total	0.306

The item "halfgebonden koolzuur" contained in the original report has not been taken into account, because it is not obvious from the figures that combined carbon dioxide present as bicarbonate is meant.

Cold Spring.

Cations.		Anions.	
Na	0.174	Cl	0.131
K	0.111	SO_4	0.028
Ca	0.011	CO_3	0.138
Total	0.296	Total	0.297

In view of the extremely small amount of calcium the combined CO_2 is calculated as CO_3."

15. *Sulphur Spring District Zoutpansberg.*

I have not been able definitely to identify the sulphur spring in the Zoutpansberg District, but there is reason to believe that it is the spring 30 miles north of Louis Trichardt. When received at the laboratory the water contained neither sulphuretted hydrogen nor sulphides.

16. *Machadodorp.*

On the farm Geluk 29, the property of the Maatschappij tot Exploitatie van Gronden en Grondrechten in Zuid Afrika, in the immediate vicinity of the village of Machadodorp, is a group of springs containing alkaline sulphides as well as sulphuretted hydrogen. Their temperature, 81.5-83.3° F., although lower than that of Malmesbury, is nevertheless exceptionally high for a sulphur spring, and, moreover, they are highly radio-active. Seven "eyes" are enclosed by a cement structure and roofed over to provide a kind of basin, from which bathing cells are fed. The above company is considering the erection of a proper establishment. One of the springs, not issuing into the basin above referred to, has been analysed separately. Whilst corresponding closely in composition and nature to the water in the basin, it was found to contain between three and four times as much sulphuretted hydrogen and sodium sulphide. The water in the basin having been exposed to the atmosphere for some time before being analysed, the sulphide probably suffered decomposition, and some of the sulphuretted hydrogen diffused out.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	0.238	Cl	0.147
K	0.005	SO_4	0.011
Li	0.005	HCO_3	0.090
Ca	0.064	SH	0.0003
Mg	0.027		
Total	0.339	Total	0.2483

17. *Cradock.*

No information obtainable.

18. *Graaff-Reinet.*

There is some doubt as to the exact locality of the Graaff-Reinet spring. In the Report of the Government Analyst for 1906 it is described as being at Rynheath, but from enquiries it would appear that the analytical data refer to a spring on the adjoining estate Kruidfontein. According to local medical opinion, these waters are anti-rheumatic and slightly laxative. There is comfortable accommodation for patients, and a number of bath-rooms have been erected in close proximity to the spring. The spring issues from Lower or Middle Beaufort Beds.

19. *Lilani.*

These hot springs are about seven miles south of Hermansburg, Natal, and the water issues from a fault line in crystalline schists and metamorphic limestone. There is a single spring, and a group of four or five about 600 yards distant. At this spot a well-appointed sanatorium has been erected, at which a physician is in residence. Provision is made for open-air bathing, and sand and mud baths are in the course of preparation. The maximum temperature of the water is 39.5°C., the minimum about 37°C. The water is reported to be radio-active, and is claimed to be efficacious in cases of rheumatism, gout, sciatica, cutaneous diseases, malaria and obesity. There is a feeble evolution of gas, containing a little sulphuretted hydrogen. According to the analysis the water contains sodium sulphite and sodium thiosulphate.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	0.446	Cl	0.099
K	0.059	SO_4	0.096
NH_4	0.011	HCO_3	0.046
Ca	0.012	SO_3	0.007
Mg	0.012	S_2O_3	0.002
Fe	0.004	SiO_3	0.247
Total	0.544	Total	0.497

20. *Lochinvar.*

The water of the hot spring from the ranch Lochinvar, Magoye, Northern Rhodesia, contains a very considerable amount both of sulphuretted hydrogen and of sodium sulphate. According to the report, it is likely to be of medicinal value, but I am not aware of any tests having been made to establish its efficacy.

21. *Weltevreden.*

The spring on the farm Weltevreden, Division Beaufort West, rises from the Lower Beaufort Beds. It is suggested that the water from this spring and from Klipbank (25) comes from the same vein. Medical opinion holds that the water is of service in cases of chronic rheumatism, gout and eczema. There are no facilities for bathing. The water is cold. Traces of iodide have been found in it. The extraordinarily high amounts of lithium, sulphuretted hydrogen, and sodium sulphide are noticeable features.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	1.393	Cl	1.305
Li	0.236	SO_4	0.287
Ca	0.183	HCO_3	0.092
Mg	0.092	SH	0.065
Total	1.904	Total	1.749

22. *Ehrlich Forest, Near Bloemfontein.*

According to the analyses recorded in the tables, the composition of the water from this borehole shows remarkable variations. If I am not mistaken, the scheme which was at one time entertained for the erection of a sanatorium has been abandoned. The temperature of the water is 67°F.

There is a long list of sulphur springs which have never been analysed. About many of these I can record very little more than the mere fact of their existence.

23. *Farm Vlagfontein, Salt River Vlei, Division Beaufort West.*

Cold. Geological formation at surface Lower Beaufort beds.

24. *Stinkfontein, Division Prince Albert, 9 Miles from Fraserburg Road Station.*

Rises from Lower Beaufort beds. Daily yield about 10,000 gallons. Warm.

25. *Farm Klipbank, about half a mile from Siding of same name, Division Beaufort West.*

Borehole in Lower Beaufort beds. There is limited provision for accommodation and bathing in the shape of four sets of rooms, consisting of bedroom, sitting-room and kitchen, with bath-room attached. Each bath-room is fitted with a geyser for heating the water. Springs 21, 23, 24 and 25 are believed to be endowed with the same therapeutic properties, and have been successfully applied in cases of chronic rheumatism, gout and eczema. The water of Klipbank is also taken internally for constipation and indigestion.

26. *Farm De Bad, Division Hanover.*

Issues probably from Middle Beaufort beds. Total solids 11 grains per gallon, chlorine 2.1 grains.

27. *Kruidfontein, Division Willowmore (the property of Mr. B. J. Stegmann.*

From the Dwyka along Tygerberg axis.

28. *Spring on the Black Umfolosi River, 36 miles east of Vryheid.*

29. *Farm Sulphur Springs, District Piet Retief.*

30. *Farm Warmbad, District Piet Retief.*

31. *Farm Onverwacht, District Piet Retief.*

32. *Calais No.* 1286.

Hot spring 30 miles south of Rhodes Drift, on the Limpopo River. Yields approximately 400 gallons per minute. Highly purgative. Is visited by occasional trekboers.

33. *Vetfontein 2299,* 100 *miles north of Pietersburg, Transvaal.*

34. *Kapessa Hot Spring.*

This is situated 5 miles from the confluence of the Zambesi and Sanyati Rivers (Northern Rhodesia), 16° 35′ South Latitude, 28° 42′ East Longitude. The spring rises through a fissure in the basaltic rocks. The water is practically boiling, and so far as can be ascertained from the natives the temperature never changes. The vapour rising from it can be seen for miles. The water flows into a morass about half a mile distant, and the natives cut the grass there during the winter time and extract salt from the deposit. It is stated that this spring proves an immediate relief for malaria.

C. Iron or Chalybeate Waters.

35. *Zwartkops.*

The water issues from a borehole in the Uitenhage beds, at a depth of 3,600 feet. The temperature is 130° F., an unusally high temperature for a chalybeate spring, and 10° above that of Caledon. The daily yield is 165,000 gallons. There are at present eight trial bathrooms in service, and there is accommodation for a limited number of visitors, but the establishment of a properly equipped sanatorium is contemplated. Cures have been effected in cases of rheumatism, eczema, dyspepsia, gallstones, kidney troubles and female complaints. The water is reported to be highly radio-active. It is the only South African chalybeate spring containing sulphuretted hydrogen, namely, 0.124 of a gram per 100,000, and it contains, in addition, 6.662 grams of free carbon dioxide per 100,000. The spring was discovered in 1909, when drilling for pretroleum The gases in solution have been analysed by Sir J. Dewar. The composition of the gas is as follows:—

Carbon dioxide	3.43 per cent.
Oxygen	11.54 per cent.
Nitrogen, hydrogen, helium, and neon	85.03 per cent.

Amount of hydrogen, helium and neon 741 parts per 1,000,000. Analysis is taken from paper by J. G. Rose.*

TABLE OF ION EQUIVALENTS (Prof. Hahn's analysis).

Cations.		Anions.	
Na	0.519	Cl	0.568
K	0.052		
Ca	0.075	Br	0.004
Mg	0.097		
Fe	0.025	SO_4	0.071
Al	0.007	HCO_3	0.127
Total	0.775	Total	0.770

36. *Tooverwater Poort.*

The springs at Tooverwater Poort rise from folded and broken Table Mountain sandstone. The one which is used balneologically has a temperature of 120° F. The five analyses given in the tables are from various springs, and it is not clear which of them refer to the medicinal spring. However, they differ only slightly in composition. There is no adequate provision for bathing. Patients bathe in the pool above the spring. There is accommodation at the adjoining farmhouse, but the majority of the patients camp in tents and wagons.

37. *Balmoral.*

The water isssues apparently from Table Mountain sandstone, but the surface is obscured by superficial deposits of black and brown oxides and hydrates of iron, which have been traced to a depth of over 40 feet. There are several springs, all of which are appreciably warm, but no reliable record of the temperature exists. The reaction of the water is acid. The water contains no combined carbon dioxide; its iron (which is deposited as a brown flocculent precipitate on standing, and which lines the irrigation furrows) is present as sulphate. Hence the bitter and astringent taste. All the other South African chalybeate springs contain the iron as bicarbonate. In places the ferriginous deposit forms circular rings which have the appearance of volcanic vents. There were formerly bathing facilities, and the water is said to have afforded relief in cases of rheumatism, but for several years the water has fallen into disuse as a medicinal spring. The water is suitable for irrigation.

* *Rept. S.A. Assoc. for Adv. of Sc.* (1910), 202.

38. *Warmbad, Olifants River Bed.*

The spring is situated in the bed of the Olifants River, a few miles above the junction of the Olifants and Gamka Rivers, and about 30 miles south-west of the town of Oudtshoorn. It is dammed up to enclose a pond about 40 feet square and 3 to 4 feet deep. When the river is in flood everything is completely submerged. The temperature of the water is 114° F., and it rises from north-dipping Bokkeveld beds. The value of the iron is considerably below that usually considered necessary to impart to a spring the nature of a chalybeate water, but this may be due to partial precipitation of the iron before analysing. According to Juritz,

> Local opinion ascribes therapeutic properties to the water, and considerable numbers of people are said to have recovered from rheumatism by the use of the baths and the subsequent sweating to which patients are subjected. Many farmers from the surrounding district visit the spot throughout the year for treatment, while during the periods of drought the spring forms the sole source of water for all domestic purposes to every inhabitant within a radius of 12 miles.*

Medical opinion holds that the water is particularly efficacious in chronic arthritis and gout. The spring was already known as a medicinal spring over 60 years ago, and is referred to by Gumprecht,† but apparently the bathing conditions are as primitive now as they were then. There is nothing more than a few miserable reed huts in the immediate vicinity.

39. *Inungi.*

There are several chalybeate springs in the bed of the Umzimvubu River, on the farm Inungi, west of Kokstad. They issue from nearly horizontal Middle Beaufort beds. The one to which the analysis refers, has a temperature of 12° C., and is remarkable for its composition. The water is accompanied by gas, which seems to be mainly carbon dioxide mixed with a little sulphuretted hydrogen. About 1½ miles downstream a spring of similar nature, but slightly warmer (24.8° C.), issues from the bank of the river. Neither of the springs have apparently been used medicinally.

40. *Caledon.*

The Caledon springs issue from south-dipping Table Mountain sandstone of the Caledon mountains, and have a temperature of 120° F. The iron content of the Caledon water is of the same order as that of the Adelheidbrunnen, Langenschwalbach (1.477 grams per 100,000), or of the Geronstère spring, Spa, Belgium. In point of temperature the water was almost unique until the Zwartkops borehole was sunk. There are very few European chalybeate springs of higher temperature. The best-known is Bain Fort, Rennes les Bains, France (51° C.). The

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* C. F. Juritz: "Underground Waters of the Cape Colony," (1908), 17.

† "Die Mineralquellen auf dem Festlande von Afrika."

water and the air in contact with it are strongly radio-active, and the water is said to retain its radio-activity for a considerable period after bottling. The total yield of all the springs is 180,000 gallons per day. There is a well-appointed hotel and sanatorium. Provision is made for ordinary and electric massage and for electric baths. The visiting physician is in attendance at the sanatorium daily. In addition to the ordinary bathrooms a large swimming-bath has been erected. In 1897 Dr. C. W. B. Daniell wrote a brochure dealing with the therapeutic properties of the Caledon waters, and in 1908 Dr. W. Darley Hartley contributed a paper to the South African Medical Congress* containing, *inter alia*, a discussion of the effects produced by the treatment with the water All information about the history of the springs, the equipment of the sanatorium, etc., is contained in an illustrated pamphlet issued by the company owning the baths, and obtainable on application.

TABLE OF ION EQUIVALENTS (PROF. ATTFIELD'S ANALYSIS).

Cations.		Anions.	
Na	0.043		
K	0.054	Cl	0.112
Ca	0.033		
Mg	0.027	SO_4	0.029
Fe	0.048		
Al	0.096	HCO_3	0.037
Total	0.301	Total	0.178

D. SALT SPRINGS.

41. *Warmbad, South-West Protectorate.*

There are five springs emanating from crevices in granite with a temperature fluctuating between 99° and 102°. A considerable quantity of gas, mainly nitrogen, is constantly bubbling up with the water. Gumprecht's statement that this gas, which imparts a vigorous motion to the water, is mainly carbon dioxide, is not corroborated by Versfeld. The data given above are taken from Versfeld's paper, "Geology of German South-West Africa."† The only information obtainable about the sanative qualities of the water is a brief reference in William Eveleigh's "South-West Africa" (1915), 28-29.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	2.387		
K	0.024	Cl	1.996
Ca	0.814	SO_4	1.135
Mg	0.045	HCO_3	0.070
Total	3.270	Total	3.201

* Reprinted in the South African Medical Record, January 10th, 1909.
† *Rept. S.A. Assoc. for Adv. of Sc.*, Kimberley (1914), 227.

42. *Rietfontein, near Haagenstad, O.F.S.*

This saline spring is situated about two miles from the Haagenstad saltpan, and about 30 miles north-west-by-north of Bloemfontein. The spring, which has a temperature of 28-30° C, issues from a sand-hill which is capped by a layer of peat formed from the roots of trees, and this overlies a bed of bones and fossil remains. Fossilised bones of extinct types, as well as human implements, have been excavated here, some of which have been described by Dr. Broom in the *Annals of the South African Museum.* In order to offer better bathing facilities, the owner of the farm has had part of the peat removed, and has erected a primitive bath-house. Through the sand-floor of the bath streams of inflammable gas force their way in hundreds of places. This gas, which can only be a decomposition product of the peat, contains about 70 per cent. of marsh gas and 10 per cent. of hydrogen, the remainder being nitrogen. The water and the gas have not been tested for radio-activity. The bath is frequented by hundreds of patients every year, and many wonderful cures are reported. Medical opinion holds that the water is particularly efficacious in cases of muscular and articular rheumatism and sciatica.

TABLE OF ION EQUIVALENTS.

Cations.		Anions.	
Na	3.235		
Li	0.010	Cl	3.679
NH_4	0.003		
Ca	0.466	SO_4	0.005
Mg	0.007		
Ba	0.001	HCO_3	0.031
Fe	0.001		
Al	0.009	NO_3	0.001
Total	3.732	Total	3.716

E. ALKALINE WATERS.

43. *Msali.*

This spring is on the farm Msali, the property of Mr. M. F. B. Dennis, near Choma Station, North-West Rhodesia. It is known to be mildly aperient.

44. *Warmbaths.*

The spring at Warmbaths, Nylstroom, has a temperature of 140° F., and is described as a mildly alkaline water. Its radio-activity is too slight to be of any consequence. The bathing establishment is the property of the Transvaal Provincial Government. The water is strongly purgative, and is reputed to be efficacious in gout and rheumatism.

TABLE OF ION EQUIVALENTS (PROF. HAHN'S ANALYSIS).

Cations.		Anions.	
Na	0.677	Cl	0.224
Li	0.005		
Ca	0.052	SO_4	0.009
Mg	0.009		
Fe	0.007	CO_3	0.517
Total	0.750	Total	0.750

45. *Rupisi River.*

This hot spring is situated 10 to 15 miles east of the Sabi River, in South Melsetter, Rhodesia, and is described as a weak alkaline water.

46. *Junction of Odzi and Wengesi Rivers.*

This hot spring is situated on vacant land south of Umvumbu farm, near the junction of the above rivers, Umtali District, Rhodesia. It is described as a weak alkaline spring. It forms a deposit which has been submitted to analysis and found to contain:—

(1) Organic matter in small quantities;

(2) A large amount of sandy silica;

(3) A considerable quantity of soluble alkali salts, chiefly sodium bicarbonate, sodium chloride and sodium sulphate.

(4) Salts of iron, aluminium, magnesium, calcium and potassium in small quantities.

47. *Badplaats or Doornpoort, District Carolina.*

No complete analysis of the water was obtainable, but from the appended analysis of the solid residue the water would appear to be a sulphated alkaline water. It appears to contain sulphuretted hydrogen, but in view of the preponderance of alkaline carbonates, sulphates and chlorides in the dissolved salts, I should prefer to class it with the alkaline rather than with the sulphur springs. The spring is Government property, and is open to the public, but no system of control has been inaugurated, and the conditions of living and bathing are most primitive. I am informed that the "season" lasts from May to September, and that the farmers camp in tents and waggons. At times there are as many as 50 to 60 patients. The following description of the spring and its geological features is taken from the Annual Report of the Geological Survey for 1913, p. 40:—

"On the Government ground Badplaats, about 36 miles east of Carolina, the spring is situated almost in the bed of a small tributary to the Buffels Spruit, and about 300 yards north-west of the main road. It issues vigorously, like boiling water, from granitic rocks on the left bank of the little tributary at an unpleasantly high temperature, so that the waters of the stream have been deviated to cool down the temperature for bathing purposes. The waters of the spring are associated with a strong sulphur smell, and said to be an excellent curative agent for rheumatic complaints. No structural features indicating faults or disturbances were found in this neighbourhood to afford a clue as to the mode of origin of the spring." Amount of total solids, 39.1 grams per 100,000

Analysis of ignited total solids (Dr. McCrae, October, 1914):

Nacl	28.2 per cent.
Na_2SO_4	32.4 per cent.
Na_2CO_3 + sodium silicate (Na_2SiO_3?)	32.1 per cent.
$CaCO_3$	7.3 per cent.
Mg salts	trace.

G. Table Waters.

48. *Van Riebeek.*

The water issues from Malmesbury beds, on the slopes of the Tygerberg. The bottling department of the Van Riebeek Natural Mineral Water Co., Ltd., is at Bellville Station, and the water is conducted thither from its source between Bellville and Durbanville by 32,000 feet of tin piping.

49 *and* 50. *Grendel and Vasco.*

These flow like the Van Riebeek spring from Malmesbury beds on the Tygerberg.

Grendel Table of Ion Equivalents.

Cations.		Anions.	
Na	2.193	Cl	2.902
K	0.009	SO_4	0.301
Ca	0.439	HCO_3	0.128
Mg	0.833	NO_3	0.017
Total	3.474	Total	3.348

51. *Driebaden.*

The farm Driebaden is near Jagersfontein, O.F.S., and the water has recently been put on the market as a table water.

In the original report it is described as a mildly alkaline water similar to Apollinaris. The bathing arrangements are at present very primitive, but it is proposed to make adequate provision at a later date.

52. *Seltzbach.*

The Seltzbach water comes from a spring at Van der Merwe, a wayside station on the Delagoa Bay line, 21 miles from Pretoria. The spring was known as Gezondheits-Bronne to the old voortrekkers, and it seems to have attained a reputation among them as a specific for malaria and as an appetite stimulant. The present owners have deepened the well to a depth of 60 feet, and concreted the whole. To prevent surface infiltration, a small domed wellhouse is built over the eye. During the process of deepening the well, interesting native cooking and drinking utensils, supposed to be of considerable antiquity, were found.

53. *Wonder Water.*

Wonder Water comes from the farm Blaauwboschkuil, District Waterberg, Transvaal. Although its principal constituents are calcium and magnesium carbonates, it scarcely answers to the definition of an earthy water, inasmuch as it contains less than 0.4 gram of dissolved solids per litre. The United Mineral Water Company, of Pretoria, has taken over the management of Wonder Water, and has issued a pamphlet containing the analysis and other information about the water.

Unclassified Springs.

54. *Farm Tierbank, north of Lindley, O.F.S.*

55. *Winburg.*

The spring is situated on the Klein Vet River, below the old main road from Brandfort to Winburg, O.F.S.

56. *Welgevonden* 1772.

District Waterberg, Transvaal, 20 miles north-west of Naboomspruit Station. Hot. Yield said to be approximately 100 gallons per minute.

57. *Rietfontein, adjoining Welgevonden.*

58. *Buffelsvlei* 196, *Right Bank of Steelport River.*

Tepid. Used by farmers against rheumatism.

59. *Chipese, on the N'Jelele River, 60 miles north-east of Louis Trichardt.*

Very hot.

60. *Adrianskop, on the Olifants River, south of Pietersburg.*

61. *Stindal, east of Rhodes' Drift.*

Slightly thermal.

62. The Report of the Government Analyst for 1900 refers to a spring on a farm near Diep River, C.P., which is credited with stimulating the kidneys when taken internally. It contains a little lithium. My repeated efforts to obtain definite information about the exact locality and nature of the spring have proved fruitless.

63. In the vicinity of Dysselsdorp Mission Station, District Oudtshoorn, there is a cold spring which was formerly successfully used for rheumatic affections. It is now only utilised for irrigation purposes.

64. In the Sebungwe District, Southern Rhodesia, there are some hot springs which are used medicinally by the aborigines. The following information is taken from a report sent by some natives to ascertain the whereabouts of the spring, and kindly placed at my disposal by Mr. Maufe, of Bulawayo: "The springs are situated at the south end of a range of kopjes in a hollow, about seven miles south of the Zambesi River. From the springs the local people procure their salt. The method of doing this is by gathering up the grass which has been encrusted by deposits from the water. The grass is then boiled, and when the water has evaporated the salt remains. The water, which is very hot, comes out of a hole in a single rock which is isolated, and when issuing makes a noise like a small steam-engine working. The steam can be seen rising at some distance before the spring is reached. The water has healing properties. The sick people make a practice of bathing in it."

65. On a farm called Wildepaarde Jacht, in the field-cornetcy Klein Drakenstein, about four miles east of Paarl, at the foot of the Drakenstein Mountains, there is a medicinal spring. Some considerable time back an attempt, which, however, proved abortive, was made to exploit the spring.

66. *Gannafontein, District Boshof, O.F.S.*

There are a number of springs covering an area of four or five morgen. The main spring has a temperature of 75° F. and a yield of approximately 4,500 gallons per hour, and is accompanied by a constant discharge of inflammable gas. There is a well-constructed bath, 20 feet square and about four feet deep, at the main spring, and satisfactory provision is made for accommodation. The springs are distant about six miles from Dealesville.

67. In the bed of the Tugela River, 4½ miles above Middle Drift, there is a spring which is hardly mineralised, but which is reputed to be medicinal, and is patronised by the farmers during the winter months. Its temperature is 124.9 to 126.3° F., and it issues from a fault-line in hornblende gneisses which is accompanied by much crystalline calcite.

Of the many lessons the war has taught us, none is more impressive than the necessity for every nation and country to be as self-contained and as independent, economically speaking, as possible. This paper on the existing and future health resorts of our country will, it is hoped, be a contribution, however humble, to the solution of the problem of finding everything we require within our own boundaries.

I record with gratitude the assistance I got in my efforts from individuals and corporations over the whole of the country. Everybody that was likely to be in possession of any information bearing on the subject was approached by me, and everywhere I found the utmost willingness to co-operate. In spite of the fact that no efforts were spared on my part to make the paper

complete, I feel that there must still be a considerable amount of information which I have not succeeded in collecting. I am particularly indebted to Dr. A. W. Rogers and Dr. A. L. du Toit, of the Geological Survey, for furnishing me with geological notes about the springs in the Cape Province; to Mr. A. L. Hall, of the Geological Survey, Pretoria, for a list and description of the majority of the Transvaal springs; to Mr. H. B. Maufe, Director of the Geological Survey, Bulawayo, for supplying me with information about the Rhodesian springs; and to Dr. C. F. Juritz, of Capetown, and Dr. McCrae, of Johannesburg, for placing many of the analytical data at my disposal. I also received valuable assistance from: Prof. P. D. Hahn, Dr. W. Versfeld, Dr. W. Darley-Hartley, Capt. Dunley-Owen, M.D., Professor A. Young, of Capetown; Rev. Mr. Smit, Muizenberg; Dr. A. L. de Jager, M.L.A., Paarl; Mr. I. Meiring, Worcester; Dr. Bensley, Beaufort West; the Caledon Baths Ltd.; Dr. Baumann, Mr. Frood, Capt. Heywood, Bloemfontein; Miss Wilman, J. W. Ross, Librarian, Public Library, Kimberley; the New Transvaal Chemical Company, Delmore; Dr. Wagner, Lieut.-Col. J. G. Rose; Dr. H. Brauns, Willowmore; Dr. Querney, Port St. John's; Mr. F. Dawson, General Manager of the New Cape Central Railway, Ltd.; Mr. H. F. Walker, Senr., Choma, North Rhodesia; Mr. T. N. H. Janson, Dullstroom; Dr. J. W. Matthews, Lilani; Mr. H. A. van Schalkwyk, Standerton; Mr. O. F. Brotherton, African Farms, Ltd., Johannesburg; Mr. H. Magennis, Balmoral, Uitenhage; Mr. F. Muller Rex, Oudtshoorn; Mr. J. Laing, Algoa Mining Company, Ltd., Port Elizabeth; Mr. A. Coster, Mr. G. Baumann, Bloemfontein; Dr. Macrae, Clocolan; Mr. J. Horne, Parys; Mr. Chas. McCulloch, Lindley; Provincial Secretary, Pretoria; Mr. A. C. Mitchell, Jagersfontein; the Van Riebeek Natural Mineral Water Co., Ltd., Capetown; the United Mineral Water Co., Pretoria; Rev. Mr. Blazey, Dysselsdorp; the Secretary of the Transvaal Medical Council; *The Medical Journal of South Africa;* the Secretary, Colonial Medical Council; Mr. A. E. V. Zealley and Mr. G. Arnott, Curator, Rhodesia Museum, Bulawayo; the Magistrate, Piet Retief; and the Mayors and Town Clerks of Aliwal North, Bloemfontein, Clanwilliam, Colesberg, Graaff-Reinet, Machadodorp, Malmesbury, Willowmore, Worcester, Uitenhage and Vryheid.

Transmission of Sound Waves.— Dr. C. Davison, in the course of an article in *Nature*,* says that the most remarkable result of recent investigations, with regard to the transmission of sound waves by the atmosphere, is the recognition of the fact that there is sometimes a zone of silence separating two detached sound areas. This zone has been traced in 22 recent explosions, of which two were due to gun-firing, four to explosions of dynamite or gunpowder, and 16 to volcanic explosions.

* 98 (1917), 438-9.

SERIES OF TABLES NO. I.—ANALYSES GIVEN IN THE ORIGINAL FORM.

A. Indifferent Waters.

Locality	District or Division	Temperature	Total solids at 105°C	Total solids at 180°C	Total solids by addition	SiO_2	$Al_2O_3 + Fe_2O_3$	CaO	MgO	Alkalies as Na_2O	K_2O	Li_2O	Cl	SO_3	Combined CO_2	$CaCO_3$	$Ca(HCO_3)_2$	$Fe(HCO_3)_2$	NaCl	KCl	LiCl	$MgCl_2$	Na_2SO_4	$CaSO_4$	$MgSO_4$	Analyst; Source and Date of Analysis
Brandvlei ..	Worcester ..	145°F	6.77	..	..	2.16	0.34	..	..	..	..		..	..	..	1.50			1.33	..		0.27	..	1.17		Report* 1896
			..	8.4	..	2.71	0.14	0.51	0.28	1.09	..		1.16	0.29	0.68	..				..	..	..	..	..	..	Report for Half Year ended June 1904.
Goudini .	Worcester ..	104°F	..	5.4	..	2.02	nil	1.30	trace	1.25	..		0.88	0.17	0.43	..					..	..	..	..		Report 1908
Olifants River	Clanwilliam	108-110°F	5.6		..	1.57	0.18	0.38	0.35	no value given	..	..	1.20	trace	not determined			..	..	..		..	..	..		Underground Waters †
Montagu .	Robertson ..	112.3°F	15.6		..	1.9	0.3	0.4	0.4	no value given	..	..	1.3	0.1	..	..	..	..	..		..		..	..		Underground Waters
			12		..	2.02	0.26	0.58	0.26	no value given	..		1.3	0.2				..	..		..		..	..		Underground Waters
			..		6.319	0.812	Al_2O_3 0.686	..	..	..				..	..		1.634	0.061	1.155	0.469	0.007		0.476	0.105	0.924	Dr. R. Marloth in pamphlet issued by New Cape Central Railway Co
Barrydale	Swellendam		..	12.3	..	3.34	0.26	1.57	0.33	2.08			2.30	0.39	1.87			..	..	..	..		..	..	..	Report 1908
Tarka Bridge	Cradock ..	80.4°F	..	38.8	..	1.76	0.06	3.82	1.23	13.67	small quantity	trace	13.79	0.33	5.33		..	..	..				..	..	..	J. G. Rose in Report 1905

Unless otherwise stated, the results in the Series of Tables No. I are given in grains per gallon.

* Abbreviation for "Report of the Senior Analyst, C. F. Juritz, Cape of Good Hope."

† Abbreviation for "Underground Waters of Cape Colony." Presidential Address, 1908, to the Cape Chemical Society by Dr C. F. Juritz, reprinted in the *Agricultural Journal of the Cape of Good Hope*, May-July, 1908.

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... which I have not succeeded in collecting. I an

detached sound areas. This zone has been traced in ...
explosions, of which two were due to gun-firing, four to exp
sions of dynamite or gunpowder, and 16 to volcanic explosions.

* 98 (1917), 438-9.

SERIES OF TABLES No. II. ALL CONSTITUENTS ARE CALCULATED AS IONS IN GRAMS PER 100,000

A. Indifferent Waters.

Locality	Temp. °C	Solids at 105°	Solids at 180°	Solids addition	Ca	Mg	Fe	Al	Na	K	Li	Cl	SO_4	HCO_3	SiO_2	Analyst and Source
Brandvlei ..	62	9.655	..	..	1.345	0.103	(0.339)	(0.257)	0.898	..	..	1.683	1.181	1.305	3.081	Report 1896
		..	11.98	..	0.520	0.241	(0.140)	(0.106)	1.153	..	..	1.654	0.496	1.345	3.865	Report 1904, Jan-June
Goudini ..	40	..	7.701	..	1.325	trace	nil	nil	1.323	..	..	1.255	0.291	0.850	2.881	Report 1908
Olifants R. Clanwilliam	42-43	7.987	..	..	0.387	0.301	(0.180)	(0.136)	no value given	..	..	1.711	trace	no value given	2.239	Underground Waters
		22.248	..	..	0.408	0.344	(0.299)	(0.227)	no value given	..	..	1.854	1.711	no value given	2.710	Underground Waters
Montagu ..	45	17.114	..	..	0.591	0.224	(0.259)	(0.197)	no value given	..	..	1.854	3.422	no value given	2.881	Underground Waters
		..	..	9.027	0.620	0.266	0.027	0.519	0.868	0.351	0.0016	1.326	1.616	1.814	1.158	Dr. Marloth pamphlet N.C.C. Railway, Ltd.
Barrydale ..	..	..	17.542	..	1.600	0.284	(0.259)	(0.197)	2.783	..	..	3.280	0.667	3.698	4.763	Report 1908
Tarka Bridge	27	..	55.336	..	3.894	1.058	(0.060)	(0.045)	14.465	distinct trace	minute trace	19.667	0.565	10.540	2.510	Report 1905, J. G. Rose

B. SULPHUR SPRINGS.

Locality	District or Division	Temperature	Total solids at 105°	Total solids at 180°	Total solids by addition	SiO_2	Al_2O_3 and Fe_2O_3	CaO	MgO	Alkalies as Na_2O	K_2O	Li_2O	Cl	SO_4	Combined CO_2
Aliwal North ..	.. Aliwal North ..	95°F.	..	..	..	1.02	..	..	..	..	..	..		.	..
Fort Beaufort	.. Fort Beaufort	.	32.20	..	..	2.62	0.30	..	..	..	..	trace	..		
Malmesbury ..	.. Malmesbury ..	94°F.	..	..	..	3.15	0.43	..	..	..	.		..		..
Isinuka I ..	.. Pondoland ..	67°F.	2455.4	..	..	2.43	0.70	39.22	15.40	1035.26	..		725.44	436.90	200.51
			.	2356.0	..	2.06	trace	36.20	15.57	1077.74			679.11	425.14	162.24
Isinuka II ..	.. ..	..	2348.6	..	..	2.12	0.58	39.52	13.98	995.35	..	..	678.39	425.90	192.61
Majesfontein ..	.. Worcester ..	..	69.65	..	..	1.05	1.75	..	.	..			..	.	..
Zongala Geyser	.. N. Rhodesia ..	52-97°C.	62.2	..	..	6.00	..	..	..	..			..		..
Gua Geyser ..	.. N. Rhodesia ..	26-63°C.	..	..	..	3.72	..	..	.	..	..		..	..	.
Koubad (warm)	.. Utrecht ..	105°F.	..	..	..	6.29	Al_2O_3 0.25, Fe_2O_3 0.02	..	..	.	..		..	.	..
			27.34	..	..	5.92	0.21	..	..	..	.		.	.	..
Koubad (cold)	..	.	26.12	..	..	5.90	0.23	..	..	..			..		..
Sulphur Springs	.. Zoutpansberg	..	..	..	22.85	..		..	..	..	.		..	..	.
Farm Geluk 29 (near Machadodorp)	Carolina ..	81.5-83.3°F.	24.4	..	..	3.04	..	1.71	trace	..	0.29	trace	4.9	..	
			..	..	..	1.87	0.17	..	..	..	.	..	..		.
Cradock	.. Cradock ..	..	13.60	..	..	3.08	0.13	0.40	0.27	..		.	1.77	1.33	..
Graaff-Reinet (Rynheath)	Graaff-Reinet	..	..	27.20	.	2.80	0.50	2.82	trace	7.88			4.25	2.40	..
Lilani ..	.. Umvoti	37-39.5°C.	..	..	22.742	..	..	..	..	..	..		.	..	..
Lochinvar, Magoye	.. N. Rhodesia ..	..	..	..	..	7.07	nil								
Weltevreden ..	.. Beaufort West	..	..	..	..	1.442	0.152	..	..	..	..		..	.	..
Ehlich Forest	.. Bloemfontein	67°F.	38	..	..	0.92	Fe_2O_3 0.14, Al_2O_3 0.18	..	..	..		.	..	.	..
			..	..	32.07	0.72	.	..	..	..	..		..	..	..
			..	..	31.148	1.24	Fe_2O_3 0.14, Al_2O_3 0.17	..	..	..	.		.	.	..
								..	..	..	.	..	..	..	..
			.	..	28.430	0.62	Fe_2O_3 0.06, Al_2O_3 0.13	..	..	..	.		..	.	..
			21.385	..	..	1.066	0.210	..	..	..	..		..		..

Locality	Na_2CO_3	K_2CO_3	Li_2CO_3	$MgCO_3$	$CaCO_3$	$FeCO_3$	NaCl	KCl	LiCl	NH_4Cl	$MgCl_2$	$CaCl_2$	NaBr
Aliwal North	.	..	0.85	..	7.41	..	61.35	..	..	.	..	8.10	0.12
Fort Beaufort	0.487	..	..	0.495	1.89	..	23.107	0.327	..	..			trace
Malmesbury	..	..	..	..	5.523	..	66.08	..	..	..	..	..	0.175
Isinuka I	..	.	..	..	.	..	..		..	..	..	..	..
	..				..		..	..		..	..	..	..
Isinuka II	..	.	.	.				..	..	..		..	..
Majesfontein	..	..	..	..	12.00	..	21.35	..	..	..	12.88	..	..
Zongala Geyser	..	..	.	..	2.10	..	12.93	41.17	..	.	..		..
Gua Geyser	..	..	..	..	1.98	.	6.06	16.54	..	.	trace	..	..
Koubad (warm)	8.1				..	..	5.12	1.13		..	0.24		..
	0.55	12.14	..		0.57	.	7.33	..	..	..	..	.	..
Koubad (cold)	0.79	7.70	.	..	0.57	.	7.67	..	.	..	.	.	.
Sulphur Springs	4.0	..	..	0.5	0.5	..	9.25	..	..	..		..	..
Farm Geluk 29 (near Machadodorp)	..	..	..	..	..	..	..	..	..	..		.	..
	3.52	0.25	..	0.48	2.23		5.85	..	0.14	..	..	..	
Cradock	..	..		..	..	..	..		.	..		..	..
Graaff-Reinet (Rynheath)	..			..	.	..	..	..	..	..		..	.
Lilani	2.676	..	.	..	0.412	0.116	1.165	3.103	..	0.480	..	..	..
Lochinvar, Magoye													
Weltevreden	..	..	..	4.41	6.65	..	52.65	..	..	..	..	..	.
Ehlich Forest	..	..	..	..	6.428	..	13.845	..	7.016	..	..	..	..
	..	..	.	.	4.76	..	24.15	2.80	1.78	.	..	..	RBr 0.05
	..	.		.	4.82	.	23.86	..	..	..	.	.	..
	..				2.45	..	31.96	2.94	0.29		0.28	1.72	..
	..	..		..	4.02		20.42	0.63	0.053	..	..	..	0.016
	..	..		trace	2.103		16.176	trace	trace			..	..

