REPORT

OF THE

TWENTY-THIRD MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT HULL IN SEPTEMBER 1853.

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The Editors of the preceding Notices consider themselves responsible only for the fidelity with which the views of the Authors are abstracted.

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

THE ASSOCIATION contemplates no interference with the ground occupied by other Institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

ADMISSION OF MEMBERS AND ASSOCIATES.

All Persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

LIFE MEMBERS shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

ANNUAL SUBSCRIBERS shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes :—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz. :—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845 a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members, who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one-third of the Publication Price. Application to be made (by letter) to Messrs. Taylor & Francis, Red Lion Court, Fleet St., London.

Subscriptions shall be received by the Treasurer or Secretaries.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons :—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether, not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S.L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
Sir T. MAKDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robison, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London. LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe.	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare. Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
Sir JOHN F. W. HERSCHEL, Bart., F.R.S., &c.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.

Sir RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. Professor Powell, F.R.S.	Henry Clark, M.D. T. H. C. Moody, Esq.
Sir ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford. OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University. Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. Rev. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
Sir DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews. EDINBURGH, July 31, 1850.	Right Hon. the Lord Provost of Edinburgh. The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal. IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich. Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society. BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, M.R.I.A., Pres. R.S. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast. Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society. HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society. William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge. William Lassell, Esq., F.R.S. L. & E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, M.D. Thomas Inman, M.D.

II. Table showing the Names of Members of the British Association who have served on the Council in former years.

Acland, Sir Thomas D., Bart., M.P., F.R.S.
Acland, Professor H. W., B.M., F.R.S.
Adamson, John, Esq., F.L.S.
Adams, J. Couch, M.A., F.R.S.
Adare, Edwin, Viscount, M.P., F.R.S.
Ainslie, Rev. Gilbert, D.D., Master of Pembroke Hall, Cambridge.
Airy, G. B., D.C.L., F.R.S., Astronomer Royal.
Alison, Professor W. P., M.D., F.R.S.E.
Ansted, Professor D. T., M.A., F.R.S.
Argyll, George Douglas, Duke of, F.R.S.
Arnott, Neil, M.D., F.R.S.
Ashburton, William Bingham, Lord, D.C.L.
Babbage, Charles, Esq., F.R.S.
Babington, C. C., Esq., F.R.S.
Baily, Francis, Esq., F.R.S.
Balfour, Professor John H., M.D.
Barker, George, Esq., F.R.S.
Bell, Professor Thomas, F.L.S., F.R.S.
Bengough, George, Esq.
Bentham, George, Esq., F.L.S.
Bigge, Charles, Esq.
Blakiston, Peyton, M.D., F.R.S.
Boileau, Sir John P., Bart., F.R.S.
Boyle, Right Hon. David, Lord Justice-General, F.R.S.E.
Brand, William, Esq.
Brewster, Sir David, K.H., D.C.L., LL.D., F.R.S. Principal of the United College of St. Salvator and St. Leonard, St. Andrews.
Breadalbane, John, Marquis of, K.T., F.R.S.
Brisbane, General Sir Thomas M., Bart., K.C.B., G.C.H., D.C.L., F.R.S.
Brown, Robert, D.C.L., F.R.S.
Brunel, Sir M. I., F.R.S.
Buckland, Very Rev. William, D.D., Dean of Westminster, F.R.S.
Burlington, William, Earl of, M.A., F.R.S., Chancellor of the University of London.
Bute, John, Marquis of, K.T.
Carlisle, George Will. Fred., Earl of, F.G.S.
Carson, Rev. Joseph.
Cathcart, Lt.-Gen. Earl of, K.C.B., F.R.S.E.
Chalmers, Rev. T., D.D., late Professor of Divinity, Edinburgh.
Chance, James, Esq.
Chester, John Graham, D.D., Lord Bishop of.
Christie, Professor S. H., M.A., Sec. R.S.
Clare, Peter, Esq., F.R.A.S.
Clark, Rev. Prof., M.D., F.R.S. (Cambridge).
Clark, Henry, M.D.
Clark, G. T., Esq.
Clear, William, Esq.
Clerke, Major Shadwell, K.H., R.E., F.R.S.
Clift, William, Esq., F.R.S.
Cobbold, John Chevalier, Esq., M.P.
Colquhoun, J. C., Esq., M.P.
Conybeare, Very Rev. W. D., Dean of Llandaff, M.A., F.R.S.
Corrie, John, Esq., F.R.S.
Currie, William Wallace, Esq.
Dalton, John, D.C.L., F.R.S.
Daniell, Professor J. F., F.R.S.
Dartmouth, William, Earl of, D.C.L., F.R.S.
Darwin, Charles, Esq., F.R.S.
Daubeny, Prof. Charles G. B., M.D., F.R.S.
De la Beche, Sir Henry T., C.B., F.R.S., Director-General of the Geological Survey of the United Kingdom.
Dillwyn, Lewis W., Esq., F.R.S.
Drinkwater, J. E., Esq.
Durham, Edward Maltby, D.D., Lord Bishop of, F.R.S.
Egerton, Sir Philip de M. Grey, Bart., M.P., F.R.S.
Eliot, Lord, M.P.
Ellesmere, Francis, Earl of, F.G.S.
Enniskillen, William, Earl of, D.C.L., F.R.S.
Estcourt, T. G. B., D.C.L.
Faraday, Professor, D.C.L., F.R.S.
Fitzwilliam, Charles William, Earl, D.C.L., F.R.S.
Fleming, W., M.D.
Fletcher, Bell, M.D.
Forbes, Charles, Esq.
Forbes, Professor Edward, F.R.S.
Forbes, Professor J. D., F.R.S., Sec. R.S.E.
Fox, Robert Were, Esq., F.R.S.
Frost, Charles, F.S.A.
Gassiot, John P., Esq., F.R.S.
Gilbert, Davies, D.C.L., F.R.S.
Graham, Professor Thomas, M.A., F.R.S.
Gray, John E., Esq., F.R.S.
Gray, Jonathan, Esq.
Gray, William, jun., Esq., F.G.S.
Green, Professor Joseph Henry, F.R.S.
Greenough, G. B., Esq., F.R.S.
Grove, W. R., Esq., F.R.S.
Hallam, Henry, Esq., M.A., F.R.S.
Hamilton, W. J., Esq., Sec.G.S.
Hamilton, Sir William R., Astronomer Royal of Ireland, M.R.I.A.
Harcourt, Rev. William Vernon, M.A., F.R.S.
Hardwicke, Charles Philip, Earl of, F.R.S.
Harford, J. S., D.C.L., F.R.S.
Harris, Sir W. Snow, F.R.S.
Harrowby, The Earl of, F.R.S.
Hatfeild, William, Esq., F.G.S.
Henslow, Rev. Professor, M.A., F.L.S.
Henry, W. C., M.D., F.R.S.
Henry, Rev. P. S., D.D., President of Queen's College, Belfast.
Herbert, Hon. and Very Rev. William, late Dean of Manchester, LL.D., F.L.S.
Herschel, Sir John F. W., Bart., D.C.L., F.R.S.
Heywood, Sir Benjamin, Bart., F.R.S.
Heywood, James, Esq., M.P., F.R.S.
Hill, Rev. Edward, M.A., F.G.S.
Hincks, Rev. Edward, D.D., M.R.I.A.
Hodgkin, Thomas, M.D.
Hodgkinson, Professor Eaton, F.R.S.
Hodgson, Joseph, Esq., F.R.S.
Hooker, Sir William J., LL.D., F.R.S.
Hope, Rev. F. W., M.A., F.R.S.
Hopkins, William, Esq., M.A., F.R.S.
Horner, Leonard, Esq., F.R.S., F.G.S.
Hovenden, V. F., Esq., M.A.
Hutton, Robert, Esq., F.G.S.
Hutton, William, Esq., F.G.S.
Ibbetson, Capt. L. L. Boscawen, K.R.E., F.G.S.
Inglis, Sir Robert H., Bart., D.C.L., M.P., F.R.S.
Jameson, Professor R., F.R.S.
Jeffreys, John Gwyn, Esq., F.R.S.
Jenyns, Rev. Leonard, F.L.S.
Jerrard, H. B., Esq.
Johnston, Right Hon. William, Lord Provost of Edinburgh.
Johnston, Professor J. F. W., M.A., F.R.S.