Locality	Na_2SO_4	K_2SO_4	$MgSO_4$	$CaSO_4$	$Al_2(SO_4)_3$	$NaNO_3$	Na_2SiO_3	H_2S	Na_2S	Na_2SO_3	$Na_2S_2O_3$	Analyst, Date and Source of Analysis	Remarks
Aliwal North	.	0.95	1.95	..	3.21	..		0.056	..	..	..	Prof. P. D. Hahn; Pamphlet issued by municipality of Aliwal North	
Fort Beaufort	1.647	..	..	..		..		0.787	..	..	.	Report, 1907	
Malmesbury	..	trace	2.16	5.321	..	..	.	0.06	..	..	.	Prof. P. D. Hahn; Prospectus issued by proprietor of Baths	
Isinuka I	..	..	..	.	..	..	..	..			..	Report, 1907	
	..	..		.	.							Report, January-June, 1904	
Isinuka II	..	..						..			.	Report, 1907	
Majesfontein	..	..	4.83	3.64	..		.	1.02			..	Report, 1897	
Zongala Geyser	..	..			..		..	..	..	..	..	D. Ferguson, Proceedings of the Rhodesia Scientific Association, Vol. III, 1902, pp. 9-18	Analysis — Grams per 100,000
Gua Geyser	..	..	.	.	.		..	..			..		do. do.
Koubad (warm)	3.18							good deal present but amount not determined	..		..	Smitz du Mont, 1899	do. Traces of phosphates and "Half gebonden koolzuur"
	..	2.76	0.41			trace				.	.	T. Perrin, 1897	Grams per 100,000
Koubad (cold)	2.00	.	trace			..			.		..	T. Perrin, 1897	do. do.
Sulphur Springs	..	..	0.2			.	5.4	..		..	..	Dr. J. McCrae, Govt. Lab., Johannesburg, 1916	do. do.
Farm Geluk 29 (near Machadodorp)	..	..	..					.			..	Dr. J. McCrae, Govt. Lab. Johannesburg	do. do.
	..	..	0.47	.			..	0.047	0.016	..	..	Prof. P. D. Hahn, 1912. Report issued by the company owning the spring	
Cradock	..	.		..		..		..	..	..	..	Report, 1902	
Graaff-Reinet (Rynheath)				.			.		.	..	..	Report, 1906	
Lilani	4.178	..	0.525	..		..	10.588	.	..	0.307	0.012	A. Heymann, Prospectus of Sanatorium.	Also contains a trace of phosphates
Lochinvar, Magoye													
Weltevreden	83.30		..	11.57			..	1.96	..	..	.	G. A. Pingstone, 1914	
Ehlich Forest	9.659	..	3.888	..			..	9.565	3.552	..		Dr. Hahn, 1911	
		.	0.36	2.41				0.016	0.012	..	..	Dr. Hahn, 1913	
	.		0.14	2.73	..			..	..		..	Dr. Marloth, 1913	
	..	..	..	2.78	..	KNO_3 0.35	..	..	H_2S combined 0.014	.	..	Thresh and Beale, 1913	
	..		0.12	2.27	..	..	..	0.011	0.031	..	..	Dr. Marloth, 1913	Contains NaI 0.006
	0.351	.	..	0.954	..	..	..	trace	trace	.	..	Govt. Lab., B'fontein, 1914	

B. SULPHUR SPRINGS.

Locality	Temp °C	Solids at 105°C	Solids at 180°C	Solids by Addition	Ca	Mg	Fe	Al	Na	K	Li	NH_4	Cl	Br	SO_4	HCO_3	SiO_2	H_2S	SH	SO_3	S_2O_3	Analyst, Date and Source of Analysis
Aliwal North	35	..	..	..	8.406	0.562	..	0.732	34.462	0.608	0.229	..	60.451	0.133	6.856	7.441	1.483	0.079	..	..	.	Dr. Hahn. Pamphlet issued by municipality of Aliwal North
Fort Beaufort	..	45.924	..	..	1.080	0.204	(0.299)	(0.227)	14.027	0.245	trace	..	20.212	trace	1.588	2.554	3.737	1.122		..	..	Report 1907
Malmesbury .. .	34.5	..	..	..	5.391	0.622	(0.429)	(0.325)	37.134	trace	..	..	57.164	0.194	7.816	4.801	4.493	0.086	.	.	..	Dr. Hahn Prospectus issued by proprietor of Baths
Isinuka I ..	19.5	3501.8	..	..	39.98	13.248	(0.698)	(0.529)	1095.5	..	..	..	1034.6	..	747.61	396.51	3.466	..	.	..	..	Report 1907
	..	..	3360.2	..	36.991	13.394	trace	trace	1140.1	..	..	..	968.55	..	727·45	320.84	2.938	..	..	..	.	.. 1904
Isinuka II	..	3349.6	..	..	40.285	11.983	(0.579)	(0.439)	1053.3	..	..	..	967.51	..	728.8	381.28	3.024	..	..	..	.	.. 1907
Matjesfontein	..	99·385	..	..	8.726	6.082	trace	1.324	11.98	..	..	..	32.148	..	9.160	10.953	1.198	1.455	..	..	..	„ 1897
Zongola Geyser	52·97	62.2	..	..	0.841	..	..	..	5.087	21.59	..	..	27.423	..	..	1.280	6.00	..	..	..	..	D. Ferguson. Proceedings of the Rhodesia Scientific Association. Vol. III. 1902
Goa Geyser	26·63	..	..	..	0.793	trace	..	..	2.384	8.674	..	..	11.542		..	1.207	3.72	.	..	..	.	
Koubad (warm)..	40.6	..	..	..	..	0.061	0.014	0.133	6.559	0.593	..	..	3.822	.	2.150	4.662	6.29	..	..	.	.	Smitz du Mont, 1899
	..	..	..	..	0.228	0.042	(0.147)	(0.111)	3.123	8.108	..	..	4.446	.	1.689	6.023	5.92	.	.	..	.	J. Perrin, 1897
Koubad (cold)	..	26.42	..	..	0.228	trace	(0.161)	(0.122)	4.008	4.357	..	..	4.652	.	1.352	4.201	5.90	.	..	..	.	J. Perrin. 1897
Sulphur Springs, Zoutpansberg	..	..	..	22.85	0.14	0.17	..	..	3.6	..		..	5.6	.	0.17	3.559	3.675	..	..	.	..	Dr. McCrae, Govt. Lab. Johannesburg. 1916
Farm Geluk 29 .	27.5-28.5	24.4	..	..	1.222	trace	..	..	..	0.241	trace	..	1.9	..	..	..	3.04	..	..	..	..	Dr. McCrae, Govt. Lab. Johannesburg
(near Machadodorp)	..	..	..	..	1.274	0.338	(0.170)	(0.129)	5.475	0.202	0.033	..	5.228	..	0.525	5.481	2.667	0.067	0.0097		..	Dr Hahn, 1912. Report by company owning the spring
Cradock	..	19.397	..	..	0.408	0.233	(0 130)	(0.098)	..	..	..	..	2.524	.	2.276	..	4.393	..	..	..	..	Report, 1902
Graaff-Reinet	..	..	38.793	..	2.875	trace	(0.499)	(0.378)	8.285	..	..	..	6.061	..	4.107	..	3.993	..	..	..	..	,, 1906
Lilani	37-39.5	..	..	..	0.235	0.151	0.100	..	10.252	2.321	..	0.207	3.519		1.627	2.829	7.446	..	..	0.278	0.121	A. Heymann. Prospectus of Sanatorium
Lochinvar	..	..	.	..	8.657	1.814	nil	nil	68 009	..	..	..	45.548		91.976	10.331	10.084	2.795	..	..	..	G. A. Pingstone, 1914
Weltevreden	..	..	..	..	3.672	1.120	(0.152)	(0.145)	32.047	..	1.650	..	46.285	..	13.741	5.588	2.057	13.67	2.146	..	..	Dr. Hahn, 1911
		54.195	..	..	3.731	0.104	0.140	0.136	13.561	2.118	0.419	..	24.912	0.048	2.835	4.138	1.312	0.023	0.007	..	..	Dr. Hahn, 1913
		..	.	45.738	3.786	0 040	..	..	13.388	..	..	..	20.642	..	2.906	4.016	1.027	..	..	..	..	Dr Marloth, 1913
Ehrlich Forest ..	19.5	..	.	18.701	3.453	0.102	0.014	0 129	12.322	2.392	0.054	..	23.13	trace	2.798	2.130	1.769	..	0.019	..	..	Thresh and Beale, 1913 (also contains NO_3 0.306)
		..	..	40.547	3.250	0.035	0.080	0.098	11.502	0.471	0.012	..	18.155	0.051	2.421	3.495	0.884	0.006	0.021	..	.	Dr. Marloth, 1913 (also contains I 0.007)
		30.499	..	..	1.602	trace	(0.210)	(0.159)	9.238	trace	trace	..	13.994	..	1.298	1 829	1.520	trace	trace	..	..	Govt Lab Bloemfontein, 1914

C. CHALYBEATE SPRINGS.

Locality	District or Division	Temperature	Total solids at 180°	Total solids by addition.	SiO_2	CaO	MgO	Alkalies as Na_2O	Cl	SO_3	Combined CO_2	Na_2CO_3	K_2CO_3	$MgCO_3$	$Mg(HCO_3)_2$	$CaCO_3$	$Ca(HCO_3)_2$	NaCl	KCl	$MgCl_2$	KBr	Na_2SO_4	$MgSO_4$	$CaSO_4$	Al_2O_3 + Fe_2O_3	$FeCO_3$	$Fe(HCO_3)_2$	H_2SiO_3	Analyst, Source and Date of Analysis
Zwartkops ..	Uitenhage ..	130° F	..	..	..	..	..	..	..	..	..	..	..	..	1.344	..	4.269	21.290	2.534	..	0.326	..	3.001	..	Al_2O_3 0.087	..	1.585	3.380	Dr. Hahn; Prospectus for proposed Sanatorium issued by Algoa Mining Co., Ltd., 1914
			..	..	..	0.88	1.76	13.82	15.52	1.75	2.48	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Report, 1909
			38.8	..	2.04	0.98	1.76	13.85	15.93	1.65	1.75	..	..	..	..	..	..	..	..	..	..	..	..	..	0.80	..	..	..	Report, 1909
			35.0	..	1.60	..	.	..	..	..	..	..	..	2.17	..	2.06	..	25.71	..	..	..	..	3.07	..	Al_2O_3 0.02	..	1.66	..	J. G. Rose in Report, 1910
			..	..	..	..	..	..	..	..	..	..	..	2.21	..	1.57	..	25.57	..	..	..	0.61	2.12	..	..	1.86	..	..	From paper by G. W. Smith; Report S.A. Assn. for Adv. of Science, 1912
Tooverwater Poort ..	Uniondale ..	120° F	8.60	..	1.04	0.42	0.34	1.88	2.83	0.25	0.16	..	..	..	..	..	..	..	..	..	..	..	..	..	0.30	..	..	..	Report 1906
			9.24	..	0.90	0.46	0.61	2.36	3.08	0.79	0.37	..	.	..	..	..	..	..	..	..	..	..	..	..	0.42	..	..	..	
			7 00	..	0.66	0.31	0.48	1.65	2.52	0.46	0.16	..	..	..	..	..	..	..	..	..	..	..	..	..	0.16	..	..	..	
			6.72	..	0.79	0.28	0.42	1.52	2.24	0.41	0.16	..	..	..	..	..	..	..	..	..	..	..	..	..	0.14	..	..	..	
			6.44	..	0.68	0.26	0.36	1.71	2.52	0.31	0.16	..	..	..	..	..	..	..	..	..	..	..	..	..	0.12	..	..	..	
Balmoral ..	Uitenhago ..	..	29.6	..	2.08	1.74	1.38	8.31	2.90	12.70	nil	..	..	..	..	..	..	..	..	..	..	..	..	..	4.86	..	..	..	Report, 1908
Warmbad, Olifants River	Calitzdorp ..	114° F	10.2	..	2.66	1.15	0.43	2.99	2.30	0.54	1.11	..	..	..	..	..	..	..	..	..	..	..	..	..	0.29	..	..	..	Report, 1908
Inungi, Bed of Umzimvubu River	Mount Currie	12° C	115.8	..	7.76	..	..	..	..	..	..	28 19	..	0.29	..	75.46	..	0.73	..	..	..	..	0.48	..	Al_2O_4 nil	7.69	..	..	J. G. Rose in Report, 1908
Caledon ..	Caledon ..	120° F	..	13.348	1.802	..	..	..	..	..	..	..	trace	..	..	trace	..	4.027	..	..	..	0.862	1.054	1.624	Al_2O_3 0.756	..	3.223	..	Dr. Hahn; Addresses and Papers, Brit. and S African Associations for the Advancement of Science, 1905, Vol. I, p. 253
			..	12.189	2 222	..	..	..	..	..	..	.	..	0.576	..	0.210	..	1.745	2.815	0.267	..	..	..	1.314	Al_4O_3 1.11	1 930	..	..	Prof. J. Attfield, 1897. Pamphlet issued by the Caledon Baths, Ltd
			..	11.62	3.05	..	..	..	..	..	..	0.23	..	..	..	1.01	..	1.22	..	..	..	..	1.05	0.79	Al_2O_3 0.06	1.20	..	..	Report, 1896

C. CHALYBEATE SPRINGS.

Locality	Temp. °C	Solids at 150°C	Solids at 180°C	Solids by addition	Ca	Mg	Fe	Al	Na	K	Cl	Br	SO_4	HCO_3	SiO_2	Analyst, Source and Date
Zwartkops ..	..	..	..	..	1.506	1.183	0.710	0.066	11.946	2.050	20.137	0.312	3.415	7.732	3.712	Dr. Hahn, 1914
	..			..	0.897	1 514	..	..	14.624	..	22.134	..	2.995	4.904	..	Report, 1909
	54.5	..	55.336	..	0.999	1.514	(0.798)	(0.605)	14 655	..	22.719	..	2.823	3.461	2.909	,, ,,
	..	..	49.917	..	1.177	1.777	0.743	0.015)	14.426	..	22.241	..	3,494	5.654	2.282	J. G. Rose, Report, 1910
	..	..	..	..	0.897	1.520	1.279	..	14.630	..	22.119	..	2.001	5.042	..	Report, S.A. Assoc. for Adv. of [Science, 1911
Tooverwater Poort	..	..	12.265	..	0.428	0 293	(0.299)	(0.227)	1.989	..	4 036	..	0.428	0.316	1.483	Report, 1906
	..	..	13.178	..	0.469	0.525	(0.419)	(0.318)	2.497	..	4.393	..	1.352	0.732	1.284	
	49	..	9.984	..	0.347	0.413	(0.160)	(0.121)	1.746	..	3.594	..	0.787	0.316	0.941	
	..	..	9.584	..	0.285	0.361	(0.140)	(0.106)	1.608		3.195	.	0.702	0.316	1.127	
	..	..	9 185	..	0.265	0.310	(0.120)	(0.091)	1.809	..	3.591	..	0.531	0.316	0.970	
Balmoral	..	..	42.215	..	1.774	1.187	(4.848)	(3 676	8.793	..	4.136	..	21 732	nil	2.966	,, 1908
Warmbad (Olifants River)	45 6	..	14.547	..	1.172	0.370	(0.289)	(0.219)	3.164	..	3.280	..	0.924	2.195	3.794	,, 1908
Inungi	12	..	165 15	..	43.078	0 120	5.287	nil	18.063	..	0.628	..	0.462	94.841	11.067	,, 1908. J. G. Rose
Caledon ..	..	..	..	19.04	0.682	0.304	1 443	0.572	2.658	trace	3.484	..	3.665	3.153	2.570	Dr. Hahn, 1905
	49	..	..	17.384	0.671	0.331	1.329	0.840	0.978	2.102	3.993	..	1.387	2.227	3.169	Prof. Attfield, 1897
	..	..	..	16.573	0.917	0.301	0.832	0.045	2.510	..	3 651	..	2.002	1.958	4.350	Report, 1896

D. SALT SPRINGS.

Locality.	Temp. °C	Solids 105°C	Solids at 180°	Solids by addit'n	Ca	Mg	Ba	Fe	Al	Na	K	Li	NH_4	Cl	SO_4	CO_3	HCO_3	NO_3	PO_4	SiO_2	Analyst, Source and Date of Analysis
Warmbad	37.2-39	..	..	..	16.322	0.550	..	(0.120)	(0.091)	54.892	0.957	..		70.770	54.520	..	4.268	trace	..	8.315	Dr. Versfeld, Report S.A. Assoc. for Adv. of Science 1914
Rietfontein	28-30	..	228.11	..	9.342	0.079	0.074	0.033	0.085	74 405	nil	0.069	0.062	130.458	0.228	..	1.869	0.038	trace	2.186	Dr. Rindl, ,, ,, ,, ,, ,, 1915
E. ALKALINE WATERS.																					
Msah		..		..	trace	trace	..	trace	trace	16.251	..	..	..	2.881	20.446	5.990	..	..	..	14.019	Geo. Pingstone. 1912
		..	..	..	1.040	0 104	..	0.199	..	15.568	..	0.032	..	7.933	0.410	15.503	..	..	..	3.494	Dr. Hahn, Union-Castle Guide to S.A
Warmbaths, near Nylstroom	60	..	..	36.40	0 89	..	..	faint trace	faint trace	13.47	..	marked trace	..	8.35	0.81	5.50	..	..	..	5.833	Dr. McCrae 1916
															2.232	8.605	..	..	..	5.67	.. .. January 1908
		37.16	..	..	1.008	0.094	..	(0.322)	(0.244)	10.981	1.445	trace	..	6.16	0.599	..	..	..	..	..	.. ,, November 1908
		37.45	..	..	1.108	trace	..	..	..	..	..	..	..	6.23	2.157	13.227	..	..	..	8.74	A. G. Holborow. 1916
Rupisi River	..	37.8	..	..	0.320	0.072	..	(0.147)	(0.111)	9.026	..	..	..	4.895	3.219	13 432	..	..		5.36	 1915
Junction Odzi and Wengesi Rivers ..	.	36.4	..	..	0.353	0.144		(0.546)	(0 414)	8.512	..	..		3 318							

D. SALT SPRINGS.

Locality	District or Division	Temperature	Solids at 105	Solids at 180	Solids by Addition	SiO_2	Al_2O_3 + Fe_2O_3	CaO	MgO	Alkalies as Na_2O	K_2O	Li_2O	Cl	SO_3	Combined CO_2	Na_2CO_3	$NaHCO_3$	K_2CO_3	Li_2CO_3	$MgCO_3$	$CaCO_3$	$FeCO_3$	NaCl	KCl	LiCl	$MgCl_2$	$CaCl_2$	Na_2SO_4	$MgSO_4$	$CaSO_4$	KNO_3	$Mg(NO_3)_2$	Analyst and Source of Analysis	Remarks
Warmbad ..	S.W. Protectorate	99-102°F	151.80	..	..	5.83	0.12	..	..	..	..	..	..	..	..	..	..	..	..	..	4.91	.	80.80	1.28	..	..	..	20.69	1.91	32.19	trace	..	Dr. Versfeld; Rept., S.A. Assn. for Advancement of Science, 1914, p. 228.	..
Rietfontein ..	Bloemfontein ..	..	..	..	..	See series of Tables No. II				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

E. ALKALINE WATERS.

Msali, near Choma	N.W. Rhodesia ..	..	..	..	..	9.83	trace	trace	trace	..	..	..	..	..	..	7.42	..	..	..	..	..	..	3.33	..	..	..	..	21.20	..	..	..	..	Geo. Pingstone, 1912	..
			..	..	..	2.45	..	..	..	..	..	..	..	..	..	16.84	..	..	0.12	..	1.82	0.29	9.17	..	..	..	..	..	0.30	..	..	..	Dr. Hahn; Union Castle Guide to South Africa	..
Warmbaths, near Nylstroom	Waterberg ..	140°F	..	..	36.40	..	faint trace	..	..	..	..	..	..	..	..	7.38	..	..	..	..	2.22	..	13.77	..	marked trace	..	..	1.20	..	..	..	..	Dr. McCrae; Govt Lab., Johannesburg, 1916	Grams per 100,000 Na_2SiO_3 11.83
			37.16	..	..	5.67	0.46	1.41	0.14	Na_2O 14.80	1.74	trace	6.16	1.86	6.31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Dr. McCrae; Jan., 1908	Grams per 100,000
			37.45	..	..	..	..	1.55	trace	..	..	..	6.23	0.50	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Dr. McCrae; Nov., 1908	Grams per 100,000
Rupisi River ..	South Melsetter, Rhodesia	..	37.6	..	..	8.71	0.21	..	..	..	..	..	..	..	..	..	17.60	..	..	0.25	0.80	..	8.07	..	..	..	..	3.19	..	..	..	..	A. G. Holborow; Dept. Agriculture, Salisbury, 1916	Grams per 100,000 10-15 miles S. East of Sabi River
Junction Odzi and Wengesi Rivers	Umtali District, Rhodesia	..	36.4	..	..	5·36	0.78			..	..	..	..	..	..	..	17.60	..	..	0.50	0.86	..	5.47	..	..	..	..	4.76	..	..	..	..	A. G. Holborow, 1915	Grams per 100,000

F. EARTHY WATERS—None.

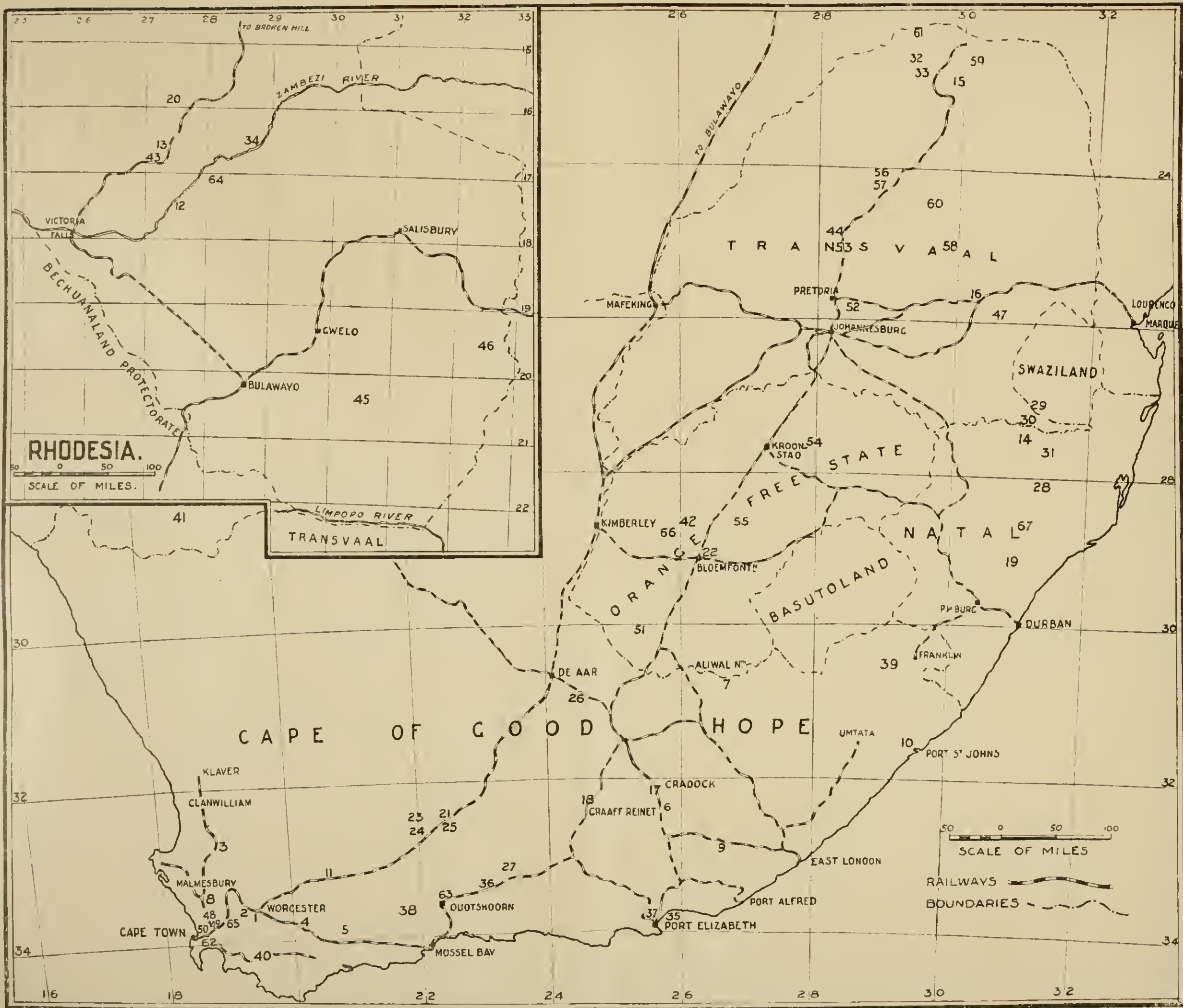
G. TABLE WATERS.

Locality	District or Division	Total solids at 105°C	Total solids at 180°C	SiO_2	Al_2O_3 + Fe_2O_3	CaO	MgO	Alkalies as Na_2O	Li_2O	Cl	SO_3	Combined CO_2	Na_2CO_3	$MgCO_3$	$CaCO_3$	$FeCO_3$	NaCl	KCl	$MgCl_2$	Na_2SO_4	$MgSO_4$	$CaSO_4$	KNO_3	$Mg(NO_3)_2$	P_2O_5	Analyst and Source of Analysis	Remarks
Tygerberg (Bellville)	Cape	..	91.4	3.24	0.32	5.15	9.04	30.63	..	45.97	6.92	3.49	..	..	..	..	..	..	..	..	..	..	..	..	..	Oct. 1912 G. F. Britten; for "The Van Riebeek Natural Mineral Water Co., Ltd."	Known as Van Riebeek Water
		..	92.8	3.14	0.40	5.20	9.07	30.13	..	45.62	6.76	3.45		..	.	..	..	..	..	..	..					Feb. 1913	
		..	87.6	3.06	0.50	5.46	8.86	17.7	..	42.97	5.00	4.05	.	..	..	..	..		.	..	..	..	..	..	..	Report, 1905	
Farm Grendel (Tygerberg	Cape	..	139.2	2.07	2.84	..	..	..	trace	..	..	..	..	..	8.96	..	89.89	0.48	23.36	..	4.93	8.79	..	0.87	trace	Dr. Versfeld	..
Tygerberg ..	Cape	179.2	..	..	..	5.25	17.22	23.87	..	83 25	6.93	trace	..	..	..	..	..	..	..	..	..	..	trace	..	..	Dr. Marloth	Known as Vasco
Driebaden ..	Fauresmith	20.72	..	..	..	..	..	..	..	..	..	..	10.815	..	..	.	43.62	0.205	..	1.557	..	..	0.103	..	..	Govt. Lab., Bloemfontein	$CaCO_3 + MgCO_3 + FeCO_3$ 0.450 Insoluble residue 2.920. Results all in grams per 100,000
Van der Merwe ..	Preteria	20 8	.	..	..	..	..	..	..	trace	trace	..	..	.	..	..	..	..	.	..	..	..	..	..	..	Dr. J. Loevy	CaO + MgO 8.0. All results, grams per 100,000. Known as Seltzbach
Blauwbosch Kuil, Radium Station ..	Waterberg	..		7.6	..	..	..	.	.	..	..	..	3.01	7.55	17.5	0.1	2.27	.	.	.	..	0.5		..	..	Dr. E. Kleiner	Known as Wonder Water
		42.45	.	8.36	0.37	10.98	2.98	6.6	..	1.75	0.24	..	.	..	..	..			..		..			..	..	Dr. McCrae, Govt. Lab., Johannesburg, 1912	Results of both analysis in grams per 100,000

G. TABLE WATERS.

Name or Locality	Solids at 105°C	Solids at 180°	Ca	Mg	Fe	Al	Na	K	Cl	SO_4	NO_3	HCO	SiO_2	Analyst, Date and Source of Analysis
Van Riebeek	..	130.36	5.250	7 776	(0.319)	(0.242)	32.412	..	65.561	11.842	..	6.783	4.621	G. F. Britten, Oct. 1912
	..	132.35	5.301	7.802	(0 399)	(0 303)	31.882	..	65.064	11.568	..	6.822	4.478	,, ,, Feb. 1913
	..	124.93	5 566	7 622	(0.499)	(0 378)	18.729	..	61.284	8.556	..	8.009	4.364	Report, 1905
Grendel ..	.	198.53	8.810	10.132	(2.833)	(2 148)	50.438	0.360	102.896	14.456	1.037	7.790	2.952	Dr. Versfeld. Contains traces
Vasco ..	255.58	..	5.352	14.813	..	..	25.258	...	118.70	11.859	trace	trace	..	Dr. Marloth [Li & phosphates
* Driebaden ..	20 720	..	(0 06[illegible])	(0 043)	(0.072)	..	6.914	0.148	2.743	..	0.063	6.504	..	Govt. Lab. Bloemfontein
Seltzbach ..	20.8	..	CaO + MgO = 8.00		..	..	..	..	trace	trace	..	..	..	Dr. T. Loevy
Wonder Water	..	..	7.024	2.178	0.048	..	2.199	..	1.377	0.035	..	17.878	7.6	Dr. E. Kleiner
	42 45	..	7.848	1.798	(0.259)	(0.196)	4.897	..	1.75	0.288	..	..	8.36	Dr. McCrae

* The original analysis gives $CaCO_3 + MgCO_3 + FeCO_3$ 0.450 grams per 100,000. The above values for Ca, Mg and Fe are calculated on the assumption that 0.150 grams of each of the carbonates are present.



Map to illustrate Medicinal Springs of South Africa.

SOME FINANCIAL FEATURES OF THE CANADIAN EDUCATIONAL SYSTEM.

By Rev. William Flint, D.D

The Government of Canada being of the federal type, it is a necessary preliminary to the study of any phase of administration to ascertain the relation in which it stands both to the Dominion and provincial authorities.

In the British North America Act there is the following clause, which may be regarded as the foundation stone of the system of national education in Canada:—

> "In and for each Province the Legislature may exclusively Make Laws in relation to Education, subject and according to the following provisions:—
>
> "1. Nothing in any such Law shall prejudicially affect any Right or Privilege with respect to Denominational Schools which any Class of Persons have by Law in the Province at the Union;
>
> "2. All the Powers, Privileges, and Duties at the Union by Law conferred and imposed in Upper Canada on the Separate Schools and School Trustees of the Queen's Roman Catholic Subjects, shall be and the same are hereby extended to the Dissentient Schools of the Queen's Protestant and Roman Catholic Subjects in Quebec;
>
> "3. Where in any Province a System of Separate or Dissentient Schools exists by Law at the Union or is thereafter established by the Legislature of the Province, an Appeal shall lie to the Governor-General in Council from any Act or Decision of any Provincial Authority affecting any Right or Privilege of the Protestant or Roman Catholic Minority of the Queen's Subjects in relation to Education;
>
> "4. In case any such Provincial Law as from time to time seems to the Governor-General in Council requisite for the due Execution of the Provisions of this Section is not made, or in case any Decision of the Governor-General in Council on any Appeal under this Section is not executed by the proper Provincial Authority in that behalf, then and in every such case, and as far only as the circumstances of each case require, the Parliament of Canada may make remedial Laws for the due Execution of the Provisions of this Section, and of any Decisions of the Governor-General in Council under this Section."

The significance of this provision is increasingly apparent the more thoroughly the educational problems of Canada are investigated. That such a clause should have been inserted in the Charter of Canadian union presupposes a condition of affairs the permanent recognition of which was deemed to be of the utmost importance. What that condition was the most cursory examination of Canadian history suffices to shew. The constituent elements of Canadian life which successfully claimed the embodiment of this principle in the fundamental law of the Dominion were to be found in the diverse characteristics of the two nationalities, French and English. The problem raised by these was at once racial, ecclesiastical and linguistic. At the first glance these three may appear to be one, but they are not really so in the eyes of the law. It does happen that they are to a large extent co-incidental, but numerous interpretations of Clause 93 in the Canadian courts have made it evident that the intention of the framers is regarded by the majority of jurists to be to ensure, not so much linguistic and racial as ecclesiastical security. One illustrative example of this may be quoted:—

"It has been recently held that the use of the French language in schools in Upper Canada attended by French-Canadian children, whether those schools were public schools or denominational (separate) schools, was not a right enjoyed by law at the date of the union, and that therefore the Provincial Legislature of Ontario has the fullest discretion as to how far the French language is to be now used or taught in the schools of that Province." (Clement's "Canadian Constitution.")

Various aspects of this question have from time to time been submitted to the test of the law-courts, some of which have been deemed of sufficient importance to reach the Privy Council for final decision. As a result of this the following principles may be said, on the authority just quoted, to have been established:—

"1. The right to establish denominational schools;

"2. The right to invoke State aid in the collection of taxes necessary for the support of such schools from their supporters;

"3. The privilege of exemption from taxation for the support of the public schools of the province;

"4. The privilege of having taught in such separate schools the religious tenets of their denomination; to which should perhaps be added the right or privilege which any member of any denomination has to choose which he will support, the separate schools of his denomination, or the public schools of the province. Any legislation of a compulsory character would, it is thought, be unconstitutional as prejudicially affecting the right or privilege which such persons had by law at the date of the Confederation."

It will thus be seen that this foundation principle of the Canadian educational system has a very important bearing on educational finance, with which it must be borne in mind this paper especially deals, these other questions only being introduced so far as they help to a better understanding of the main issue.

In such a vast territory as Canada, and a country with a population which is far from homogeneous, the problems which arise in the course of educational development are necessarily varied. This fact, however, calls for notice that the Dominion

Government has not forced all the provinces into the same mould. The principles previously noted run through all the educational administrations, but it is found that there are reasons why, for instance, equal language rights cannot be afforded to all sections of the community. An example occurs where, in some of the western provinces, immigration has been much more rapid, and in much larger national proportions than could be at once assimilated by the established body politic, there have arisen new forms of linguistic difficulty. Certain large communities, chiefly from South-Eastern Europe, have been led to ask for the right of education in their own tongues, but this is not being granted to any great extent, because it is felt that the new-comers, who have escaped, in some instances, from the most unfavourable social and political conditions in their native lands to surroundings of an entirely different nature, may very reasonably be expected to give up something for what is believed to be for the ultimate and permanent good of the community as a whole. The seeming discomfort and disability of such a condition as having to accept English as their educational language, it is held, will be amply compensated for by the fact that the people will be able the more readily and advantageously to become a part of a great homogeneous nation and people. That may be unsentimental and utilitarian, but it is probably politically sound, though temporarily there may be some educational disadvantages. The larger outlook and the long view lend a large measure of support to the system under which the western provinces believe themselves to be justified in working.

It remains to be seen how all these principles have affected the financial administration of the different provinces in relation to education.

In the Dominion as a whole, Government Grants, coupled with Local Assessments, may be said to be the basal principle of educational finance, but to these two sources of revenue we find additions peculiar to individual provinces under the heads of Clergy Reserves, Debentures, and other titles.

As between the amount of income from the Government and local sources, the former does not, as a rule, stand in a large proportion to the latter except in one instance, that of Prince Edward Island, where nearly three-fourths of the cost of education is borne directly by the Government. In Nova Scotia the proportion for a given year is roughly 22.3 per cent.; in New Brunswick 19.8 per cent; in Quebec 21 per cent.; in Ontario 5.3 per cent; in Manitoba 5 per cent.; in Saskatchewan 9 per cent.; in Alberta 7.5 per cent.; and in British Columbia 40 per cent. In the instances in which the grant is relatively very low it will be found that there are sometimes other sources of income than the simple local assessment. The separate provinces may now be examined in order.

Prince Edward Island.—This island did not enter the Union at its formation, although it had enjoyed responsible government since 1851. It was received in 1873, and four years later passed a Public Schools Act, which is the basis of its present system of education. The control lies with a Board of Education, consisting of Members of the Executive Council, the Superintendent of Education, and the Principal of the Prince of Wales College and Normal School. For the purposes of administration of the Schools Act the province is divided into school districts, which consist of the whole town in urban centres, and for rural communities of areas about four miles square. The local management for each school is in the hands of three trustees, with the exception of two towns, which have seven trustees, four of which are appointed by the Board of Education and three by the City Council. The schools are divided into three grades—primary, advanced and first-class schools. In each district an annual school meeting is held, at which a budget is submitted and moneys are voted for all school purposes. The amount required for the year is made up of a government grant, and the remainder is obtained from a local rate levied by assessment on property. Should the ratepayers at the annual meeting so decide, they may also levy a poll-tax not exceeding one dollar. The annual revenue, according to the latest return available, was £43,600, of which £31,300 was received as grant and £12,300 as local assessment.

NOVA SCOTIA.—In this province the problem is a little more complex. It entered the Dominion at the time of union, carrying with it a system of education which had only recently been adopted. The control of education is vested in a Council, which is identical with the Executive Council, the Superintendent of Education being the Secretary of the body. The Premier, as Financial Secretary, is practically the Minister for Education, and the Superintendent of Education becomes virtually his deputy. An Advisory Board of Education, consisting of seven members, five appointed by the Lieutenant-Governor in Council, and two elected by the teachers at the convention of the Provincial Educational Association, advises the Council of Public Instruction and the Superintendent respecting text-books, qualifications and examination of teachers, courses of study, and other educational matters. District Boards, each consisting of not less than 7 commissioners appointed by the Council of Education, exercise a limited jurisdiction over 33 areas, each averaging half a county. They have the power to condemn school buildings, appoint school trustees, and order levies of money to keep schools open in cases where the ratepayers fail in respect of these duties. The local management of schools is entrusted to a Board of Trustees elected by the ratepayers in the school sections into which the province is divided, but in the towns the Board consists of three members of the Town Council and two appointed by the Government. The annual meeting acts similarly to that of Prince Edward Island, and at the same time has the power of determining whether compulsory attendance clauses shall be effective.

The school revenue is obtained from a Government Grant, which is given as aid to teachers, and amounts to £68,426, the remainder being made up of Municipal Funds £32,996, and Local Assessments £200,593, a total of £302,015. It should be noted in this connection that the cost of the College of Agriculture is not included in this amount, but is paid through the Department of Agriculture, and that certain Rural Science Schools have also been instituted, the charges for which are met by a special Dominion grant. A word as to the manner of raising the municipal school fund and the method of its distribution may not be out of place. The fund is derived from a tax of 35 cents per head in each rural municipality, but levied on the real and personal property, and is distributed to school boards at the rate of £5 for each teacher employed, and the balance, about half the total aggregate, according to the attendance of the pupils. The law allows municipalities at their option to raise a larger fund, and three have a fund based on a 50 cents basis, distributed at the rate of £10 per teacher. It may be also of interest to note that the Government aid is paid to teachers on the following professional basis: Class D (third class), £12 per annum; Class C (second class), £18; Class B (first class), £24; Class A (superior first class), £30; and Class "Academic," which implies graduate status, £36 or £42, according to position.

New Brunswick.—The supreme control of the schools in this province is vested in a board composed of the Lieutenant-Governor, the Members of the Executive Council, the Chancellor of the University of New Brunswick, and the Chief Superintendent of Education. The local administration is by school districts of a similar constitution to that of Nova Scotia, but in towns the boards of trustees consist of from nine to eleven members, the majority of whom are appointed by the City or Town Council, and the remainder by the Executive Council of the province. Two of the members may be women, one appointed by the Town Council and one by the Executive Council. The schools are maintained by Government Grants upon the basis of the qualifications and service of the teachers, and by county funds provided by municipal assessment at the rate of 60 cents per head of the population. From this fund £6 per annum is given to the trustees for each school or department in operation for the full term. The balance of the fund is distributed among the schools according to the attendance as compared with that of the whole county. Any other funds required must be raised by direct taxation on the local school district. The amounts under the various heads are given as follows: Government Grant £39,052; County Assessment £19,389; and Local Assessment £140,895; making a total of £197,336.

Quebec.—In this Province the educational problem is in many respects unique. Largely French-speaking and Roman Catholic in character, a system of education some three centuries old is met with, and although numerous modifications of the original have necessarily been made, the influence of forces at work dating back to the 17th century is apparent. More recent history is what concerns us most, and we find that when confederation took place there was already in operation a law which is the basis of the existing administration, and which says much for the clear-sightedness and liberal spirit of those who framed it. In 1841 a Department of Education was established, and by 1846 had succeeded so far in gauging the needs of the colony as to initiate and pass the legislation named.

The school organization is under the control of a Council of Public Instruction, presided over by a Superintendent of Education. His duties are in part defined by law, and in all matters not specifically set forth he receives instructions from the Government through the Provincial Secretary, in whose department education is included. This Council is composed of all the Roman Catholic Bishops or Vicars Apostolic, whose dioceses or parts of whose dioceses are in the province of Quebec, now numbering 15, an equal number of Roman Catholic laymen appointed by the Crown, and an equal number of Protestants similarly appointed. This Council is divided into two Committees, one composed of the Roman Catholic and the other of the Protestant members. Four Associate Members work with the Roman Catholic Committee, two being priests, principals of normal schools, and two laymen who are officers of public instruction. The Protestant Committee has six Associate Members elected by the Committee, and one annually elected by the Protestant Teachers' Provincial Association. The Associate Members of the Protestant Committee have the same powers as the other members, except that they are not members of the Council. The whole Council does not meet except to consider such educational questions as concern the interests of the schools collectively, and ordinarily the Committees meet separately, and have independent and final jurisdiction over their own schools. How far the powers of these Committees extend may be seen by the fact that, subject to the approval of the Lieutenant-Governor in Council, each Committee makes regulations for the organisation, administration and discipline of public schools, for division of the province into inspection districts, for normal schools, for boards of examiners, for examination of candidates for school inspectorships, and for school holidays. The Superintendent has a staff of 49 inspectors, and these are placed under two Inspectors-General, one for each class of schools. For the purposes of organization, school municipalities are established, and the local authority in each of these is vested in a board of five commissioners elected by the ratepayers. The board is responsible for the erection, equipment and maintenance of schools, the administration of the property, and the fixing of the school assessments and monthly dues from the parents. In the cities of Montreal and Quebec the boards are not elected but are appointed, and in Montreal the rate of taxation has been fixed by a provincial statute. These municipalities have a separate existence as Roman Catholic or Protestant, and are then divided into school districts. It should, however, be mentioned that under certain conditions religious minorities may withdraw from the jurisdiction of the committees, form a separate corporation, and establish schools of their own under rules which cannot be specified here at length. The Secondary Schools are usually under the same committees as control the Primary Schools.

The finances are derived from a grant of the Legislature, which is divided proportionately to the number of children enrolled, and from local rates which are levied on all rateable property of a school municipality, in addition to which there is collected for every child from 7 to 14 years of age who attends school, or who should attend school, a monthly fee which cannot exceed 50 cents a month, nor be less than five cents; but school boards may, by resolution, abolish the fee, and in the city of Montreal, for instance, elementary education is free to all Protestant and Jewish children under the jurisdiction of the Protestant Committee. The average fee collected is stated to be about 25 cents, and in no case is a teacher allowed to receive it from the pupils, nor can a child be excluded for non-payment.

The amounts administered in a given year are: Government Grants for Elementary Schools £131,765, other schools £213,057, Local Assessments, Elementary and Superior Schools £1,293,687, a total of £1,638,509. As a matter of interest it may be noted that the monthly fees in an average of three years amounted to some £60,000 per annum.

Quebec presents us with a school system which is unique, but one which seems to offer a working solution, of a confessedly difficult problem, fairly satisfactory to the people of that province.

Ontario.—This province has now a Department of Education, although its institution in its present complete form is as recent as 1909. The Minister of Education presides over its affairs, and a Deputy Minister is its permanent chief. A Superintendent of Education has the general supervision of the educational affairs of the province. The work of education was co-ordinated and organized in the same year as that of Quebec, in 1846, and after several changes and developments the School Law of 1871 gave effect to these principles, *viz.*, free tuition, compulsory education, county inspection, and uniform examinations for promotion to the high schools. In 1909 the whole question of education was more fully dealt with by legislation, and no less than 11 different Acts were passed dealing with various phases of the work. They were Acts respecting the Department of Education, Public Schools, Continuation Schools, High Schools, Truancy and Compulsory School Attendance, Acquisition of Land for School Purposes, Boards of Education, University Amending Act, Veterinary College Act, a School of Mining and Agriculture Act, and one regarding Art Schools. It is not possible to outline these in this paper, nor is it necessary for the end in view. There are two or three principles which must be noted. The Act constituting the Department of Education provides for an Advisory Council for the Superintendent which is widely representative of educational interests. The President of the University of Toronto is chairman, the Superintendent of Education is a member without a vote; there are seven other members representing the Universities, two representing High School Teachers, two representing Public School Teachers, one representing Separate School Teachers, two representing Public School Inspectors, and two representing School Trustees of the Province. This Council is consultative, and confers with the Minister on such subjects only as he may submit to it or its committees.

Elementary Education is provided for in Public Schools, and in what are known as Separate Schools for the children of Roman Catholics. These schools are controlled by Boards of Trustees. The province is divided into school sections for rural districts, each with three trustees, and in towns each ward has two trustees, or if there are no wards six trustees are elected. The duties of these trustees are the provision, equipment and maintenance of schools, engagement of teachers and preparation of financial estimates. The financial support is obtained from three sources, Government Grants, County Rates and Municipal Assessments. There is also a certain income from land reserves. The Separate Schools are similarly managed, and under the Act it is provided that any number of heads of families, not less than five, being resident Roman Catholics, may unite and establish a Separate School. They then become Separate School supporters, and are exempted from the payment of rates for the ordinary public schools. Secondary Education is provided for by High Schools and Colleges, controlled by trustees and supported financially by Government Grants, district or municipal grants, and fees from students.

The cost of Elementary Education, as met by Government Grants, is £155,630, by Local Assessments £1,971,276, by income from Land Reserves £805,057, a total of £2,931,963.

There are many interesting features, such as uniform text-books, and kindred regulations, which testify to a highly-organized system of education in the province of Ontaria.

MANITOBA.—This Province differs from the older parts of the Dominion in that its educational system was subjected at a certain period of its history to a radical change. The first system, established in 1871, was similar to that of Quebec, with a central control consisting of a Board of Education, divided into two sections, Protestant and Roman Catholic, with local management entrusted to trustees elected by the public. In 1890 the Public Schools Act repealed all previous legislation, and established a system of national non-sectarian education throughout the province. A Minister of Education, advised and assisted by a Deputy Minister and a Superintendent, controls education in both Elementary and Secondary Schools. These, again, are assisted by an advisory board, consisting of 12 members, two of whom are elected by the Public School Teachers of the province, one by the High School Teachers, one by the Inspectors, while the rest are appointed by the Department of Education, with the provision that two of these appointments are selected from, and represent, the rural school trustees of the province. Education is free and compulsory, every person in rural municipalities between the ages of 5 and 21 years, and in cities, towns, and villages between the ages of 6 and 21 years, having the right to attend some school. The extension of the age to 21 years does not apply to the compulsory principle, but is designed to meet the requirements of a new country in which school attendance is often limited to certain months of the year only. As in the East, the school district is the unit of local administration, the average rural district covering an area of about 16 square miles. The revenue required is derived first from Government Grants, at the rate of 3s. 1d. per teacher per day. There is also a local contribution raised over the whole area of a municipality, which may comprise from 10 to 50 school districts. This is known as the General School Tax, and is distributed to the school districts on a basis of 6s. 3d. per day. The balance required beyond these amounts is raised by a special tax upon the lands comprising the school district. A little elasticity is introduced into the method of financing the schools, which allows of an additional grant of £20 if the people in the locality are unable, through poverty, to raise a sufficient sum to carry on the school, also an additional £20 is given if the district has been formed beyond the municipal organization area. A reference having been made to the system of payment by days, it is, perhaps, desirable to explain that schools in Manitoba vary in the periods for which they are opened, and the provision for payment is made adaptable to those circumstances. An interesting feature of the Manitoba school organization, and one affecting finance, is that of the consolidated school district, which also obtains in Ontario and Saskatchewan. The clauses of the Public Schools Act dealing with this question provide for the consolidation of districts without any limitation of area—"if the Council shall provide by the bye-law that the trustees of such district must make and carry out suitable arrangements for conveying to and from school once a day each way all pupils who would have further than one mile to walk in order to reach the school, and after the formation of such enlarged school district it shall be the duty of the trustees thereof to make and carry out such arrangements and to provide for the expense of such conveyance." Of the cost of this transportation the Government may pay a sum not exceeding 50 per cent., provided that the contracts are first approved by the Department. The average attendance of such schools is said to be from 88 to 97 per cent., as against 55 or 60 per cent. in ordinary rural schools.

For purposes of revenue Manitoba has a system of raising loans by debentures. School Boards, with the authority of the Department, may thus finance their schools and provide for special needs on condition that provision is made for repayment by instalments or a sinking fund. The income under different heads for the latest year is: Government Grant £78,116, Local Assessment £534,690. Special £922,104; total, £1,534,190.

SASKATCHEWAN.—As a sister province, Saskatchewan has many points of resemblance in its financial economy to Manitoba. Education is controlled by a duly-organized Department, at the head of which is the Minister of Education. He is assisted by an Educational Council consisting of five members, who are appointed by the Lieutenant-Governor. The Council holds sessions once a year at least, and all general regulations regarding the inspection of schools, the examination, training and licensing of teachers, the grading of teachers' courses of study, the affairs of teachers' institutes, and text and reference books, are referred to this Council for consideration and report before being adopted or amended. A Superintendent of Education has the general supervision and direction of High Schools, collegiate institutes, model schools, Public and Separate Schools, and matters relating to teachers, inspectors, libraries and kindred affairs. The School Act also provides for the establishment of schools wherever necessary, and any portion of the province with an area not exceeding 20 square miles may be organized into a school district, providing there are residing therein 10 children of school age, and four persons, each of whom on its organization is liable to be assessed for school purposes. Under such conditions the claims of the most sparsely-populated district have an opportunity of being met. The control is again in the hands of trustees chosen by popular vote, and teachers are appointed by these trustees, having first received their certificate of qualification from the Department of Education.

The educational budget for a typical year reveals four sources of income—Government Grants £144,400, Local Assessments £582,627, Proceeds of Debentures £415,075, Loan Account £494,167, a total of £1,638,269.

As a young province, Saskatchewan has shewn a remarkable interest in education, and school districts have been created in almost incredible numbers within the last decade. The consolidated school system, in its results, reveals a great advantage over the one-roomed, one-teacher provision of the ordinary school in rural districts.

ALBERTA.—The education of this newly-formed province is controlled by a Department of Education, presided over by a Minister of Education, assisted by a Deputy Minister as permanent administrative head. The local administration is again through the school district, which usually includes an area of about four square miles, and may be organized as soon as eight children of school age are resident, and four resident ratepayers are found to take the initiative. Indifference on the part of the people, or opposition on the part of settlers, is met by a mandate of the Minister to establish such a district without regard to the attitude of the ratepayers, or on the failure of trustees to satisfactorily administer the school affairs on the area, the Minister may appoint an official trustee to perform all the usual functions of a board. The local board of trustees is not, however, burdened in every instance with the task of raising funds. When the school district is situated in a town, the trustees requisition the amount required for school purposes, and the municipal council is responsible for assessment, levying and collection of taxes to the amount required. In rural municipalities the council is also entrusted with the collection of the tax, but in village districts these duties and responsibilities rest with the school board and its officials.

So much of the work of education being in the initial stage, special provision is made for school buildings, and these are usually erected from the proceeds of school debentures. Such debentures must first be authorised by the Department, and when issued, registered and countersigned by the Department before they are marketable. In order to secure a good market for these, it is usual for several districts to combine in their issue. The revenue required for these, and all other school expenditure is derived from Government Grants and local taxation. The grants are apportioned in such a way as to give the greatest proportional aid where Government assistance is most needed, so that a newly-organized district usually gets a relatively larger amount than an older district. The more populous districts are thus thrown more and more upon their own resources, though not without some compensation, as Government provision is often made for special instruction in such centres in subjects like manual training, music, art and agritulture.

The revenue for the last available year was—Government Grants £111,536, Local Assessments £605,755, Debentures £199,270, and other amounts £554,276, a total of £1,470,837.

The system provides for 12 grades of teaching, of which one to eight belong to the Public Schools, and children are required to attend until these are passed, or they have completed their fifteenth year. The higher grades merge into University work, as a candidate may enter on the first year of his University course on completing his 11th grade, or on the second year's work on completing his 12th grade.

British Columbia.—In this Province the system dates back to an earlier period than in those last named. As far back as 1872 a complete system of free education was established. The central control is vested in a Council of Public Instruction, which consists of the members of the Executive Council, the Provincial Secretary carrying the portfolio of Education. A Superintendent of Education has the supervision and direction of inspectors, teachers and schools, subject to the control of the Council of Public Instruction. The unit of local administration is the school district with elected trustees, and these districts are definitely divided into three classes, controlling municipality schools, rural schools, and assisted schools. The municipality schools are divided into three classes, according to average daily attendance, and are governed by boards of seven, five or three trustees, according to class. The assisted schools are those established in outlying districts, aided by sums granted by the provincial Government.

The revenue required is derived from Government Grants and Local Assessments. The relative amounts are: Government Grant £377,131, Local Assessments £549,844; total, £926,975. Of the Government Grant it may be noted that about two-thirds was spent in education proper and one-third in buildings.

The North-Western Territories and Yukon, in their present immature stage, do not call for detailed notice.

This rapid review suggests many queries which remain to be answered, such as the relations between school and university education in the various provinces, but that particular aspect may possibly be dealt with in a second paper.

It is also provocative of comparisons at many points with our own local conditions, legal enactments and administrative regulations, and it has not proved easy to resist the temptation to enter into some of these. However, the chief object has been to give information which others may find possible to utilise for their own special studies. In this relation certain phases might easily be elaborated in order to confirm our faith in the excellencies of our South African systems, or, on the other hand, it is just possible that some facts brought forward may suffice to reveal defects in our methods, the existence of which the most ardent supporter of the Union will acknowledge it is not treason to allege.

TRANSACTIONS OF SOCIETIES.

South African Society of Civil Engineers.—Wednesday, March 14th: R. W. Menmuir, M.I.C.E., President, in the chair.—"*Short history of the present state of the survey of South Africa*" (Presidential address): R. W. **Menmuir**. A short arc of meridian was measured by Abbé de la Caille in 1752. In 1841 Sir Thomas Maclear began measurement of a base line in the Western Province, and triangulation work was then commenced. A secondary triangulation was undertaken in 1903, and at its rate of progress 70 years will be required to complete the survey of the Cape Province. An aerial survey, photographing from a baloon or aeroplane was suggested, and it was pointed out that, previous to the outbreak of war, it had been decided in Vienna to undertake an aerial photographic survey of South-West Africa.

South African Association of Analytical Chemists.—Thursday, March 15th: J. McCrae, Ph.D., F.I.C., Vice-President, in the chair.—"Routine work in a fertiliser factory": M. **Rosenberg**.—"*Determination of oil in seeds*": W. B. **Gray**. The author described the use of the Kreussler oil extractor.

FINELY-POWDERED MERCURIC CHLORIDE ($Hg\ Cl_2$) FOR THE DESTRUCTION OF THE ARGENTINE ANT. *IRIDOMYRMEX HUMILIS* MAYR.

By Charles William Mally, M.Sc., F.E.S., F.L.S.

In his article on "Measures Suggested against the Argentine Ant as a Household Pest."* Prof. Wilman Newell recommended "Ant Tape" as a repellant, because "ants of this (and some other) species will not cross cotton cloth or tape which has been thoroughly soaked in a saturated water solution of corrosive sublimate and then dried." In his bulletin on "The Control of the Argentine Ant,† Prof. C. W. Woodworth, in discussing the value of corrosive sublimate as a deterrent for ants, states that "The Argentine Ant seems to be very little influenced by this poison, and in many experiments tried at the ant laboratory lines of ants were found re-established across the poison inside half-an-hour after the most liberal treatment." This left me in doubt as to the real value of corrosive sublimate as a deterrent for ants. As I had intended using corrosive sublimate for the purpose of isolating grape vines in fumigation experiments for Vine Mealybug (*Pseudococus capensis* Brain) so as to prevent a native species of ant (which was attending the mealybug in the vineyard), and also other insects, including mealybug, from possible secondary host plants from crawling up the stems of the vines, it was important that all doubt should be removed. While preparing some "ant tape" for trial, it occurred to me that its effectiveness probably depended on the fine layer of corrosive sublimate crystals on the surface of the tape coming into contact with sensitive tissue on the antennæ or on the feet of the ants. In such case it seemed likely that finely-powdered corrosive sublimate would give better results than "ant tape," because the small particles would be more easily available, and hence a larger quantity would get on to the ants. There was also the possibility that they would poison themselves by attempting to clean their feet and antennæ by drawing them through the mouth, the same as cockroaches are said to do with sodium fluoride.

During a fine spell of weather, in August, 1913, the Argentine Ants were very active near the base of a large oak tree at Mowbray. I surrounded the opening of the nest with a cordon of finely-powdered corrosive sublimate, about one-half inch wide, about an hour before sundown, the base of the tree being shaded by the house. Both incoming and outgoing ants were thrown into confusion immediately they came in contact with the poison. Some would advance on to it and then hastily retreat along the trail. Others would get to the middle of the cordon and then

* *Journal of Economic Entomology* (1909), 2 [5].

† *Univ. of California Bul.* 207 (Oct., 1910), 81.

wander around on it from side to side in a confused manner, as if loath to leave it. On three occasions an incoming ant seemed to communicate with an ant on the poison, and then suddenly catch it by a leg or an antenna and pull it off the poison, and then release it after struggling for a few seconds. Others would skirmish along the poison and suddenly "storm" across it; but the great majority refused to cross, and finally retreated along the trail. On the whole I felt satisfied that unless there was some exceptional reason for crossing the poison they would avoid it. Circumstances prevented further tests being made until February, 1914, when I had occasion to place some eggs of the Maize Stalk Borer (*Sesamia fusca* Hamp.) on a young maize plant at the Roseband Experiment Station.[1] Argentine Ants were abundant, and to prevent the eggs being carried away I decided to isolate the plant by a cordon of finely-powdered corrosive sublimate before covering it with a cage.[2] In view of my observations in August, 1913, I instructed the Assistant Entomologist, Mr. C. P. van der Merwe, who was responsible for making detailed observations, to keep careful watch and note the effect of the corrosive sublimate on the ants. After a few days had elapsed he called my attention to the fact that there were a great many dead Argentine Ants in the cage around the corrosive sublimate. I instructed him to continue the observations with a view to determining the cause of the mortality, and he later on reported that the ants, as soon as they came in contact with the poison, especially in bright sunlight, became confused, and in a short time started "leg-pulling," as he described it—*i.e.*, one ant would seize another ant by the leg or antenna, and start pulling; a third ant would seize a leg of one of the two contestants, and so on till there was a "chain" of five or six ants. This at once recalled the fact that during the first trial the ants showed a tendency to pull each other about. On watching the ants closely by means of a magnifying glass, I soon saw that they were not merely "leg-pulling," but that it was a real tug-of-war in which they were literally tearing each other to pieces. In the mass of dead ants the great majority had been injured to some extent, but many died without being mutilated. It seems probable that they were poisoned by trying to clean their antennæ and feet.

The finely-powdered sublimate is more active in sunlight than in the shade.

With the assistance of Mr. Van der Merwe, a large number of experiments were conducted under varying conditions, and it soon became evident that by placing a very little of the finely-powdered sublimate around the entrance to the nest, the whole colony would ultimately be annihilated because they could neither leave nor enter the nest without getting into the poison. Foraging queens are affected the same as the workers, the latter attacknig the queen the same as they do each other. They are evidently too confused to recognise her.

Under some conditions the ants become excited before they actually touch the powder. This suggests that there may be very fine particles of the sublimate floating about. When the sublimate has been sprinkled on to the soil at any point, it remains sufficiently virulent to affect the ants for a long time. Certain protected spots treated eight or nine months ago still react on the ants when they wander over them. Heavy rains carry the corrosive sublimate away to a very large extent, but light rains simply carry it into the soil, and then, as the moisture evaporates, there is a tendency for the corrosive sublimate to be deposited on the surface, thus reproducing "ant-tape" conditions. This suggests that it may be possible to treat the foundations of buildings, either during construction or afterwards, with corrosive sublimate in solution, and fortify them against ant invasion.

GEOLOGY OF SOUTH WEST AFRICA.— Some months ago Prof. S. J. Shand, of Victoria College, Stellenbosch, visited South-West Africa for the purpose of studying the occurrences of alkaline rocks in the desert south of Lüderitz Bay. On arrival there Dr. Shand found that Prof. Erich Kaiser, the distinguished petrologist of Gilssen, was in the country as a prisoner of war, and had come out from Europe for the express purpose of studying those very rocks. Dr. Shand writes to the *Geological Magazine** that Prof. Kaiser has utilised his enforced leisure by studying the alkaline rocks most minutely, and mapping the occurrences on special, large-scale topographic sheets. Under the circumstances Dr. Shand has abandoned his intention of writing anything about these rocks for the present. In the meantime, he declares that Prof. Kaiser's memoir on the subject, when it appears, will be found to possess a quite extraordinary interest for petrologists.

POTASH FROM SEAWEED.—A recent issue of *Nature*, quoting from United States publications, refers to the existence of nearly 400 square miles of seaweed beds along the United States Pacific coast. It is officially estimated that these beds can supply 59,000,000 tons of seaweed annually, capable of producing an aggregate of 2,300,000 tons of potassium chloride. The United States Department of Agriculture is undertaking the experimental production of potash from this seaweed on a commercial scale. An appropriation of 175,000 dollars has been made for this purpose, and the plant, which will probably be put up in Southern California, will be capable of dealing with 200 tons of wet seaweed per day, thus producing about five tons of potassium chloride daily. Numerous experimental methods will be employed, but for the most part distillation processes will be used.

* (1917), 4 [5], 235.

ROCK PAINTINGS OF THE NORTHERN TRANSVAAL.

By Rev. Noel Roberts.

(*Plates* 17-22.)

The northern horizon of the town of Pietersburg is bounded by a range of mountains, which, like the body of a monster serpent, stretches in sinuous folds from east to west across the almost level plains. The head of the monster is lost to view in the dim and distant low veld to the east, but fold on fold, for twenty miles or so, its body can be traced against the northern sky. Near the brackish "pan" from which the mountain takes its name (the *Zoutpansberg*) it dips precipitately underground, then, reappearing further on towards the setting sun, the *Blaauwberg* marks the sacral portion of its body which slopes away in a great southern curve to its tail in *Makabene*.

During the construction of the railway to Messina, which passes through the Zoutpansberg, great excitement was created by the announcement that a set of Bushman paintings had been discovered. From time to time reports have been received of frescoes in the Blaauwberg, but the most important relics of the Bushman race are to be found in the wild country at the western extremities of the range. The Makabene is a rugged plateau, triangular in shape, and protected on almost every side by precipitous walls of stone. This natural fortress appears to have been a favoured Bushman haunt. Its heights command a boundless view across the plains, where mighty herds of antelope, of buffalo, giraffe and elephant provided them with sustenance, and watered glens and rocky kloofs afforded safe asylum from their foes.

The headquarters of the local Bushman tribe appears to have been situated in a narrow ravine at the western end of the plateau. The precipices on each side of this gorge abound in shallow caves such as the Bushmen loved, and everywhere traces of their occupation can still be seen in coloured frescoes on the rocks.

Some of these are very fine, and compare most favourably with the work of Bushman artists in Natal and elsewhere. Yet they have a distinct character of their own. The eland, which is a favourite subject almost everywhere, is not represented here at all, as far as I am aware, its place being taken by the hartebeest and pallah. There are but few representations of animal-masked men, and a large number of headless human groups occur.

No visitor can look upon these drawings without expressing wonder as to how the pictures were produced, the composition of their paints, and the objects served by the frescoes.

In many parts of Natal and the Cape Province a round stone which contains a nucleus of ochre is found in the vicinity of Bushman caves, and this is popularly supposed to have pro-

Fig. 1.

Fig. 2.

Rev. N. Roberts.—Bushman Paintings.

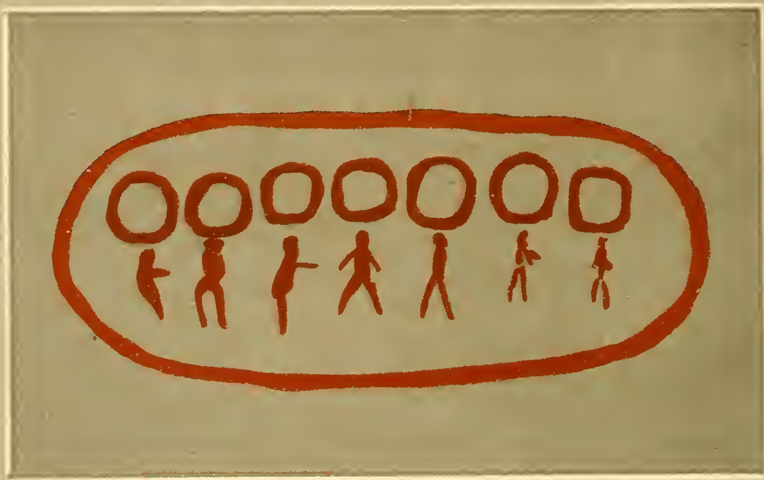


Fig. 3.

Fig. 4.

Rev. N. Roberts.—Bushman Paintings.

vided these pigmy artists with at least one colour. This theory, however, has been challenged by the Magistrate of Polela, who reported to the Department of Justice as follows:—

The paints used by the Bushmen are a lost secret with the exception of dark red, which I have found in two places. The paint is a greasy substance interleaved with yellow sandstone, and when exposed to the air hardens very quickly. . . . The fine, rather sandy, substance often found inside round stones in the bed of the rivers, and so often asserted by many people to be the real Bushman paint, is no such thing, although the same colour can be obtained, for this reason—that, however many coats be applied, and no matter how long it be left to dry, it can be immediately rubbed off.*

The natives of the Makabene confidently assert that the white paint of the Bushmen was obtained from the milky kernel of the *Stamvruchte* (*Chrysophyllum magalismontanum*, Sond.), and this appears to agree with the testimony of a native who traces his descent from the Bushmen in Natal, who stated that the paints of his forefathers were of vegetable origin. These native theories, however, are wanting in confirmation. During a visit to the Makabene I had the good fortune, however, to unearth a store of Bushman paints in the course of excavating one of the caves, and these confirm the testimony of Stow, who declared that as much care was exercised in the manufacture of their paints as was shown in the production of their poisons, or the chipping of their implements of stone.† Among the specimens now in my possession there are several which bear unmistakeable evidence of having been carefully scraped, apparently for the purpose of obtaining a fine powder. The material in most cases is of low specific gravity, and is brick-like in texture, as though the original ingredients had been finely compounded and then artificially dried by heat. When paint was required, a quantity of this fine powder was presumably scraped from one of the cakes and mixed with (raw?) fat or other medium, and stored in little pots ready for use.‡

It is possible that the blood of the animals they hunted may have formed one of the ingredients, for reasons which will be shown later.

The meaning and purpose of these rock-paintings provides another problem which has exercised the minds of many students.

* *Vide Pretoria News*, February 13th, 1913.

† There were certain secrets among many of the tribes, which were not known to every member of them. . . . This seems to have been especially the case not only in the manipulation and preparation of their poisons and the antidotes thereto, but even in a more marked manner among those tribes that produced the great artists of their race, the proper mixture and employment of colours was only known to the few, and not to the many" (Stow, "The Native Races of South Africa," p. 76).

‡ Stow describes a painter's outfit as follows: "The last-known Bushman artist of the Malutis was shot in the Witteberg Native Reserve, where he had been on a marauding expedition and had captured some horses. . . . He had ten small horn pots hanging from a belt, each of which contained a coloured paint ("Native Races of South Africa, p. 230).

The most commonly accepted explanation is that they are the records of historical incidents, or depict the doings of the chase. Plate 17, Fig. 2, is a picture of this kind. It is curiously reminiscent of the cartouche in which the names of Egyptian kings are recorded on the monuments. After reading Stow's description of the manner in which the "emblem" of each tribe was "conspicuously painted in some central part of the great cave of the chief of the clan"* an enthusiastic student gifted with imagination might well be forgiven if he thought he had here a connecting link between the Bushmen and the ancient civilization of Northern Africa. Another might interpret the figure as the record of a treaty, in which each cave or clan is represented by a rude circle, under which is affixed the mark of each chief within the common bond of union. These interpretations illustrate the manner in which one is tempted to allow the imagination to run riot when examining Bushman work. The picture of a man rescuing the body of an antelope from the jaws of a snarling panther† is another example of this kind. Stow discusses the question at considerable length, and arrives at the conclusion that "*they are purely historical.*"

That his conclusions are justified by a very large number of rock-paintings in many parts of South Africa cannot be denied, but this explanation does not account for the *origin* of the practice of painting on the rocks which appears to have been common to all troglodytic peoples. Once a man or a race had acquired the art, the representation of things seen or done follows as a natural corollary, but it is difficult to imagine that such a primitive race, steeped in the lowest savagery, to whom agriculture was unknown, and whose principal tools were implements of wood and stone, should have been ready to devote time and interest to the acquirement and perfection of knowledge and skill to the degree undoubtedly possessed by the Bushman artists, had there not been some ulterior motive behind it all.

Professor Frazer has taught us the enormous value of *comparative* ethnology in the study of human life, and by applying its principles to the problem before us it is possible that we may get a clearer insight into the working of the Bushman mind than those who actually studied the Bushmen themselves, since we have a greater body of material to work upon than they had.

We know, from the records of Dr. Bleek, and others whose knowledge of the Bushmen was obtained at first hand, that they were very superstitious and that they firmly believed in magic, and magic provides a far more reasonable explanation of the origin and purpose of the rock-paintings and incised figures of these pygmies than that usually given.

Before we consider the arguments in favour of this theory, let us consider:

1 *The objects aimed at* in the practice of magic. These are:

* "Native Races," p. 32.
† Plate 17, Fig. 1.

Fig. 5.

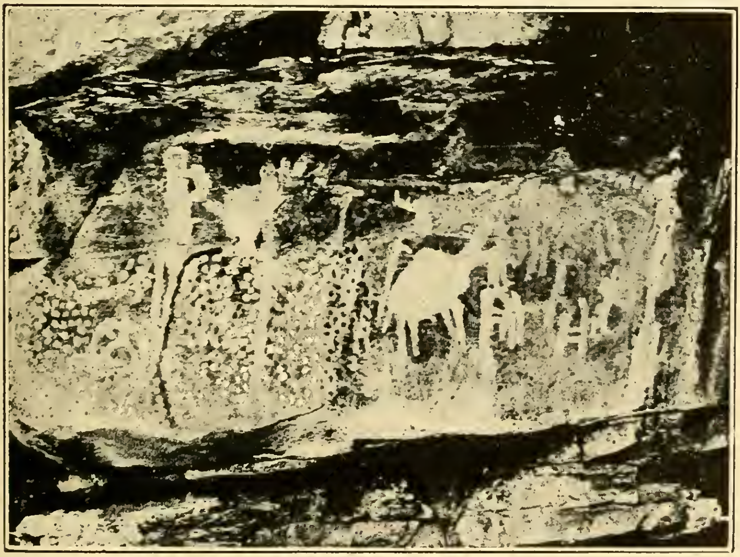


Fig. 6.

REV. N. ROBERTS.—BUSHMAN PAINTINGS.

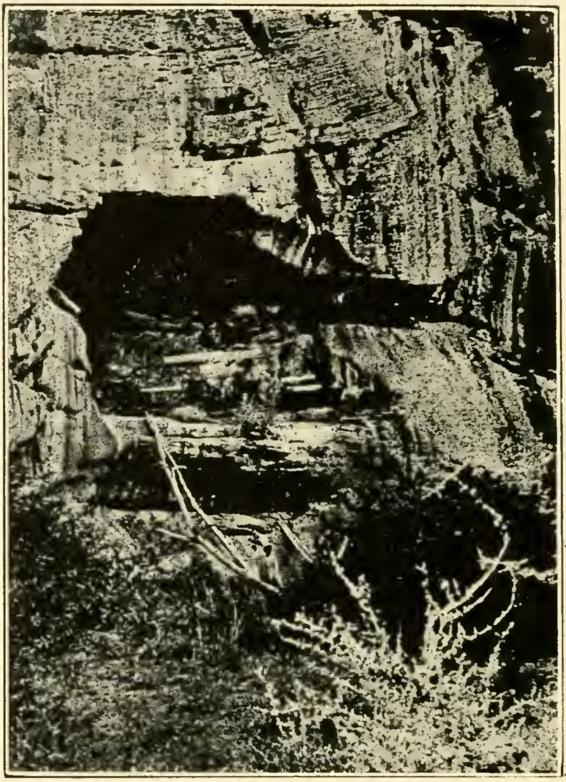


Fig. 7.

Fig. 8.

Rev. N. Roberts.—Bushman Paintings.

(*a*) To ensure the fertility of crops, herds or families.
(*b*) To secure the preservation or increase of the food supply.
(*c*) To ensure prosperity in warfare, the chase, or any other undertaking.
(*d*) To bring misfortune, disease or death upon an enemy, etc.

2. *The methods usually employed* to bring about these results.

The following examples in which savages have been known to make use of *representations of animals* and other objects as instruments of magic in (i) securing the food supply, or (ii) bewitching an enemy, taken from the enormous quantity of material collated by Professor Frazer in "The Golden Bough," will be enough for our purpose, and help us to understand the motive lying behind many of the cave drawings, not only of the Bushmen, but also of the early Cave Men of Europe and other parts of the world

Homœopathic, and in general sympathetic magic plays a large part in the measures of the rude hunter or fisherman to secure an abundant supply of food. On the principle that like produces like, many things are done by him and his friends in deliberate imitation of the result which he seeks to attain; and on the other hand, many things are scrupulously avoided because they bear a more or less fanciful resemblance to others which would really be disastrous.*

When he (the Cora Indian) wishes to multiply his flocks or herds, he models a figure of the animal he wants in wax or clay, or carves it from turf, and deposits it in a cave of the mountains.†

Perhaps the most familiar application of the principle that like produces like is the attempt that has been made by many people in many ages to injure or destroy an enemy by injuring or destroying an image of him, in the belief that just as the image suffers, so does the man, and that when it perishes, it must die. . . . For thousands of years it was known to the sorcerers of ancient India, Babylon, and Egypt, as well as of Greece and Rome, and at this day it is still resorted to by cunning and malignant savages in Australia, Africa, and Scotland. Thus the North American Indians, we are told, believe that by drawing the figure of a person in sand, ashes or clay, or by considering any object as his body, and then pricking it with a sharp stick, or doing it any other injury, they inflict a corresponding injury on the person represented.‡

In a similar fashion a photographer will often experience great difficulty in persuading natives in this country to allow themselves to be photographed, for fear lest the photograph might be used for malign purposes.

In the state of our present knowledge, therefore, it is reasonable to assume that the Bushmen paintings were magical instruments created for the purpose of augmenting or preserving the food supplies or other objects, and this view is greatly strengthened by a consideration of the following points:—

1. It explains the origin of the art, for faith in the efficacy of this method would provide a strong incentive to a study of

* Frazer, "The Magic Art," 1, 85.
† *Ibid.*, p. 87, note 1.
‡ *Ibid.*, p. 55.

the technical side of the work on the grounds that the more faithful the portrait, the more successful the charm.

2. It is a well-known fact that the animals which were hunted for food by the Bushmen are usually represented with great fidelity,* whereas the human form is usually depicted by a few crude strokes after the manner of the figures drawn by a child, and exceptions to this rule are generally of non-Bushman type. This is explained by the fact that the former were used in the ritual practised to ensure the food supplies, whereas the representation of any individual by a portrait would probably be regarded as a distinct breach of etiquette, if not a penal offence.†

3. It explains the reticence of the Bushmen to impart the secrets of their art to others, and the jealous care they bestowed upon many of their works.

Unfortunately these interesting relics of an extinct race in the Makabene are being rapidly destroyed by the present Bantu inhabitants of the district, who have been daubing over them with clay in the endeavour to enhance their outlines or imitate their forms, and nothing, apparently, is being done to prevent such acts of vandalism.

The original efforts of the Bantu are easily distinguished, apart from their lack of skill, by the crude materials used for paint. In some cases this is nothing but a paste of ashes and water, and many fine specimens of Bushman work have been hopelessly ruined by having their outlines "renewed" with this material.‡ The natives explain this practice by saying they admired the pictures on the rocks, and hoped by tracing over the earlier works to acquire the artists' power of reproducing the likeness of things seen.

Most of the unaided efforts of the Bantu are crude imitations of the Bushman style, though occasionally they show distinct originality. Most of their work is done in white, and a deep black made from charcoal is not uncommon.

The most interesting specimens of Bantu work in the Makabene were found in a grotto scooped out of the solid rock high up on the face of a cliff, and represent a series of railway trains —third class only—and a train of "coco-pans" (Plate 18, Fig. 3, and Plate 20, Fig. 8). They were executed by a native who

* *Cf.* Stow, p. 171. "In the course of the journey he (Barrow) saw several thousand figures of animals, but none had the appearance of being monstrous; none that could be considered as works of the imagination; they were generally as faithful representations of nature as the talents of the artist would allow." *Cf.* Plate 18, Fig. 4.

† A confirmation of the theory that a picture might be used for malignant purposes is probably afforded by a painting I discovered on the rocks overhanging the Umchezaan River in Natal. It seems to represent a 'Nadro, or leader, in one of the mystic dances so dear to the heart of these pygmy folk, his body transfixed by three darts or other lethal weapons. A copy of this beautifully executed painting may be seen in the collection of the Transvaal Museum, Pretoria

‡ Plate 19, Figs. 5 and 6.

Fig. 9.

Fig. 10.

Rev. N. Roberts.—Bushman Paintings.

Fig. 11.

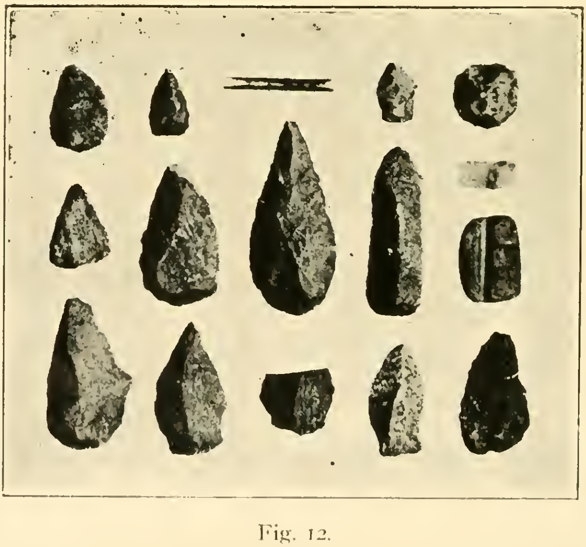


Fig. 12.

Rev. N. Roberts.—Bushman paintings.

contracted miners' phthisis while working on the Rand gold mines, and was sent home to die. He was sent to live in this cave, which was used a sleeping-place by cattle herders. During the long hours of loneliness while the boys were out hunting or herding the cattle he whiled away his time by drawing on the rocks, and one can well imagine him describing the wonders of the world he knew, the White Man's magic, and the White Man's ways, before his youthful, awe-struck audience, as they cowered round the fire at night.

A careful exploration of these caves should bring to light an abundance of material in the form of artefacts of different kinds. In most cases the caves are floored with solid rock, and the detritus is rarely more than a few inches in depth. In the short time at my disposal I spent a few hours in examining the debris in two caves, with the help of Mr. Winter, who is shown at work in the accompanying photograph,* and, in addition to the pigments already referred to, a number of stone implements of the type illustrated (Plate 22, Fig. 12) were discovered.

Explanation of Plates.

Plate 17.

Fig. 1.—Bushman painting on "Mont Blanc," No. 1083.
Fig. 2.—Bushman painting on "De la Roche," No. 1087.

Plate 18.

Fig. 3.—Bushman palimpsest (?), "De la Roche."
Fig. 4.—Bushman painting, "De la Roche."

Plate 19.

Fig. 5.—Bantu palimpsest. "Bonne Esperance," No. 1088.
Fig. 6.—Bantu palimpsest. "Bonne Esperance."

Plate 20.

Fig. 7.—Cave on "De la Roche."
Fig. 8.—Bantu rock painting: in cave at Fig. 7.

Plate 21.

Fig. 9.—Bantu imitations of Bushman work, "De la Roche."
Fig. 10.—Excavating.

Plate 22.

Fig. 11.—Bushman painting (direct photograph), "De la Roche."
Fig. 12.—Artefacts from caves on "De la Roche."

* Plates 20, Fig. 7; 21, Fig. 10.

VARIATION IN *AGARATUM CONYZOIDES* (FAMILY COMPOSITÆ).

By STEPHEN GOTTHEIL RICH, M.A., B.Sc.

In this common "Blue Weed" I have charted the variation in number of florets in a head, for 77 specimens studied. This work was done from May 29 to June 2, 1916.

The results here presented are collected from Nature-Study work of native students under me at Amanzimtoti Institute. The countings presented were made by them; the collation of results is mine.

We examined about one hundred heads of "Blue Weed" (*Agaratum conyzoides*). Separating the cluster of heads into its units, I had the students count the number of florets in a head, that they might have a better idea of the nature of the inflorescence in the family Compositæ. Owing to choice of immature heads, and to known errors in counting, I present the results for 77 heads only. This work was done about June 1; I believe that a study at this time would show larger numbers of florets per head.

I classify the heads in groups with a range of five florets in each: *e.g.*, the first ("55") is 55 to 59 florets per head. Above 115 per head the range is ten florets per group. Numbers of heads:—

Over 55 florets	1
,, 60 ,, ...	2
,, 65 ,, ...	3
,, 70 ,, ...	6
,, 75 ,, ...	10
,, 80 ,, ...	9
,, 85 ,, ...	4
,, 90 ,, ...	4
,, 95 ,, ...	9
,, 100 ,, ...	7
,, 105 ,, ...	8
,, 110 ,, ...	4
,, 115 ,, ...	1
,, 120, 130 florets . . . . each	2
,, 140, 150, 160 florets, each	1

The chief points of interest are:—

(1) There are *two* modes: one at 75 to 79 florets; another at 95 to 109 florets. Roughly speaking, the former is modal for heads *distal* in the cluster, and the latter for heads centrally located.

(2) The occasional occurrence of heads with up to 170 florets may be noted. In specimens examined about June 25, these large heads are more plentiful.

(3) The immense *range* of the variation.

This is contributed as a preliminary study only. I attempt no interpretation of these results until further work can be added.

FIRE-RESISTING BUILDING CONSTRUCTION.

By William John Delbridge, A.R.I.B.A.

(*Not printed.*)

STANDARDS AND STANDARD METHODS IN THE ANALYSIS OF FOOD AND DRUGS.

By James Sprunt Jamieson, F.I.C., F.C.S.

(*Not printed.*)

WATTLE-GROWING: ITS EFFECT ON THE WATTLE INSECT PROBLEM.

By Christiaan Bernhardus Hardenberg, M.A.

(*Not printed.*)

THE FARMING INDUSTRY IN NATAL.

By Rev. James Scott.

(*Not printed.*)

ON CERTAIN REMARKABLE RESEMBLANCES BETWEEN THE FORMATION OF IMAGES AND COLOUR VISION IN MAN AND CERTAIN VERTEBRATE ANIMALS.

By George Lindsay Johnson, M.A., M.D.

(*Not printed.*)

A BACTERIAL BLIGHT OF PEAR BLOSSOM.

By Ethel Mary Doidge, M.A., D.Sc., F.L.S.

(To be printed in Annals of Applied Biology.)

TRADE SCHOOLS AS AIDS TO INDUSTRY.

By Prof. John Orr, B.Sc., M.I.C.E., M.I.Mech.E.

(*Plates 23-27 and one text figure.*)

The war has forced upon us the consideration of many new problems; it has also led us to view many old problems in a less conservative light. Not the least important of these problems is that of the scientific organisation of industry. It is gratifying to observe the increasing sympathy with which technical education is viewed, which is most encouraging to those engaged in that work. The present conflict has caused an inward searching as to whether many of our "rule-of-thumb" methods can be allowed to continue unchecked, and it is to be hoped that the present progressive spirit will continue and redound to the lasting benefit of the British Empire. Improved methods must be adopted; as Sir William Beardmore has said, "The nation which does not continually search for improvement, must fall behind in the struggle for supremacy."

It is admitted that our educational systems require overhauling; as the President of the South African Teachers' Association said in his address at Grahamstown last June, "All educationalists are agreed that after the war things cannot remain as they were before. The lines along which our boys and our girls are to be taught will have to be adapted to the new conditions." And as Prof. Unwin has said in his presidential address to the Institution of Mechanical Engineers:—

> It is no condonation of the military crime of Germany to recognise that the enormously rapid industrial advance in that country has serious lessons for us. Before the war many of us had an immense respect for German science and learning. We have not lost that, because we now appreciate the inordinate vanity, the preposterous political ambitions deliberately fostered among Germans, and the insolence of the Army.

In this paper I wish to confine my remarks to one aspect of an important national question—the fitting of our youths to take their place, as efficient units, in the industries of this country. The rapid growth of the school population of South Africa, more particularly in the Transvaal, while exceedingly satisfactory from the national point of view, has become, more especially in recent years, a very embarrassing factor for School Boards and the authorities responsible for the efficient carrying on of education work. Unfortunately financial resources and school accommodation have not kept pace with the increase in the number of pupils, and something in the nature of a crisis has now been reached, accentuated greatly by the abnormal times.

The following schedule, taken from the Annual Report of the Director of Education, shews the position regarding the number of schools and scholars in the Transvaal since 1902:—

		Schools.	Scholars.
December,	1902	178	16,265
,,	1903	395	26,922
,,	1904	395	27,518
June	1905	400	29,456
,,	1906	435	32,360
,,	1907	503	37,529
,,	1908	631	44,452
,,	1909	720	47,488
,,	1910	739	49,996
December,	1911	706	54,882
,,	1912	718	58,676
,,	1913	738	64,370
,,	1914	764	65,953
,,	1915	802	76,487

Fig. 1 shews graphically the position as given in the Director's Report.

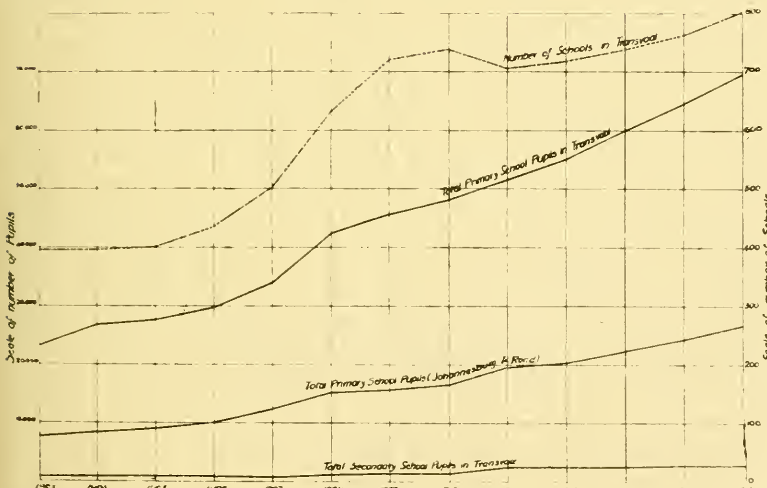


Fig. 1.