Keleher, William, Esq.
Kelland, Rev. Professor P., M.A.
Lansdowne, Henry, Marquis of, D.C.L., F.R.S.
Lardner, Rev. Dr.
Latham, R. G., M.D., F.R.S.
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Lee, Robert, M.D., F.R.S.
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THE GENERAL TREASURER'S ACCOUNT from 1st of September

RECEIPTS.

	£	s.	d.
To Balance brought on from last account	237	9	11
Life Compositions at Belfast and since	118	0	0
Annual Subscriptions at Belfast and since	241	1	0
Associates' Subscriptions at Belfast	510	0	0
Ladies' Tickets at Belfast	292	0	0
Composition for the Reports	5	0	0
Dividends on Stock	101	18	10
Interest on Cash at Belfast	8	1	10
From the Sale of Publications, viz.—Reports, Catalogues of Stars, &c.	201	9	11
	£1715	1	6

JOHN P. GASSIOT,
WILLIAM HENRY SYKES, } *Auditors.*

1852 (at Belfast) to the 5th of September 1853 (at Hull).

PAYMENTS.

	£	s.	d.	£	s.	d.
For Sundry Printing, Advertising, Binding, Expenses of Meeting at Belfast, Petty Disbursements made by the General Treasurer and Local Treasurers				216	16	10
Balance of Account for Printing Report of the 20th Meeting				175	9	6
Printing Report of the 21st Meeting				422	2	9
Engraving, &c. for the Report of the 22nd Meeting				117	12	6
Salaries, 12 Months				350	0	0
Maintaining the Establishment of Kew Observatory				165	0	0
Grant for Experiments on the Influence of Solar Radiation				15	0	0
Researches on the British Annelida				10	0	0
Dredging on the East Coast of Scotland				10	0	0
Ethnological Queries				5	0	0
Balance at the Bankers	224	12	5			
Balance in the hands of the General Treasurer and Local Treasurers	3	7	6			
				227	19	11
				£1715	1	6

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Report of the Proceedings of the Council in 1852–53, as presented to the General Committee at Hull, Wednesday, Sept. 7th, 1853.

"1. With reference to the subjects referred to the Council by the General Committee at Belfast, the Council have to report as follows:—

"2. The Committee appointed for the purpose of 'considering a plan by which the Transactions of different Scientific Societies might become part of one arranged system, and the records of facts and phænomena be rendered more complete, more continuous, and more systematic than at present,' has obtained from the greater part of its members written communications embodying their respective opinions on the subject in question, and it is proposed that on the return from Italy of Professor Thomson, the originator of the resolution, these communications shall be discussed and a report prepared.

"3. On the request of the General Committee being communicated to the President and Council of the Royal Society, it was ordered by them that the Huyghenian object-glass of 123 feet focus should be mounted as an aërial telescope in the same manner as when employed in 1719 by Pound and Bradley. The superintendence of the mounting has been undertaken by Mr. De la Rue.

"4. In consequence of a communication from the President of the British Association to the President and Council of the Royal Society, a Committee was formed for the purpose of taking such steps as they should deem most desirable to procure the establishment in the Southern Hemisphere of a Telescope of large optical power for the observation of the southern nebulæ. The Committee consisted of the following persons:—The Earl of Rosse, President of the Royal Society, Chairman; Lord Wrottesley, Sir John Lubbock, Bart., Sir John Herschel, Bart., the Dean of Ely, J. C. Adams, Esq., G. B. Airy, Esq., Sir David Brewster, E. J. Cooper, Esq., W. Lassell, Esq., J. Nasmyth, Esq., John Phillips, Esq., Rev. Dr. Robinson, and the Officers and Council of the Royal Society. The Committee have conducted their proceedings partly by meetings and partly by printed correspondence; and having decided on the nature and size of the Telescope and the mode of mounting which they deemed most advisable, they appointed a deputation to communicate with the Earl of Aberdeen, with a view to obtaining the sanction of Her Majesty's Government, and the requisite funds for the construction of the Telescope; the Council have learned with satisfaction that the Deputation was very favourably received by Lord Aberdeen, and they have reason to entertain the hope that the necessary funds for the construction of the Telescope will be included in the estimates presented to Parliament in its next session.

"5. The resolution of the General Committee recommending that the publication of the Townland Survey of Ireland, upon the scale of an inch to a mile, should be accelerated, has been communicated to the Master-General of the Ordnance, and a favourable reply received.

"6. In compliance with the resolution directing the Council to solicit the cooperation of the Royal Society in meteorological investigations attainable by balloon ascents, a communication was addressed to the President and Council of the Royal Society, which was most cordially received, and four such ascents have been made under the direction of the Kew Observatory Committee, by the aid of funds placed at their disposal by the Royal Society. A highly satisfactory account of these ascents, and of the results obtained, is given in a communication to the Royal Society, drawn up by Mr. Welsh by whom the observations were conducted, of which communication 500 copies have been presented to the British Association.