For Johannesburg and the Rand, the increase in the number of scholars in the primary schools has been from 7,477 in 1903 to 26,859 in 1915, the increase in 1915 over the previous year being 2,454.

In the absence of any definite statistics, it is difficult to say how many of these primary school children are cast out into the world every year to earn their own living without further preparation. Free secondary education should undoubtedly be the means of inducing many to continue their education at the secondary schools, but the statistics shew that there has not been the phenomenal increase anticipated in the number of secondary pupils during the past official year; in fact, the totals for the Transvaal Province have decreased from 2,754 in 1914 to 2,740 in 1915. This may be due to the abnormal times and to the abolition of secondary departments in primary school districts where secondary schools exist, but to the establishment of Commercial and Trades Schools, having a combined enrolment of over 500 on the Rand, must also be attributed some of the responsibility for this decrease.

A high educational authority estimates that the number of children leaving annually the schools of the Rand is in the neighbourhood of 1,200, and the problem to be faced is what to do with them. This problem is immensely complicated by the discouraging facts that South Africa generally is not as yet an industrial country, that facilities for learning the majority of skilled trades are non-existent, that difficulties arise from the existence and position of the native, and that there is an absence of opportunities of employment for unskilled boy labour. To be "unskilled" in South Africa carries with it an ever-present danger of developing into a "poor white," competing for employment with the native. The keynote of the Indigency Commission's recommendations was "education," and the conclusions of the Relief and Grants-in-Aid Commissions of 1916 point in the same direction; and there is no more profitable form of investment for any country than educational development.

It was to prevent the increase of unskilled whites, following what is frequently called "blind-alley" occupations, and to open up new avenues of employment in connection with skilled trades, that attention was first drawn in this country to the question of Trade Schools. I may here remark that I think that perhaps too much use is made of the expression "blind-alley" in connection with employment, or, rather, too much hope is built on the cry to abolish such occupations. It is impossible for every lad leaving school to become a skilled craftsman. Think of the great armies of unskilled workers in Europe and America. Statistics shew that the proportions of unskilled boy labour for various large towns are as follows: Munich, 10 per cent.; Berlin, 40 per cent.; London, 68 per cent.; and Chicago, 80 per cent.; although naturally a certain number are gradually absorbed into skilled trades.

Yet trade and vocational schools do much to divert into the skilled trades many lads who, either through want of opportunity or inclination, would, in this country, go to swell the ranks of the "poor whites" into which the unskilled tend to develop.

After the problem had for some time exercised the minds of educational authorities and engineers, vocational training was first introduced in the Trade School form in South Africa in 1909, the trial being made in Pretoria. A similar step was taken in Johannesburg in 1912, by the opening of the Johannesburg Trades School.

A considerable amount of controversy, which I need not dilate on here, has taken place as to the value of trade-school teaching, and the nature of the work which should be attempted in such a school. As originally established at Pretoria, and later at Johannesburg, it was the intention of the authorities that the school training should, to a great extent, supplant the regular workshops or commercial apprenticeship, and not merely supplement or prepare for it. The course laid down was a three-and-a-half years' one, including a probationary period of six months. The intention was, therefore, to turn out what has generally been known as "improvers." The system was doomed to failure when it was found that employers did not want this type of product, and that the trade unions objected strongly to half-trained men, as non-indentured improvers, being dumped upon the labour market, and it was found almost impossible to place the lads in suitable employment.

This attitude is justifiable. There are several objections to the system of indenturing lads to the Principal of a Trades School for such an extended period. It is claimed by employers that a lad should come into contact with practical work, on a commercial scale, when he reaches the age of 16. The trade unions insist upon an indentureship beginning with commercial apprenticeship, so that the conditions in each trade may be susceptible of regulation, and the objections from the school point of view are also serious. To keep a lad in the Trades School more than two years would require the carrying on of work on a commercial scale, if the lads are to be properly trained. To do this, and scrap the products, would cause a prohibitive expense to the Government, and to sell the products would involve entering into commercial competition with private firms by means of subsidised labour, a position impossible owing to its unfairness from both the employer and the employee's points of view, and likely to defeat the very objects for which the schools had been established. Many, it must be remembered, objected very strongly to the existence of the Trades School at all; it was not popular with the trades unions, and was looked at askance by the employers, who did not, at the early stages, in any way recognise the time spent at the school as shortening the period of apprenticeship.

Thus the position with regard to the schools, after three years' trial, was most unsatisfactory, and the whole question was therefore thoroughly investigated and reviewed by the Governing Body of the Johannesburg Trades School. A committee was appointed to determine how far trade-school training should count towards apprenticeship. But this was a matter which could only be decided after testing the product, and the employers, so far, had not been in any way consulted. A series of meetings was therefore arranged with the various employers' associations, and with the S.A. Institution of Engineers and the Association of Certificated Engineers of the Transvaal. The Institution of Engineers appointed a sub-committee to investigate the question. A large amount of data was collected with reference to the requirements and possibilities in the various trades, and the main conclusion arrived at was that, as far as the engineering trades were concerned, to merit the support of the employers, the school course should be of a general preparatory nature, not pointing to particular trades, and extend over two years only. The Association of Certificated Engineers, the members of which I am fully justified in saying have proved themselves the best friends of the school, took the same view, but suggested specialisation after the probationary period, and this opinion was found to be shared by all other employers' associations.

It was then decided to consult the various trade unions on the Rand, and in all a series of about 30 meetings were held. Time forbids an analysis of the results, but I select as examples the points discussed, and the decisions arrived at, at the meetings with an employers' association—the Association of Certificated Engineers—on the one hand, and a trade union—the Amalgamated Society of Engineers—on the other.

1. The representatives of the Association complained that, as representing the resident engineers on the Rand who controlled all engineering apprentices, they had not been consulted by the Government when trade schools were started.

2. *Position with regard to Apprenticeship.*—The Association was strongly in favour of apprentices in the engineering trades being indentured in outside workshops after completing their trade school course.

3. *The Term "Improver."*—The Association condemned the ordinary use of this term, and wished by "improver" to be understood one who had served his full apprenticeship, but was not expert enough at his trade to command the standard rate of wages paid to journeymen.

4. *The Term "Learner."*—The Association took exception to the term "learner" as used in connection with the engineering trades. All apprentices should be indentured, and all white youths in workshops, who are not thus indentured, should be classed as "white labourers."

5. *Period of Training at Trades School.*—The Association was in favour of this being limited to two years for all engineering trades; this period to include a six months' probationary period.

6. *Nature of Training at Trades School.*—The Association strongly supported a specialised course of training for all engineering trades, after the six months' probationary period; it objected to a general course, as not being in the best interests of the lads.

7. *Minimum Standard of Education for Apprentices.*—The Association agreed to Standard VI. as the minimum standard to accept as practicable at present, but was very much in favour of having Standard VII. regarded as the minimum for apprentices in the engineering trades.

8. *Support to Trades School.*—The Association was, after investigation, favourably impressed with the training being given at the Trades School, and was prepared, whenever possible, to

give preference to Trade School pupils when vacancies for apprentices arose.

9. *Indentureship in Trades School.*—The Association was of opinion that no useful purpose was served by having an indentureship system for pupils in the Trades School. In view of the fact that it insisted upon indentureship in the commercial workshops, it preferred to regard the Trades School training as preparatory course for indentured apprenticeship, and would be satisfied with a certificate, from the Principal of the school, that the pupil had satisfactorily completed the two years' course.

10. *Value of Trades School Training.*—The Association was of opinion that the time spent at the Trades School should count for such a period as the employer might consider adequate after a sufficient individual test had been made during a probationary term, provided that such period did not exceed the period spent in the school; the wages received to be the standard rate of pay to ordinary apprentices who had served the period allowed in respect of the trade school training.

11. *Nature of Work done in School.*—Whenever possible, the work should be of a useful nature, but there should be no unfair competition with outside firms.

The Amalgamated Society of Engineers endorsed all these views, and added:—

(1) That with regard to improvers, such should be recognised for a period of six months only after completion of apprenticeship.

(2) That apprenticeship should not begin before the age of 16, and, including the period of exemption for Trades School pupils, should be for five years.

(3) That attendance at continuation classes should be made compulsory on the part of all apprentices, who should be allowed off at least one afternoon per week for purposes of study and attendance at classes.

One immediate result of these conferences was the decision of the Governing Body to recommend that the course become a two-years' one, and that the system of indenturing at the school be abandoned; this was not done in a day, but the changes have been made, and they have proved entirely satisfactory.

Steps were then taken to ascertain by actual trial the commercial value of the trade-school course as regards reduction in the period of apprenticeship. One of the mines agreed to take three pupils on trial, with the result that they were accepted as apprentices, with an allowance of two years off the normal period, and with the corresponding rate of wages.

A word may now be said with regard to the work done at the school. Quoting from the prospectus:—

> The object of the school is to afford a preparatory training for the different trades. It must be clearly understood that no attempt is made to train the pupil for any but a working career as an artisan or "bench" hand, *i.e.*, as a mechanical fitter, and not as a mechanical engineer.

The course consists of a probationary period of six months, spent in all the workshops, followed by 18 months' specialised training in the workshops. The object of the probationary period is:—

(1) To afford the lad an insight into the various trades, and so give some guidance in his choice of his future means of livelihood;

(2) To discover the lad's aptitude for the different trades, and advise his parents or guardians as to the trade in which he will probably succeed; and

(3) To ascertain whether the lad will profit from the instruction given in the school.

The curriculum and time-table for the two years' course are shewn below:—

CURRICULUM AND TIME-TABLE.

	Course II. 1st Half-year.	Course II. 2nd Half-year.	Course III. (Ex VI)	Course IV.	Course V.
Arithmetic	4	3	3	2 (Arithmetic, Algebra, Pure Geometry)	2 (Algebra, Pure Geometry, Geometrical Drawing)
Algebra	2	1	1		
Pure Geometry ...	1		1		
Geometrical Drawing	2		2		
Science	4	2	2	–	–
English	2		2	1	1
Geography	1		1	–	–
Mechanics	–		–	3	3
Trade Theory ...	1		1	1	1
Trade Drawing ...	2		2	2	2
Workshop	$18\frac{1}{3}$		$22\frac{1}{2}$	$26\frac{2}{3}$	$28\frac{2}{3}$
Interval	$\frac{2}{3}$		$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$
	38		38	38	38 hrs.
	1st year.			2nd year.	

Originally there were five courses, as the test of admission was the passing of Standard IV., but the standard of admission having been raised to Standard V. and the age to 14, the work is now being covered in two years. The natural anticipation is the raising of the Standard to the VIth, so that the school may be brought into line with the secondary and commercial schools.

The present enrolment is about 120. All the lads could be placed in satisfactory employment though the enrolment were much larger. The arrangement with the resident engineers for shortening the period of apprenticeship has been confirmed by the Chamber of Mines, and it is hoped to get from that body a definite guarantee of employment to lads who have completed the Trades School course, and that they may even undertake to engage only these as apprentices. Poverty excludes many from the school, but much assistance is available in the form of bursaries—tuition, boarding and travelling—and sums of nearly £800 and £1,000 were spent in this way at Johannesburg and Pretoria respectively during the past year. The tuition fees are only £4 per annum, while in necessitous cases tuition is free. Last year the cost to the Government per pupil per annum was approximately £45 at Johannesburg, and £50 at Pretoria. This is admittedly more than the Government should be called upon to pay, but an enrolment of 300,* which I feel ought to be reached at an early date, when I hope the only avenue to apprenticeship in the engineering trades will be through the Trades School, would put the financial position on a more reasonable basis and reduce the cost per pupil-year to that approximating to the secondary schools, which, during the past year, amounted to £23 5s. 3d. If the total cost of the Trade Schools be divided by the total enrolment of both day and evening pupils, the capitation cost is £13 14s. 11d., as compared with £7 14s. 1d. for each primary school pupil and £9 4s. 6d. for each pupil taught in all the schools under the Transvaal Education Department, including continuation classes.

One difficulty with which the school has to contend is the amount of leakage; boys leave before completing their course. Some of this is due to their inability to cope with the work, and some to genuine poverty; but much is due to the selfish folly of parents who prefer a few immediate pounds earned in a blind-alley occupation to the remoter but greater earnings after sacrifice that yields such a manifold return in a career for the lads as skilled tradesmen.

Another drawback is that very little can be done with lads of a low standard of general education. Their apprenticeship is practically completed before they are capable of entering technical classes proper. Everyone acknowledges that from 14 to 16 is a critical period in the age of a lad. The sudden release from school discipline and contact with the world often causes him to run amok. The ordinary school lessons, even with the amount of manual training which is part of the school curriculum, having become irksome, he begs his father to release him from school, and the parent, too often a willing victim, falls. It is here where, in the case of a lad who wishes to become an artisan, the Trade School comes in. Certainly the wages which he might earn have to be sacrificed, and he must be provided with food and clothing for two years, but school again becomes attractive; he continues his general education while he does something useful with his hands; he knows that he is being initiated into a trade, and that the time spent in the school will count towards his apprenticeship, which is practically assured; and, perhaps the most important consideration of all, he is retained under discipline at the most impressionable years of his

* The enrolment at the beginning of the first term in 1917 was 187.

life—a most potent factor in connection with his future industrial efficiency. The small present enrolment at the Trade Schools can only point to one fact—that parents do not fully realise the advantages of a Trade School course for their sons.

The Johannesburg School has had one more difficulty to contend with—the majority of the pupils want to be mechanical and electrical engineers, with the result that the fitting, machine and electrical shops are liable to be overcrowded. The remaining four trades are to a certain extent neglected, so that the school is unable to supply the demand for blacksmiths, boilermakers, joiners, plumbers, etc.—all good trades to learn. It should be distinctly remembered that the school provides only a preparation for the skilled crafts, and the difficulty experienced has been attributed to the loose use of the term "engineer" when fitter or turner is meant. As one writer has very correctly said:

> While it is important to provide facilities for the able youth to rise from the ranks to a technical position, it is an error to assume that every trade apprentice is capable of so doing, and to direct educational efforts solely to that end. The fundamental fact must be recognised that the majority of such apprentices will work at the bench all their lives, and their training should consequently be such as to fit them for this sphere.

Much of the prejudice against which Trade Schools have had to contend is rapidly disappearing. This prejudice has been due mainly to conservatism and to a fear on the part of many that the Trade Schools might introduce unfair commercial competition with outside employers. This attitude has been fully realised by the Governing Body of the Johannesburg Trades School, which has safeguarded the position by passing the following resolutions:—

(1) The Governing Body is of opinion that it would be inadvisable to undertake commercial work in the departments already established in the school, unless with the approval of those engaged commercially in the trades concerned. It feels that the undertaking of commercial work without such approval would alienate the sympathy of both the workers and the employers.

(2) With regard to Government work, the Governing Body shall satisfy itself that such work does not involve too much repetition work, and that it is of an educational nature, suitable for the pupils in the shops concerned.

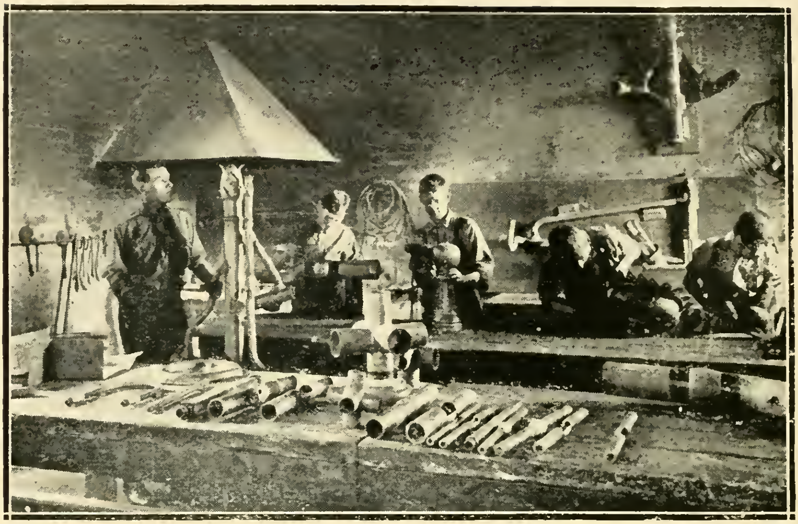
These resolutions appear to have satisfactorily defined the position.

It is pleasant to find support for the Trade School movement from the representatives of the scholastic profession. The President of the S.A. Teachers' Association, in the address referred to, expresses the opinion: "Trade Schools will have to be established, and, if we are not to be left behind by more enlightened nations, at least two years' compulsory training in these institutions will be required of all boys who intend to become artisans."

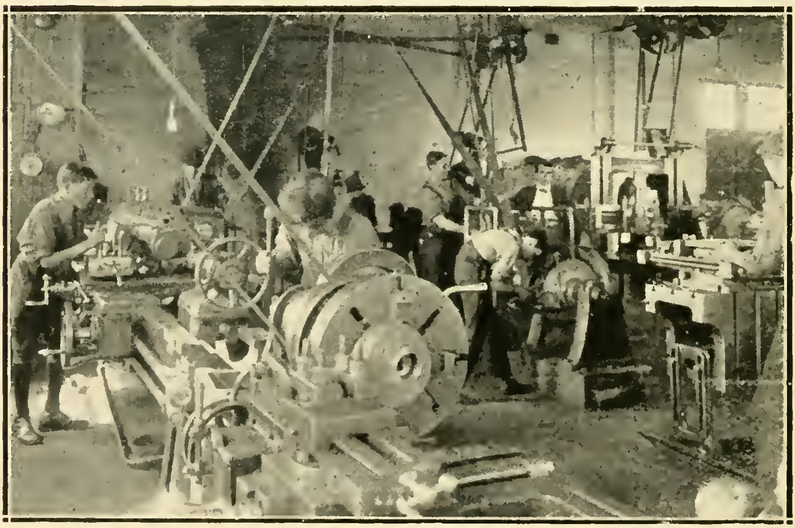
The Director of Education (Transvaal), in his annual re-

View of Buildings, Johannesburg Trades School.
Fig. 1.

Blacksmiths' Shop, Johannesburg Trades School.
Fig. 2.



Plumbers' Shop, Johannesburg Trades School.
Fig. 3.



Machine Shop, Mechanical Section, Johannesburg Trades School.
Fig. 4.

port (1915), has also the following encouraging remarks to make with reference to Trade Schools:—

> Perhaps the best testimony to the progress of these schools is the readiness of employers of labour to engage pupils who have been through the course. At the Johannesburg School the demands of employers have been greater than the supply of the school. It is also very satisfactory to learn that the reports on the pupils which have so far been received are most favourable. It is to be understood that the two years' course is only a preliminary to apprenticeship. In other words, the school is not intended to replace the trade workshop, where the boy works under actual economic conditions. It is certain, however, that the development of general intelligence which the Trade School aims at, and the very considerable experience of tools and trade processes which it supplies, make the Trade School pupil a valuable recruit for labour.

There is every indication that the Trade School movement has taken firm root in Johannesburg, and will continue to advance. Pl. 23, Fig. 1, shews the present buildings, to which it is hoped very large extensions will shortly be made. Pls. 23, Fig. 2, and 24, Figs. 3 and 4, shew the boys at work in the workshops indicated.

I have referred in detail to the Johannesburg School because of the intimate knowledge I have of that institution. The Pretoria School is conducted on similar lines, except for the important difference that the course is of three and a half years' duration.

A step of a somewhat different character has recently been taken in the establishment of a handicraft school for both sexes at Fordsburg, with a view to making school work more attractive to children of neglected education. This School of Industries, as it is called, admits pupils who have passed Standard III. and are over 13 years of age. Pupils attend for one day per week from the various primary schools in Johannesburg. On the boys' side considerable time is devoted to drawing, but woodwork is the basis of the scheme for Standard III, woodwork and metalwork equally for Standard IV, and either woodwork or metalwork for Standard V. It is hoped, later, to give the work a trade bias. At the time of a recent visit there were 154 children on the roll, having ages ranging from 13 to 15, the majority being of Dutch extraction. They all appeared to be keenly interested in their work.

Now, let us examine briefly the position with regard to Trade Schools and apprenticeship in Great Britain and other industrial centres in Europe. Generally speaking, Trade Schools for artisans may be classified as follows:—

(1) Trade Schools aiming at producing complete workmen, that is, supplanting the ordinary commercial workshop apprenticeship. Such are to be found in France and Holland, but only to a limited extent in Germany, and then usually confined to furniture-making, lock and key making, etc.

(2) Whole-time day preparatory Trade Schools, preparing for and reducing the period of commercial workshops apprenticeship, such as the Trade Schools of Johannesburg and Pretoria.

(3) Voluntary evening continuation schools for the various trades, giving theoretical instruction and sometimes practical instruction, to supplement the workshops' training during the day. This is the usual British system.

(4) Compulsory part-time continuation schools for those engaged in the various trades. This is the German system.

(5) Apprentice schools which form an integral part of commercial workshops. Such are fairly common in the United States, and in Westphalia and North Germany.

London has taken the lead in England as regards Trade School teaching, and the following table shews the Trade Schools for boys carried on under the auspices of the London County Council:—

TRADE SCHOOLS FOR BOYS (London County Council).

Special Training and Institution.	Duration of Course. Years.	Fee per Session. £ s. d.
FOR BOYS ABOUT 16 YEARS OF AGE.		
Bakery and Confectionery—		
Borough Polytechnic, Borough Road, S.E.	2	7 7 0
Building Trades (Architects, Surveyors, or Structural Engineers)—		
Northern Polytechnic, Holloway Road, N., *Architectural Day School*	2	10 10 0
L.C.C. School of Building, Brixton, S.W., *Senior Technical Day School*	3	9 9 0
Carriage and Motor Body Building—		
Regent Street Polytechnic, W.	2	10 10 0
Pupil Teachers of Handicraft—		
L.C.C. Shoreditch Technical Institute, Hoxton, N.	4	9 0 0
FOR BOYS OF 14 YEARS OF AGE AND UNDER.		
Book Production (Printing and Bookbinding)—		
L.C.C. Central School of Arts and Crafts, Southampton Row, W.C.	3	1 10 0
Building, Carpentry, Masonry, Bricklaying, Plumbing, Painting and Decorating, Architectural Drawing—		
Northern Polytechnic, Holloway Road, N., *Junior Technical School*	3	1 10 0
L.C.C. School of Building, Brixton, S.W., *Junior Technical School*	3	1 10 0
Engineering and Metal-Working Trades—		
L.C.C. Beaufoy Institute, Lambeth, S.E.	3	1 10 0
Borough Polytechnic, Borough Road, S.E. ...	3	3 0 0
L.C.C. Hackney Institute, Dalston Lane, N.E...	3	3 0 0
Northern Polytechnic, Holloway Road, N... ...	2	3 10 0
L.C.C. Paddington Technical Institute, W. ...	2	2 5 0

Special Training and Institution.	Duration of Course. Years.	Fee per Session. £ s. d.
L.C.C. School of Engineering and Navigation, Poplar, E.	2	3 0 0
Woolwich Polytechnic, Woolwich, S.E.	2	3 0 0
Furniture, Cabinet-Making, and Woodwork Trades—		
L.C.C. Shoreditch Technical Institute, Hoxton, N.	3	1 10 0
Photo-Engraving and Photo-Process Work—		
L.C.C. School of Photo-Engraving and Lithography, Bolt Court, Fleet Street, E.C.	2	1 10 0
Professional Cookery (Chefs)—		
L.C.C. Westminster Technical Institute, Vincent Square, S.W.	3	9 9 0
Professional Waiting—		
L.C.C. Westminster Technical Institute	1	1 10 0
Silversmithing, Jewellery, and Engraving—		
L.C.C. Central School of Arts and Crafts, Southampton Row, W.C.	3	1 10 0
Tailoring:		
Regent Street Polytechnic, W.	4	5 0 0 (on entry)
Wood-Carving—		
School of Art for Wood-Carving, South Kensington, S.W.	3	£7 (1st yr.) £6 (2nd yr.) £5 (3rd yr.)

There are approximately 35,000 boys leaving London elementary schools every year, of whom roughly two-thirds enter unskilled trades. Very few of these ever have a chance of becoming skilled craftsmen. It is to reduce this proportion and to assist in meeting the competition of foreigners, large numbers of whom flock to London, that the Trade Schools have been established. The curriculum is designed in all cases to carry on the general education of the pupils, as well as to give specialised technical training. The prospectus states:—

> Character, cultivated observation, intelligence, and adaptability are the essential factors aimed at.

The boys go out after one, two or three years' training, and become apprenticed or work as improvers. The prospectus further says:—

> Some have risen to positions of responsibility and trust, and it may be said that where employers have had an opportunity of giving the products of these schools a fair test, they have found the results of the system highly satisfactory, and have readily expressed their appreciation.

Some provincial towns have moved in the same direction, and what are called Preparatory Trade Schools have more recently been established in Leeds, Liverpool, Manchester, etc. The course is a two-years' one. General education is continued, and the practical work, which consists of woodwork and ironwork only, is of a comparatively elementary character. Writing to me recently, the Secretary for Education, Leeds, where there are two such schools, says:—

The work of the schools is more and more appreciated by the employers in Leeds, and the movement generally is taking a firmer hold on the people. The war, of course, is interfering considerably with educational developments in England, but there is no doubt that the day *Preparatory* Trade School is the special line of development of education in England in the near future.

The Liverpool School, which has been at work for some years, shews much success. In the course of a letter to me, the Director of Technical Education of that city says:—

The satisfaction of the Committee with the work of the Toxteth Trades School continues, and they are satisfied that the school has justified itself as providing a sound preparation for a number of students entering industrial employment. I can see the effect of the training of the school on the students when they enter the evening classes on taking up their apprenticeship, for they show out amongst the keenest and most capable students in those classes."

He also states that, but for the disturbance due to the war, another school would likely have been established.

It must be emphasised that in these schools the work is of a purely preparatory nature, and that instruction is given in woodwork and metalwork only, without attempting to specialise in individual trades.

Edinburgh must be regarded as one of the most progressive cities from the point of view of trade teaching for artisans. The School Board has established workshops as an adjunct to a secondary school, which are attended by apprentices during three afternoons per week, following what has come to be known as the "Munich" system.

About seven years ago a beginning was made with Trade Schools at Newcastle-on-Tyne, and the movement in this important industrial centre had every promise of success. On the occasion of another visit about 18 months ago, I found that the scheme had been abandoned owing to the somewhat inexplicable opposition of the trade unions, and that Day Technical Schools were being substituted.

It will thus be seen that, in Great Britain, outside of London, Trade Schools, as we know them, are practically non-existent. The main reason for their development in London is the fact that London has, to a great extent, ceased to be an industrial centre, and efforts are being made to hold and recover as many industries as possible. The London County Council is spending enormous sums on technical and trade education, but a prominent London educational authority has admitted to me that he questioned very much whether it was receiving value for its money.

The general position in Great Britain is that workshops apprenticeship constitutes to-day, as it did in the past, practically the sole method of learning a trade, this being supplemented by voluntary evening class instruction. Apart from Trade Schools proper, a great deal is being done in the workshops of polytechnics and technical institutes, mainly, however, in evening classes. The system of training an artisan in Great Britain is, therefore, essentially to place him in the workshops and offer him facilities for technical or trade training at evening classes, attendance at which is entirely optional.

The numerous polytechnic institutes in London are too well known to require detailed description. The day classes are frequently of a University standard, students being prepared for the degrees of London University. As a rule they are well staffed, excellently equipped, and well housed. The day classes cater mainly for the well-to-do, and workshop trade teaching forms only a minor part of the instruction. There is a great variety in the subjects taught; some have specialised in certain branches and even developed regular Trade Schools—such, for example, as the Bakery and Confectionery School at the Borough Polytechnic—but as a rule such schools cater only for the sons of employers. The main work is done in the evening classes, which, although reaching in many cases the highest standard, cater largely for the artisan. Classes in the printing trades are held only in the evenings, and are confined to those engaged in the trade during the day. This applies to the majority of other trades.

Similar institutions are to be found in practically every large provincial town; in fact, very few towns are now without their technical institute. While the majority cater mainly for the engineering trades, many specialise in the other principal trades and industries in the immediate vicinity. For example, Bradford is also strong in its weaving trades. An excellent weaving school has recently been added at Halifax, while at Leeds University itself there is to be found probably the finest weaving school in the world. Manchester Institute of Technology has made elaborate provision for local trades; the Heriot Watt College, Edinburgh, has developed sufficiently on its higher side to form an integral part of Edinburgh University, while it does not neglect any branch of trade. The Royal Technical College, Glasgow, the largest technical institution in Great Britain, does technical work of a University standard in every department of engineering, architecture, chemistry, etc., yet it houses the Scottish School of Bakery as a day department, and has most successful evening schools of plumbing, sheet-metal working, printing and allied trades, bootmaking, watch and clock-making, etc., the various employers' associations and trade unions being represented on the committees.

There are certain institutions which have been founded and are supported by the Guilds of London. One of the most interesting of these, of a trade nature, is the Leather Trades School, at Bethnal Green Road, established in 1889 for persons engaged in the boot and shoe industry. The object of the school is to provide instruction of a practical kind in the principles of the various branches and processes of the boot and shoe trades. The day classes are mainly attended by the sons of manufacturers, and the evening classes are confined to those engaged in the trade during the day. Afternoon lectures are also given to shop assistants and bespoke makers. On the occasion of my visit there were 20 day and 180 evening students in attendance.

Another important institution established by a guild is the Leather Sellers' Company's College, which has been erected by that company at a cost of £20,000, and it also defrays the annual cost of £3,000. It is equipped on a commercial basis, with upto date machines, so that the products may be sold. Leather of every possible quality and make is manufactured from the raw hides and skins. At the time of my visit there were 30 day students, including men from Canada, India, France, Spain, Portugal and Japan. In addition, there were 80 to 90 evening class students, all being men engaged in the trade.

No one can visit the various technical and trade institutions of Great Britain, as I have done, without being very much impressed with the valuable character of the work done, and the amount of money and brains which is devoted to it. Why, then, is it claimed, and admitted by many, that Great Britain has been wanting in the industrial struggle, that technically her workmen have been outstripped by German competitors, and that as a manufacturing nation she has been overhauled and even surpassed in many directions? The answer may be given in two words: *Compulsory education.*

In drawing attention to German systems of education I do not wish to be misunderstood. I agree with Mr. Horne, the Organiser for Technical Education in the Transvaal, when, in his last report, he says:—

> No reference to the progress of vocational education in Europe would be complete without the fullest consideration of what has been effected in Germany. The horror we feel at her recent actions as an avowed enemy must not prevent the examination of her educational progress in this direction, which may enable us to defeat a more subtle form of invasion—the swamping of the local workers by foreigners of better vocational attainment.

I think that all will agree that it is our duty to consider German educational systems, and even to adopt or improve on them, if it is in our interests to do so. We now know that Germany has for many years been engaged in an unscrupulous commercial war against the British Empire, and only now do we fully realise how much we have been dependent on German manufacturers.

A most valuable report, entitled "Trade and Technical Education in France and Germany," was issued by the London County Council in March, 1914. In an introduction to this report, Sir Robert Blair, the Director of Technical Education to the London County Council, says:—

> It will be observed how in Germany the State, the Municipality, the employed, and the employer, have all come to believe in education of all types, including compulsory continuation education. German belief in education, as is well known, has derived its strength from the period of reconstruction after Jena and from the extraordinary industrial and com-

mercial developments since 1870. The State and the parents have both adopted the long view, the former in looking forward to the ultimate value of the work of the schools, and the latter in foregoing immediate wage returns of their children for future prospects.

In Berlin, Munich, Leipsig, and other towns (he adds) the organised efforts of the State and the Municipality are reaching every boy (and in a few cases every girl) in a way that would hardly be credited in England but for the fact that experienced officers have seen it in operation. Continued education in England still follows the plan of *laissez-faire* or go-as-you-please. Germany possesses a national organisation for definite national objects.

The British method makes the best top; it also produces the worst tail, and it does not do much for the general raising of the great mass of workers. It must not be forgotten that the London evening student on the average makes 50 hours' attendance per session, while the German boy makes 240. The German boy must take a three or four years' continuation course; the English boy may take as much as he pleases, and 75 per cent. between 14 and 17 either cannot or do not please, even for one year.

The German schoolmaster, in the continuation school, has a great advantage over the London schoolmaster. The German can turn all his attention to his teaching and to the improvement of his syllabus of instruction. The London schoolmaster is greatly concerned with enrolment and attendance. Practically all the energy—and it is great—put into securing enrolment and attendance in England is in Germany set free for other purposes.

The question of compulsory continuation education, say to the age of 18, if not for the complete term of a lad's apprenticeship, is one fraught with great consequences to the youth of this country, and is one which, I feel sure, must be considered at an early date. Compulsory attendance at evening classes on the part of apprentices was first introduced by De Beers Company in 1898. About nine years ago a form of indenture was introduced by the Association of Mine Managers of the Transvaal in which attendance at evening classes was made compulsory, and the apprentice was granted one afternoon per week out of the working period without deduction of pay, in which to attend such classes, this instruction being supplemented by attendance at evening classes during one or two evenings per week. Considerable difficulty was at first experienced in enforcing this attendance, but time has solved the problem, and the system now works very smoothly indeed. Apprentices are being most generously considered by the Mining Groups; the fees, which are very low, are deducted in small sums over a period of 16 weeks, and the amount is returned as a bonus provided a satisfactory report is received and an attendance of 80 per cent. is made. Still, I hope that something more may yet be done. I think we should aim at compulsory continuation classes for all youths, with at least two afternoons per week devoted to study. And as an essential part of such a scheme it will have to be recognised that this continuation work cannot be performed with maximum efficiency by evening classes alone.

Referring now to Continental methods, it is difficult to explain in a few words the systems of apprenticeship and trade teaching adopted. Holland, as early as 1857, adopted the Trade School method. Now there are over 40 schools in which specific trades are taught, the age of admission being 14 years and the course generally extending over three years. Attendance is voluntary, but there appears to be little chance of a lad becoming apprenticed unless he can produce a Trade School certificate. France has also introduced Trade Schools, Paris possessing 15, seven for boys, and eight for girls. They deal mainly with furniture and the decorative arts; the courses last from three to four years, and the principal aim is to train foremen, who shall in turn instruct the workmen in the shops.

German technical education systems, which are clearly defined and do not overlap, as in Great Britain, may be classified into:—

(1) Technical High Schools, training for the higher professional positions and involving a preliminary secondary education.

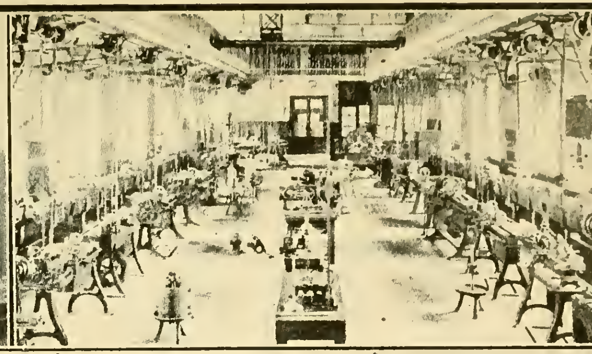
(2) Middle Technical Schools, corresponding largely to the British Technical Institutes, but devoting more attention to practical work.

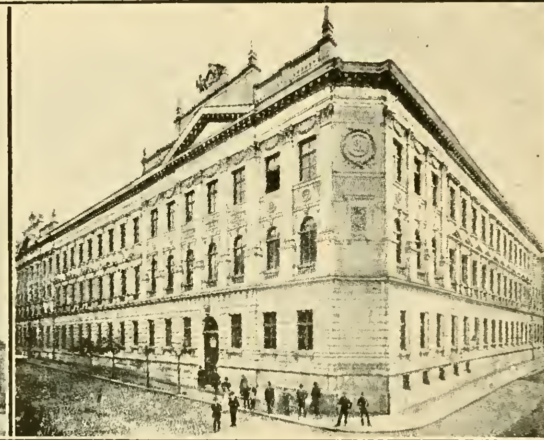
(3) Institutions for Artisans.

The "Gewerbeschule," an example of the Middle Technical School, is an important institution in Germany and Austria-Hungary, there being considerably over 100 in Germany alone. The object in most cases is to train for the "master's" certificate, an employer not being allowed to have apprentices unless their training is supervised by one possessing this certificate, as well as for the higher grades of employment; and one to two years' practical work is required before admission. The buildings and equipment are as a rule magnificent, and the trade instruction is very thorough. As examples of such schools visited by me, Pl. 25 shews the buildings of the "Maschinenbandschule" at Leipzig, one of the finest of the kind; the State institution in Prague; the corresponding institution at Buda-Pest; and a view of one of the machine shops.

In connection with the German institutions for artisans, compulsory continuation classes for males under 18 years of age was instituted in 1891. It was optional for a district or town to adopt it by bye-law, but the system has become universal. A lad is permitted to leave school at the age of 14, but until 18 he must attend a school bearing on his trade or occupation for from six to nine hours per week, either one whole day per week or, more usually, two half-days per week. Employers are obliged to make provision for the youth's absence from work, and special schools have been established for practically every trade and calling.

As the extent to which this continuation school system is carried on in Germany is not generally realised, and as the movement for compulsory continuation classes is growing rapidly in South Africa, I reproduce below the three years' course for "*unskilled workers*" at the Municipal Continuation Schools, Berlin.

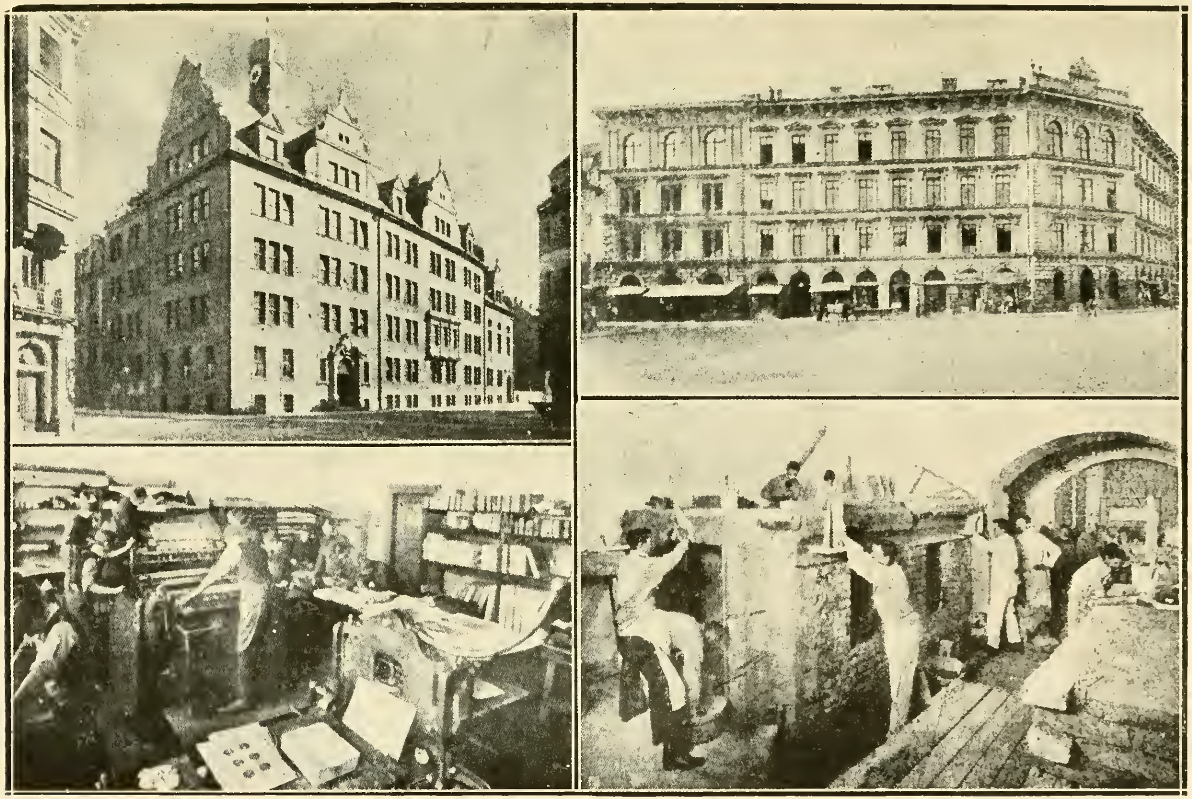




State Institution, Buda-Pest.
Maschinenbandschule, Leipzig.

Machine Shop, Buda-Pest.
State Institution, Prague.

J. Orr.—Trade Schools.



"Gewerbeschule" in Liebherr Street. Commercial School Buildings.
Lithographers. Masons, Bricklayers, and Plasterers.

Trade Schools in Munich.

PROGRAMME FOR UNSKILLED WORKERS.

First Year of Course: The Juvenile Worker in his Personal Capacity.

Amount of time.	Employment and Citizenship.	Writing Work.	Arithmetic.
weeks.	1. Beginning to earn a livelihood— (a) Choice of an occupation. Skilled and unskilled work; desire to obtain a situation; significance of work. (b) The continuation school.	Police announcements; canvassing; use of envelopes; notice of a change of work; dictation.	The four fundamental methods of reckoning with whole numbers and fractions; finding percentages; coinage, measurement, and weight system in connection with decimal fractions. 1. Exercises based on entry to industrial life, fees, cost of advertisements, seeking situations. Putting together and estimating advertisements.
6 weeks.	2. Position in the new working community— (a) Work and wages book; arrangement of work. (b) Conduct. Duties in dealing with employers. Conduct in intercourse with other people.	Work book, work placards, excuses on account of illness, greetings and letters of sympathy; dictation.	2. Exercises based on personal requirements and wages; income and expenditure (filling in forms); wages.
5 weeks.	3. Hygiene— (a) Personal hygiene. Food, temperature, alcohol, clothing, care of the skin.	3. Dictation.	3. Exercises connected with hygiene.
4 weeks.	(b) Hygiene in the house and the workshop, ventilation, heating and lighting.	4. Dictation.	Do.
5 weeks.	(c) First-aid in case of accidents.	5. Dictation.	Do.
4 weeks.	(d) Use of spare time for gymnastics, walking and play, for education and conversation.	Letter to a friend, *e.g.*, invitation for a walk; dictation.	Do.
7 weeks.	4. General welfare— (a) Insurance and arrangements for meeting illness. (b) Insurance and arrangements for dealing with accidents. (c) Insurance and arrangements for invalidity and old age.	Notifying sick fund societies; notices of accidents; cards for invalidity (not to be filled up, but completed examples to be shown).	4. Exercises connected with the law relating to insurance, and arrangements for the common weal

Second Year of Course: The Juvenile Worker in his Employment.

Amount of time.	Employment and Citizenship.	Writing Work.	Arithmetic.
5 weeks.	1. His activity in trade as messenger— (a) Town trade.	In addition to drafts, letters, dictation, etc., to be prepared regularly, notices of appointment, delivery and receipt forms, letters of advice for parcels, parcel traffic. Dictation.	Percentages of all kinds and their application, in addition to the use of the fundamental rules of arithmetic. 1. Exercises connected with trade life. (a) Town life.
5 weeks.	(b) Railway traffic.	Freight letters, card notices, railway parcel addressing, tying on labels.	(b) Railway traffic.
4 weeks.	(c) Postal traffic.	Addressing parcels, ordinary parcels, and registered parcels; sticking on labels; post cards of the world. Dictation.	(c) Postal traffic; telegrams.
4 weeks.	(d) Money exchange.	Postal orders; money orders by post, etc. Dictation.	(d) Money exchange.
6 weeks.	2. His activity in the workshop (as a working lad). (a) Important products of handwork in Greater Berlin, as far as they affect the juvenile workers concerned. (b) General arrangements in the workshop. (c) Examples of the division of labour and partnership.	Bills of lading; factory orders. Dictation.	2. Exchange. Exercises. (a) Concerning raw products and the products of labour. (b) Measurements.
4 weeks.	3. His wages— (a) Meaning and kind of wages. (b) Prudent use of wages.	Weekly notes; wage list; industrial law actions in case of wage disputes. Dictation.	3 Exercises on wages and their allocation; savings and personal economy.
4 weeks.	4. His status as a worker— (a) Examples of agreements for services and work. (b) Appointments, commissions, and their discharge.	Calculations; bills. Dictation.	4. Exercises in connection with buying and selling.

Second Year.—Continued.

Amount of time.	Employment and Citizenship.	Writing Work.	Arithmetic.
4 weeks.	5. The meaning of work— (a) The value of work in connection with the possibility of advancement. (b) The value of work for the State and society; former and present day work.	Dictation.	5. Exercises for thoroughly grasping the subjects learned in the second year of the course.

Third Year of Course: The Worker as a Member of the Community.

Amount of time.	Employment and Citizenship.	Writing work.	Arithmetic.
5 weeks.	1. The worker in the family— (a) The family as the foundation for civilisation and the common weal. (b) The respect for parents for maintaining life and the home; economical management; insurances.	Contracts; knowledge of contracts; envelopes for registered letters. Dictation.	1. Exercises connected with the household; the savings bank; life and fire insurance; money orders.
6 weeks.	(c) Parental authority and the duty of maintenance, inheritance, and wills; guardianship; children's duties.	Dictation, including memorials to officials.	Do. 2. Domestic bookkeeping.
3 weeks.	2. The worker as a member of societies and unions, trade societies, educational and social clubs.	Letters of excuse; pneumatic tube post. Dictation.	—
8 weeks.	3. The worker as a member of the community— (a) Arrangements made by the local authority for the welfare of the citizen; public hygiene; the care of the poor and of waifs; arrangements for education; taxes. (b) Administration by the local authority.	Dictation.	3. Local taxes; bookkeeping in a small business house.
7 weeks.	4. The worker as a member of the State— (a) The Kingdom and Government officials; the Kaiser, the Bundesrat, and the Reichstag; revenues; army and the navy.	Soldiers' letter, etc. Dictation.	Rates and taxes.
7 weeks.	(b) State arrangements and State officials; the King and the Landtag; State revenues.	Registration of births; letters to officials. Dictation.	Do.

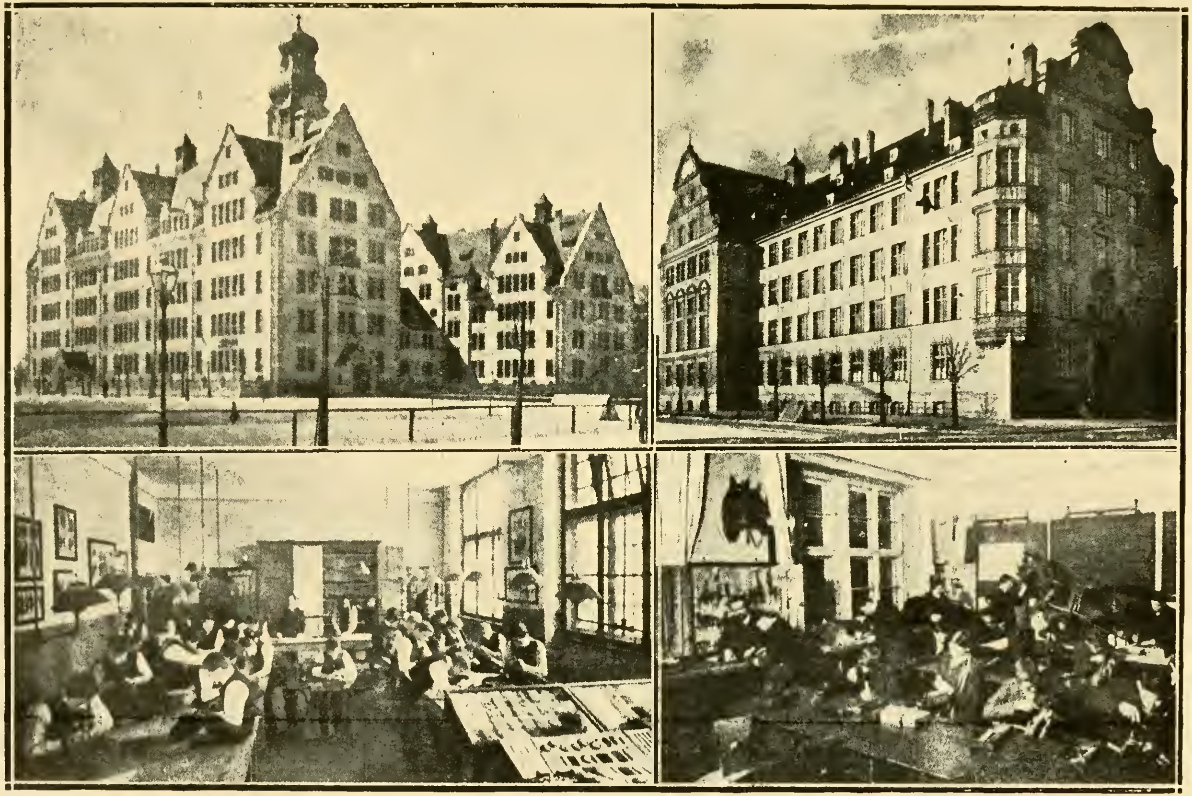
Until recently there was a difference of opinion in North and South Germany as to the nature of the instruction to be imparted in these schools. In Berlin the instruction was purely theoretical with no workshops training, but the Munich system of having a workshop for every trade or calling is now being generally adopted. The great success of the Munich schools is to be seen from the fact already mentioned, that only 10 per cent. of the lads in that town remain unskilled workers. The growth of these schools in Munich, during the six years prior to 1913, is shewn in the following table:—

MUNICH CONTINUATION SCHOOLS.

Year.	Number of Trade Continuation Courses	Total Number of pupils.
1907-8	46	6,133
1908-9	50	6,876
1909-10	54	7,818
1910-11	55	9,330
1911-12	55	9,617
1912-13	54	10,329

The comprehensive nature of the trade school training given in this town alone is shown by the following list of schools and trades taught in them:—

Building.	Trade Courses.	No of Classes	No. of Pupils.
Liebherr Street ..	Turners, Druggists, Tanners and Glovemakers, Wood and Ivory Carvers, Chimney Sweeps, Coachmen, Saddlers and Trunkmakers, Cobblers and Brushmakers, Locksmiths, Blacksmiths, Joiners, Shoemakers, Upholsterers, Decorators, etc , Potmakers and Stovemakers, Watchmakers and Wheelwrights.	55	1,226
Pranekh Street ..	Mechanics Instrument makers, Sheet Metal Workers, Joiners, Locksmiths, Spinners and Metal Workers, Tin Workers, Bookbinders, Printers Lithographers, Photographers, and Photo-process Workers, Type founders, Engravers, etc	103	2,628
Elizabeth Place ..	Coppersmiths, Mechanics, Locksmiths, Tailors and Farriers, Joiners.	39	1,023
Gotzinger Place ..	Mechanics, Locksmiths, Joiners.	31	852
General Continuation School ..	Barbers, Hairdressers and Wigmakers, Bakers, Gardeners, Innkeepers, Confectioners, Butchers, Musicians, etc.	58	1,492
Louise Street ..	Bricklayers, Masons and Carpenters, Dental Mechanics, Jewellers, Gold and Silver Smiths, Plasterers and Sculptors	28	652
Westenrieder Street	Decorative Painters, Varnishers, Gilders, etc., Glaziers, Glass, Porcelain and Enamel Painters	16	352
Commercial Continuation School ..	Shop Assistants, etc., Clerks and Civil Service employees.	56	1,613



J. Orr.—Trade Schools.

The various buildings, together with the boys at work in each school, are shewn by the slides, of which typical examples are reproduced in Plate 26.

As a typical time-table of these compulsory continuation courses, that for printers is given below:—

Subjects.	Years.			
	I.	II.	III.	IV.
Religion	1	1	—	—
Trade Composition and Reading	1	1	1	1
German Language	C 2	C 1	—	—
Foreign Language	—	—	C 1	C 1
Arithmetic and Bookkeeping ..	1	1	1	1
Citizenship and Trade History	1	1	1	1
Materials, Tools, and Machine Knowledge	1	1	1	1
Practical work	M 2	C 1, M 2	C 2, M 3	C 2, M 3
Trade Drawing	2	2	2	2
Weekly Hours	9	9	9	9

C indicates Compositors; M Machine Hands.

The fifth class of trade school, *viz.*, that established by large engineering firms in their own workshops, would appear to be on the increase in Germany. Apprentices attending such are exempted from the compulsory continuation schools. Usually theoretical instruction only is given, but there are at least two large workshops in Berlin where practical instruction is given in a special training shop for apprentices.

The trade school systems, outlined for Germany, are also to be found in Austria, Hungary, and Switzerland. Hungary has been a pioneer in establishing a type of school in which the apprentice is completely trained. The School of Instrument Making and Horology, Buda-Pesth, is the most complete of any of this kind I have visited. The Director received his technical training at Leeds University, and is most progressive in his ideas. The work carried on is of a commercial nature, mostly for government departments. As Hungary is not a manufacturing country, the majority of the pupils emigrate on the completion of their course.

The war has focussed attention on the unsatisfactory features of the British system of training the workers. As the writer of the report referred to says:

> The British system may be regarded as more philanthropic than patriotic; the ideal is admirable, but the bulk of the nation's workers are not catered for by this ideal, and on the bulk of the workers much of the material prosperity of a nation must depend.

And again:

> Germany is systematically training the whole nation in different ways for their different spheres. The effect of this in a generation will be of far-reaching consequences.

These, however, are but samples of the unheeded warnings issued before the war to the British people.

The same writer arrives at the following conclusions:

1. There has been, broadly speaking, a difference of ideals between Germany and Britain in organising technical courses. Germany is aiming at benefiting the nation by training properly all the workers through definitely specialised courses. Britain has organised so that individuals may secure what they think best for their own advancement.

2. The fundamental basis of any course of study for technical students must be their trade or employment. If this is recognised and acted on in the preliminary years from 14 to 18, there is little danger of work at more advanced stages, even if irregularly organised, being ineffective.

3. Germany is aiming at making good citizens and has realised that a good citizen must be a good workman.

4. Germany has come to believe that workshop training alone is insufficient to make a sound industrial nation; that it must be reinforced by adequate education specialised to trades.

5. This specialised education must include specialised calculations, technology, drawing, and citizenship. Munich also believes in trade work in the compulsory schools, Berlin does not.

6. Citizenship must be taught to enable the worker to recognise his industrial position in the State, his position with respect to his employer and his fellow-workmen, his family and social duties, the relative position of his trade in his own country and in the world's commerce and industry.

It must be remembered that the German law, with regard to compulsory continuation classes, applies not only to apprentices, but to every lad. It is claimed that

> The plan of vocational training in Germany must aim at the diminution of economic waste by ensuring that all occupations, however mean, shall be practised by men who have been taught to do their work scientifically.

We see how, in all this organisation, Germany has prepared so thoroughly in her industrial war against the world, and more especially Great Britain. Now that we realise the German menace it is incumbent on us all to fight it with her own weapons—organisation, education, and efficiency.

As a well-known authority has recently said:

> It must be remembered that, after this war is over in a military sense, we shall immediately commence another war of a different kind, in which the weapons will not be bullets and shells, but our national powers of invention, scientific research, commercial organisation, manufacturing capabilities and education, and these will be pitted against those of a highly organised Germany, determined to win back in commerce by any and every means, fair or foul, that which has been lost in war.
>
> That commercial and industrial war will be waged by our enemies with the same ruthlessness and neglect of all scruples as their military operations. We have said good-bye now and for ever to those easy-going amateur British methods which have held up in the past. What we require is to obtain a higher percentage of efficiency in all our operations. We have to attain larger and better results in education, scientific research, and industrial work to increase our national output in every way.

A PRELIMINARY ACCOUNT OF SOME BREEDING EXPERIMENTS WITH FOXGLOVES.

By Prof. Ernest Warren, D.Sc.

(*Not printed.*)

NOTE ON THE EVERSION OF THE PTILINUM DURING THE EMERGENCE OF THE HOUSE FLY, *MUSCA DOMESTICA*, LINN.

By Charles William Mally, M.Sc., F.E.S., F.L.S.

On making a critical study of the published descriptions of the transformations of the House Fly, *Musca domestica*, Linn., I found divergent statements as to how the eversion of the ptilinum during the emergence of the fly was brought about—some specify that air is forced into it, and others that blood is forced into it. From my own observations I felt sure that the eversion was due to a liquid being forced into it.

To test the matter, house fly puparia were placed in a small glass tube plugged with cotton wool. As the flies forced their way past the cotton wool sufficiently to expose the everted ptilinum it was punctured by means of a needle. A droplet of clear yellowish liquid at once came forth. This was repeated with numerous flies, and always with the same result. As soon as the ptilinum had been punctured the flies remained helpless between the glass and the cotton wool.

This shows clearly that the eversion and the introversion of the ptilinum is due to the liquids in the body being driven alternately forward and backward by alternating muscular contraction and expansion, the contraction beginning in the posterior part of the abdomen.

When the flies which had been subjected to the operation, which I shall designate *ptilinal puncture*, were isolated in clean glass tubes plugged with cotton wool, they remained alive and active for days—practically as long as normal unfed flies—but the wings did not expand, neither did the mouthparts nor the sexual organs come to perfection. The flies became darker in colour, but otherwise they remained in the condition they were when the ptilinum was punctured.

AN ACCOUNT OF THE CHIEF TYPES OF VEGETATION IN SOUTH AFRICA; WITH NOTES ON THE PLANT SUCCESSION.

By Prof. John William Bews, M.A., D.Sc.

(*Printed in* Journal of Ecology, *Vol.* 4, *Nos.* 3 & 4, *Dec.*, 1916.)

COMMERCIAL AFFORESTATION IN SOUTH AFRICA.

By Thomas Robertson Sim.

(*Not printed.*)

THE RESPIRATORY ORGANS OF DRAGON-FLY LARVÆ.

By Stephen Gottheil Rich, M.A., B.Sc.

The larvæ of dragonflies, as we all know, are aquatic, living among the weeds or burrowing in the mud at the bottom of still pools. They all possess that form of respiratory system which Pantel, in 1879, called "the closed tracheal system." This system is unique in animal respiration, in that it provides for the passage of gases as such from the state of solution in water to a free state in air-chambers within the body of the animal, and *vice versa*. This accomplished, the respiration of each takes place in the way normal for insects: *i.e.*, fine tracheal branches provide for direct access of air to all cells, obviating the use of hæmoglobin or similar blood-substances as efferents of carbon dioxide or afferents of oxygen.

The apparatus for extracting air from water and passing carbon dioxide into it, as found in the dragon-fly larva, is the most perfect mechanism of its kind known. This statement applies to the Anisoptera, or large dragonflies, and only in a limited degree to the Zygoptera, which are the smaller fluttering species.

Let us examine the Anisopteran respiratory organs. If we remove the dorsal body-wall of the larva of *Anax*, we see tracheal trunks and branches passing into all parts of the body, as in every insect. Peculiar to this group, however, is the enlargement of the tracheal trunks lying dorsal to the gut, as they pass caudad. In the last four abdominal somites they give off a series of re-dividing branches which pass to a much enlarged rectum. This rectum is, in fact, a gill-chamber. Internally it carries six longitudinal rows, each a double row, with twenty to twenty-four low gills in it. These gills are set diagonally, have a thick "cushion" of epithelium on each side, and are filled with fat. Each gill carries on its crest eight to eleven villi, making a total of roughly 3,000 villi.

These villi are the functional respiratory parts. The tracheal branches, repeatedly dividing, pass into them, and ultimately form loops, rejoining each other. Sadones, 1895, showed that these loops are in actual contact with the chitinous cuticle of the villi. I shall explain, below, the functioning of this mechanism.

To cut off this gill-chamber from the digestive part of the gut, a muscular band crosses the ileum in somite 5 of the abdomen, and is fastened at each end to the ventral body-wall. It can thus be made to act as a pinch-cock at the animal's will.

The rectum has six longitudinal bands of muscle, between the gill-rows. It has over its whole outer surface the usual insectean loose bands of circular muscles. Thus the rectum may be contracted forcibly—a movement used by the animal to propel itself forward by recoil from this anal jet of water.

The rectum has a short anal canal at its caudal end, terminated by three overlapping flaps and five spiny appendages which enable the opening of the gill-chamber to be closed tightly against harmful liquids or solids.

We thus see that the larvæ respiratory rectum in *Anax imperator*, var. *mauricianus*, our largest African dragonfly, is a singularly complete and well-protected mechanism. This apparatus, as shown in European species of *Anax*, was studied by Cuvier and by a dozen others since him. The general opinion, expressed by all up to even the latest, Miss Andrews, an American, who worked in 1901, was that there were perhaps 60,000 villi. This I corrected by counting gills and villi per gill, arriving at 3,000 as *maximum* number of villi.

In the same family (Æshnidæ) as Anax we have four other genera in this country. I take up two. *Anaciæshna*, in the same sub-family (Æshninæ), differs markedly from *Anax*, in that instead of having gills and villi, the middle of each double row of gills has a tall, thin, longitudinal fold, to which the gills, much enlarged, stand as buttresses. Here the distal margin of gills and fold are the functioning parts.

Mesogomphus, the medium-sized green dragonfly, whose larva is the most common odonate of our Natal streams, is more like *Anax*. The gills here are depressed into flat fatty pads, around whose edge arise long villi. This form has 4,000 villi. In all other features both *Mesogomphus* and *Anaciæshna* are like *Anax*. I made a survey of eight American Æshnids in 1915, and found much detail variation, but all forms were much like these three.

If we turn now to the family Libellulidæ, to which our common red, golden-winged, blue, and variegated-winged dragonflies belong, we shall find the rectal respiratory organ practically identical in all genera. I choose the genus *Sympetrum*, the dark-red autumn dragonfly, as type. The larvæ of all the Libellulids are broad in the abdomen, which correlates with the internal features. We note first of all that the tracheal trunks send off their branches to the rectum as a sort of fan-shaped mass, from one point. The rectum lacks an anal canal, but is right at the valve. The respiratory parts show a different grouping; each of the six longitudinal rows has a longitudinal muscle as its axis. We have in each row 24 flat gills, thumb-shaped in side view, with loops of tracheæ in the distal part, with a "cushion" on one side only, and with little fat in them. In all there are about 280 gills.

Our common *Trithemis*, *Lindenia*, *Orthetrum*, etc., show only slight divergences from this—namely, in the number of gills, which is sometimes 360. We owe to Scott, 1905, and Sadones, 1895, the first good studies of the gill-chambers of two Libellulids. My work herein has been to extend this investigation to a dozen genera.

Here I may add that the tracheation of the rectum is not entirely from the two main dorsal tracheal trunks. In all Anisoptera the ventral third of the rectum is tracheated from ventral trunks, which are connected to the dorsal ones caudally. A "post-dorsal" trachea passes to the extreme caudal gills.

Two African Libellulids, *Tramea* and *Pantala*, deserve brief notice. In *Tramea* the gills grade upwards regularly in size passing caudad. In *Pantala* the caudalmost five gills are very large, and all the gills carry setæ. In all other genera the gills or villi or folds are of practically one size throughout.

Let us turn to the Zygoptera now. These larvæ have no respiratory rectum, but just behind the Malpighian tubes is an enlarged ampulla, with three fatty pads much tracheated. There is record of Zygopteran nymphs drawing water into the rectum, but the organ for respiring therefrom has thus far been undiscovered.

The physiology of the dragonfly larval respiratory system is simple. Chitin, as shown by Dewitz, 1890, is water-impervious, but allows oxygen and carbon dioxide to diffuse freely. In the gills or villi there is only chitin between water and the air in the tracheæ. The metabolism of the animal produces high partial pressure of carbon dioxide and low partial pressure of oxygen in the tracheal air: the former diffuses out into the water, the latter in therefrom. The movements of the animal keep the tracheal air in circulation, even if diffusion alone were not sufficient to pass oxygen to the cells and carbon dioxide away from them.

Mature larvæ possess open spiracles on the thorax, and can breathe air directly as well as *via* the water. At metamorphosis, the respiratory part of the rectum shrivels up and its tracheæ vanish.

THE ASSOCIATION OF GAME WITH TSETSE-FLY DISEASE IN ZULULAND.

By David Thomas Mitchell, M.R.C.V.S.

(*Not printed.*)

A BACTERIAL SPOT OF CITRUS.

By Ethel Mary Doidge, M.A., D.Sc., F.L.S.

(Printed in the Annals of Applied Biology, Vol. III, Nos. 2 and 3, January, 1917.)

CITRUS CANKER IN SOUTH AFRICA.

By Ethel Mary Doidge, M.A., D.Sc., F.L.S.

(*Printed as Bulletin No. 20, 1916, of Union of South Africa Department of Agriculture.*)

SOME PLACE-NAMES OF TSOLO.

By Rev. John Robert Lewis Kingon, M.A., F.L.S.

A.—Preliminary Considerations.

The District of Tsolo is centrally situated in the Transkeian Territories. If for no reason other than that of its insulation from European influences, it is fitting that the first attempt at a study of Transkeian place-names should cover this district. In the main the district is peopled by the Pondomisi tribe, who have as yet made little advance out of heathenism. At the same time, it must be remembered that at one time it was the Government policy to introduce small communities of other tribes, so as to divide up peoples who might be warlike—and in this way, after the Pondomisi rebellion of 1879, small groups of Tembus and Fingoes were settled strategically in Tsolo District. It must also be borne in mind that the original inhabitants were Bushmen and Hottentots, and many place-names were handed down from these people to those who subsequently entered the country.

Traces of the Bushmen are still to be found in the shape of implements, and even one or two very small communities. In the Kambi Forest Mr. Viedge found a place some few years ago, where the Bushmen had been extracting iron ore and working it so as to supply the neighbouring natives with assegai heads.

Certain implements found at the spot were taken to Germany, and experts there confirmed the view that they had been used in the working of iron. Apart from these, flint implements are still to be found, and Bushmen paintings at Ntywenka, St. Augustines, and Gqaqala. The natives call these paintings *Ubala amatwa*—writing of Bushmen.

In addition to these evidences of Bushmen habitation, it is perhaps worth recording here that these people enjoy a great reputation as rainmakers amongst the natives. The Chief of the Pondomisi was wont to send them presents of cattle and sheep in times of drought. I think the origin of this belief is to be found in the fact that the natives lived in watertight huts, and did not need to worry about the rain, whereas the nomadic Bushmen, living in shallow caves, were troubled by the wet weather, and so were on the watch for changes that would indicate approaching rain. Perhaps this made them "discern the skies" better than the natives, and might well have given rise to claims that they were able to produce rain.

Of the Hottentots there is little to say. That they were here at some time seems to be proved by the name Qakancu, which is now the native name for Hottentots. The word itself was no doubt (like many others) a Hottentot word originally.

Realising, then, the background on which we must work, let us proceed to our study of the place-names.

In the course of this study I have been interested to find that even the smallest of places seems to be given a name. Many of these would be general in character—such, for instance, as a group of aloes on a ridge, which would be called *amakala, i.e.,* the aloes, or *Ngqubusini*, meaning "at the waterfall." Names such as these are worthy of mention, without drawing too much attention to them, for later we may find that they give us a clue to such general principles as may be applied in naming places.

It seems, also, that while a name may have a general meaning, yet usually there is some particular application which is the real origin of the name, and this information is only obtainable from the old people who live in the neighbourhood. As this old generation is rapidly passing, much of this information is in danger of being lost, and the sooner it is collected the better.

Further, a good many names apply to old tribal wars and raids, and, if left much longer, it will be difficult to find out with exactness the incidents which gave rise to these names.

Another point showing the value of this study, and the need for extending it, remains to be mentioned. In tracing out the origins and derivations of the names in Tsolo District, quite a number of words not in our latest and best dictionary* have come to light, and these, I hope, will find their way into the next edition. Doubtless we shall find more new words in the course of investigating the derivation of those names which as yet remain unexplained.

In conclusion I would suggest that the study of place-names might well be introduced into the native schools. Perhaps the suggestion on the surface appears revolutionary; but it is not really so, and it would serve as an introduction to geography and history, the geography of the locality and district in which the school is situated, and the history of their own forefathers. The present school curriculum requires children in Standard II "to know the chief natural features of the country in the vicinity of the school; to know the cardinal points; to draw a plan of the schoolroom; to be familiar with a plan of the immediate neighbourhood of the school." I suggest that the study of place-names would lend interest and promote a healthy spirit of enquiry among the children.

B.—Suggested Classification.

As a first step I would suggest that the following classification affords a good working basis for our present study. Later it may be necessary to modify and enlarge it, as the study extends over a wider area:—

I. Names with Historical Associations.
II. Names according to Shape or Special Characteristics.
III. Names after Trees or Plants.
IV. Names after Animals.
V. Names after Parts of the Human Body.
VI. European names—

* A most valuable piece of work, edited by Rev. R. Godfrey M.A.

1. Mission Stations.
2. Farms.
3. Trading Stations.
4. Dutch Names.

VII. General Names.
VIII. Names derived from Non-native Sources.
IX. Names whose Derivation is remote and not yet traced.

I.—*Names Having Historical Associations.*

Having given some indication of a suggested classification of place-names, we now turn to a more detailed study of each section.

A large number of the names have historical associations, some being related to events of great importance in the national life, and others taking note of the most trivial circumstance. Often some comparatively trivial incident was emphasized by a place-name called forth by that incident. A woman fleeing from the enemy during some raid is overcome by her condition and gives birth to a child and so the spot in which she took refuge in her travail is given a name that will for all time indicate the event; or, again, some quarrel is patched up, and the place of reconciliation is named. These are but instances to be found everywhere in the Territories revealing a principle on which names were given, and it is just because place-names in Kaffirland crystallize specific events that it is so important for us to undertake a careful study while the information is still obtainable. It is for the same reason that this attempt begins with only one district, and not with a very wide area. If our information is to be exact, the study must be microscopic, for every stream and rock has a name, and the harvest awaiting the patient investigator is by no means to be underestimated.

The first name which we need to consider is obviously the one which distinguishes the district itself. The earliest magistracy was established at the foot of a conical-shaped hill, called by the natives *Tsolo*. Later, when the Podomisi rebellion took place in 1879, the Magistrate, together with his staff, and a number of refugees, were besieged in the jail, until they were relieved by the Rev. J. S. Morris, now of Buntingville, at the head of an army of 400 loyal Pondos. At the conclusion of the rebellion it was felt that the Residency should be nearer to the protection of Umtata, and accordingly, by agreement with Bishop Key, it was moved 15 miles nearer to that town, to a site on the Xokonxa Stream, then occupied as an outstation by the Anglican Church. The vacant Residency site was handed over to the United Free Church of Scotland, and Somerville Mission was established there. In this way the name of that conical hill was transferred to a spot some 10 miles distant, where Tsolo Village has now arisen; but the natives still call the hill Tsolo, and the village Xokonxa. As a matter of fact, the natives seldom know places by the European names, the native names being in general use throughout the Territory.

The following complete series of most interesting names is clearly traceable in the district:—

Emfabantu.—At the time of Tshaka's great invasion of the Colony, the Bacas were being driven before his victorious army. After retiring across the Tsitsa River, they came to the ridge of the Malepelepe Plateau, and the narrow kloof at the side seemed to offer fair prospects of successful defence. Accordingly Matiwane's men lined the ridge and awaited the oncoming horde. A brave stand was made, and apparently the fiercest fighting took place. In addition to the usual weapons stones were rolled down the mountain-side, killing many, and the losses on either side were so heavy that for years after bones and skulls were still to be seen in the dongas in the vicinity.

The invaders were, however, successful, and Matiwane and his people fell back into the mountains, now named after him, but the scene of this battle ever after was called *Emfabantu*, which, being interpreted, means "death of the people."

All along the line of retreat skirmishes no doubt took place at many points. It seems that a fight took place at *Sebeni*, in the forest, and Silwangangubo, one of the leaders, was killed. To this day it is related that he was dressed in a beautiful tiger-skin,* and seems on that account to have been a man of special note. As one man put it to me in conversation, "He got his honour from the clothes in which he fought!"

But the main fight took place on the mountains of *Mbolompo*. It was really here that the power of Matiwane was broken and his army scattered in all directions.

At *Mbawelanga* he himself was reputed to have been killed. He, however, fled to Natal. Curiously enough, this place is, according to our ways of thinking, quite misnamed, for Mbawelanga means "the way of the sun"—that is, the rays of the rising sun fall first on this place, which is high up on the mountain-side. Surely the setting sun would afford a more fitting idea in the naming of the place where it was supposed this gallant chief fell. The *Matiwane Range* of mountains are a worthy memorial to his name.

The broken army dispersed in scattered bands, and this fact is perpetuated in the name *Qelana*, given to a neighbouring stream. In this place there are small hollows in the mountain-side, each filled with dense bush, and as the rest of the mountain-side is bare, we have literally scattered groups of bush, each bush capable of concealing a few men. Now *i-qela* means "a company," and the diminutive *i-qelana* means a small group or company. Whether the name was given to the scattered groups of bush originally, or to the small bands of men who sheltered in them, one cannot determine at this late date. So far as I can discover, the name

* Usually worn by a chief.

was given to the place because of the fugitive groups, and these would necessarily have been small, because the bushes could not accommodate large bands of men.

Those who escaped into the mountains were ruthlessly hunted down by the victors. The name *Gqoggora* gives a tragic picture of what happened, and at the same time enlarges our knowledge of the language. We meet with the same name near Main, Engcobo. The verb *uku-gqora* means to break off branches for firewood. There is, however, another verb (not given in the dictionary) *uku-gqogqa* meaning to shoot, or throw, at random, and would be used were fugitives escape into a bush and cannot be seen, and the pursuers hurl assegais, or shoot at random in the hope of hitting. Apparently many Bacas were killed here in this way.

The *Xokonxa* stream, flowing past Tsolo village, also owes its name to the aftermath of this great defeat. A large number of the Bacas seems to have escaped to the Goqwana Plateau, and to have made their way to the rocky ridge of the eastern slopes, which would afford many good hiding-places. Here they were discovered, but could only be dislodged with difficulty on account of the rocks. The verb *ukuxokonxa* means "to irritate by prodding," and it is specially used for prodding at a snake with a long stick. This process of prodding out fugitives at the point of the assegai was carried on for some weeks, until the ridge was eventually cleared.

One of the leaders, by name *Nondzaba*, escaped to an adjoining pointed hill, and evaded discovery for a time, but the avenging bands soon found his hiding-place, and he and his followers died fighting. The hill and the stream are honoured with his name.

This interesting series of place-names owing their origin directly to Tshaka's invasion give us some idea of the upheaval caused by this great warrior. It surely is but an indication of a much larger series of place-names to be found in the track of his invading army from the Natal Border. It would be an interesting study to find all the places which perpetuated the achievements of his followers, for these must be traceable in the place-names as far north as Delagoa Bay, and across to Griqua country in the west, and Barotse country in the north, an area covering about 100,000 square miles.

Quite a number of other names which obviously are traceable to a warlike origin probably are due to petty tribal wars and raids. I have tried as far as possible to classify these separately, and I think all belonging to the Tshaka period are correctly classified. One or two of those which I am now about to mention are a little doubtful, and may also belong to the days of the invasion, but on the whole I think all take origin in the wars of a later period. Thus the *Lutshaba* drift across the Umtata River was often used by raiders. The word means "an enemy." The *Xabane* stream is the boundary between the Pondomisi and the Pondos. The Pondomisi used from time to time to raid the Pondos and carry off their cattle, and these raids are perpetuated in the war songs of the Pondomisi. No doubt honours were fairly even, and what the Pondos lost one day they regained some other day. After a raid, however, the Pondomisi used to divide the spoils on crossing a certain stream, and while busied thus no doubt quarrels arose sometimes, and at others the Pondos came upon them. Xabane, "a quarrel," was the name fitly given to the stream.

Etyeni, meaning "at the stones," probably signifies some grim tragedy of the kind suggested by the name *Xokonxa*, but at a later date, I understand.

Another class of historical event is perpetuated in the name *Nomhala*. This name has quite an interesting little story of its own. A certain girl was married to Ngubencuka, Chief of the Tembus, and son of Hala, and she was then called Nomhala—*i.e.*, mother of the Hala tribe. The date may be fixed by the fact that Dalindyelo, the present (1916) paramount chief of the Tembus, was a son of Gangelizwe, grandson of Mtirana, and great grandson of Ngubencuka by Nomhala. But evil days came upon Nomhala. She was accused of witchcraft, and in order to escape the consequences ran home to her people at Ntshumane, in Tsolo District.

Ngubencuka sent out a party to chase her and bring her back, and a councillor of the chief was actually successful in stealing her from the hut in which she was sleeping. However, as she was being carried away she cried out, and her friends attempted a rescue. In the mêlée which ensued she was killed with many others, and so the place was called Nomhala after her.

It is interesting to note that *Ntshumane,* the original name of the place (which was taken from a sub-tribe of the Pondos, the Matshomani), has been quite superseded by Nomhala, and is only perpetuated by the tradition which lingers vaguely in the memory of the old people.

Another interestinbg name is *Elunyaweni*. For a considerable time I could get no information about this name. It means "at the foot," but I could never discover at the foot of what, for it was on top of a plateau, and there were no mountains in the vicinity. At last, one day I heard it spoken of as "*Elunyaweni inkuku*"—"at the foot of the fowl," and there was the explanation. After the Pondomisi rebellion (Umhlonhlo's) the Government planned to settle European farmers along the foot of the Drakensberg Mountains, and included in this scheme was the laying-out of a group of farms to be mentioned later. When the surveyors set to work they marked a certain spot with the usual arrow-head. The raw natives, seeing white men at work with theodolite and chains and flags, would be deeply interested, and this would be the object of wonder and the subject of conversation for many days through all the countryside. The threefold impress of the ordinary surveyor's mark (the arrowhead mark) would at once remind them of the "spoor" left on the ground by a fowl, and so they called the place "at the foot of the fowl"!

Pepelo arises out of the Ethiopian troubles which occurred some years ago in the Mission Field. A section of native church-members seceded from the United Free Church of Scotland, and the leader of the seceders called the place where he lived *Pepelo*, meaning "place of refuge." Another new word.

Nyembezi, signifying "a tear," would seem to indicate some incident causing unusual sorrow in that locality.

Ubalamatwa means "writing of the Bushmen," and is the name given to the places where Bushmen paintings are to be found. The name really is a contraction of two words, "*ubala amatwa*."

Sigonyela, a grandson of Faku, and once located at the place which still retains his name.

Sindeko, Diko, Majaba, and *Lochenberg*, have all perpetuated their memories by giving their names to places. The last-named is of more than usual interest, as will be seen from the following quotation:—*

> There had been living in Pondoland for some time a man named Lochenberg, who had created various disturbances in that part of the country. Associated ever since 1793 with renegades from the Cape Colony, this man had been notorious years before among the southern tribes, but the fate that had overtaken his companions seemed tardy in reaching him.
>
> His career, however, had at last come to a close. At the head of a party of marauders he attacked a tribe that was at war with Faku, the Paramount Pondo Chief, and was killed in battle.

His descendants are still to be found in the Tsolo District, on the borders of Pondoland. A location is named after him, and one of his descendants is a headman.

These instances are sufficient to show how the native place-names perpetuate incidents and persons of the past.

II.—*Named According to Shape or Special Characteristics.*

Mbokotwana.—The rounded stones used as grindstones by the natives are called *i-Mbokoto*, and the place-name is just the diminutive form. As a matter of fact, a doleritic outcrop in the neighbourhood has produced numerous hard dolerite nodules, and this has given the place its name.

Sebeni, "at the branches," marks the place where a spur is sent out, a branch, from the Matiwane Range.

Cingco, the name given to a pointed hill, reveals another new word to us. The word, I understand, means "pointed."

Mjika is given to the place where the Umtata River makes a complete turn in its course, and is derived from the verb "to turn."

Ntlangano signifies a junction, as when the Tsitsa River meets the Inxu River, and also is apparently a new discovery.

Qolombana, a small cave.

Emhlabati.—Ihlaba is a special kind of soil which no doubt is plentiful in the vicinity.

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* G. McCall Theal's "South African History and Geography," 84.

Sigxojeni.—Here again we seem to have a new word, for this term would be applied to a marshy place, and would mean "at the marshy place."

Mbuto, the name given to a commonage, which would probably be the meeting-place of the people from different parts in dry seasons when pasturage was scarce. An *mbuto* is a gathering, and might even be applied to the ordinary gathering of herd-boys at the pasturage. This word also appears to be new.

Tsitsa.—From the verb *uku-tsitsa*, to come out under pressure from within. This name is given to a river; and in the diminutive form, *Tsitsana*, to a tributary of the river.

Tafileni, "at the table," indicates the predominating character in the vicinity.

Jenca, the name of a mountain which stands apart from the main range as if it had been chopped off, from the Pondomisi verb *uku-jenca*, to chop (as with an axe). This also is a new word.

Mhlakulo, a hoe, spade.

Mhlahlane, stream "dividing" Pondos and Pondomisi.

Qanda, an egg. The name given to an egg-shaped kopje.

Ngxasa, an abbreviation of the Bushman word *Ngxangxasi*, a waterfall, or cascade. Therefore one would be in the vicinity.

Lukalana Nek.—Probably connected with um-kala, which comes to mean a bridle, or bit, the nek having some resemblance, real or supposed, to the "bit."

Luduli Mountains, from *iduli*, a battle between two chiefs, would mean "at the place where the warriors meet."

Lotana, from *um-lota*, the ashes of a burned hut, in its diminutive form.

Cofimvaba, from *ukucofa*, to squeeze (as a bag to find out contents), and *imvaba*, a skin sewn up so as to hold milk. That is, there would be many of these skins in that kraal to be squeezed to prevent the soured milk being in lumps. The name denotes plenty.

Ntongana, "a little stick."

Ludaka, a stream, probably derives its name from its muddy appearance, *u-daka* meaning mud, the significance of the name being "at the muddy stream."

Baxa, is a branch or fork, and would be given to a tributary stream.

Dikidiki, lukewarm, tasteless, is the name of a stream probably answering to one or other of these characters.

Elujecweni, "at the cutting off," from *ukujeca*, to cut off. Compare *Jenca*, above.

III.—*Named after Trees or Plants.*

Esidwadweni.—*Isi-dwadwa* is the name of a small tree, and the name is in the locative case, signifying "at the *dwadwa* trees."

Mqokolweni.—In the same way a certain kei-apple tree is singled out as the characteristic by which this place is named.

Umnga simply indicates "the mimosa" (*Acacia horrida*). Probably in that region the mimosa trees are very plentiful.

Ncolosi.—The native name for St. Cuthbert's Anglican Mission is full of interest. For long one could not trace its derivation until the hint came that probably, as we have a place called Ncolora, and another called Nconcolora, so with this name there might be a Ncolosi, and a Nconcolosi. This proved eventually to be the clue. It appears that the Bushmen used a root in olden days for the making of fire, by means of a long stick rapidly rotated between the palms of the hands. This was called *Nconcolosi*, and the bush growing plentifully in the locality, the name became transferred from the object to the place.