"7. Respecting 'a series of experiments on a large scale on the thermal effects experienced by air in rushing through small apertures,' a representation, as recommended, has been made to the Royal Society, and a grant of £100 from the Government Fund at the disposal of the Royal Society has been made to Messrs. Thomson and Joule, for the necessary apparatus.

"8. The recommendation of the General Committee, that, in the event of a survey of the Gulf-stream being undertaken, provision should be made for investigating its zoology and botany, has been communicated to the Hydrographer of the Admiralty and favourably received. A proposition from Dr. Bache, Director of the Coast Survey of the United States, for a joint survey of the Gulf-stream by the United States and Great Britain, having been addressed to the President of the British Association since the Belfast meeting, has been forwarded to the Hydrographer of the Admiralty, and has given rise to the following correspondence:—

"'*Dr. Bache to Colonel Sabine.*

"'Washington, October 20, 1852.

"'Dear Sir,—In the report of the proceedings of the recent Meeting of the British Association, over which you presided, I observe a recommendation which refers to a 'Survey of the Gulf-stream.' A systematic survey of the Gulf-stream at and below the surface, for hydrographic purposes, was commenced in connexion with the survey of the coast of the United States, under my direction, in 1844, and has been continued, as means served, each season since, and we have now carried the examination by sections perpendicular to the stream from off the capes of New York to Cape Hatteras. Might it not be useful to connect the work proposed by your Association with our labours; and if so, who is the proper person to address in regard to the matter? Will you oblige me by informing me in this matter?

"'Yours truly and respectfully,
"'A. D. BACHE.'

"'Colonel Edward Sabine,
President of the British Association.'

"'*Colonel Sabine to Rear-Admiral Sir F. Beaufort, K.C.B., Hydrographer.*

"'Woolwich, November 10, 1852.

"'SIR,—I beg leave to enclose the copy of a letter which, as President of the British Association for the Advancement of Science, I have received from Dr. Bache, Director of the Coast Survey of the United States of North America.

"'The recommendation of a 'Survey of the Gulf-stream,' referred to by Dr. Bache, is contained in the accompanying address of the President at the commencement of the Belfast Meeting of the British Association; the paragraph (page 19) is marked, and is to be taken in connexion with the preceding paragraph, referring to the correspondence which has recently taken place between the British and United States Governments and the British Government and the Royal Society of London, on the subject of a conjoint investigation into the currents and temperatures of the ocean by the ships of both nations under their respective hydrographic offices.

"'It is possible that the British Government may have acceded to the proposition to this effect made to them by the Government of the United States, and strongly recommended in the report which the Earl of Malmesbury requested from the President and Council of the Royal Society; and that the department of the Admiralty over which you preside may have received directions to communicate accordingly with the Hydrographic Office of the United States; in this case you may be able to inform me at once to whom I should recommend Dr. Bache to address himself.

"'Should, however, no such directions have yet issued, it appears to me most desirable that I should place Dr. Bache's letter in your hands, to be communicated, should you think proper to do so, to the Lords Commissioners of the Admiralty; manifesting as it does, the desire which is felt by a gentleman in his high official position in the United States, to cooperate with the British Navy in accomplishing a 'systematic survey of the Gulf-stream for hydrographic purposes,' in consonance with the general plan proposed by the Government of the United States to Her Majesty's Government.

"'I have the honour to be, Sir,
"'Your obedient Servant,
"'EDWARD SABINE,
"'*President of the British Association for the Advancement of Science.*'

"'The Hydrographer of the Admiralty.'

"'Hydrographic Office, Admiralty, May 5, 1853.

"'SIR,—I have to thank you for the Copy of Dr. Bache's letter, which shows how rapidly every useful project in art or science is taken up in the United States, and then how energetically it is pushed forward. With respect to its immediate subject, you have long known that a thorough examination of the Gulf-stream has been, in my estimation, an object of great importance to navigation, and you may be therefore sure that whenever, and by whomsoever it may be undertaken, no effort of mine will be wanting to contribute to its success.

"'I confess, however, that I do not at once perceive how the two countries could profitably cooperate in the work; but there is no use in discussing the *modus operandi* till the Admiralty think proper to give me some direct orders to consider and report upon the subject, which has not yet been done.

"'I have the honour to be, Sir,

"'Your most obedient Servant,

"'Colonel Sabine, R.A., Woolwich.' "'F. BEAUFORT, *Hydrographer*.'

"'London, May 6, 1853.

"'MY DEAR SIR,—I have this day received, and at once transmit to you a copy of, the British Hydrographer's reply to my letter of November 10th, 1852, enclosing a copy of your letter to me on the subject of a joint survey of the Gulf-stream by the United States and this country. You will see by Sir Francis Beaufort's letter that he fully concurs with you in recognizing the great importance to navigation of such a survey, and that no effort on his part is likely to be wanting to contribute to its success, whensoever it shall be undertaken.

"'You have probably seen by a discussion which took place in the House of Lords, on Tuesday the 26th of April, that Lieut. Maury's proposition for an extensive system of Hydrographical inquiry, to be carried out conjointly by the ships of the two nations, has been favourably received by Her Majesty's Government, and the measures required for British cooperation are now under consideration.

"'The part which this country might take in a survey of the Gulf-stream must necessarily be under the direction of the Hydrographer; and consequent on instructions received by him from the Admiralty. It is to be inferred from Sir Francis Beaufort's reply that it does not consist with the practice of his department to communicate to the Admiralty the fact that the Director of the Coast Survey of the United States has expressed a desire to undertake the survey of the Gulf-stream conjointly with Great Britain. Under these circumstances the best suggestion which I am able to make to you, in reply to your question to whom your proposition should be made, is, that you should take the same course which Lieut. Maury has done, viz. that the proposition should proceed through your own Secretary of State, and the American Minister in this country, to Her Majesty's Secretary of State for Foreign Affairs, by whom it will be communicated to the proper executive Department, and an official reply returned.

"'I think that I may safely and confidently assure you that any assistance which the British Association for the Advancement of Science can give in furtherance of a proposition of so much scientific as well as maritime importance, will be most readily given.

"'Believe me, most sincerely yours,

"'EDWARD SABINE,

"'Dr. A. D. Bache.' "'*President of the British Association*.'

"9. An application, as directed by the General Committee, has been made to the Master-General and Board of Ordnance to supply instruments for measuring the direction and amount of earthquake vibrations in the Ionian Islands, and instructions have in consequence been issued for the construction of the necessary instruments.