Ncembu, the name of a blue lily which grows plentifully near the edge of the plateau above the Matiwane Mountains.

Matyeba, a sort of herb said to be used for healing assegai and other wounds; also largely used in circumcision in the same way as *izicwe*; also in the old days used before going into battle as a "wash," applied to the whole body and supposed to protect from all danger. While one cannot say with certainty, it is most probable that this *amatyeba* grew either plentifully, or specially well, near the stream, and so the name came to be applied to the stream. Another possible derivation is from *ityeba*, a riem, plural *amatyeba*, riems. But this explanation does not commend itself. Rather would we suggest that rushes used in basket-making, when split for that purpose having the appearance of a "riem," grew in that spot.

Goqwana.—*Igoqo* = a piled heap of anything, specially firewood ready for use. *Wana* is diminutive. The name would indicate the place where the wood, or rushes, grow. The full name is *e-Goqwana*, which would seem to differentiate it from *um-goqwana n.6.*

Bulembu is the name given to a hill forming part of the Malepelepe Plateau. In the pools and streams in the vicinity the green spirogyra grows plentifully, and accordingly this characteristic gives the place its name. *Bulembu* means "moss," and is no doubt used also of the spirogyra; it also is the name given to the "hair" protruding from green mealie cobs. This word is new.

Kambi may be classified either here, or under Group 4, according as one decides the derivation. The krantz of the hill certainly does look like the chewings (to be seen on every footpath in season) ejected after the juice has been extracted from the sugar-cane. It may also bear resemblance to a spider's moult.

Gwali.—Hottentots made tea of a certain bush, and used bark as a purgative. These bushes evidently grew plentifully around the stream, and so locality came to be called by the name of the bush.

Mncetyana, a small bush, root used by Pondos for making penis caps.

Ntozani, a forest, said to be named after the grass to be obtained here, used for making mats. The idea of a mat may, however, have been suggested by the appearance of the extensive forest which is stretched out like a mat. Probably a new word lies hidden here, and further investigation should be made on the spot.

Qungu.—The tambookie grass used for thatching by the natives (*Andropogon marginatus*) is probably found plentifully in this vicinity, hence the name, which is the word for tambookie grass.

IV.—*Named after Animals.*

Qebeyi.—This place-name may with equal propriety be classified under the previous section, for not only is it the name given to a certain snake, but also is it given to a certain grass. Curiously enough, both this particular grass and the snake are plentiful in that neighbourhood. There is a great superstition attaching (amongst the Pondomisi) to this snake. Certain tribes will not kill it if they come across it on the veld. I cannot give its scientific name, but it is well known in the district, and is brick-red in colour, with a white spot on the neck. In winter the *qebeyi* grass is turned by the frost to a purplish brick-red colour.

Ntibane, apparently a Hlubi name. The si-Xosa equivalent would be (I believe) *Ntutyane*—a word not recorded in dictionary—and, moreover, *ntibane* in Tsolo does not refer to the red-capped lark (*Calandrella cinerea*), but to the variety of lark so plentiful in Tsolo District, especially at this spot.

Tshisane.—Also new word, name of a bird not yet identified, whitish grey in colour, size of a dove, and hawk-like.

Ntywenka.—A deep pool—the sort of place a hippopotamus would live in. Equivalent to Dutch " zeekoe gat."

Inxu.—I have always understood that this name was the Kaffir equivalent of the Dutch name for the River, *viz.*, Wildebeeste. It may be, however, that the naming was quite independent, and so the derivation of the Kaffir name does not refer to the gnu at all. In Davis's English-Kaffir Dictionary we are informed that the gnu is called inqu. But the difference in the words is only one of a click, the *q* or the *x* click? In Godfrey *inxu* is not given, but *inqu* is given as the white-tailed gnu. McLaren also gives this explanation. It would seem then that the spelling of this name is in error, and that we are perpetuating the mistake.

Ntabengwe.—The name of a ridge fringed with bushes and rocks, just the sort of place in which the leopard (*Felis pardus*) would delight to make its lair. " The mountain of the leopard " is the meaning of the name.

Mbinja, the name of a trading station, has a curious derivation. Evidently a fierce, and/or ugly, dog (possibly even a bull-dog seen for the first time by the natives) was kept at this place and by the coalescence of two words meaning " ugly dog " the place was named.

Mpukane.—The meaning of this name has been ascribed by various informants to three different sources. I have been told it was so named on account of the flies in the vicinity, on account of a certain bush which grows there, or on account of the mice. The first explanation is the most reasonable.

Impukunkona.—This elaborate name, whose prefix is spelt on a different plan to the extent that the initial vowel has not been elided as is usually done in place names, is formed from two words. Whatever difficulty we may have had in the previous name, there is no room for doubt about the presence of the mice in this vicinity. " The mice are here."

Zingcuka.—Probably also a victim of bad spelling! *i-Ncuka* is the name for the brown hyena (*Hyæna brunnea*), and apparently the name indicates the home of these beasts.

Before passing to the next section I wish to point out what valuable information is afforded us of the presence of certain animals in this one district. By the time we have covered all 27 districts no doubt we shall have a valuable addition to, and confirmation of our knowledge of the distribution of animals in this region of Cape Province.

V.—*Named after Parts of the Human Body.*

This is a seemingly small section, but the paucity of material must not be regarded as being due to the fact that places are not named in this way. The point is that many names are, and have been, suppressed because there is no point in perpetuating unsuitable and undesirable names. The heathen mind does not hesitate to give publicity to that which is private. We give a few illustrations of names of this class which are met with in Tsolo District.

Govane.—The uvula in the throat, which this particular place was supposed to resemble.

Bele.—Name of a mountain shaped like a female breast. Around this mountain are settled large numbers of the Bele tribe of Fingoes.

Bokwana Hill possibly owes its derivation to a resemblance to a nose, for the word *umboko* means snout, nose,proboscis. *Ana* is of course diminutive in force.

VI.—*European Names.*

Our study would not be complete if we did not make some reference to the European place-names of the district.

(*a*) In the first place mission stations have played a long and honourable part.

St. Augustine's, founded by Bishop Key, was burned down during Umhlonhlo's rebellion. After the " war " the main station was established at *St. Cuthbert's* (see Ncolosi), which is now a mission of some importance. *St. Bartholomew's* is one of the outstations in the Tsitsa basin.

Somerville, a mission station of the United Free Church of Scotland, stands on the site of the old Residency. When the Fingoes were moved down from the Maclear District after the Pondomisi War, the missionary was invited to follow the people to their new location, and since the Residency (see *Tsolo*) had been removed, the site was given to the Mission, and was the scene of the devoted labours of the Rev. D. L. Erskine for 27 years.

(*b*) This same rebellion was responsible for the policy of introducing a zone of white farmers along the foot of the Drakensberg Mountains. Accordingly at this time a large strip of country was surveyed off into suitable farm allotments, and these were carefully named, but never allocated. After a long time some natives were settled there, and now the whole of the farms in that part of the district have reverted to location. The names, however, have some interest as marking the episode, and the policy now abandoned.

The following are the names of farms on Maclear Border in Tsolo District:—

Glen Melville.
Kilmainham.
Fairfield.
Middlemarch.
Carlyle.
Edendale.
Inxu Gorge.
Oberon.
Silver Stream.
Lohengrin.
Freshfield.
Ben Strachan.
Glen Grey.
Hawarden.
Stanford's Grove.
Lothair.
Blunderstone.

Between Xokonxa and Umtata the road passes (*i.e.,* the old road) through a beautiful gorge into a beautiful valley, and on to a splendid grassland plateau. This approach to Tsolo was for reasons of protection very necessary in those days, also surveyed off. One was given to a loyal policeman of the Nxasana tribe, and the farm took his name, *Kilili.* Another loyal policeman of the Nahlambe tribe was rewarded with the farm *Hlangena,* also named after him. One other name, *Umti,* was evidently given because that farm was distinguished by the presence of (*mirabile dictu!*) a tree.

The following are the names of the Goqwana farms, and from the names we glean some idea of the character of the district:—

Grasslands.
Fairview.
Highcliff.
Ferndale.
Middleton.
Waterfall.
Kilili.
Hlangeni.
Umti.

(*c*) The trading stations do not show very much originality in their naming, and I give only those which have European names:—

Silverdale.
Junction Ferry.
Tsitsa Bridge.
Inxu Drift.

It will thus be seen that only four, and strictly speaking only two, stations depart from the native name of the locality, for obvious reasons.

(*d*) Dutch names are met with only occasionally in this region, the flow of emigration having gone further north. Nevertheless some pioneers pressed eastwards and added their quota to the list of place-names. One or two "neks" indicate their presence, and a few stray names.

Thus the Inxu River is still spoken of as the Wildebeest, and a small stream finds it way down from the Gatberg, away in the Drakensberg Range, and so is named. Diko's Nek, and Nkwancu Nek, and Pot Rivier (the Tsitsa) also serve as reminders.

VII.—*General Names.*

These also are but a small class, indicating kloofs, junctions, waterfalls, aloes, stones, and other groups of objects.

Thus we meet with *etyeni*, "at the stones," fairly often, and *Ngqubusini*, "at the waterfall," or *Ngxangxasini*, used to indicate the same place. *Amakala*, "the aloes," *Amawa*, "the precipices," *Madwaleni* (a name which I believe hides a new word), used of certain large exposed stone surfaces; and other similar general terms. *Mdibaniswent*, "at the meeting place," from *uku-dibanisa*, "to mix together separate things"; *engxingweni*, "at the kloof"; "*esikolweni*, "at the school."

VIII.—*Names Derived from Non-Native Sources.*

This is another small but interesting section.

Engesenges.—For long this name was an enigma to me. Even now it seems to be fading from memory, for careful enquiry in the neighbourhood was without result until I got the clue. There had been a great "battle" up the valley very many years ago; some of the old cannon were still lying about. The English soldiers had defeated a large native army. The natives had cried out in their way, "English! English!" Thus had the name been born. I have been told that as a matter of fact the soldiers had been sent to help this native remnant who had been hard pressed, in Tshaka's time, and were fleeing from him. Through some error, when they did fall in with the natives they had come to befriend they attacked them and slaughtered them, thinking they were enemies. On this point the history books do not give us much enlightenment.

Lutshintsho, in much the same way represented the effort of the native to reproduce our English word "*change*." At this particular spot the post-carts were wont to change their horses year in and year out, and no doubt that word would tend to be Kaffirised.

Balasi goes back to the days of unrest, when the police, camping for the night, perhaps for a long period, at this spot, made a barracks. As is well known the native cannot pronounce the *r* sound, which is invariably changed into *l*, and so *balasi* seems to have emerged.

Mabulu.—Along similar lines, the Boers coming among the natives were called *bulu*, with the plural prefix *ama*. Thus the place where the Boers settled was referred to simply as *Amabulu*, the initial *a* being elided, and so giving the name.

Uvete.—Then, again, the distant mountains being covered with snow, the whiteness would be constantly referred to by the Boers, and *witte* would be altered by the natives in their own characteristic way to the name *uvete*.

IX.—*Names whose Derivation is Remote and not yet Traced.*

This section is the largest of all, and we may expect many points of interest and value to emerge in the elucidation of the origin, or possible origins of these names. It is probable that many new words—and when we speak of new words we mean words still unknown to us—will be found as a result of efforts to ascertain the correct derivation of these names. Perhaps it is necessary to remind ourselves that the natives are *very* ignorant of their own language; that just as our uneducated white people know only a limited number of English words, so the vast mass of illiterate heathen natives have only a small vocabulary; that the language is still in process of being reduced to grammar, and words are still being collected, this work of developing the language being almost wholly in the hands of the missionaries, who are writing the grammar, and producing a literature for the natives. Indeed, some of our missionaries know far more about the Kaffir language than do the natives themselves!

Over and over again, in tracing out the meanings of place-names, fully qualified native teachers have given me conflicting information, or have confessed that they did not know the meanings of the Kaffir words about which I was enquiring.

Furthermore, different tribes have different names for the same thing, and different usages of words, and this sometimes produces confusion of thought. But the relative ignorance of the native, even when "educated," emphasises the need of making Kaffir a separate subject, as well as the medium of instruction up to a high standard, in the native school curriculum; and in passing I wish once more to lay stress upon this important point.

The following is the list of names in this class:—

Bedlana.	Gxebe Hill.
Binta.	Magutywa.
Bovube Hill.	Malepelepe.
Cebence Stream.	Mbango.
Cengane Hill.	Mbidlana.
Ceka Forest.	Mgwakwa.
Duba.	Mkumenge.
Esinxaku (or Esinxago).	Mncema.
Esiqungqwini.	Mncwangele.
Gelani.	Mqobiso.
Gemfana.	Mqunye.
Gongo.	Mtobisi.
Gqaqala.	Myezweni.
Gungqwane.	Ncakubeni Mount.
Gungululu.	Ncambele.

Ncolora.
Ndzebe.
Ngcele.
Ngxeteya.
Ngxoto.
Ngqokwe.
Nieke Hill.
Nongxola.
Nowaxa Drift (perhaps Nowaca).
Noziyongwana.
Nqaba.
Nqabara.
Nqabarana.
Nqadu.
Ntshiqo.
Qurana.
Qutubeni.
Tikitiki.
Umlenge.

Perhaps, as already stated, of all the groups suggested this is at once the most interesting and valuable for the purposes of our study. It is here that we shall expect to find new words, and usages, the diamonds left behind after the other material has passed through the meshes of our present knowledge—and in the very effort to discover the derivation of these names we shall probably come across other gems for which we do not search. Let us therefore examine our harvest more minutely. The first process is to distinguish between names of Hottentot and Bushman origin, and those of more recent date, that is, those given by the natives. The strict rule appears to be that only names with double clicks are to be regarded as of Hottentot-Bushman origin. We, however, include all names having a click at all, and get the following arrangement of our list:—

Hottentot and Bushman.	*Native.*
Cebence Stream.	Bedlana.
Cengane Hill.	Binta.
Ceka Forest.	Bovube Hill.
Esinxaku (or Esinxago).	Duba.
Esiqungqwini.	Gelani.
Gqaqala.	Gemfana.
Gungqwane.	Gongo.
Gxebe Hill.	Gungululu.
Mncema.	Magutywa.
Mncwangele.	Malepelepe.
Mqobiso.	Mbango.
Mqunye.	Mbidlana.
Ncakubeni.	Mgwakwa.
Ncambele.	Mkumenge.
Ncolora.	Mtobisi.
Ngcele.	Myezweni.
Ngxeteya.	Ndzebe.
Ngxoto.	Nieke Hill.
Ngqokwe.	Noziyongwana.
Nongxola.	Tikitiki.
Nowaxa.	Umlenge.
Nqaba.	
Nqabara.	
Nqabarana.	
Nqadu.	
Qurana.	
Qutubeni.	

From this arrangement it will at once be seen that the district has a preponderating number of names of Hottentot and Bushman origin. Nevertheless it must not be concluded off-hand that it was widely populated by these tribes, for the natives coming later, and having learned the clicks of these people, may have named the places, at a much later date, with names in which Bushman clicks were used. The strict rule is, as indicated, that the only names which we can be sure have a true Hottentot and Bushman origin are those in which we find a *double* click.

Thus we have *Cebence, Esiqungqwini, Gqaqala, Ngxagxasi.* But other names are to be found which obviously are abbreviations of names once rejoicing in a double click. In some cases we have both forms perpetuated in different parts of the country. Thus we have *Ncolora and Nconcolora.* It was this which gave me the clue to the meaning of *Ncolosi.* I argued that if we had a *Ncolora* and a *Nconcolora,* we might just as well have a *Ncolosi* and a *Nconcolosi,* and on enquiry I found that this second word was known to the natives, as described elsewhere. Arguing from the termination of the word, we get further light, namely, a confirmation that words ending in *ra* are of Bushman origin. A most interesting illustration is to be found in the three names, *Nqaba, Nqabara, Nqabarana.* After what has already been said we might also expect a *Nqanqaba.* If there is one, I have not yet come across it, but the word *i-Nqanqaba* (which is a Bushman word), means a steep ascent, and this is an exact description of the *Nqaba* valley! It becomes steeper and steeper until a high waterfall is encountered, and in any case the sides are strikingly steep. The *ra* has the force of toning down, and giving an impression that at the *Nqabara* stream the ascent is steepish. In the third instance the additional suffix, *ana,* has a diminutive force, the *Nqabarana* being the small stream at the steepish ascent. All this is seen to have value when we come to names like *Nqadu,* and *Qurana.* Is there a *Nqanqadu,* by means of which we shall come to discover the at present obscure meaning of the simpler form? And in the case of *Qurana,* must we take away two suffixes—"*ana*" and "*ra,*" and so come to the root of the name, and thus to an understanding? Thus, the general rule is seen to be capable of wide extension, and the circle of strictly Bushman names is visibly enlarged, including many in which there is only one click.

Confining our attention to certain selected names, we find some further facts emerging, full of interest and value.

Esiqungqwini.—A name which no one in the neighbourhood was able to explain, probably shelters another word as yet unknown to us. I think there must be a Bushman word *qungqu,* meaning a hump, or lump, and that the humpy sort of mountain there gave the name to the neighbourhood. I gathered as much from one man, but was not able to establish it, and the explanation certainly has very much to commend it.

Esinxaku, or *Esinxago,* quite baffles me. I tried again and again to find out what it signified, but was not able to get even so much as a suggestion.

Gqaqala.—This name is philologically interesting. It is obviously of Bushman origin, and the place thus named is where the last lingering old Bushman died some three years ago. There used to be quite a Bushman colony there at one time, and the place is closely associated with them, being as it were, the ancestral home in this district. In my earliest enquiries I was told that this name was given to the place at the time of the Mfecane invasion, when the people were split up at *Qelana* into small bands, and destroyed in the bush at *Gqogqora* by their conquerors, and that then some escaped only by creeping away on hands and knees, and so the place was called *Gqaqala.* The verb *ukagaqa* means to creep on hands and knees.

Another explanation was that at that time the men were scattered, one here, one there, by their defeat, and so since there is a verb *ukuti-gqagqa,* meaning to be scattered, one here and there, that that was why the place was named *Gqaqala.*

The third explanation was that the place came to be associated with the obscene word *uku-gqa* in an intensive form by duplication, namely, *ukugqagqa,* meaning to copulate.

Now the first explanation would be quite interesting and acceptable in itself, only the place name is spelt *Gqaqala,* and the verb is *ukugaqa.*

In the second case, the verb becomes *ukuti-gqagqa,* and in the place name there is no second *g.* This same difficulty is met with in the third explanation also. It would thus seem that either there is a word quite unknown to us, or else the spelling is wrong —that is, the spelling of the place-name.

One more name must suffice for the purposes of the present paper, and this one we select from the list of native names.

Malepelepe.—For long every effort ended in failure. At last in conversation with a native I got the suggestion, and a new word. It seems that *amalepelepe* is used to denote a thick viscid fluid as castor oil. It is a noun of the second class, having no plural.

When an ox is very tired the saliva running out of its mouth would be called *amalepelepe.* Thus we would say, "*Inkomo ipuma amalepelepe,*" the cow lets out saliva; or, again, "*Umlambo uzele gamalepelepe,*" the river is full of froth.

Since the plateau named *Malepelepe* is doleritic in origin, one wonders if there has been any suggestion of this viscid volcanic fluid in the naming of the place? Is it possible that that amount of knowledge was theirs? Probably the slimy spirogyra in the stream had something to do with the name chosen.

May I conclude, for the present, by inviting correspondence on the subject-matter of this tentative effort. If the effort has been tentative, at least enough has been done to demonstrate what a wealth of material of historical interest and philological value must lie hidden in the place-names of Kaffraria.

MEMBERS OF THE GENUS *ALOE* IN SOUTH AFRICA.

By Iltyd Buller Pole Evans, M.A., B.Sc., F.L.S.

(*Not printed.*)

EULOGIES (*izi BONGO*) OF THE ZULU KINGS.

By James Stuart.

(*Not printed.*)

MORE EUROPEANS, AND HOW.

By John Kirkman, J.P., M.P.C.

(*Not printed.*)

AFRICA AND SKIN COLOUR.

By J. T. Gibson.

(*Not printed.*)

INSURANCE AGAINST LITIGATION.

By John Richard Leech, M.D., C.M.

(*Not printed.*)

NOTES ON SOME OF THE TREES AND SHRUBS OF THE MELSETTER DISTRICT OF RHODESIA.

By Charles Francis Massey Swynnerton, F.L.S., F.E.S., F.R.H.S.

(*Not printed.*)

A PLEA FOR THE SCIENTIFIC INVESTIGATION OF RACE DIFFERENCES AS A BASIS FOR SOCIAL LEGISLATION IN CONNECTION WITH THE SOUTH AFRICAN RACES.

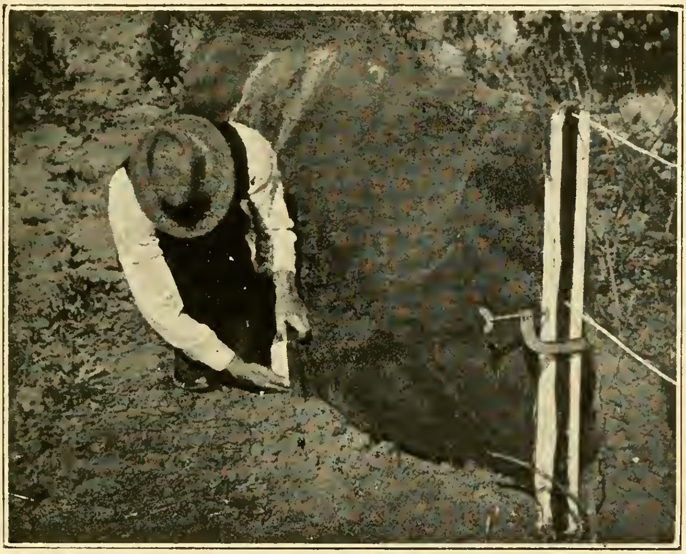
By Samuel George Campbell, M.D., M.Ch., F.R.C.S.E., M.R.C.S., D.P.H.

(*Not printed.*)

Details of Generator.

The Generator in Operation.

C. W. Mally.—Hydrocyanic Acid Gas Generator.



Method of inserting generator under tent, and method of closing the ends of the tent over the trellis wires.

A CONVENIENT TYPE OF HYDROCYANIC ACID GAS GENERATOR FOR FUMIGATING VINEYARDS FOR THE DESTRUCTION OF THE MEALY BUG, *PSEUDOCOCCUS CAPENSIS* BRAIN.

By Charles William Mally, M.Sc., F.E.S., F.L.S.

(*Plates 28-29.*)

In fumigating grape vines with hydrocyanic acid gas during the winter season for the destruction of the Vine Mealy Bug, *Pseudococcus capensis* Brain, it is necessary to use very small amounts of acid and cyanide because of the small space enclosed by the long, low, narrow, gas-tight oiled canvas covers for trellised or "stump" vine (see Plate *29*). It not only required a great deal of time to weigh or measure off the chemicals, but it was not easy to drop them into the generating vessel without loss of gas. It was therefore decided to dissolve the cyanide in water and use the solution to combine with the acid.

Different methods of handling the acid and cyanide solution were tried, with the result that the generator illustrated in Plate 28 was invented.

It is made of lead (South African Lead Works, Cape Town), and the essential feature is the pair of tubes in the lid, one for acid and the other for cyanide solution. In this generator the lid was perforated and a tube secured across the top to emphasize lateral diffusion as the gas escapes from the generator. But in practice the gas escapes with such force that this tube is not necessary. A small hole on either side just below the edge of the lid serves the same purpose

To charge the generator the lid is held upside-down, the tubes filled with the proper amount of liquid, the generator inverted over it and pressed down in position. When ready, introduce the generator under the tent, turn it right side up, and withdraw the hand quickly. The gas is generated instantaneously and rushes out of the lateral openings in the form of jets, thus allowing ample time for the hand to be withdrawn before the gas can diffuse towards the opening under the tent. This saves a great deal of time, there is no loss of gas, the generator is easily cleaned and strong enough to stand rough handling by coloured boys in the vineyards, and the two lateral openings utilize the force of the chemical reaction to insure the rapid lateral diffusion of the gas.

BILHARZIASIS; OR THE RISKS OF RIVER BATHING.

By Frederick Gordon Cawston, B.A., M.B., B.C., M.R.C.S., L.R.C.P.

(*Not printed.*)

ON EQUILATERAL TRIANGLES INSCRIBED IN ELLIPSES AND REGULAR TETRAHEDRA INSCRIBED IN ELLIPSOIDS.

By Prof. W. N. Roseveare, M.A.

If 1 2 3 is an equilateral triangle inscribed in the ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1,$$

we have $(x_1 - x_2)^2 + (y_1 - y_2)^2 = (x_1 - x_3)^2 + (y_1 - y_3)^2$.

$$\therefore\ (x_2 - x_3)(2x_1 - x_2 - x_3) + (y_2 - y_3)(2y_1 - y_2 - y_3) = 0.$$

Now $(x_2 - x_3)\dfrac{x_2 + x_3}{a^2} + (y_2 - y_3)\dfrac{y_2 + y_3}{b^2} = 0$.

and if $x_1 + x_2 + x_3 = 3\bar{x}$, $y_1 + y_2 + y_3 = 3\bar{y}$, $(\bar{x}\,\bar{y})$ is the centre of the $\triangle$,

and $\dfrac{3\bar{y} - y_1}{b^2}(x_1 - \bar{x}) = \dfrac{3\bar{x} - x_1}{a^2}(y_1 - \bar{y})$.

$$\therefore\ x_1 y_1 (a^2 - b^2) - x_1 \bar{y}(3a^2 - b^2) + y_1 \bar{x}(3b^2 - a^2) = -3\bar{x}\bar{y}(a^2 - b^2)$$

$$\therefore\ \{x_1(a^2 - b^2) + \bar{x}(3b^2 - a^2)\}\{y_1(a^2 - b^2) - \bar{y}(3a^2 - b^2)\}$$

$$= \bar{x}\,\bar{y}\left\{\begin{matrix} -3a^4 - 3b^4 + 6a^2b^2 \\ -10a^2b^2 + 3a^4 + 3b^4 \end{matrix}\right\}$$

$$= -4a^2b^2\bar{x}\,\bar{y}.$$

(i) - - - - -

$$\therefore\ x_1(a^2 - b^2) = \bar{x}(a^2 - 3b^2 + 2a^2k)$$

and $y_1(a^2 - b^2) = \bar{y}\left(-b^2 + 3a^2 - \dfrac{2b^2}{k}\right)$,

with similar equations for $(x_2\,y_2)$ and $(x_3\,y_3)$.

$\therefore$, using $\dfrac{x_1^2}{a^2} + \dfrac{y_1^2}{b^2} = 1$,

$$\frac{\bar{x}^2}{a^2}(a^2 - 3b^2 + 2a^2k)^2 + \frac{\bar{y}^2}{b^2}\left(b^2 + 3a^2 - \frac{2b^2}{k}\right)^2 = (a^2 - b^2)^2 \text{ - - - - (ii).}$$

This is an equation of the fourth degree for k in terms of $\bar{x}\,\bar{y}$; and the properties of the roots give (the roots being $k_1\,k_2\,k_3\,k'$)

$$\Sigma k + k' = \frac{-a^2 + 3b^2}{a^2},\ \Sigma\frac{1}{k} + \frac{1}{k'} = \frac{-b^2 + 3a^2}{b^2},\ k_1 k_2 k_3 k' = \frac{b^2\bar{y}^2}{a^2\bar{x}^2}.$$

Now from (i), since $x_1 + x_2 + x_3 = 3\bar{x}$ and $y_1 + y_2 + y_3 = 3\bar{y}$,

$$3\bar{x}(a^2 - b^2) = \bar{x}(3a^2 - 9b^2 + 2a^2\Sigma k)$$

and $3\bar{y}(a^2 - b^2) = \bar{y}\left(-3b^2 + 9a^2 - 2b^2\Sigma\dfrac{1}{k}\right)$

$$\therefore\ \Sigma k = \frac{3b^2}{a^2},\quad \Sigma\frac{1}{k} = \frac{3a^2}{b^2}.$$

$$\therefore\ k' = -1, \text{ and } k_1 k_2 k_3 = -\frac{b^2\bar{y}^2}{a^2\bar{x}^2}.$$

Hence $\frac{\bar{x}^2}{a^2}(a^2+3b^2)^2 + \frac{\bar{y}^2}{b^2}(b^2+3a^2)^2 = (a^2-b^2)^2$ - - - - (iii).

and $k_1 k_2 k_3$ are the roots of

$$\left.\begin{aligned} &\left(k^3 - \frac{3b^2}{a^2}k^2\right) - \frac{b^2\bar{y}^2}{a^2\bar{x}^2}\left(\frac{3a^2}{b^2}k - 1\right) = 0, \\ &i.e.\ \ (k^3a^2 - 3k^2b^2)\bar{x}^2 - (3a^2k - b^2)\bar{y}^2 = 0. \end{aligned}\right\} \text{- - - - (iv).}$$

∴ the centre of any equilateral triangle inscribed in the ellipse lies on the coaxial ellipse $\frac{\bar{x}^2}{a'^2} + \frac{\bar{y}^2}{b'^2} = 1$ - - - - (iii).

And the radius R of the triangle is given by

$$R^2 = (x_1 - \bar{x})^2 + (y_1 - \bar{y})^2 = \frac{4(a^2k - b^2)^2\bar{x}^2 + 4\left(\frac{b^2}{k} - a^2\right)^2\bar{y}^2}{(a^2-b^2)^2}$$

and from (iv), $\frac{a^2k^3 - 3k^2b^2}{\bar{y}^2} = \frac{3a^2k - b^2}{\bar{x}^2} = \frac{(a^2k - b^2)^3}{\bar{y}^2a^4 + \bar{x}^2b^4} = \frac{4(a^2k - b^2)}{\bar{y}^2/k^2 + \bar{x}^2}$

$$\therefore\ R^2 = \frac{16(a^4\bar{y}^2 + b^4\bar{x}^2)}{(a^2-b^2)^2}.$$

Also, if $x(a^2 - b^2) \equiv \bar{x}(a^2 - 3b^2 + 2a^2k) = -\bar{x}(a^2 + 3b^2)$

and $y(a^2 - b^2) \equiv \bar{y}(-b^2 + 3a^2 - 2b^2k) = \bar{y}(b^2 + 3a^2)$,

we have $\frac{x}{a} = -\frac{\bar{x}}{a'}$ and $\frac{y}{b} = +\frac{\bar{y}}{b'}$

and $(x + \bar{x})^2 + (y + \bar{y})^2 = \frac{\bar{x}^2(4b^2)^2 + \bar{y}^2(4a^2)^2}{(a^2-b^2)^2} = R^2.$

Hence the following construction for inscribed equilateral triangles: with any point $(\bar{x}\,\bar{y})$ on $\frac{x^2}{a^2}(a^2 + 3b^2)^2 + \frac{y^2}{b^2}(b^2 + 3a^2)^2 = 1$ as centre, draw the circle which passes through the point $(x, -y)$ where $x\,y$ has the same eccentric angle on the original ellipse as $\bar{x}\,\bar{y}$ has on the inner one: the circle cuts the ellipse in 3 other points which are the corners of an inscribed equilateral △ with $\bar{x}\,\bar{y}$ as centre.

Now, for tetrahedra inscribed in ellipsoids, one of the faces must be an equilateral triangle inscribed in an ellipse. Suppose the direction cosines of this section to be $(l\ m\ n)$, then the elementary work on sections of an ellipsoid gives for the co-ordinates of the centre $\theta l a^2$, $\theta m b^2$, $\theta n c^2$, and for the principal radii $k\alpha$, $k\beta$, where α, β are the principal radii of the parallel central section, given by

$$\frac{l^2}{\frac{1}{a^2} - \frac{1}{r^2}} + \frac{m^2}{\frac{1}{b^2} - \frac{1}{r^2}} + \frac{n^2}{\frac{1}{c^2} - \frac{1}{r^2}} = 0, \text{ and } k^2 + \theta^2(a^2l^2 + b^2m^2 + c^2n^2) = 1.$$

The direction cosines $\begin{vmatrix} \lambda & \mu & \nu \\ \lambda' & \mu' & \nu' \end{vmatrix}$ of these principal radii are

$$\lambda = \frac{P\,l}{\dfrac{1}{\alpha^2} - \dfrac{1}{a^2}}, \text{ etc.} \qquad \lambda' = \frac{P'\,l}{\dfrac{1}{\alpha^2} - \dfrac{1}{\beta^2}}, \text{ etc.,}$$

$$\text{where } l^2 = \frac{\left(\dfrac{1}{a^2} - \dfrac{1}{\alpha^2}\right)\left(\dfrac{1}{a^2} - \dfrac{1}{\beta^2}\right)}{\left(\dfrac{1}{a^2} - \dfrac{1}{b^2}\right)\left(\dfrac{1}{a^2} - \dfrac{1}{c^2}\right)} \text{ and } P^2 = \frac{\left(\dfrac{1}{\alpha^2} - \dfrac{1}{a^2}\right)\left(\dfrac{1}{b^2} - \dfrac{1}{a^2}\right)\left(\dfrac{1}{c^2} - \dfrac{1}{a^2}\right)}{\dfrac{1}{\alpha^2} - \dfrac{1}{\beta^2}}.$$

Now if the centre of this $(l\ m\ n)$ equilateral face is $\xi\eta$ referred to the principal axes, we have, from (iii) above,

$$\frac{\xi^2}{k^2\alpha^2}(k^2\alpha^2 + 3k^2\beta^2)^2 + \frac{\eta^2}{k^2\beta^2}(k^2\beta^2 + 3k^2\alpha^2)^2 = (k^2\alpha^2 - k^2\beta^2)^2$$

$$\therefore (\alpha^2 - \beta^2)^2 k^2 = \frac{\xi^2}{\alpha^2}(\alpha^2 + 3\beta^2)^2 + \frac{\eta^2}{\beta^2}(\beta^2 + 3\alpha^2)^2.$$

$$\text{and (its radius)}^2 = \frac{16(\xi^2 k^4\beta^4 + \eta^2 k^4\alpha^4)}{(k^2\alpha^2 - k^2\beta^2)^2} = \frac{16\left(\dfrac{\xi^2}{\alpha^4} + \dfrac{\eta^2}{\beta^4}\right)}{\left(\dfrac{1}{\beta^2} - \dfrac{1}{\alpha^2}\right)^2}$$

and the height of the regular tetrahedron being $R\sqrt{2}$, we have for the opposite corner $x = \theta\, l\, a^2 + \lambda\xi + \lambda'\eta \pm R\sqrt{2}\,.\,l$, etc.

The condition $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} + \dfrac{z^2}{c^2} = 1$ gives

$$1 = \theta^2\Sigma(l^2a^2) + \xi^2\Sigma\frac{\lambda^2}{a^2} + \eta^2\Sigma\frac{\lambda'^2}{a^2} + 2R^2\Sigma\frac{l^2}{a^2} \pm 2R\sqrt{2}\left\{\theta + \xi\Sigma\frac{l\lambda}{a^2} + \eta\Sigma\frac{l\lambda'}{a^2}\right\}$$

$$\therefore k^2 = \frac{\xi^2}{\alpha^2} + \frac{\eta^2}{\beta^2} + 2R^2\left\{\Sigma\frac{1}{a^2} - \Sigma\frac{1}{\alpha^2}\right\} \pm 2R\sqrt{2}\left\{\ldots\ldots\right\}$$

$\therefore$, P, P' being $\Sigma\dfrac{l\lambda}{a^2}, \Sigma\dfrac{l\lambda'}{a^2}$,

$$\pm 2R\sqrt{2}(\theta + P\xi + P'\eta) = \frac{\xi^2}{\alpha^2}\left\{\frac{(\alpha^2 + 3\beta^2)^2}{(\alpha^2 - \beta^2)^2} - 1\right\} + \ldots - 2R^2\left\{\Sigma\frac{1}{a^2} - \Sigma\frac{1}{\alpha^2}\right\}$$

$$= \frac{\xi^2}{\alpha^2}\cdot\frac{8\beta^2(\alpha^2 + \beta^2)}{(\alpha^2 - \beta^2)^2} + \ldots - \ldots = R^2\left\{\tfrac{1}{2}\Sigma\frac{1}{\alpha^2} - 2\left(\Sigma\frac{1}{a^2} - \Sigma\frac{1}{\alpha^2}\right)\right\}$$

$$\therefore \theta + P\xi + P'\eta = \pm\frac{R}{2\sqrt{2}}\left\{2\tfrac{1}{2}\Sigma\frac{1}{\alpha^2} - 2\Sigma\frac{1}{a^2}\right\} = \pm\frac{RC}{2\sqrt{2}}, \text{ say.}$$

And, if $\bar{x}\,\bar{y}\,\bar{z}$ is the centre of the tetrahedron,

$$\bar{x} = \theta a^2 l + \lambda\xi + \lambda'\eta \pm \frac{R}{2\sqrt{2}}\,.\,l,$$

$$= \xi(\lambda - P a^2 l) + \eta(\ .\ .\ ) \pm \frac{R}{2\sqrt{2}}(Ca^2 + 1)$$

$$= \xi\lambda\frac{a^2}{\alpha^2} + \eta\lambda'\frac{a^2}{\beta^2} \pm \ldots\ldots$$

$$\therefore \frac{\bar{x}}{a^2} = \frac{\lambda \xi}{a^2} + \frac{\lambda' \eta}{\beta^2} \pm \frac{R\, l}{2\sqrt{2}}\left(C + \frac{1}{a^2}\right).$$

$$\therefore \Sigma \frac{1}{a^4}\left(\bar{x} \pm \frac{R\, l}{2\sqrt{2}}\right)^2 = \frac{\xi^2}{a^4} + \frac{\eta^2}{\beta^4} + \frac{R^2 C'^2}{8} = \frac{R^2}{16}\left\{\left(\frac{1}{\beta^2} - \frac{1}{a^2}\right)^2 + 2\, C'^2\right\}.$$

Again, $P\lambda + P'\lambda' = \dfrac{P^2 l}{\frac{1}{a^2} - \frac{1}{a^2}} + \dfrac{P'^2 l}{\frac{1}{a^2} - \frac{1}{\beta^2}}$

$$= l \cdot \frac{\left(\frac{1}{b^2} - \frac{1}{a^2}\right)\left(\frac{1}{c^2} - \frac{1}{a^2}\right) - \left(\frac{1}{b^2} - \frac{1}{\beta^2}\right)\left(\frac{1}{c^2} - \frac{1}{\beta^2}\right)}{\frac{1}{a^2} - \frac{1}{\beta^2}}$$

$$= l\left\{-\frac{1}{b^2} - \frac{1}{c^2} + \Sigma \frac{1}{a^2}\right\}$$

$$= + \frac{l}{a^2} + l\left\{-\Sigma \frac{1}{a^2} + \Sigma \frac{1}{a^2}\right\}$$

$$\therefore \left(C + \frac{1}{a^2}\right) l = \left(\frac{3}{2}\Sigma \frac{1}{a^2} - \Sigma \frac{1}{a^2}\right) l + P\lambda + P'\lambda'.$$

Hence $\dfrac{\bar{x}}{a^2} = \lambda\left(\dfrac{\xi}{a^2} \pm \dfrac{P\, R}{2\sqrt{2}}\right) + \lambda'\left(\dfrac{\eta}{\beta^2} \pm \dfrac{P'\, R}{2\sqrt{2}}\right) \pm \dfrac{R\, l}{2\sqrt{2}}\left(\dfrac{3}{2}\Sigma \dfrac{1}{a^2} - \Sigma \dfrac{1}{a^2}\right)$

$$\therefore \Sigma \frac{\bar{x}^2}{a^4} = \left(\frac{\xi}{a^2} \pm \frac{P\, R}{2\sqrt{2}}\right)^2 + \left(\frac{\eta}{\beta^2} \pm \frac{P'\, R}{2\sqrt{2}}\right)^2 + \frac{R^2}{8}\left(\frac{3}{2}\Sigma \frac{1}{a^2} - \Sigma \frac{1}{a^2}\right)^2.$$

The right side gives, possibly, a solid inner ellipsoidal shell as the locus of $\bar{x}\, \bar{y}\, \bar{z}$: but I have not yet succeeded in finding the maximum value of the expression, subject to the known equations.

A PRELIMINARY STUDY OF THE COMPARATIVE MENTALITY OF EUROPEAN AND NATIVE SCHOOL PUPILS; WITH SPECIAL REFERENCE TO THE THEORY OF ARRESTED MENTAL DEVELOPMENT IN THE NATIVE.

By C. T. Loram, M.A., LL.B., Ph.D.

(*Not printed.*)

THE RELIGION OF THE ZULU.

By Rev. A. T. Bryant.

(*Not printed.*)

AN INTESTINAL BEETLE OF THE BANTU AS A POSSIBLE ORIGIN OF THE SACRED SCARAB CULT OF ANCIENT EGYPT.

By Rev. A. T. Bryant.

(*Not printed.*)

TRANSACTIONS OF SOCIETIES.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, March 17th; Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*Silicosis in Rats in a Witwatersrand Mine*": J. P. **Johnson.** The author presented the results of researches carried on concurrently with a research extending over 2½ years on the causation, incidence, pathology, symptoms, and radiographic appearances of silicosis (miners' phthisis) on the Witwatersrand. The development of silicosis in rats closely resembles its development in a white miner. The first sign of silicosis was noticed in animals after continuous exposure of seven months underground.

Saturday, April 21st: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*Notes on treatment of Pilgrim's Rest ore*": R. **Lindsay.** The Pilgrim's Rest district is, next to the Rand, the most important goldfield in South Africa, and produced during 1916 over £815,000 worth of gold. The ore consists of horizontal sheets of vein quartz embedded in dolomites and associated with much ferruginous matter. The power supply is furnished by the waterfall at Belvedere 19 miles to the north, and the Central Plant is capable of treating 13,000 tons of ore monthly. Details of the ore and sand treatment and of the methods of precipitation were given.

Saturday, May 19th: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*The Natal coalfields—phases in development*": W. T. **Heslop.** Nearly 50 years ago the digging of coal was commenced close to the present town of Dundee and in 1880 the coal output reached a total of over 25,000 tons. The phases of development to which the author gave special attention included (1) the extension of railway connection to the coal-fields; (2) the surmounting of difficulties arising from the dangers of fire-damp; (3) the hardness of drilling, and costliness of blasting the large horizontal sheets of intrusive dolerite; (4) the geological effects of the dolerite on the Natal coalfields; (5) the alternative extremes of risk to the safety of the collieries, and loss of coal apt to be associated with the pillar extraction method; (6) the fear of goaf fires, the first of which occurred in 1908.

ROYAL SOCIETY OF SOUTH AFRICA.—Wednesday, March 21st: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Note on Palmstrom's generalization of Lamé's equation*": Sir **Thomas Muir.** "Mestoma antarcticum *(sp. nov.) from Bloemfontein*": Dr. T. F. **Dreyer.** A description of a worm found in a small pond on clay soil near Bloemfontein. The specimen shows an almost negligible amount of variation from *M. mutabile* from Tierra del Fuego.—"*Colour and chemical constitution; a study of the phthaleins and related compounds*": Dr. J. **Moir.** A series of nearly 50 derivatives of phenolphthalein and fluorescein have been spectroscopically examined, the colours being found to range over the entire spectrum. The author stated a number of conclusions which he had drawn as to the effect of substitution on colour. A new discovery is the behaviour of these 50 substances in concentrated sulphuric acid, the colouration being about five times as intense as in alkali and of a different band wave length. The author claims to have discovered a law explaining this change of colour.

Wednesday April 18th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Note on the expansian of the product of two oblong arrays*": Sir **Thomas Muir.** The author explained the relation between the sum of products of pairs of determinants resulting from Binet and Cauchy's expansion of 1812.—"*Notes on radiation of crystals*": J. S. **van der Lingen.** Five sets of crystals had been studied, and the radiation patterns were described. They included (1) the transformation of magnesium hydroxide into magnesium oxide; (2) diamond tests; (3) Bultfontein apophyllite; (4) serpentine, malachite, and crocidolite; (5) iodine.—"*A summary of the distribution of the genera of South African flowering plants (with special reference to the flora of the Uitenhage and Port Elizabeth Divisions)*": Prof. S. **Schonland.** This summary was compiled in connection with a study of the flora of Uitenhage and Port Elizabeth, but it is hoped that it may be welcome to other botanists who desire to have readily available a summary showing the general trend of distribution of South African genera.—"*Note upon the endocranial cast obtained from the ancient calvaria found at Boskop, Transvaal*": G. **Elliot Smith.** The author described the cast of the cranial cavity of the skull-cap from Boskop and stated that whatever the date of the Boskop remains may be the evidence suggests that this early inhabitant of the Transvaal represents the type of the immediate ancestors of the men of the *Upper Palaeolithic Age*, possibly somewhat modified in the course of his southern migration. It probably represents the earliest (not necessarily in actual age) known phase of *Homo sapiens* in the course of his transformation from a condition analogous to that of Neanderthal man to that of Cro-Magnon.

GEOLOGICAL SOCIETY OF SOUTH AFRICA.—Monday, April 2nd: J. J. Garrard, A.M.I.C.E., Vice-President, in the chair.—"*The contact belt of the older granite in the Barberton district and Northern Swaziland*": A. L. **Hall.** The object of the author was to supply information, hitherto lacking in respect to the nature of the relationship of the granite to the other formations of the Swaziland System in the Barberton district and regarding the distribution and character of the altered rocks. Veins of granitic origin are traceable continuously from the main granite into the Moodies and Jamestown Series, and detached tongues of similar origin occur at at least eleven separate localities all round the areas of older groups. Phenomena of metamorphism are widespread, both on the south and north side of Barberton Mountain, and the distribution of the metamorphic rocks points to a contact belt up to about three miles wide. Endomorphic modifications within the granite itself are indicated by the development of finer grained or gneissic structures, oriented with reference to the strike of the neighbouring older rocks. The distribution of the granite margin round Hectorspruit strongly indicates an inclusive relationship. It was therefore concluded that the older granite had intruded into both the Jamestown and Moodies Series. The Jamestown Series probably represents originally a series of basic rock itself intrusive into Moodies Series, and the metamorphism of the latter might conceivably be due to the former rather than to the granite.

Monday, May 21: A. L. du Toit, B.A., D.Sc., F.G.S., President, in the chair. —"*The Dyke System of the De Kaap and Komah River Valleys*": A. L. **Hall.** Owing to their resistant nature the dykes stand out as conspicuous and fairly straight ridges especially in the low-lying granite valleys. Out of 110 dykes separately mapped, 78 run from south-east to north-west over an area of country measuring 45 by 56 miles. They are usually from 20 to 50 feet across, but some are much thicker—up to 130 and even 200 feet. The bulk of these occurrences belong to the gabbro and diabase families. The author concluded that the direction of alignment was predetermined by the intrusion of the older granite into the surrounding rocks and the dykes have no community of origin with the granite but represent the dyke phase of the basic margin of the Bushveld Complex, and should be assigned to the group of aschistic dykes.—"*Interesting migmatic rocks from the Gordonia District, Cape Province*": Dr. P. A. **Wagner.** The rocks referred to occur on farms in the Southern Kalahari, about 45 miles west-north-west of Upington. The most widely distributed type of migmatic rock is a composite garnet-sillimanite-biotite-gneiss.

South African Association of Analytical Chemists.—Tuesday, April 10th: J. McCrae, Ph.D., F.I.C., Vice-President, in the chair.—"*Demonstration of Higgins' and Marriott's method of determining carbon dioxide in air*": Dr. J. **Moir.** The author demonstrated the method used and pointed out its adaptability in determining carbon dioxide in mine air.—"*Some considerations on fertility of soils*": A. **Baguley.** The author dealt shortly with the many considerations which seriously affect soil fertility and gave a concise survey of the present theories.

Tuesday, May 8th: J. McCrae, Ph. D., F.I.C., Vice-President, in the chair.—"*The volumetric estimation of water and water extracts*": W. **Torrance.** The author outlined an adaptation of the Pfeiffer and Wartha method as used at the Government School of Agriculture, Grootfontein, for the analysis of water and water extracts.—"*A note on the local manufacture of shoes and dies.*": Prof. G. H. **Stanley.** The experimental plant for the manufacture of shoes and dies from scrap was described and details of the working of the electrical plant given.

South African Society of Civil Engineers.—Wednesday, April 11th: R. W. Menmuir, M.I.C.E., President, in the chair.—"*The Construction of the Gamtoos-Patentie 2-feet gauge railway.*" J. C. **Simms.** The question of opening up the fertile valley of the Gamtoos River had engaged the attention of Government for 25 years, but the great cost of a railway along the precipitous sides of the valley through hard conglomerate cliffs, intersected by numerous narrow kloofs caused the undertaking to be deferred. In 1911 the author received instructions to undertake the survey and construction of a line as far as Patentie—a distance of 17 miles. The detailed survey cost £95 per mile and the staking out of the centre line £41 per mile. There are two major bridges over the line, one over the Geelhoutboom Kloof, and one over the Klein River. The 17 miles of line cost, when completed, £71,200. The line was completed in March, 1914, or 28 months after commencement.—"*Notes on the construction of the Aliwal North-Zastron Railway*": The author commenced construction of the line in 1914. The length of the line is 55½ miles, and the total cost of the survey was £63.2 per mile of constructed line. The country traversed involved no engineering works of any magnitude except the crossing of the Orange River at Aliwal North. This bridge comprises six spans of 125 feet each.

Wednesday, May 9th: R. W. Menmuir, M.I.C.E., President, in the chair. "*White labour*": G. **Whitehouse.** The author's object was to show that on unskilled work on railway construction the white labourer is able to compete successfully against the native labourer under the conditions of use which have hitherto been in practice. White labour, however, cannot be successful in South Africa as long as it is considered an experiment, given on philanthropic lines to the unemployed in times of stress and poverty, and looked on as charity by the charitable, and as relief work by the labourer. The object at which this experiment aims should be a certain fixed idea of white employment everywhere.—"*Small power stations, with special reference to the Worcester hydro-electric scheme*": Prof. H. **Bohle.** The great distances which separate municipalities in South Africa make it necessary to erect power stations at almost every place where electric light is desired, necessitating large capital expenditure and high charges. The source of Worcester's water supply lies six miles away, up in the mountains. The installation consists of two 60-h.p. Pelton wheels running at 1,000 revolutions per minute. The cost of the scheme was nearly £15,000 and to make it self-supporting the annual income should reach about £2,400.

South African Institution of Engineers.—Saturday, April 14th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Notes on dust prevention in mines*": A. C **Whittome** and J. H. **Veasey.** The authors laid down that the allaying of dust and gases and the improvement of ventilation—both as regards quantity and temperature of air—should be treated as one subject. The water used for allaying dust and gases, and for cooling the air can best be atomised by the use of compressed air. The control of all the operations of dust and gas allaying, as well as the regulation of ventilation should rest with one official. Miners should be unable to regulate the quantities of air and water used in water blasts. Dust and deleterious gases should be removed from the air as soon as possible after they are generated. Atomised water is the best means for removing dust, and all deleterious gases except carbon mon-oxide, from air; therefore the whole of the mine workings should be filled with atomised water as soon as it is possible after blasting. The "deadly" dust is invisible; therefore continuous means of removing it from the air, and of ascertaining the daily condition of the air itself should be provided at selected points in the main air-ways. Watering down of faces and walls should be done with atomised water; only heaps of rock should have streams of water directed upon them. The mechanical ventilation of dead ends should be on a system by which induced currents could be directed to the working faces, whilst foul air would be exhausted from the working places. There should be a simple and immediate indication as to whether the water-blast has been put into operation by the miner responsible. This check should be available as soon as the miner is out of the mine. The owners of those mines—and the underground employees therein—in which it can be shown that there is no dry dust during working shifts should be relieved from all contributions to the Phthisis Compensation Fund. The authors concluded with a description of the "Apex" water blast.

South African Institute of Electrical Engineers.—Thursday, April 19th: W. H. Perrow, M.I.E.E., President, in the chair.—"*Notes on three-phase and Ward-Leonard winding equipments*": A. L. **Ballard.** No attempt has thus far been made to state definitely the limits between which one system has advantages over the other. Generally speaking the three-phase equipment will be found economical on straightforward winds of moderate depths and weights, but for greater depths than 3,000 ft., probably up to 4,000 feet there will not be much to choose between the two systems, while above this depth the advantage will be with the Ward-Leonard equipment. The author went on to discuss the effect of drum profile, of balance or tail ropes and of other factors on a choice between the two systems.

Wednesday May 16th: L. B. Woodworth, A.M.I.E.E., Vice-President, in the chair.—"*A short description of the circle diagram*": Prof. W. **Buchanan.** An exposition of the properties of the circle diagram, prepared as an introduction to the succeeding paper.—"*A new construction for the circle diagram*": G. M. **Adams.** The object of the author was to introduce a new and simple method of constructing the circle diagram, from which the maximum power factor and the full load stator current of an induction motor can easily be obtained.

Thursday, June 21st: W. H. Perrow, M.I.E.E., President, in the chair. —"*Some modern developments in Roentgenology*": Dr. L. E. **Ellis.** A short discription was given of some of the most important types of apparatus used in the modern production of the Roentgen rays. The principle and details of the Coolidge tube were also described, and the author then proceeded to illustrate the medical and surgical applications of X rays, with special reference to the examination of the gastro-intestinal tract.

South African Society of Civil Engineers.—Wednesday, June 13th: R. W. Menmuir M.I.C.E., President, in the chair.—"*Possibilities of the Wemmer's Valley Watershed*": R. W. **Menmuir**. The subject was discussed with a view to the possibilities of a water supply for the City of Capetown. In this connection the yield of the watershed and the cost of constructing a dam and pipe line were compared with similar statistics in respect of the Steenbrass catchment area.

South African Institution of Engineers.—Saturday, May 12th: B. Price, M.I.E.E., A.M.I.C.E., President, in the chair.—"*Cleaning condensor tubes in their place with hydrochloric acid*": G. M. **Robertson.** The paper described an application of the method by the author for the removal of calcareous scale. The condensor contained 4,725 brass tubes of five-eighths of an inch inside diameter, and 14 feet long. 4,000 lbs. of acid of 1.150 sp. gr. were obtained. The condensor was filled with water and the water warmed. Circulating was then started and the acid added to the water at the rate of one carboy every 20 minutes, the circulation being kept up for about 16 hours in all. Water was then circulated through the condensor for five or six hours to wash away the remaining acid. It was estimated that 8½ hours after commencement of the operation 1,261 lbs. of scale had been dissolved, and 5 lbs. of copper from the tubes and ferrules, out of a total weight of 33,960 lbs. The condensor, after the operation, was said to be as good as new. The cost of acid and preparing the condensor was £50, and the work was stated to have paid for itself in one week by the saving in coal due to improved vacuum.—"*Friction of slime pulp in pipes*": E. J. **Laschinger.** Records were given of the results of certain tests, and of the data thus collected regarding the friction of slime pulp in steel pipes. The matter is of importance, since in nearly all reduction plant on the Rand the slime is handled in pulp form by means of centrifugal pumps and piping. The slime pulp consists of the finely comminuted particles of rock, which will generally pass a screen of 200 meshes per lineal inch, mixed with water in proportions varying from 1 to 1 of solids to water, down to almost pure water. The friction head for slime was found to be 13½ per cent. less than for water. The power of a motor driving a pump to elevate slime would have to be about 50 per cent. greater than required for water-pumping.

Royal Society of South Africa.—Wednesday, June 20th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Note on a case of hermaphroditism*": H. V. **Exner** The author described a case of hermaphroditism occurring in a person of unsound mind, who had the outward appearance of a Kaffir girl.—"*Note on the genus* Terfezia, *a truffle from the Kalahari*": I. B. **Pole Evans** The truffle *Choeromyces*, hitherto unknown in Africa, has recently been reported from South Africa. The author pointed out that the best known South African truffles belong to the genus *Terfezia*. The distinction between the two genera was indicated, and a description given of a truffle, *T. Claveryi* chat., recently sent to the author from the Griqualand West district in the Kalahari.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, June 23rd: Prof. J. A. Wilkinson, M.A., F.C.S., President, in the chair.—"*The construction and maintenance of slime dams*": J. E. **Thomas** and E. A. **Osterloh.** Slime dams have generally to be built from the slime itself, and so the most that can be attempted is to make the outside walls of suitable thickness, avoiding excess of moisture in construction. How this may be effected the authors proceeded to explain in detail.—"*Some notes on explosioons of firedamp and occurrences of gob fires in Natal*": J. E. **Vaughan** and F. A. **Steart.** An account of the history of colliery explosions in Natal was given and concluded with a number of preventive recommendations. Amongst these were extraction of the top seam, retention of as little timber and coal as possible in the goaf, measures for complete isolation of any section where the temperature rises above 70 degrees, and also when the odour of benzene appears.

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Maritzburg.

R. A. Buntine, M.B., B.Ch., M.L.A.
Prof. E. Warren, D.Sc.

V. RHODESIA.

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LIST OF MEMBERS

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1ST JULY, 1917.

* Indicates Foundation Members (30th June, 1902).
† Indicates Life Members.
Names of **PAST PRESIDENTS OF THE ASSOCIATION** are Printed in **THICK CAPITALS.**
Names of MEMBERS OF COUNCIL for the 1916 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.
1916. Abbit, William, B.A., Maritzburg College, Pietermaritzburg, Natal.
1916. Abrahams, Abraham Mark, Jewish Government School, End Street, Johannesburg.
1902. *Aburrow, Charles, M.I.C.E., M.S.A., P.O. Box 534, Johannesburg.
1905. Adamson, John E., M.A. (Pres. D, 1915), Education Department, Pretoria.
1916. Adler, Henry, P.O. Box 1059, Johannesburg.
1904. Aiken, Alexander, P.O. Box 2636, Johannesburg.
1904. Ainsworth, Herbert, P.O. Box 1553, Johannesburg.
1915. †Akerman, Conrad, M.A., M.B., B.C., Conethmoar, Alexandra Road, Pietermaritzburg.
1905. †Albu, *Sir* George, P.O. Box 1242, Johannesburg.
1913. Alexander, William, A.M.I.C.E., A.R.T.C., South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1916. Anders, Paul Clement, B.A., LL.D., P.O. Box 4284, Johannesburg.
1910. ANDERSON, ALFRED JASPER, M.A., M.B., D.P.H., M.R.C.S., City Hall, Capetown.
1916. Anderson, Peter von M., B.Sc., P.O. Box 41, Springs, Transvaal.

Year of Election.

1902. *Andrews, G. S. Burt, M.I.C.E., M.I.Mech.E., M.S.A., P.O. Box 1049, Johannesburg.

1914. Anstey, Norman, P.O. Box 1003, Johannesburg.

1903. Arnold, Frank Arthur, M.B., D.P.H., L.S.A., P.O. Box 211, Pretoria.

1916. Ashkanazy, A. W., Castle Mansions, Eloff Street, Johannesburg.

1904. Auret, A. A., P.O. Box 838, Johannesburg.

1916. Austin, Kenneth, M.Am.I.M.E., P.O. Box 4305, Johannesburg.

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.

1916. Ball, *Mrs.* Olivia Wolfenden, Amberley, Shafton Post, Howick, Natal.

1903. †Balmforth, *Rev.* Ramsden, "Shirley," 6, Stephen Street, Capetown.

1914. Bancroft, Alfred Ernest, M.A., M.Sc., South African College High School, Capetown.

1916. Bankes, Pauline Alice, St. Andrew's School, Girton Road, Parktown, Johannesburg.

1916. Barkby, Ernest Arthur, M.I.M.E., P.O. Box 3286, Johannesburg.

1917. †Barker, William Edward, A.I.E.E., P.O. Dynamite Factory, Somerset West, C.P.

1911. Barratt, Gaston Frederick Sharpe, Bembezaan, Queque, Southern Rhodesia.

1911. Barratt, Rowland Lorraine, Bembezaan, Queque, Southern Rhodesia.

1905. †Basto, H. E. Alberto Celestine Ferreira Pinto, 95, Rua Luiz-de-Camoes, Lisbon, Portugal.

1903. †Baxter, William, M.A., South African College School, Capetown.

1902. *†Beattie, John Carruthers, D.Sc., F.R.S.E. (Pres. A., 1910), Principal of the South African College, Capetown.

1916. Beatty, J. W., Consolidated Buildings, Johannesburg.

1915. Bedford, Gerald Augustus Harold, F.E.S., Veterinary Research Laboratory, Onderstepoort, P.O. Box 593, Pretoria.

1913. Beerstecher, Leonard, P.O. Box 2888, Johannesburg.

1916. Bertram, J., 134, Market Avenue, Benoni, Transvaal.

1916. Bertram, Reginald Hermanus, P.O. Box 3518, Johannesburg.

1916. Bews, John William, M.A., D.Sc., Professor of Botany, Natal University College, P.O. Box 375, Pietermaritzburg.

Year of Election.

1916. Bird, Fred William, Government School, Benoni, Transvaal.

1910. Bisset, James, M.I.C.E., M.R.San.I., Beauleigh, Kenilworth, Cape Division.

1905. Blackshaw, George N., B.Sc., F.C.S., c/o British South Africa Co., 2, London Wall, London, E.C., England.

1915. Blundell, Frederick Moss, 308, Orient Street, Arcadia, Pretoria.

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, Capetown.

1913. Botelho, *Lieut.* João Baptista, Chief Veterinary Officer, Department of Agriculture, P.O. Box 255, Lourenço Marques.

1916. Botting, Robert Frederick, A.M.I.E.E., P.O. Box 700, Johannesburg.

1916. Bottomley, Averil Maud, B.A., P.O. Box 1294, Pretoria.

1906. Bourne, A. H. J., M.A., Principal, High Schools, Kimberley, C.P.

1913. Bracht, Oscar, P.O. Box 134, Port Elizabeth, C.P.

1915. Brain, Charles Kimberlin, M.A., M.Sc., Division of Entomology, Pretoria.

1915. Breijer, Hermann Gottfried, Ph.D., Director of the Transvaal Museum, P.O. Box 413, Pretoria.

1914. Brierly, James D., Department of Agriculture, Bloemfontein.

1917. Brigham, A. F., Diamond Mining Co., Ltd., Jagersfontein, O.F.S.

1910. Brill, J., Litt.D., L.H.D., Ph.Th.M., Lorothwana, 65, Park Road, Bloemfontein.

1905. Brincker, J. C. H., c/o The Montagu Co-operative Wines, Ltd., Montagu, C.P.

1914. Brinton, Arthur Greene, F.R.C.S., L.R.C.P., F.R.S.M., P.O. Box 4307, Johannesburg.

1910. Britten, Gilbert Frederick, B.A., Government Chemical Laboratory, Capetown.

1903. Brown, Alexander, M.A., B.Sc., F.R.S.E., Professor of Applied Mathematics, South African College, Capetown.

1914. Brown, *Rev.* Holman, P.O. Box 82, Bulawayo, Rhodesia.

1907. †Brown, William Bridgman, M.A., Penryn, Cyphergat, C.P.

1913. Browne, Rowland F., A.M.I.C.E., P.O. Box 432, Lourenço Marques.

1909. Brownlee, John Innes, M.B., C.M., Alexandra Road, Kingwilliamstown, C.P.

Year of Election.

1912. Brummer, *Rev. Prof.* N. J., M.A., B.D., Victoria College, Stellenbosch, C.P.

1902. *Buchan, James, Assistant Resident Engineer, Rhodes Buildings, Bulawayo.

1916. Bull, Henry Walter, 352, Burger Street, Pietermaritzburg.

1916. Buntine, Robert Andrew, M.B., B.Ch., M.L.A., Pietermaritzburg.

1905. Burroughs, Herbert John, 10A, Clarence Street, Troyeville, Johannesburg.

1903. †Burtt-Davy, Joseph, F.L.S., F.R.G.S. (Pres. C), P.O. Box 1148, Johannesburg.

1916. Burtt-Davy, *Mrs.* J., Burttholm, Vereeniging, Transvaal.

1916. Bush, Herbert Henry, M.Sc., A.M.I.C.E., P.O. Box 2303, Johannesburg.

1916. Butt, Thomas P. E., P.O. Box 179, Randfontein, Transvaal.

1903. Caldecott, W. A., B.A., D.Sc., F.C.S., P.O. Box 67, Johannesburg.

1902. *†Campbell, Allan McDowell McLeod, B.A., Resident Engineer, South African Railways, Bandolier Kop, Transvaal.

1916. Campbell, Edmund, P.O. Box 688, Durban.

1916. Campbell, Samuel George, M.D., M.Ch., F.R.C.S.E., M.R.C.S., D.P.H., 28, Musgrave Road, Durban.

1908. Carlson, K. A., Forestry Division, Department of Agriculture, Bloemfontein.

1916. Carruthers, Somerville Craig, M.I.A.A., P.O. Box 266, Johannesburg.

1910. Cattell, E. J., Chamber of Commerce, Johannesburg.

1916. Cawston, Frederick Gordon, B.A., M.B., B.C., M.R.C.S., L.R.C.P., 65, Ockerse Street, Krugersdorp, Transvaal.

1903. †Cazalet, Percy, P.O. Box 1056, Johannesburg.

1906. †*Champion, Ivor Edward (address wanted).*

1914. Chandler, *Right Rev.* Arthur, M.A., D.D., Bishop of Bloemfontein, Bishop's Lodge, Bloemfontein.

1917. Chappell, Ernest, P.O. Box 1124, Johannesburg.

1913. Charters, Robert Hearne, M.I.C.E., Professor of Civil Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1916. Clark, Gowan Creswell Strange, C.M.G., Railway Offices, Johannesburg.

1916. Clark, Hugh, B.Sc., A.M.I.E.E., 197, Moore Road, Durban.

1903. Clark, John, M.A., LL.D., Arderne Professor of English Language and Literature, South African College, Capetown.

1916. Clayden, Harold William, A.M.I.E.E., A.M.I.M.E., P.O. Box 1242, Johannesburg.

Year of Election

1916. Clayton, Emily Jane Mason, 100, Market Street, Pretoria.
1917. Cleghorne, William Shaw Hamilton, B.Sc., A.M.I.Mech.E., P.O. Box 181, Potchefstroom, Transvaal.
1916. Clephan, Ethel Hunter, Girls' High School, Park Street, Pretoria.
1903. Cohen, Walter P., F.R.P.S., Hon. Sec., Johannesburg Field and Naturalists' Club, P.O. Box 68, Johannesburg.
1916. Collard, J. Aldred, P.O. Box 4439, Johannesburg.
1908. Collie, J., 274, Eastwood Street, Arcadia, Pretoria.
1904. †Collins, Ernest A. E., 66, Pritchard Street, P.O. Box 723, Johannesburg.
1906. Collins, M. R., Irrigation Department, P.O. Box 399, Pretoria.
1917. Colquhoun, Ludovic, Dynamite Factory, Modderfontein, Transvaal.
1916. Cook, Junius Ford, M.E., Whitney Point, New York, U.S.A.
1915. Cooke, Howard, B.S.A., Grootfontein School of Agriculture, Middelburg, C.P.
1904. Cooper, Fred W., Public Library, Port Elizabeth, C.P.
1915. Cordiner, William Smallie, 121, Loveday Street, Wanderers' View, Johannesburg.
1914. Cory, George Edward, 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.
1916. Cox, George Walter, F.R.Met.S., P.O. Box 399, Pretoria.
1902. *†Cox, Walter Hubert, Royal Observatory, near Capetown.
1909. Crawford, David Chambers, M.A., B.Sc., B.Sc.Agr., Elsenburg, Mulder's Vlei, C.P.
1902. *†**CRAWFORD, LAWRENCE**, M.A., D.Sc., F.R.S.E. (President, 1916), Professor of Pure Mathematics, South African College, Capetown.
1916. Croghan, *Dr.*, 28, High Road, Fordsburg, Transvaal.
1916. †Crookes, George Joseph, The Cedars, Renishaw, per Private Bag, Durban.
1916. Cruden, Frank, Alicedale, C.P.
1916. Cullen, Dan, M.E., P.O. Box 4352, Johannesburg.
1903. †Cullen, William, M.I.M.M. (General Secretary, 1905-1908), British South Africa Explosives Co., Ltd., 612, Salisbury House, Finsbury Circus, London, E.C., England.
1916. Currie, Richard, 112, Commissioner Street, Johannesburg.
1903. Currie, O. J., M.B., M.R.C.S., Claremont, Capetown.
1916. Curry, N. O., P.O. Box 2303, Johannesburg.

Year of Election.

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.

1915. Dalton, John Patrick, M.A., D.Sc., Professor of Mathematics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1913. Damant, E. L., P.O. Box 1176, Johannesburg.

1916. Danckwerts, Ernst, P.O. Box 486, Johannesburg.

1913. Daniel, John, Armley House, 30, Plein Street, Johannesburg.

1916. Davidson, D. M., P.O. Box 455, Germiston, Transvaal.

1903. Davies, J. Hubert, M.I.E.E., M.I.Mech.E., A.M.I.C.E., P.O. Box 1386, Johannesburg.

1916. Davis, Carl Raymond, E.M., M.Am.I.M.E., P.O. Box 3, Brakpan, Transvaal.

1903. Davis, Frederick H., B.Sc., M.I.E.E., P.O. Box 1934, Johannesburg.

1916. Daymond, William Henry, P.O. Nigel, Transvaal.

1916. Deakin, James Alfred, Dunswart Iron and Steel Works, Benoni, Transvaal.

1916. De Fenton, John, Ph.D., Seymour Memorial Library, P.O. Box 2561, Johannesburg.

1915. De Klerk, Arie, 486, Schoeman Street, Pretoria.

1915. De Kock, Gilles van de Wall, M.R.C.V.S., Veterinary Research Office, P.O. Box 593, Pretoria.

1914. De Kock, *Dr.* Servaas Meyer, P.O. Box 321, Bloemfontein.

1913. Delbridge, William John, A.R.I.B.A., P.O. Box 120, Capetown.

1915. Delfos, Cornelis Fredrik, P.O. Box 24, Pretoria.

1904. Delmore, *Dr.* J. Schlesinger, P.O. Box 1455, Johannesburg.

1916. De Ropp, Stephen Edward, *Baron*, B.Sc., F.G.S., University College, Johannesburg.

1916. Des Clayes, Raymond, P.O. Box 155, Johannesburg.

1915. De Villiers, C. G. S., 681, Pretorius Street, Arcadia, Pretoria.

1916. De Villiers, *Rt. Hon.* Charles Percy, *Baron*, Rustenburg, Stellenbosch.

1915. De Villiers, Louis Celliers, Ph.D., M.E., Lecturer in Geology and Mineralogy, Transvaal University College, Pretoria.

1915. †Dick, *Colonel* James, St. Thomas Road, Durban.

1916. Diethelm, Carl Robert, P.O. Box 3228, Johannesburg.

1916. Dinwoodie, James Herbert, F.C.S., 53, Cavendish Road, Yeoville, Johannesburg.

Year of Election.

1917. Dobson, *Lt.-Col.*, Joseph Henry, D.S.O., M.Sc., M.Eng., M.I.Mech.E., M.I.E.E., A.M.I.C.E., P.O Box 699, Johannesburg.
1916. Dodds, Herbert Henry, M.Sc., F.C.S., c o Messrs. Kynoch, Ltd., Umbogintwini, Durban.
1909. Dodt, J. J., National Museum, Bloemfontein.
1917. Doering, F. Emanuel, M.D., D.D.S., P.O. Box 2165, Johannesburg.
1915. Doidge, Ethel Mary, M.A., D.Sc., F.L.S., P.O. Box 1294, Pretoria.
1911. Dornan, *Rev.* Samuel S., M.A., F.G.S., P.O. Box 510, Bulawayo.
1908. Drège, Isaac Louis, P.O. Box 148, Port Elizabeth, C.P.
1914. Dreyer, P., Resident Magistrate's Office, Capetown.
1915. Dreyer, Thomas F., B.A., Ph.D., Grey University College, Bloemfontein.
1917. Dreyfus, Paul, P.O. Box 5836, Johannesburg.
1906. †Druce, P. M., M.A., The College, Potchefstroom, Transvaal.
1902. *Drury, Edward Guy Dru, M.D., B.S., D.P.H., Grahamstown, C.P.
1915. Du Boulay, Alice Mary Houssemayne, Transvaal Education Department, Pretoria.
1917. Du Pasquier, Arthur Edmund, M.I.M.E., M.I.E.E., P.O. Box 3633, Johannesburg.
1917 Du Plessis, *Rev. Prof.* Johannes, B.A., B.D., Theological Seminary, Stellenbosch.
1913. Du Toit, A. E., M.A., Professor of Mathematics, Transvaal University College, Pretoria.
1915. Du Toit, Pieter Johannes, Under-Secretary for Agriculture, Union Buildings, Pretoria.
1906. Duerden, James E., M.Sc., Ph.D., A.R.C.S., Professor of Zoology, Rhodes University College, Grahamstown, C.P.
1915. Dumat, Henry Aylmer, M.D., F.R.C.P.E., 7, Devonshire Place, Durban, Natal.
1910. Duncan, A., P.O. Box 1214, Johannesburg.
1904. Duncan, Patrick, C.M.G., Sauer's Buildings, Johannesburg.
1909. Dunkerton, Edward B., c/o Messrs. Lennon, Ltd., West Street, P.O. Box 266, Durban, Natal.
1917. Duthie, Augusta Vera, M.A., Victoria College, Stellenbosch.
1911. †Duthie, George, M.A., F.R.S.E. (Pres. D., 1911), Concession Siding, Private Bag, Salisbury, Rhodesia.
1912. Dwyer, E. W., B.A., Forest Department, Kingwilliamstown.

Year of Election.

1916. Eadie, Duncan MacIntyre, 669, Currie Street, Durban, Natal.

1904. Eaton, William Arthur, 74, St. George's Street, Capetown.

1916. Eccles, Bertram Joseph, M.R.C.S., L.R.C.P., L.D.S., Thrupp's Buildings, Pritchard Street, Johannesburg.

1909. Edwards, Charles J., c/o Messrs. Heynes Mathew & Co., P.O. Box 242, Capetown.

1914. Elsdon-Dew, William, M.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., (Pres. C, 1916), Chief of the Division of Plant Pathology, Department of Agriculture, P.O. Box 1294, Pretoria.

1905. EVANS, MAURICE SMETHURST, C.M.G., F.Z.S. (Pres. D., 1916), Hillcrest, Berea Ridge, Durban, Natal.

1905. †Evans, Samuel, 153, Nuggett Street, Johannesburg.

1916. Evans, S., Modder B Gold Mining Co., Benoni, Transvaal.

1914. Eveleigh, *Rev.* William, Seymour, C.P.

1904. Ewing, Sydney Edward Thacker, M.I.E.E., P.O. Box 3, Brakpan, Transvaal.

1906. Eyles, Frederick, F.L.S., M.L.C. (Pres. C., 1911), c/o Department of Agriculture, Salisbury, Rhodesia.

1915. Fairbridge, William Ernest, P.O. Box 1014, Johannesburg.

1916. Falcon, William, M.A., Hilton College, Hilton Road, Natal.

1917. Fantham, Harold Benjamin, M.A., D.Sc., A.R.C.S., F.Z.S., Professor of Zoology and Comparative Anatomy, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1905. Farrar, Edward, P.O. Box 1242, Johannesburg.

1914. Farrow, Frederick Denny, M.Sc., Rhodes University College, Grahamstown, C.P.

1916. Faure, Jacobus Christian, B.S., M.A., P.O. Box 502, Bloemfontein.

1905. Feetham, Richard, Sauer's Buildings, c/o Loveday and Market Streets, Johannesburg.

1915. Ferreira, Frederick Herbert, Resident Magistrate's Office, Herschel, C.P.

1915. FIELDEN-BRIGGS, H., M.D., L.D.S., F.C.S., P.O. Box 1213, Johannesburg.

1915. Findlay, George Schreiner, 151, Esselen Street, Pretoria.

1916. Finlay, *Professor* James, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1913. Fischer, Christian Ludwig, B.A., 9, Ryneveld Street, Stellenbosch, C.P.

1913. FitzHenry, *Rev.* J., Bedford, C.P.

Year of Election.

1912. FitzSimons, F. W., F.Z.S., F.R.M.S. (Pres. C. 1912), Director, Port Elizabeth Museum, Port Elizabeth, C.P.

1902. *Flack, *Rev.* Francis Walter, M.A., The Rectory, Uitenhage, C.P.

1902. Flanagan, Henry George, F.L.S., Prospect Farm, Komgha, C.P.

1916. Fletcher, Richard Evelyn, King Edward VII School, Johannesburg.

1902. *†FLINT, *Rev.* WILLIAM, D.D. (Pres. D., 1910), Wolmunster Park, Rosebank, Capetown.

1902. *Flowers, Frank, C.E., F.R.G.S., F.R.A.S., P.O., Box 1878, Johannesburg.

1907. FOOTE, J. A., F.G.S., F.E.I.S., (GENERAL SECRETARY, Pres. D., 1913), Principal, Commercial High School, Plein Street, Johannesburg.

1914. Ford, Thurston James, Secretary, De Beers Benefit Society, Kimberley, C.P.

1917. Forest Department, Union Buildings, Pretoria.

1914. FORSYTH, THOMAS M., M.A., D.Phil. (Vice-Pres. D), Professor of Philosophy, Grey University College, Bloemfontein.

1914. Forsyth, *Mrs.* T. M., Eagle's Nest, P.O. Box 238, Bloemfontein.

1916. Fouché, Carl Hercules, M.A., P.O. Box 1176, Johannesburg.

1905. †Frames, P. Ross, P.O. Box 148, Johannesburg.

1906. †Frankenstein, *Miss* Adelia, B.A., 9, Knight Street, Kimberley, C.P.

1916. Fraser, John, J.P., P.O. Box 149, Pietermaritzburg.

1916. Freeland, Hubert, P.O. Box 2863, Johannesburg.

1902. Fremantle, Henry Eardley Stephen, M.A., F.S.S., Bedwell Cottage, Rosebank, Capetown.

1916. Frerichs, J. A., Rand Club, Johannesburg.

1913. Frew, John, P.O. Box 1, Johannesburg.

1916. Frood, George Edward Bell, M.A., M.I.M.M., Mines Department, Bloemfontein.

1914. Frood, *Dr.* T. M., Rand Club, Johannesburg.

1902. *Fuhr, Harry A., A.M.I.C.E., Public Works Department, Kingwilliamstown, C.P.

1904. Fuller, W. H., Chairman, Public Library, East London, C.P.

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, C.P.

Year of Election.

1913. Garbutt, Herbert William, F.R.A.I., J.P., c/o Curator, Museum, Bulawayo, Rhodesia.

1915. Garlick, *Miss* Winifred Marguerite, Thornibrae, Green Point, Capetown.

1902. *†Gasson, William, F.C.S., Dutoitspan Road, Kimberley, C.P.

1915. Gatherer, John Frederick William, P.O. Box 433, Bloemfontein.

1904. Gellatly, John T. B., M.I.C.E., P.O. Box 37, Bethulie, O.F.S.

1912. Gibson, Harry, J.P., F.S.A.A., P.O. Box 1643, 85, St. George's Street, Capetown.

1916. Gibson, James Young, 211, Commercial Road, Pietermaritzburg.

1917. Gie, Johan Coenraad, Lalisa, Surbiton Road, Rosebank, Capetown.

1902. *Gilchrist, John Dow Fisher, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S. (General Secretary, 1903-1908), Professor of Zoology, South African College, Capetown.

1917. Gilchrist, Thomas B., M.D., C.M., J.P., P.O. Box 161, Fordsburg, Transvaal.

1903. Gilchrist, W., M.S.A., Mariendahl, Mulder's Vlei, C.P.

1916. Gill, Harold Warren, B.Sc., F.I.C., Chief Resident Chemist, Magadi Soda Co., Lake Magadi, British East Africa.

1910. Ginsberg, Franz, M.P.C., P.O. Box 3, Kingwilliamstown, C.P.

1916. Glyn, Charles, M.E., P.O. Box 1026, Johannesburg.

1912. Goddard, Ernest James, B.A., D.Sc. (Vice-Pres. C), Professor of Zoology, Victoria College, Stellenbosch, C.P.

1913. Goddard, *Mrs.* E. J., Stellenbosch, C.P.

1902. †Godfrey, *Rev.* Robert, M.A., Somerville Mission, Tsolo, C.P.

1916. Goldstein, Benjamin, L.D.S., Walter Mansions, Johannesburg.

1916. Goodall, Frederick, P.O. Box 909, Durban.

1904. Gorges, Edmond Howard Lacam, M.V.O., Administrator, South-West African Protectorate, Windhuk.

1915. Gould, Robert Howe, P.O. Box 4941, Johannesburg.

1913. Graça, Captain Alberto C. de Faria, Sub-Chefe de Estado Major, Quartel Geral, P.O. Box 485, Lourenço Marques.

1915. Graham, George Smith, Avondale, P.O. Box 40, Queenstown, C.P.

1908. Grant, Charles C., M.A., Education Department, Bloemfontein.

1914. Grant, William Frank, B.Sc., South African College High School, Capetown.

Year of Election.

1907. Gray, Charles Joseph, Office of Inspector of Mines, P.O. Box 405, Krugersdorp, Transvaal.
1907. Gray, James, F.I.C., P.O. Box 5254, Johannesburg.
1915. Green, Henry Hamilton, D.Sc., F.C.S. (Vice-Pres. B.), Veterinary Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1916. Greenacre, Walter, "Waveney," Musgrave Road, Durban.
1916. Griffin, Joseph D., P.O. Box 2155, Johannesburg.
1906. Grimmer, Irvine Rowell, Assistant General Manager, De Beers Consolidated Mines, Ltd., Kimberley, C.P.
1916. Grindley-Ferris, Vyvyan, Consolidated Gold Fields of South Africa, Ltd., Johannesburg.
1917. Grobbelaar, Coert Smit, M.A., Heemstede, Riebeek Street, Stellenbosch.
1912. Gubbins, John Gaspard, B.A., Ottoshoop, Transvaal.
1913. Gundry, Philip G., B.Sc., Ph.D., A.R.C.S., Professor of Physics, Transvaal University College, Pretoria.
1915. Gunn, David, P.O. Box 1013, Pretoria.
1905. †Gutsche, Phillipp, M.D., Villa Torrita, Kingwilliamstown, C.P.
1903. Gyde, Charles J., A.M.I.C.E., Public Works Department, Capetown.

1904. Haagner, Alwyn K., F.Z.S., Zoological Gardens, P.O. Box 754, Pretoria.
1904. †Haarhoff, Daniel Johannes, J.P., Market Street, Kimberley, C.P.
1902. * **HAHN, PAUL DANIEL,** M.A., Ph.D. (PRES. A, 1903, PRESIDENT, 1911), Jamison Professor of Chemistry and Metallurgy, South African College, Capetown.
1916. Haig, W., c/o Messrs. Fraser & Chalmers, Ltd., Corner House, Johannesburg.
1907. Hall, Carl, A.M.I.C.E., F.G.S., 28, Club Arcade, Durban, Natal.
1910. Halm, Jacob K. E., Ph.D., F.R.S.E., Royal Observatory, C.P.
1907. Hammar, August, 441, Burger Street, Pietermaritzburg, Natal.
1902. *Hancock, H., A.M.I.C.E., P.O. Box 192, Klerksdorp, Transvaal.
1903. †Hancock, Strangman, M.Am.I.M.E., Kennel Holt, Cranbrook, Kent, England.
1914. Harbor, William Alfred Henry, Mochudi, Bechuanaland Protectorate.
1916. Hardenberg, Christiaan Bernhardus, M.A., New Hanover Rail, Natal.
1904. Harries, W. M., P.O. Pox 2189, Johannesburg.