"10. With reference to the resolutions regarding the Agricultural Statistics of Great Britain, the Committee appointed to carry out the wishes of the

General Committee have reported to the Council, that having ascertained that measures having those objects in view had already been adopted by Her Majesty's Government, they have confined themselves to an expression of satisfaction therewith, and of readiness to afford any practicable aid on the part of the British Association.

"11. On the subject of a grant in aid of the publication of Mr. Huxley's zoological and physiological researches in H.M.S. Rattlesnake, the Council have to report that the application made in the last year by the Presidents of the Royal Society and of the British Association to the Earl of Derby, has been renewed in the present year to the Earl of Aberdeen by the Earl of Rosse, on behalf of both institutions. No reply has yet been received. The Council desire to take this occasion of calling the attention of the General Committee to the want which has been felt in this instance, as in many others, of suitable and systematic arrangements on the part of Government for the due publication of the results of scientific researches executed at the public expense by naval officers acting under the instructions of the Admiralty.

"12. The Council, having been directed by the General Committee to take into consideration the expediency of procuring copies of M. Dovè's Maps and Memoir on the Distribution of Heat over the Surface of the Globe, made arrangements for obtaining from M. Dovè 250 copies of the maps from the original stones, and have directed them to be bound up with a translation of M. Dovè's Memoir, presented by Colonel Sabine, to be disposed of to members of the Association at the cost price of the plates, the printing, and the binding.

"13. In reference to the resolutions respecting the proposed cooperation of the British Association in recommending to Her Majesty's Government, in conjunction with the Royal Geographical Society, the examination of a portion of the eastern coast of Africa, the exploration of the countries around the river Magdalena with a view to their natural products, and the ascent of the river Niger to its source, much delay was experienced from the circumstance that no papers whatsoever relative to those subjects were given at the close of the Belfast Meeting to the Assistant General Secretary, and that the Council were unable subsequently to procure such memorials, embodying such statements of the objects and grounds of the recommendation, as it is the practice of the British Association to obtain in all cases of application to Government and to the East India Company. The subjects were thus necessarily left in the hands of the Royal Geographical Society.

"14. The Council have great pleasure in expressing their conviction of the increased and increasing usefulness of the establishment at Kew, and subjoin the report which they have received from the superintending Committee. The Council recommend a continuation of a grant to this establishment to the same amount as in the last year.

"15. The Council have been informed that the invitations formerly received by the British Association from Liverpool and Glasgow, to hold the meetings of the next two years at those places, will be renewed by deputations appointed to attend at Hull for that purpose. They have also been informed that it is the intention of the mayor, aldermen, and citizens of Gloucester, to present on the same occasion an invitation to the British Association to hold an early meeting in that city."

The Report of the Kew Committee, signed by J. P. Gassiot, Esq., Chairman, referred to in the Report of the Council, was read and ordered to be entered in the Minutes. It is as follows:—

"*Report of the Kew Committee of the British Association for* 1852–53.

"Since the last meeting of the British Association, the Kew Committee have completed the series of balloon ascents which they had contemplated—four ascents in all having been made, viz. on Aug. 17, Aug. 26, Oct. 21, and Nov. 10, 1852. A Report of these ascents was communicated by the Kew Committee to the Council of the British Association, on the 29th Nov. 1852. *A detailed account* of the experiments, with a discussion of the general results, having been prepared by Mr. Welsh, was communicated in April last, by the Council of the British Association, to the Royal Society, and has since been printed in the Philosophical Transactions. At the request of the Council of the British Association, the Royal Society have granted to them 500 copies of the paper for distribution among their members; 50 copies have been presented to those gentlemen who took a part in the experiments, by making contemporaneous meteorological observations or otherwise. The remaining copies will be distributed to the purchasers of Dovè's Isothermal Lines. The sum of 261*l.* 2*s.* 5*d.* was granted by the Royal Society, from their Wollaston Fund, to defray the expense of these ascents.

"Of this sum 243*l.* 2*s.* 5*d.* was expended, leaving a balance of 18*l.*, which has been repaid to the Treasurer of the Royal Society.

"The Committee have, up to this time, been enabled to supply seventy thermometers, graduated under their superintendence by Mr. Welsh.

"All the applications yet received have now been complied with, except three or four for instruments of unusual construction or extent of graduation.

"On the 30th of May, 1853, the Committee passed the following resolutions:—

"'1st. That in order to facilitate the comparisons of thermometers with the standard at Kew, the Committee are prepared to furnish such instrument-makers as may apply to them with a standard thermometer at the charge of 1*l.*

"'2nd. The Committee are prepared to receive thermometers and to furnish a table of their errors, provided such thermometers are forwarded to Kew free of expense.—It was subsequently resolved that the charge for the verification of such thermometers should be 3*s.* 6*d.* for each instrument.

"'3rd. That as there are many very carefully recorded series of observations made with thermometers that have not been previously verified, the Committee will also be prepared (on receiving applications from the observers) to furnish the results of a comparison with the Kew standard. Such instruments to be forwarded to the Observatory free of expense.'

"The above resolutions having been forwarded to the editors of the *Athenæum* and the *Literary Gazette*, were kindly noticed by them in their respective journals, but with one exception (by an optician for a thermometer) no further application has been received by the Committee. It is, however, very probable that when such facilities for the correction of observations made with imperfect thermometers are more generally known, further applications will be received. Except to those who have been actually engaged in reducing such observations, it is almost impossible to conceive the amount of comparatively useless observations that have been and are now daily recorded, owing to the imperfect instruments employed.

"During the past year a very considerable portion of the time of Mr. Welsh has been occupied in the arrangement for and the discussions of the results of the balloon experiments, and as he has no one to assist him in the carrying out of any meteorological observations, the amount of general work in the Observatory during the past year has necessarily been much less than in previous years; at the same time it will be seen that the expenditure has been proportionately diminished. The total amount is 159*l.* 11*s.* 1*d.*, exclusive of the sum expended in the ascents, which, as has already been stated, was wholly defrayed by the Royal Society.

"The Committee suggest that, with regard to the balance in hand, the same principle as that hitherto adopted should be continued, viz. that the balance from former years should be still held at the disposal of the Kew Committee (in the event of its being re-appointed), in addition to the usual annual grant of 200*l.* The strict œconomy with which the funds have been hitherto used is a sufficient guarantee that no unnecessary expenditure will be incurred.

"The Committee recommend that an application should be made to the Commissioners of Woods and Forests for the temporary use of a small portion of the ground near the Observatory for the erection of suitable places for observing; the expense would be very trifling, while the position of the Observatory, in the centre of 450 acres of a level field, combined with its near proximity to the metropolis, renders it in every respect a most suitable place for the carrying on those scientific researches which are so intimately connected with the objects of the British Association.

"During the past year, an application has been received by the Council of the Association for a portion of the electrical apparatus belonging to the Association for the use of the Observatory at Toronto. This application was referred by the Council to the Committee. The following is an extract from their Minutes, 4th August, 1853:—'Read a letter from Capt. Lefroy to Dr. Royle, dated Woolwich, 21st July, 1853. Resolved, that as the electrical apparatus referred to in Capt. Lefroy's letter is a portion of that constructed by Mr. Ronalds for the carrying out of his original experiments in atmospherical electricity, and in which the British Association has always taken so much interest, the Committee cannot recommend that any portion of it should be withdrawn from the Observatory, more particularly as Mr. Newman could supply a more perfect apparatus under the superintendence of Mr. Ronalds at a comparatively trifling cost.'

"Part of the Government Grant placed at the disposal of the Royal Society having been entrusted to the Meteorological Sub-Committee, they have been enabled to prosecute their experiments for the improvement of meteorological instruments, and have, in furtherance of this object, obtained from M. Œrtling a set of standard weights, made under the direction of Dr. Miller, with especial reference to facility of intercomparison. They are now in the hands of Prof. Miller, of Cambridge, for verification, and he expects in the course of about a month to have the trials of them complete. These weights consist of the following—a standard pound of gun-metal thickly electro-gilt; a set of weights for ordinary use made of the same material, viz.

1 of 7000 grains.	1 of 700 grains.
1 „ 4000 „	1 „ 400 „
1 „ 2000 „	1 „ 200 „
2 „ 1000 „	2 „ 100 „

A set of platinum wire weights for the smaller subdivision—

1 of 70 grs.	1 of 7 grs.	1 of ·7 gr.	1 of ·07 gr.
1 „ 40 „	1 „ 4 „	1 „ ·4 „	1 „ ·04 „
1 „ 20 „	1 „ 2 „	1 „ ·2 „	1 „ ·02 „
2 „ 10 „	2 „ 1 „	2 „ ·1 „	1 „ ·01 „

The standard scale, prepared by Messrs. Troughton and Simms, is awaiting Mr. Sheepshanks' leisure for comparison with the bars in his possession. This scale is composed of a brass rolled bar, about 41 inches long, $1\frac{1}{2}$ inch wide, and half an inch thick—the standard yard is laid down between two gold pins, inserted for the purpose, and the interval of 36 inches is marked off on them by two fine lines; near an edge of the bar, 40 inches subdivided into tenths, have been marked off, and one-tenth has further been divided into hundredths of an inch.

"Application having been made from the Hydrographer to the Admiralty for advice as to the thermometers to be supplied to Her Majesty's Navy for meteorological observations to be made at sea, the Committee have undertaken to recommend and provide a specimen of the form of instrument they consider best adapted for the purpose, and experiments are now being made by Mr. Welsh, with this object in view.

"Lieut. Maury, of the United States Navy, has also requested the opinion of the Committee upon the best form of a Marine Barometer, and the subject is now under their consideration.

"The Standard Barometer is not as yet mounted, but two tubes of an inch in internal diameter, have been boiled at the Observatory, by Messrs. Negretti and Zambra, under the inspection of the Committee, and the mounting is shortly expected to be completed.

"The Committee cannot close their report without expressing their high estimation of Mr. Welsh's services. The constant and unremitting attention to his duties, combined with the ability he has always evinced in their discharge, entitle him to the warmest thanks and individual support of every member of the British Association.

"JOHN P. GASSIOT,
"*Chairman.*"

REPORT OF THE PARLIAMENTARY COMMITTEE OF THE BRITISH ASSOCIATION, TO THE MEETING HELD AT HULL, IN SEPTEMBER 1853.

"The Parliamentary Committee have the honour to report as follows:—

"The subjects to which the attention of the Committee has been directed, since the date of their last Report, are—

"1. The extravagant rates of postage charged on the transmission of presentation copies of scientific works to correspondents in foreign parts; and

"2. Lieut. Maury's Scheme for the improvement of Navigation.

"As to the first, Mr. Heywood moved, in the House of Commons, for a copy of the return, which has been already printed by order of the House of Lords, on the motion of Lord Wrottesley, showing the great amount of the rates now levied on the postage of letters to foreign countries (and such communications as those above alluded to can only be sent as *letters* by the existing regulation), and the same return was produced and printed accordingly. This return is No. 32 of the sessional papers of the House of Lords, and No. 142 of those of the House of Commons.

"Your Committee likewise solicited and obtained an interview with the Postmaster-General, on the 13th of July, and directed his attention to the statements contained in the letter to Lord Malmesbury, of last year, on this subject, and to the facts disclosed by the above-mentioned returns; and a letter was subsequently written at Lord Canning's request, embodying in writing the observations which had been already addressed to him orally in this behalf. Lord Canning seemed to admit the hardship of the case, and the following letter, which was afterwards received from Colonel Maberly, contains the substance of the answer given by him to the Deputation:—

"'General Post-Office, August 2nd, 1853.

"'My Lord,—The Postmaster-General has had under consideration your Lordship's letter of the 22nd ultimo, and I am directed to inform you that he considers it would be difficult to establish any special regulation for the transmission of scientific works only, through the post, to and from foreign countries at a low rate of postage.

"'Lord Canning's attention, however, has been directed for some time to the importance of entering into arrangements with the several foreign countries, with which this department is under convention, for the purpose of extending to these countries, as nearly as circumstances will permit, the provisions under which printed publications generally may be forwarded by post, at a cheap rate, to a large number of Her Majesty's colonial possessions abroad; and I have to state that his Lordship is already in correspondence on this subject with the Prussian post-office, acting on behalf of the greater part of Germany; and that he will take care that this point is borne in mind in any future negotiation with foreign post-offices.

"'I have the honour to be, &c.,

"'W. Maberly.'