Year of Election.

1905. Harris, Lionel, M.E., B.Sc., 113, Sivewright Avenue, Doornfontein, P.O. Box 1311, Johannesburg.

1915. Harrison, Charles William Francis, F.R.G.S., F.R.S.S., Nel's Rust, Natal.

1914. Harvey, Sidney Francis, P.O. Box 1386, Johannesburg.

1916. Hastings, Isabel, Wykeham School, Pietermaritzburg.

1905. Hatchard, John George, F.R.A.S., Longview, Shannon, P.O. Box 499, Bloemfontein.

1916. Hattersley, Alan Frederick, B.A., Natal University College, Pietermaritzburg.

1917. Hawkins, John Charles, A.M.I.C.E., A.M.I.Mech.E., P.O. Box 54, Vereeniging, Transvaal.

1916. Hawthorne, Sydney Charles James, P.O. Box 1161, Johannesburg.

1916. Hay, William, J.P., P.O. Box 521, Capetown.

1916. Heather, Henry James Shedlock, B.A., M.I.C.E., M.I.E.E., F.Am.I.E.E., Professor of Electrotechnics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1916. Healey, John Edward, P.O. Box 2, Maraisburg, Transvaal.

1914. Henderson, *Miss* Janetta, c/o Dr. J. B. H. Ruthven, P.O. Box 6253, Johannesburg.

1902. *Henkel, John Spurgeon, Conservator of Forests, Pietermaritzburg.

1904. †Herdman, G. W., M.A., M.I.C.E., Public Works Department, P.O. Box 439, Pretoria.

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.

1915. Hewitt, Strafford Smith, P.O. Box 192, Bloemfontein.

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.

1916. Higham, Joseph, B.Sc., P.O. Box 1176, Johannesburg.

1916. Hodges, Ruth Mary, B.Sc., Wykeham School, Pietermaritzburg.

1914. Holdsworth, J. W., c/o Irrigation Department, Cradock, C.P.

1913. Holgate, V. G., P.O. Box 1176, Johannesburg.

1905. Holm, Alexander (Vice-Pres., C), Department of Agriculture, Pretoria.

1916. Holmes, George G., A.R.S.M., P.O. Box 1096, Johannesburg.

1915. Honey, Thomas, Superintendent, Municipal Gardens, P.O. Box 403, Lourenço Marques.

Year of Election.

1902. †Honnold, W. L., Hyde Park Hotel, 66, Knightsbridge, London, S.W., England.
1902. *Horne, William James, A.M.I.C.E., A.M.I.E.E., Education Department, P.O. Box 432, Pretoria.
1902. *†Hough, Sydney Samuel, M.A., F.R.S., (Vice-Pres., A), Astronomer Royal, Royal Observatory, near Capetown.
1914. Howitt, A. Gordon, B.Sc., Civil Service Club, Capetown.
1916. Hughes, Archibald Charles, Rand Club, Johannesburg.
1910. Hughes, George Robert, Under-Secretary for Lands, Pretoria.
1905. †Humphrey, William Alvara, B.A., Ph.D., F.G.S., Vryheid, Natal.
1912. Hunt, Donald Rolfe, Sub-Native Commissioner, Secocoeniland, *via* Lydenburg, Transvaal.
1913. Hutcheon, James, M.A., F.R.S.G.S., P.O. Box 1176, Johannesburg.
1916. Hutton, C.E., P.O. Box 164, Germiston, Transvaal.
1916. Hutton, Jessie Margaret, P.O. Box 8, Oudtshoorn, C.P.
1904. **HYSLOP, JAMES,** D.S.O., M.B., C.M. (PRESIDENT, 1907), The Huts, Pietermaritzburg, Natal.

1916. Imroth, G., Johannesburg Consolidated Investment Buildings, Johannesburg.
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; PRESIDENT, 1915), 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.

1916. Jackson, *Hon. Justice* Cecil Gower, 185, Prince Alfred Street, Pietermaritzburg.
1915. Jackson, Harry Percival, M.Sc., Jeppe High School, Johannesburg.
1915. Jackson, Percy, 28, Floss Road, Kensington, 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.
1915. Janse, Antonius Johannes Theodorus, F.E.S., Lecturer in Biology, Normal College, Pretoria, 1st Street, Gezina, Pretoria.

Year of Election.

1911. Jarvis, E. M., F.R.C.V.S., Jelf Estate, Umtali, Rhodesia.
1910. Jeffrey, John, Standard Bank, P.O. Box 57, Capetown.
1916. Jenner, Alice, Girls' High School, Oudtshoorn, C.P.
1903. Jennings, Hennen, 2221, Massachusetts Avenue, Washington, U.S.A.
1913. Jensen, Axel Emil, 24, Maddison Street, Jeppestown, Johannesburg.
1916. Jensen, Ragnvald, C.E., P.O. Box 1361, Johannesburg.
1916. †Joel, Solomon Barnato, P.O. Box 433, Johannesburg.
1912. Johnson, *Miss* Alta, New Street, Wellington, C.P.
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., 3, Link Road, Bloemfontein.
1914. Johnson, W. S., M.A., Professor of English, Grey University College, Bloemfontein.
1915. Jolly, William Adam, M.B., Ch.B., D.Sc., Professor of Physiology, South African College, Capetown.
1916. Jones, J. E., P.O. Box 2354, Johannesburg.
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. (Pres. B, 1909, GENERAL SECRETARY, 1910-1917), Agricultural Chemical Research Laboratory, Department of Agriculture, Capetown.

1907. KANTHACK, FRANCIS EDGAR, C.M.G., M.I.C.E., M.I.M.E. (Pres. A, 1915), Director of Irrigation, Union Buildings, Pretoria.
1912. Kehoe, D., M.R.C.V.S., P.O. Box 593, Pretoria.
1903. Kent, *Professor* Thomas Parkes, M.A., South African College, Capetown.
1915. Kenway, Harold Cecil, Public Works Department, Pretoria.
1905. King, Austin, Director of Mines, Macequeçe, Portuguese East Africa.
1915. King, Ethel Louise May, Eunice High School, Bloemfontein.
1915. King, Francis Edward, P.O. 802, Pretoria.
1916. King, James, Lynedoch, Nottingham Road, Natal.
1914. Kingon, *Rev.* John Robert Lewis, M.A., F.L.S. (Vice-Pres. E), St. Andrew's Manse, 7, Victoria Park Drive, South End, Port Elizabeth.
1913. Kirkland, John Wilkinson, M.Am.I.E.E., P. O. Box 1905, Johannesburg.
1907. Kirkman, John, J.P., M.P.C., 331, Musgrave Road, Durban.
1904. Kisch, C. H. M., P.O. Box 668, Johannesburg.

Year of Election.

1916. Kleudgen, Cæsar, P.O. Box 1164, Johannesburg.
1915. Klooster, Willem, 576, Church Street, Arcadia, Pretoria.
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.
1916. Krause, Hubert Louis, A.S.M., P.O. Box 193, Germiston, Transvaal.

1916. Lamont, William John, Grootfontein School of Agriculture, Middelburg, C.P.
1913. Landau, Nathan, Survey Office, Modder Deep Level, P.O. Box 376, Benoni, Transvaal.
1914. Lange, *Hon. Justice Sir* Johannes H., Kt., LL.B., Judge's Chambers, Kimberley, C.P.
1916. Lanyon, John E., P.O. Box 25, Benoni, Transvaal.
1903. †Laschinger, E. J., B.A., P.O. Box 149, Johannesburg.
1904. Leech, *Dr.* John Richard, Union Club, P.O. Box 1112, Johannesburg.
1904. †Leeds, R. Q., P.O. Box 928, Johannesburg.
1903. Legat, C.E., Department of Agriculture, 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, C.P.
1902. *Lenz, Otto, P.O. Box 92, Johannesburg.
1916. Leslie, Charles Duff, P.O. Box 1167, Johannesburg.
1916. †Leslie, Robert, M.A., F.S.S. (Vice-Pres. D.), Jagger Professor of Economics, South African College, Capetown.
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.
1917. Lindsay, Alan, P.O. Box 74, Pretoria.
1916. Linscott, Arthur Burrow, A.M.I.C.E., A.M.I.M.E., P.O. Box 4013, Johannesburg.
1916. Loeser, *Dr.* H. F., Crown Mines, Ltd., Johannesburg.
1903. Logeman, William H., M.A., Professor of Physics, Grey University College, Bloemfontein.
1916. Loram, Charles Templeman, M.A., LL.B., Ph.D., P.O. Box 902, Durban.
1903. Lorentz, Henri, P.O., Box 55, Johannesburg.

Year of Election.

1902. Lounsbury, Charles Pugsley, B.Sc., F.E.S., (Pres. C, 1915), Chief of the Division of Entomology, Department of Agriculture, P.O. Box 513, Pretoria.

1916. Lugg, Harry Camp, Native High Court, Pietermaritzburg.

1902. *Lunt, Joseph, D.Sc., F.I.C., Royal Observatory, C.P.

1914. Lyle, James, M.A., Grey College School, Bloemfontein.

1902. *Lynch, *Major* F. S., J.P., Kimberley Waterworks Co., Ltd., P.O. Box 630, Kimberley, C.P.

1905. †McArthur, Duncan Campbell, M.R.C.S., L.R.C.P., District Surgeon, Clanwilliam, C.P.

1905. McCallum, William, P.O. Box 4889, Johannesburg.

1917. McCracken, John, c/o Messrs. Fraser & Chalmers, Corner House, Johannesburg.

1916. McDavid, W., Trades School, Smit Street, Johannesburg.

1916. McDonald, David Paterson, M.A., B.Sc., P.O. Box 1176, Johannesburg.

1909. Macdonald, G., M.A., Normal Training College, Bloemfontein.

1902. *McEwen, T. S., A.M.I.C.E., "The Links," Rondebosch, C.P.

1908. Macfadyen, William Allison, M.A., LL.D., Professor of Philosophy, Transvaal University College, Pretoria.

1909. McFeggans, Alexander, P.O. Box 26, Umtata, C.P.

1914. McGregor, *Rev.* Andrew Murray, M.A., B.D., Blommestein, Three Anchor Bay, Capetown.

1916. MacIntyre, Joseph Mansfield Bell, M.A., Twist Street, Government School, Johannesburg.

1916. McKay, *Mrs.* Helen Millar, Malvern Government School, Johannesburg.

1904. McKenzie, Archibald, M.D., C.M., M.R.C.S., Glen Lyon, Musgrave Road, Durban, Natal.

1915. †McLoughlin, Alfred George, Chief Magistrate's Office, Umtata, C.P.

1916. McLove, I. G., P.O. Box 899, Johannesburg.

1914. MACMILLAN, WILLIAM MILLER, B.A., Professor of History, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1913. Macpherson, Henry Wingate, 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, F.G.S., Government Geologist of Western Australia, Bon Accord, 3, Ventnor Terrace, Perth, Western Australia.

1910. Malan, *Hon.* François Stephanus, B.A., LL.D., M.L.A., P.O. Box 450, Pretoria.

Year of Election.

1912. †Malherbe, D. F. du Toit, M.A., Ph.D., Professor of Chemistry, Transvaal University College, Pretoria

1914. Malherbe, Daniel François, B.A., Ph.D., Professor of Modern Languages, P.O. Box 424, Bloemfontein.

1904. Malherbe, H.L., P.O. Box 208, Pretoria.

1917. Malherbe, Willem Elisa, B.A., B.Sc., Professor of Physics, Victoria College, Stellenbosch.

1902. †Mally, Charles William, M.Sc., F.E.S., F.L.S., Division of Entomology, Department of Agriculture, Capetown.

1914. Mandy, George Stephen Thomas, Provincial Roads Department, Kokstad, C.P.

1915. Manning, Charles Nicolson, P.O. Box 98, Pietersburg, Transvaal.

1915. Marchand, Bernard de Coligny, B.A., D.Sc., Chemical Laboratory, Department of Agriculture, Pretoria.

1909. Marchand, *Rev.*, Bernard P. J., B.A. (Pres. D.), Clairvaux, Rondebosch, C.P.

1904. Marks, *Hon. Senator* Samuel, Hatherley Buildings, P.O. Box 379, Pretoria.

1902. * †**MARLOTH, Professor RUDOLF**, M.A., Ph.D. (Pres B, 1903, President, 1914), P.O. Box 359, Capetown.

1916. Marshall, William Benjamin, P.O. Box 159, Pietermaritzburg.

1904. †Marshall. W. S., P.O. Box 3055, Johannesburg.

1905. Martini, J. D., P.O. Box 34, Beira, Portuguese East Africa.

1916. Martyn, J. F., 13, Kock Street, Johannesburg.

1911. Maufe, Herbert Brantwood, B.A., F.G.S., P.O. Box 168, Bulawayo.

1902. Melle, G. J. McCarthy, M.B., C.M., Robertson, C.P.

1903. Mellor, Edward, T., D.Sc., M.I.M.M., F.G.S., 5, New Law Courts, Johannesburg.

1902. *Menmuir, R. W., A.M.I.C.E., National Mutual Buildings, Church Square, Capetown.

1914. Mesham, Paul, M.A., 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.

1916. Meyer, Edward C. J., B.Sc., P.O. Box 57, East Rand, Transvaal.

1905. Miller, Allister M., The Swaziland Corporation, Ltd., Mbabane, Swaziland.

1917. Miller, Thomas Maskew, P.O. Box 396, Capetown.

1917. Mills, Frederick William, M.I.E.E., Headquarters, South African Railways, Johannesburg.

Year of Election.

1915. Mitchell, David Thomas, M.R.C.V.S., Veterinary Research Office, P.O. Box 405, Department of Agriculture, Maritzburg, Natal.
1916. Mitchell, Hugh, P.O. Box 98, Langlaagte, Transvaal.
1916. Mitchell, John, Jeppes Central Government School, Johannesburg.
1915. Mogg, Albert Oliver Dean, B.A., P.O. Box 1294, Pretoria.
1912. Moll, *Dr.* A. M., P.O. Box 4708, Johannesburg.
1916. Moore, Mary Elizabeth Constance, Wykeham School, Pietermaritzburg.
1903. Morice, George T., B.A., K.C., P.O. Box 1275, Pretoria.
1916. Morrison, John Todd, M.A., B.Sc., F.R.S.E., A.M.I.E.E., Professor of Applied Mathematics, Victoria College, Stellenbosch.
1912. Mortimer, *Dr.*, W., M.R.C.S., Potchefstroom, Transvaal.
1917. Moss, Charles Edward, M.A., D.Sc., F.L.S., F.R.G.S., Professor of Botany, South African School of Mines and Technology, Johannesburg.
1915. Mudd, Norman, M.A., Grey University College, Bloemfontein.
1902. ***MUIR, Sir THOMAS**, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E. (President, 1910), Elmcote, Sandown Road, Rondebosch, C.P.
1915. Munro, Hugh Kenneth, Division of Entomology, P.O. Box 513, Pretoria.
1913. Munro, James, P.O. Box 19, Lourenço Marques.
1916. Munro, John, P.O. Box 433, Johannesburg.
1917. Murray, Charles, M.A., Department of Education, Capetown.
1904. Murray, George Alfred Everett, M.D., F.R.C.S., L.R.C.P., P.O. Box 105, Johannesburg.
1911. Musselwhite, *Rev.* E. W. H., B.A., Zonnebloem College, Capetown.

1916. Nance, Francis James, Office of Engineer-in-Chief, South African Railways, Johannesburg.
1916. Narbeth, Benjamin Mason, B.Sc., F.C.S., Principal, Technical College, Durban.
1910. Nauta, *Prof.* Renicus Dowe, South African College, Capetown.
1917. Nay, Arthur Mac, M.I.Mech.E., P.O. Box 951, Durban.
1916. Neame, Hugh Austin, P.O. Box 3921, Johannesburg.
1905. Neilson, A. M., Manager, Safco Fertilizers Co., Umbilo, Natal.
1916. Neitz, *Rev.* Johannes, P.O. Box 19, Potgietersrust, Transvaal.

Year of Election.

1915. New York Public Library, 42nd Street and Fifth Avenue, New York City, U.S.A.
1914. Newhall, Percy Melrose, B.Sc., P.O. Box 485, Johannesburg.
1916. Newhouse, Hans, P.O. Box 1156, Johannesburg.
1916. Newman, Arthur Dudley, P.O. Box 231, Johannesburg.
1902. *Nicholson, *Colonel* George Taylor, M.I.C.E., Resident Engineer, Docks, Capetown.
1913. Nicol, John, M.R.C.V.S., Government Veterinary Surgeon, Kingwilliamstown.
1916. Nicol, John, 39, Currie Street, Durban.
1916. Niven, James Just, M.I.C.E., P.O. Box 205, Pietermaritzburg.
1904. Nixon, Edward John, M.R.C.S., L.R.C.P., P.O. Box 57, Heidelberg, Transvaal.
1902. Nobbs, Eric Arthur, Ph.D., B.Sc., F.R.H.S., Director of Agriculture, Salisbury, Rhodesia.
1915. Norton, *Rev.* William Alfred, B.A., B.Litt. (Vice-Pres. E), The Rectory, Maitland, Capetown.

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, 1914), Professor of Physics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1915. Orenstein, Alexander Jeremiah, M.D., M.R.C.S., L.R.C.P., P.O. Box 1056, Johannesburg.
1914. Orford, *Rev. Canon* Horace William, 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., M.I.Mech.E. (PRESIDENT: Pres. A, 1916), Professor of Mechanical 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.
1916. Otto, Cyril Saxon Douglas, Otto's Bluff, Natal.

1905. †Paisley, William, M.B., B.Ch., P.O. Box 127, Queenstown, Cape.
1908. Palmer, W. Jarvis, B.Sc.A., P.O. Box 4557, Johannesburg.
1905. †Papenfus, H. B., K.C., P.O. Box 5155, Johannesburg.
1914. Parry, John, P.O. Box 192, Kimberley.
1912. Paterson, *Mrs.* T. V., Redhouse, near Port Elizabeth.
1916. Paterson, William, 103, Eloff Street, Johannesburg.

Year of Election.

1902. †Pattrick, C. B., A.M.I.C.E., 159, Banket Street, Johannesburg.

1903. †Payne, Albert E., A.R.S.M., P.O. Box 15, Langlaagte, Transvaal.

1916. Pearce, William, Illovo, Natal.

1917. Pealing, Harold, M.Sc., South African College, Capetown.

1916. Pellissier, *Rev.* George Murray, B.A., B.D., 7, Langham Street, Pietermaritzburg.

1913. Pepulim, *Dr.* D., P.O. Box 704, Lourenço Marques.

1913. Perez, Manoel A. Jr., Chief Assistant, Observatorio Campos Rodriguez, Lourenço Marques.

1907. Péringuey, Louis Albert, D.Sc., F.E.S., F.Z.S., Director South African Museum, Capetown.

1910. †Perold, Abraham Izak, B.A., Ph.D., Professor of Viticulture and Oenology, Victoria College, Stellenbosch.

1912. Perrins, George Richard, "Grange," 106, Cape Road, Port Elizabeth, C.P.

1905. Petersen Carl Olief, P.O. Box 4938, Johannesburg.

1915. Pettey, Franklin William, B.A., Entomologist, Government School of Agriculture, Elsenburg, Mulder's Vlei, C.P.

1904. Pettman, *Rev.* Charles, Wesleyan Parsonage, Chapel Street, Kimberley, C.P.

1915. Phillips, Edwin Percy, M.A., D.Sc., F.L.S., South African Museum, Capetown.

1916. Phillips, Martin, M.A., P.O. Gezina, Pretoria.

1912. Pickstone, Harry Ernest Victor, Lekkerwyn, Groot Drakenstein, C.P.

1903. Pim, Howard, B.A., F.C.A. (General Treasurer, 1906–1907), P.O. Box 1331, Johannesburg.

1915. Plowman, George Thomas, C.M.G., Provincial Secretary, Pietermaritzburg.

1915. Pollard, Miss Grace E., F.R.H.S., Huguenot College, Wellington, C.P.

1914. Pooley, John, F.S.A.A., F.R.C.I., P.O. Box 189, Kimberley.

1916. Pott, Ethel K. A., S. Cyprian's School, Annandale Street, Capetown.

1916. Potts, Alexander, P.O. Box 2863, Johannesburg.

1905. †Potts, George, M.Sc., Ph.D. (Pres. C, 1914), Professor of Botany, Grey University College, 91, Park Road, Bloemfontein.

1916. Powell, Owen Price, P.O. Box 192, Germiston, Transvaal.

1916. Price, Bernard, M.I.E.E., A.M.I.C.E., A.M.Am.I.E.E., P.O. Box 2671, Johannesburg.

1916. Price, Roger, P.O. Box 1242, Johannesburg.

1913. Provay, Giuseppe, Chief Electrical Engineer of Harbours and Railways, P.O. Box 1479, Lourenço Marques.

Year of Election.

1910. Purcell, William Frederick, M.A., Ph.D., C.M.Z.S., Bergvliet, Diep River, C.P.

1906. Pym, Frank Arthur Oakley, Public Museum, P.O. Box 51, Kingwilliamstown, C.P.

1902. †Quinan, Kenneth B., Chemist and Engineer, Cape Explosive Works, Somerset West, C.P.

1915. Ramsbottom, Kathleen Nora, B.A., Eunice High School, Bloemfontein.

1916. Read, Herbert Alfred, F.R.S.A., P.O. Box 1056, Johannesburg.

1916. Reeve, Herbert C., M.A., High School, Krugersdorp, Transvaal.

1906. Reid, Alexander William, M.D., C.M., Assistant Medical Officer of Health, City Hall, Capetown.

1902. *Reid, Arthur Henry, F.R.I.B.A., F.R.San. I. (Vice-President, Vice-Pres. A.), P.O. Box 120, Capetown.

1914. Reid, Walter, F.R.I.B.A., P.O. Box 746, Johannesburg.

1916. Reunert, Jack, Messrs. Reunert & Lenz, Consolidated Buildings, 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., 29 and 30, Holborn Viaduct, London, E.C.

1913. Reyneke, Andries Adriaan Louw, B.A., Durbanville, C.P.

1913. Reyneke, *Rev.* Jacobus Cornelius, De Pastorie, Cradock, C.P.

1916. Reynolds, Frank Umhlali, Esperanza, Natal.

1916. Reynolds, H., M.I.Mech.E., P.O. Box 92, Johannesburg.

1916. Reynolds-Tait, Joseph St. Guido, P.O. Box 502, Durban.

1916. Rice, Frank Peabody, P.O. Box 930, Johannesburg.

1916. Rich, Stephen Gottheil, M.A., B.Sc., Adams Mission Station, Natal.

1909. Rindl, Max Morris, Ing.D. (Pres. B.), Professor of Chemistry, Grey University College, Bloemfontein.

1903. Ritchie, William, M.A. (Pres. D, 1914), Professor of Latin, South African College, Capetown.

1916. Robb, Andrew D., Trades School, Smit Street, Johannesburg.

1902. ***ROBERTS, ALEXANDER WILLIAM**, D.Sc., F.R.A.S., F.R.S.E. (Pres. A 1908; President, 1913), Lovedale, C.P

Year of Election.

1915. Roberts, Austin, P.O. Box 413, Pretoria.
1914. Roberts, John Lloyd, P.O. Box 529, Salisbury, Rhodesia.
1913. Roberts, *Rev.* Noel (Pres. E), The Vicarage, Orchards, Johannesburg.
1909. Robertson, Colin C., M.F., c/o Forest Department, Pretoria.
1906. Robertson, John, P.O. Box 138, Bloemfontein.
1915. Robinson, Eric Maxwell, M.R.C.V.S., P.O. Box 593, Pretoria.
1902. †Rogers, Arthur William, M.A., Sc.D., F.G.S. (Pres. B, 1910), Geological Survey, P.O. Box 1190, Johannesburg.
1915. Romyn, *Mrs.* Elizabeth, Zonnehoek, 157, Troye Street, Pretoria.
1902. *Rose, James Wilmot Andreas, M.I.C.E., Municipal Offices, Stellenbosch, C.P.
1905. †Rose, *Lieut.-Col.* John George, D.S.O., F.C.S., Government Chemical Laboratory, Capetown.
1912. Roseveare, W. N., M.A. (Vice-President, Pres. A), Professor of Mathematics, Natal University College, P.O. Box 375, Pietermaritzburg.
1914. Ross, John, P.O. Box 636, Kimberley.
1917. Ross, John Carl, B.A., M.S., Ph.D., Grootfontein School of Agriculture, Middelburg, C.P.
1903. Rouliot, G., 37 bis, Rue de Villejust, Paris, France.
1902. *Runciman, William, M.L.A., Simonstown, C.P.
1915. Ruthven, Jane Buchanan Henderson, M.D., L.R.C.P., L.R.C.S., F.R.S.A., P.O. Box 6253, Johannesburg.

1915. Schlupp, William Francis, B.Sc., Lecturer in Zoology and Entomology, Government School of Agriculture, P.O. Box 181, Potchefstroom, Transvaal.
1902. *Schönland, Selmar, M.A., Ph.D., F.L.S., C.M.Z.S., (Pres. C., 1908), Professor of Botany, Rhodes University College, Grahamstown, C.P.
1913. School of Agriculture, Cedara, Natal.
1913. School of Agriculture, Elsenburg, Mulder's Vlei, C.P.
1913. School of Agriculture and Experimental Farm, Glen, O.F.S.
1913. School of Agriculture and Experimental Station, Grootfontein, Middelburg, C.P.
1913. School of Agriculture and Experimental Farm, Potchefstroom, Transvaal.
1916. Schreiber, Oscar Albert Egmont, P.O. Box 396, Pietermaritzburg.
1914. Schreiner, *Rt. Hon.* William Philip, M.A., M.L., South African Chambers, Capetown.
1916. Schulz, Aurel, M.D., Krantz Kloof, Main Line, Natal.

Year of Election.

1903. Schumacher, R. W., c/o Central Mining and Investment Corporation, Ltd., 1, London Wall Buildings, London, E.C., England.
1902. SCHWARZ, ERNEST H. L., A.R.C.S., F.G.S. (Vice-President, Pres. B. and C., 1908), Professor of Geology, Rhodes University College, P.O. Box 116, Grahamstown, C.P.
1916. Scott, *Rev.* James, Claridge, Natal.
1914. Searle, *Mrs.* Amy M., B.A., Great Brak River, C.P.
1912. SERUYA, SALOMON, Vice-Consul for Portugual, P.O. Box 5633, Johannesburg.
1912. Shand, Samuel James, Ph.D., D.Sc., F.G.S., Professor of Geology, Victoria College, Stellenbosch, C.P.
1903. Shanks, Robert, 10, Graf Street, Johannesburg.
1916. Sheridan, Norman, M.D., B.S., Chudleigh's Buildings, Johannesburg.
1916. Sherwell, Percy W., City Deep Gold Mining Co., Johannesburg.
1916. Shore, John, P.O. Box 2997, Johannesburg.
1902. *Shores, J. W., C.M.G., M.I.C.E., Rutland, Scottsville, Pietermaritzburg, Natal.
1916. Siedle, Otto, P.O. Box 931, Durban, Natal.
1916. Sim, Thomas Robertson, 168, Burger Street, Pietermaritzburg.
1916. †Simon, Frank, M.I.M.E., P.O., Minnaar, Transvaal.
1917. SIMONS, LEWIS, B.Sc., South African College.
1916. Simpson, Archibald James Grant, A.M.I.E.E., P.O. Box 239, Capetown.
1917. Skaife, Sydney Harold, B.A., Government Experimental Station, Rosebank, Capetown.
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, C.P.
1916. Smith, Arthur Herbert, P.O. Box 141, Durban.
1916. Smith, *Hon.* Charles G., P.O. Box 43, Durban.
1915. SMITH, EDWARD HOLMES, B.Sc., School of Agriculture, Potchefstroom, Transvaal.
1906. Smith, Frank Braybrooke, Secretary for Agriculture, Union Buildings, Pretoria.
1915. Smith, Frank Cumming, Grootfontein School of Agriculture, Middelburg, C.P.
1912. Smith, George William, A.M.I.C.E., 11, Constitution Hill, Port Elizabeth, C.P.
1903. Smith, James, M.A., Normal College, Capetown.
1917. Smith, Johannes Jacobus, B.A., Professor of French and German, Victoria College, Stellenbosch.
1906. Smuts C., P.O. Box 1088, Johannesburg.
1905. Smuts, *Rt. Hon.* Jan C., B.A., LL.D., Minister of Defence, P.O. Box 1081, Pretoria.

Year of Election.

1914. †Smyth, *Right Rev. Bishop* William Edmund, M.A., M.B., c/o English Church House, 61, Burg Street, Capetown.
1916. Smyth, Robert Milner, F.R.C.S., L.R.C.P., F.R.I.P.H., Government Hospital, Durban.
1910. Smythe, John Oswald, 123, Loop Street, Pietermaritzburg.
1903. Solly, *Mrs.* Julia F., Knor Hoek, Sir Lowry's Pass, C.P.
1903. Solomon, *Hon. Justice Sir* W. H., High Court of Appeal, Capetown.
1908. Somerville, A. J., M.A., Milton High School, P.O. Box 11, Bulawayo, Rhodesia.
1910. †Soutter, John Lyall, P.O. Box 403, Pretoria.
1916. Sowter, Godfrey Dennis, P.O. Box 1020, Johannesburg.
1906. †Spencer, *Dr.* Henry Alexander, M.R.C.S., L.R.C.P., Middelburg, Transvaal.
1915. †Spensley, James Carter, M.A., Lecturer in Chemistry, Transvaal University College, Pretoria.
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, C.P.
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, 1914), Professor of Metallurgy and Assaying, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1904. Stead, Arthur, B.Sc., F.C.S., School of Agriculture, Grootfontein, Middelburg, C.P.
1908. Steedman, *Miss* E. C., M.A., Gando Farm, Gwelo, Southern Rhodesia.
1917. Stein, Philip, B.A., P.O. 1176, Johannesburg.
1913. Stephen, Alexander, M.A., P.O. Box 518, Pretoria.
1903. Stevens, J. D., P.O. Box 1782, Johannesburg.
1909. Stewart, G. A., City Engineer, Bloemfontein.
1905. †STONEMAN, *Miss* BERTHA, D.Sc., Huguenot College, Wellington, C.P.
1917. Storey, Francis Wylie, B.Sc., F.C.S., 31, Monument Road, Bloemfontein.
1902. *Stott, Clement H., F.G.S., M.S.A., P.O. Box 7, Pietermaritzburg, Natal.
1916. Strapp, Walter Russell, M.D., 248, Loop Street, Pietermaritzburg.
1904. Struben, A. M. A., A.M.I.C.E., P.O. Box 317, Pretoria.
1906. Stuart, James, 34, Loop Street, Pietermaritzburg.
1906. Stucke, W. H., P.O. Box 2271, Johannesburg.

Year of Election.

1915. Swierstra, Cornelis Jacobus, F.E.S., P.O. Box 413, Pretoria.
1915. Swynnerton, Charles Francis Massey, F.L.S., F.E.S., F.R.H.S., Gungunyana, Melsetter, Southern Rhodesia.
1904. Syfret, S. B., B.A., M.B., B.C., Main Road, Mowbray, C.P.

1905. †Tannahill, Thomas Findlay, M.D., C.M., D.P.H., Queenstown, C.P.
1916. Taylor, John T., Prospect House, Howick Road, Pietermaritzburg.
1909. Teasdale, *Miss* Emma L., Government School, Maraisburg, Transvaal.
1913. Teixeira, *Lieut.* Augusto D'Almeida, Observatorio Campos Rodrigues, Lourenço Marques.
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.
1914. Thompson, Frederick Handel, B.A., Inspector of Schools, P.O. Box 4439, Johannesburg.
1916. Thompson, James, 6, Rissik Street, Johannesburg.
1902. *Thompson, William Wardlaw, F.Z.S., Kimberley Cottage, Kalk Bay, C.P.
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.
1910. Thornton, Russel William, Principal, Government School of Agriculture, Grootfontein, Middelburg, C.P.
1903. †Tietz, Heinrich C. J., M.A., Ph.D., Buona Vista, Burham Road, Observatory Road, C.P.
1916. Tomes, *Rev.* Alfred Edmund Godfrey, B.A., 181, Loop Street, Pietermaritzburg.
1902. *Townsend, Stephen Frank, C.E., Rhodesia Railways, Ltd., P.O. Box 215, Bulawayo, Rhodesia.
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.
1916. Trubshaw, Henry Arthur, Seventh Avenue, Mayfair, Johannesburg.
1903. Tucker, William Kidger, C.M.G., P.O. Box 9, Johannesburg.
1916. Tucker, William Petre, Reunion Estate, Reunion, South Coast, Natal.

Year of Election.

1916. Turner, F. E., P.O. Box 407, Johannesburg.
1906. Tyers, F. G., M.A., The College, P.O. Box 93, Potchefstroom, Transvaal.

1916. Udwin, M., Rand Water Board, Johannesburg.
1917. Union Observatory, c/o Union Astronomer, Johannesburg.

1915. Van der Bijl, Paul Andries, M.A., D.Sc., F.L.S., Natal Herbarium, Berea, Durban.
1912. Van der Lingen, Jan Stephanus, B.A., Erinville, Milton Road, Sea Point, Capetown.
1909. Van der Merwe, C. P., Government Entomologist, Point, Durban.
1910. Van der Riet, Berthault de St. Jean, M.A., Ph.D., (Pres. B, 1912), Professor of Chemistry, Victoria College, Stellenbosch, C.P.
1904. Van der Sterr, W. C., P.O. Box 1066, Johannesburg.
1903. Vaughan, J. A., P.O. Box 1132, Johannesburg.
1917. Viljoen, Hendrik Geldenhuys, B.A., D.Litt., Market Street, Stellenbosch.
1916. Visser, Cornelis François, B.A., Ph.D., 130, Zastron Street, Bloemfontein.
1916. Visser, Wilhelmus Hendrikus B.Sc., P.O. Box 231, Johannesburg.
1915. Von Mengershausen, Frederich Karl, B.Sc., Lecturer in Mining Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1903. Von Oppell, Otto Karl Adolf, Department of Lands, Pretoria.

1916. Wade, Walter B., P.O. Box 932, Durban.
1912. Wager, Horace Athelstan, A.R.C.S., Professor of Botany and Zoology, Transvaal University College, Pretoria.
1916. Wagner, Percy Albert, Ing.D., B.Sc. (Vice-Pres. B), P.O. Box 1277, Pretoria.
1913. Wahl, R. Owen, B.A., Grootfontein School of Agriculture, Middelburg, C.P.
1912. Walker, James, M.R.C.V.S., P.O. Box 593, Pretoria.
1902. *Waller, Arohm H., A.M.I.C.E., F.R.Met.S., Town Engineer, Bulawayo, Rhodesia.
1902. *Walsh, Albert (General Treasurer, 1910-17), P.O. Box 39, Capetown.
1913. Walsh, Lionel Henry, Brackley, Kenilworth, Capetown.
1916. Walton, Arthur John, Rose Deep, P.O. Box 6, Germiston, Transvaal.

Year of Election.

1914. Wark, *Rt. Rev.* David, M.A., Moderator of the General Assembly of the Presbyterian Church of South Africa, The Manse, Woodley Street, Kimberley, C.P.

1907. Warren, Ernest, D.Sc., Professor of Zoology, Natal University College, Pietermaritzburg, Natal.

1916. Waterhouse, Osborn, M.A., Professor of English and Philosophy, Natal University College, Pietermaritzburg.

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, C.P.

1906. Watkins-Pitchford, Wilfred, M.D., F.R.C.S., D.P.H., South African Institute for Medical Research, P.O. Box 1038, Johannesburg.

1916. Watson, Frederick William, B.Sc., F.I.C., P.O. Box 108, Germiston, Transvaal.

1914. Watson, Thomas Hunter, P.O., Box 1400, Capetown.

1915. Watson, William Cruickshank, 13, Yeo Street, Yeoville, Johannesburg.

1906. Watt, Dugald Campbell, M.D., 131, Pietermaritzburg St., Pietermaritzburg, Natal.

1916. Waugh, Edward Henry, A.R.I.B.A., P.O. Box 1049, Johannesburg.

1912. Way, William Archer, M.A. (Pres. D, 1912), Grey Institute, Port Elizabeth, C.P.

1914. Webb, George Arthur, A.I.E.E., M.S.A., P.O. Box 3136, Johannesburg.

1916. †Webber, Walter Solomon, B.A., P.O. Box 1088, Johannesburg.

1911. Welch, *Rev.* Sidney Read, B.A., D.D., Ph.D., St. Mary's, Bouquet Street, Capetown.

1916. Wertheim, Louis, P.O. Box 354, Johannesburg.

1903. Wessels, *Hon. Justice Sir* J. W., Kt., B.A., LL.B., Pretoria.

1916. Wessels, Johannes Jacobus, M.E., P.O. Box 1392, Johannesburg.

1916. White, *Mrs.* E. L., King Edward Mansions, Port Elizabeth.

1902. †White, Miss Francis Margaret, Trescoe, Cornwall Place, Wynberg, C.P.

1910. White, H. A., P.O. Box 41, Springs, Transvaal.

1902. †White, *Miss* Henrietta Mary, B.A., Trescoe, Cornwall Place, Wynberg, C.P.

1902. *White-Cooper, William, M.A., F.R.I.B.A., P.O. Box 11, Cradock, C.P.

1915. Whitmore, Sidney W., Public Works Department, Pretoria.

1909. Whitworth, Walter S., Koffyfontein Diamond Mine, O.F.S.

1910. Wiener, Ludwig, F.R.G.S., Riebeek Street, P.O. Box 365, Capetown.

Year of Election.

1904. Wilhelm, A. R. A., M.B., C.M., Barkly East, C.P.
1915. Wilkinson, David, A.R.S.M., P.O. Box 485, Johannesburg.
1915. Wilkinson, Frank, Lecturer in Dairying and Dairy Bacteriology, Grootfontein School of Agriculture, Middelburg, C.P.
1904. †Wilkinson, J. A., M.A., F.C.S. (Pres. B, 1916), 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. Willey, Edgar A., L.D.S., Potchefstroom, Transvaal.
1902. *Williams, Alpheus Fuller, B.Sc., Mining Engineer, De Beers Consolidated Mines, Ltd., P.O. Box 616, Kimberley, C.P.
1916. Williams, Charles Herbert, P.O. Box 2155, Johannesburg.
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, C.P.
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, C.P.
1903. †Wilson, Arthur Marius, M.D., B.S., L.R.C.P., M.R.C.S., Jesmond House, Hof Street, Capetown.
1916. Wilson, Charles Edmund, A.M.I.E.E., P.O. Box 930, Johannesburg.
1909. Windram, James Thomas, P.O. Box 3547, Johannesburg.
1912. Winter, *Rev.* Johannes August, Onverwacht, P.O., Sekukuni, District Lydenburg, Transvaal.
1903. †Winterton, Albert Wyle, F.C.S., Lemoenfontein, near Beaufort West, C.P.
1906. WOOD, H. E., M.Sc., F.R.Met.S. (Vice-President, GENERAL SECRETARY 1913-1916), Union Observatory, Johannesburg.
1905. †Wood, James, M.A., P.O. Box 2, Kingwilliamstown, C.P.
1916. Woods, *Mrs.* Sarah Ann, 211, Commercial Road, Pietermaritzburg.
1916. Wright, Kathleen Margaret, B.Sc., High School for Girls, Barnato Park, Johannesburg.
1915. Wyatt, Stanley, M.Sc., Normal College, P.O. Box 855, Pretoria.
1916. Wylie, James Scott, K.C., Scotswood, Ridge Road, Durban.

1917. Yaldwyn, Sibert Halcott, Government School, Malvern (Denver Delivery), Johannesburg.
1904. Young, *Professor* Robert B., M.A., D.Sc., F.R.S.E., F.G.S., (Pres. B, 1913), P.O. Box 1176, Johannesburg

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THE

SOUTH AFRICAN JOURNAL OF SCIENCE:

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1916.

MARITZBURG.

Issued Monthly.

VOL. XIII. AUGUST, 1916. NO. 1

CAPE TOWN.
PUBLISHED BY THE ASSOCIATION.
1916.

[Price 2s.

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ADVANCEMENT OF SCIENCE.

1916.

MARITZBURG.

Issued Monthly.

VOL. XIII. SEPTEMBER, 1916. NO. 2.

CAPE TOWN.
PUBLISHED BY THE ASSOCIATION.

1916.

[Price 2s.

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1916.

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MARITZBURG.

Issued Monthly.

VOL. XIII. NOVEMBER, 1916. NO. 4.

CAPE TOWN.

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VOL. XIII. APRIL, 1917. NO. 9.

CAPE TOWN,

PUBLISHED BY THE ASSOCIATION.

1917.

[Price 2s.

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DOUBLE ISSUE.

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VOL. XIII. JUNE, 1917. NO. 10.

CAPE TOWN,
PUBLISHED BY THE ASSOCIATION.

1917.

[Price 2s.

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ADVANCEMENT OF SCIENCE.

1916.

MARITZBURG.

VOL. XIII. JULY, 1917. NO. 11.

CAPE TOWN,
PUBLISHED BY THE ASSOCIATION.

1917.

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