"Secondly. The subject of Lieut. Maury's plan, for making hydrographical and meteorological observations at sea, by the co-operation of the principal maritime nations, was referred to your Committee by your Council on the 29th November, and also by Colonel Sabine, your President; and, at the meeting of the Committee on the 11th of February, Lord Wrottesley was requested to call the attention of the House of Lords to this very important scheme. This was accordingly done on the 26th of April, and Lord Wrottesley thought it right on this, the first occasion of an appeal to Parliament, to take advantage of the opportunity that afforded to him to make some remarks on the advantages arising from the cultivation of abstract science, and on the duty of protecting and fostering a pursuit from which this country more especially had derived such inestimable benefits. On the 13th of July Sir Robert Inglis, in the House of Commons, as representing your Committee, again urged the importance of Lieut. Maury's plan on the attention of Government, and the reply of Admiral Berkeley not being deemed satisfactory, your Committee solicited and obtained an interview with Sir James Graham on the 18th of July, on this subject. The Deputation consisted of the Chairman, the Earl of Harrowby, the Earl of Rosse, the Bishop of Oxford, Sir Robert Inglis, and Mr. Heywood, assisted by your President, Col. Sabine, and Sir Roderick Murchison, who were invited to accompany the Committee. Sir James Graham stated he was prepared to issue instructions to captains of men-of-war to take the temperature of sea-water, and that he would send Capt. Beechy to Brussels on the 23rd of August to confer with Lieut. Maury, who had arranged to meet at that time and place representatives of many of the maritime powers of Europe; he also stated to Sir Robert Inglis, on another occasion, that he was willing to cooperate with the United States Government by sending a vessel to explore the ocean between the Cape of Good Hope and Cape Horn. He stated, further, to the Deputation, that he was not yet prepared to recommend to the House of Commons the establishment of a separate department or office, for the purpose of receiving, reducing, and coordinating the observations made either by ships of war or the mercantile marine. The Deputation, in reply, expressed their regret at this determination, and showed that unless an office of this kind were provided, it was in vain to expect that observations would be made, and that, if made, they would be productive of little or no benefit to navigation or science; and they called attention to the fact that valuable hydrographical and meteorological observations had already been made by scientific naval officers, and had produced no fruit, owing to the want of a provision for their collation and reduction. Your Committee entertain a confident hope that when the attention of merchants and shipowners has been completely awakened to the wonderful results which have flowed from the adoption of the system in question in the United States, and when they perceive, as they cannot fail to do in the course of time, how materially their pecuniary interests are likely to be advanced by its unreserved adoption, that they will either attempt to carry it into effect themselves without aid from any other source, or make such an appeal to the Government as it will be difficult to resist; and symptoms of such a movement have already exhibited themselves. Your Committee are happy to be able to conclude their report with an announcement that the Council of the Royal Society have, by a Resolution dated the 17th of February last, recognized the importance of the step taken by the British Association, in appointing a Committee of Members of the Legislature to watch over the interests of science.

"Wrottesley,
"*Chairman.*"

"24th August, 1853."

Recommendations adopted by the General Committee at the Hull Meeting in September 1853.

Involving Grants of Money.

That the sum of £200 be placed at the disposal of the Council for the maintenance of the establishment of the Observatory at Kew.

That the Committee appointed to investigate the physical aspect of the Moon be requested to endeavour to procure photographs of the Moon, from telescopes of the largest size which can be made available; with £25 at their disposal for the purpose.

That the expense of certain thermometers constructed for the inquiry on Conduction of Heat, by Professor Forbes, amounting to £4 : 2*s.*, be paid.

That Dr. Hodges be requested to continue his investigations on Flax; with £20 at his disposal for the purpose.

That Mr. Rankine, Mr. Fairbairn, Dr. Robinson, Professor Hodgkinson, and Mr. Ward, be requested to continue the Report on the Cooling of Air in Hot Climates; with £20 at their disposal for the purpose.

That Mr. Fairbairn be requested to prepare a Report on the effects of Temperature on Wrought Iron Plates; with £10 at his disposal for the purpose.

That Mr. Mallet be requested to continue his Experiments on Earthquake Waves; with £50 at his disposal for the purpose.

That Dr. Lankester, Professor Owen, and Dr. Dickie, be a Committee to draw up Tables for the registration of periodical phænomena; with £10 at their disposal for the purpose.

That Dr. Lankester, Professor E. Forbes, and Professor Bell, be requested to assist Dr. Williams in drawing up a Report on British Annelida; with £10 at their disposal for the purpose.

That Mr. Hyndman, Mr. Patterson, Dr. Dickie, and Mr. Grainger, be requested to carry on a system of Dredging on the North and East coasts of Ireland; with £10 at their disposal for the purpose.

That Dr. Daubeny, Professor Lindley, and Professor Henslow, be requested to continue their experiments on the Vitality of Seeds; with £5 10*s* at their disposal for the purpose.

That the Committee for providing a large outline Map of the World, be re-appointed, with the addition of Sir James Ross and Dr. R. G. Latham; with £15 at their disposal for the purpose.

Not involving Grants of Money or Application to Government or Public Authorities.

That Lieut.-Colonel Portlock, Professor James Forbes, Mr. Mallet, Mr. Phillips, Dr. Robinson, Colonel Sabine, and Professor Stokes, be requested to consider and report upon the best form of apparatus for registering the direction and amount of earthquake vibrations.

That Colonel Sabine be requested to prepare a Report on the principal magnetical results obtained at the magnetical observatories.

That Dr. Gladstone be requested to continue his inquiries on the influence of light on the vitality of plants.

That Mr. Robert Hunt be requested to continue his investigations of the chemical action of the solar rays.

That the following Gentlemen be a Committee to report on the best means of preserving pyritous and other specimens of organic remains which are liable to decomposition, viz. J. S. Bowerbank, Esq., Professor Johnston, J. E. Lee, Esq.

That Mr. Spence Bate be requested to give a Report on the present state of our knowledge of the lower forms of British Crustacea.

That the Kew Committee be requested to furnish a Report to the Council, on the definition of the boiling-point of water at present adopted in this country for the thermometric scale; and that the Council be requested to communicate with the President and Council of the Royal Society, should any change in that respect be deemed desirable.

That Professor Johnston be requested to furnish a Report on the relations of Chemistry to Geology.

That the following papers, with the consent of the authors, be printed in full in the Transactions of the British Association for the year 1853:—

W. Fairbairn Esq.—Account of experimental researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosions.

James Oldham, Esq.—On some of the Physical Features of the Humber.

————————. On the Rise, Progress, and Present Position of Steam Navigation in Hull.

J. P. Bell, Esq., M.D.—Observations on the Character and Measurements of Degradation of the Yorkshire Coast.

That Mr. John Frederick Bateman, C.E., F.G.S., be requested to Report on the state of our knowledge on the supply of water to towns.

That the thanks of the British Association be given to the Parliamentary Committee, for the unceasing attention they have paid to the interests of science, both in communications to Government, and in proceedings in the Houses of Parliament.

The Members of the British Association have learned with satisfaction that it is the intention of Government to direct, that in future, daily meteorological observations shall be made at sea, in correspondence with the plan adopted by the Government of the United States, on the suggestion of Lieut. Maury, and to take such further steps, in reference to the Mercantile Marine of Great Britain, as may be best suited to stimulate and encourage the Masters of British merchant ships to take interest in investigations by which the times of passage between different ports have already, in many instances, been materially shortened, and which may lead to other results of the greatest importance to practical navigation.

The British Association entirely concurs in the opinion, that to make the observations thus contemplated serviceable for the purposes for which they are designed, it will be necessary to make provision for their co-ordination, and for deriving from them the instruction which they may be capable of yielding, primarily for the advantage of navigation, and secondarily for the benefit of science.

In this view the General Committee requests that the Council will communicate on the subject with the Parliamentary Committee, and will take such steps, either by deputation to Government or otherwise, as may appear to them desirable.

That as very great inconvenience is frequently occasioned by the injury or destruction of instruments and specimens arriving from Foreign parts, arising from careless re-packing at the Custom-House, it be referred to the Council to consider of the best mode of obtaining a remedy for the evil.

Synopsis of Grants of Money appropriated to Scientific Objects by the General Committee at the Hull Meeting in September 1853, *with the Name of the Member, who alone, or as the First of a Committee, is entitled to draw for the Money.*

	£	s.	d.
Kew Observatory.			
At the disposal of the Council for defraying Expenses	200	0	0
Physical Science.			
Earl of Rosse.—Committee to investigate the Physical aspect of the Moon	25	0	0
Forbes, Prof.—Expense of certain Thermometers constructed for the inquiry on Conduction of Heat	4	2	0
Chemical Science.			
Hodges, Prof.—Investigations on Flax	20	0	0
Rankine, Mr.—On the Cooling of Air in Hot Climates	20	0	0
Fairbairn, Mr.—On the Effects of Temperature on Wrought Iron Plates	10	0	0
Geology.			
Mallet, Mr.—Experiments on Earthquake Waves	50	0	0
Natural History.			
Lankester, Dr.—Tables for the Registration of Periodical Phænomena	10	0	0
Lankester, Dr.—On British Annelida	10	0	0
Hyndman, Mr.—Dredging on the North and East Coasts of Ireland	10	0	0
Daubeny, Dr.—Vitality of Seeds	5	10	0
Geography and Ethnology.			
Murchison, Sir R. I.—Large outline Map of the World	15	0	0
Grants	£379	12	0

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	3
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (strength of)	60	0	0
Animal and Vegetable Substances (preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2

	£	s.	d.
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phænomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

	£	s.	d.
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11
1842.			
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (British Association Catalogue of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8
1843.			
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0

	£	s.	d.
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Observations on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Researches into the Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas, 1842	100	0	0
Geographical distributions of Marine Zoology 1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds 1842	8	7	3
Researches on Exotic Anoplura	15	0	0
Experiments on the Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument, 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
Experiments on the Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Registration of Earthquake Shocks 1843	15	14	8
	£830	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0

	£	s.	d.
Computation of the Gaussian Constants for 1839.........	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Experiments on the Strength of Materials	60	0	0
Researches in Asphyxia......	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds.........1844	2	15	10
Vitality of Seeds.........1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain...	10	0	0
Exotic Anoplura.........1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs........	2	3	6
Researches on Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality at York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1839...	50	0	0
Habits of Marine Animals...	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Researches on Atmospheric Waves	6	9	3
Vitality of Seeds..............	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Researches on Atmospheric Waves	3	10	9
Vitality of Seeds..............	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants.........	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds...............	5	8	1
On Growth of Plants.........	5	0	0
Registration of Periodical Phænomena	10	0	0
Bill on account of Anemometrical Observations......	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phænomena	15	0	0
Meteorological Instrument, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Experiments on the Theory of Heat	20	1	1
Periodical Phænomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850).....................	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland...	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds..............	10	6	2
Strength of Boiler Plates ...	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0

Extracts from Resolutions of the General Committee.

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, John Taylor, Esq., 6 Queen Street Place, Upper Thames Street, London, for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the Members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

General Meetings.

On Wednesday, Sept. 7th, at 8 P.M., in the Saloon of the Mechanics' Institution, Colonel Edward Sabine, R.A., V.P. and Treas. R.S., resigned the office of President to William Hopkins, Esq., M.A., F.R.S., F.G.S., who took the Chair at the General Meeting, and delivered an Address, for which see page xli.

On Thursday, Sept. 8th, a Soirée took place in the Music Hall, at the Public Rooms.

On Friday, Sept. 9th, at 8 P.M., in the Saloon of the Mechanics' Institution, John Phillips, Esq., M.A., F.R.S., F.G.S., delivered a Discourse on some peculiar Phænomena in the Geology and Physical Geography of Yorkshire.

On Saturday, Sept. 10th, at 9 P.M., a Soirée took place, by invitation of the Mayor of Hull, in the Station Hotel.

On Monday, Sept. 12, at 8 P.M., in the Saloon of the Mechanics' Institution, Robert Hunt, Esq., delivered a Discourse on the present state of Photography.

On Wednesday, Sept. 14, at 3 P.M., the concluding General Meeting of the Association was held in the Saloon of the Mechanics' Institution, when the Proceedings of the General Committee, and the Grants of Money for scientific purposes were explained to the Members.

The Meeting was then adjourned to Liverpool *.

* The Meeting is appointed to take place on Wednesday, the 20th of September, 1854.

ADDRESS

BY

WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S.,

PRESIDENT OF THE CAMBRIDGE PHILOSOPHICAL SOCIETY.

GENTLEMEN OF THE BRITISH ASSOCIATION,

BEFORE I proceed to those remarks which I may have to address to you on matters of science, let me avail myself of this opportunity of expressing to you the sense I entertain of the honour which you have conferred upon me in electing me to the Presidency of the Association. When this high office was first proposed to me, I could not but feel the importance of the duties attached to it. I felt, also, that there must be others who had higher claims to the honour than myself. But I was aware how frequently difficulties will occur in the immediate appointment to such offices of the persons most competent to fill them; and, after having been invited to the office by those best qualified to decide such points, I conceived it right not to shrink from its responsibilities, but at once to accept it, with the determination of performing the duties it might impose upon me to the best of my ability. I have had the less hesitation in adopting this course from a knowledge of the effective and ready assistance which I should always receive, not only from our excellent Secretary, Mr. Phillips, but also from my predecessor in this Chair, who is so intimately acquainted with the whole working of the Association, to which he has rendered so long and so cheerfully such invaluable services. After thanking you, Gentlemen, as I do most sincerely, for the high compliment you have paid me, and assuring you of my best efforts in the cause of the Association, I proceed to lay before you such statements and remarks on scientific subjects as have presented themselves most prominently to my own mind for this occasion. In doing this, I cannot but regret my inability to do justice to many subjects which might be interesting to you; and, indeed, the limited time for which I should be justified in demanding your attention to an oral communication, will oblige me to omit, this evening, several even of those points which I was prepared to bring under your notice.

Astronomical research still continues to prove to us how much more populous is that portion of space occupied by the solar system than was suspected only a few years ago. Between the 23rd of June, 1852, and the 6th of May, 1853, nine new planets were discovered, of which seven have been found since the last meeting of the Association. Of these nine planets, our countryman, Mr. Hind, has discovered four. The number now known, exclusive of the large planets, but including the four old asteroids, amounts to twenty-six, nor have we any reason to suppose that we have yet approximated to the whole number of these minor planetary bodies. All those which have been recently recognized appear like stars of magnitudes not lower than the eighth or ninth, and are consequently invisible to the naked eye. The search for them has now assumed, to a considerable extent, a more systematic form, by a previous mapping of the stars up to a certain magnitude, and contained within a belt of a few degrees in breadth on either side of the ecliptic. Any small planet will in the first instance be inserted in the map as a small star, but will on the re-examination of the same area some time afterwards, be recognized in its true character from the fact of its having moved from the place in which it was first observed. This mapping of the ecliptic stars from the eighth to higher magnitudes is still comparatively limited; nor has the length of time during which any one portion, perhaps, of the space been thus mapped, been sufficiently great to ensure the passage through it, within that time, of any planet whose period is as long as the possible periods of those which may yet remain unknown to us. Analogy would therefore lead us to conclude in favour of the probability of their number being much greater than that at present recognised. All those which are now known lie between the orbits of Mars and Jupiter, but many may exist more distant and of much smaller apparent magnitudes; and thus almost the same careful telescopic research may be necessary to make us acquainted with some of our planetary neighbours as with the remoter regions of space. Nor is the telescopic mode the only one by which we may detect the existence of remoter planets; for as Uranus betrayed the existence of Neptune, so may the latter hereafter reveal to us the retreats in which some more distant member of the system has hitherto hidden himself from the observation of man.

There would seem to be a tendency in the human mind to repose on the contemplation of any great truth after its first establishment. Thus, after the undisputed reception of the theory of gravitation and the complete explanation which it afforded of the planetary motions, men seemed to think little of any further revelations which the solar system might still have to make to us respecting its constitution or the physical causes which it calls into operation. The recent discovery, however, of so many planets shows how imperfectly we may yet be acquainted with the planetary part of the system; and the continual discovery of new comets seems to indicate that in this department still more remains to be done. These curious bodies, too, may possibly have to reveal to us facts more interesting than any which the planets may still have in reserve for us. The experience of these latter bodies, if I may so speak, is more limited, and their testimony, consequently, more restricted. But they have already told us a noble tale. In moving, as they do, in exact obedience to the law of gravitation, and thus establishing that law, they have affirmed the highest generalization in physical science which it has been accorded to the human mind to conceive. At the same time the approximate circularity of their orbits prevents their passing through those varied conditions to which comets are subjected. Thus, while the latter obey, in common with the planets, the laws of gravitation, they frequently present to us, in their apparent changes of volume, form, and general character, phænomena the explanation of which has hitherto baffled the ingenuity of astronomers. One of the most curious of these phænomena has been recently observed in Biela's comet. This comet has a period of about six years and a half, and has been observed a considerable number of times on its periodical return to the neighbourhood of the sun. It appeared in November 1845, and in the following January the phænomenon alluded to was observed for the first time. The comet had become divided into two distinct parts with separate nuclei. Sometimes the one and sometimes the other appeared the brighter till their final disappearance. The elements of the orbits of these twin comets were calculated by Professor Plantamour, from observations made at Geneva in 1845–46, assuming them to be uninfluenced by each other's attractions. The correctness of these elements could only be determined on the next return of the comet, which took place in the autumn of last year, one of the nuclei having been first seen by Signor Secchi at Rome, on the 25th of August, and the other on the 15th of September. The subsequent observations made upon them show that the elements of the orbits, as previously calculated from the Geneva observations, were far from exact. A complete discussion of all the observations which have been made on these comets during their last and previous appearances, is now in progress by Professor Hubbard, of the Washington Observatory. The distance between the two nuclei was much increased on their last appearance. Judging from the apparent absence of all influence and sympathy between these bodies, it would seem that their physical divorcement, though without known precedent, is final and complete.

Stellar astronomy continues to manifest a vigour and activity worthy of the lofty interest which attaches to it. Bessel had made a survey of all stars to those of the ninth magnitude inclusive, in a zone lying between 45° of north and 15° of south declination. Argelander has extended this zone from 80° of north to 31° of south declination. It comprises more than 100,000 stars. Last year was published also the long-expected work of M. F. G. W. Struve, containing a catalogue of stars observed by him at Dorpat, in the years 1822–43. They are principally double and multiple stars, which had been previously micrometrically observed by the same distinguished astronomer. Their number amounts to 2874; the epoch of reduction is 1830. The introduction contains the discussion of various important points in stellar astronomy.

Notices have been brought before us, from time to time, of the nebulæ observed through Lord Rosse's telescope. This noble instrument, so unrivalled for observations of this kind, continues to be applied to the same purpose, and to add yearly to our knowledge of the remotest regions of space into which the eye of man has been able to penetrate. Almost every new observation appears to confirm the fact of that curious tendency to a spiral arrangement in these nebulous masses, of which mention has so frequently been made. To those persons, however, who have neither seen the objects themselves, nor careful drawings of them, a mere verbal description must convey very indistinct conceptions of the spiral forms which they assume. I have therefore had the drawings made, which are suspended in the room for your inspection. They will convey to you at once an idea of the spiral forms alluded to. I am indebted to the kindness of Lord Rosse for the use of the original drawings, and for these large and accurate copies of them to our excellent Secretary, Mr. Phillips, who, with his usual ready activity in the cause of the Association, has had them prepared for the purpose of this evening. Most of them are representations of nebulæ which have been very recently observed.

Two pairs of these are respectively drawings of the same object, the larger one of each pair representing the nebula as seen through the large telescope, the other as seen through a smaller one of Lord Rosse's of only three feet aperture. You will observe how little resemblance there is between them, except in the external boundary, and how entirely the characteristic details of the larger drawings are lost in the smaller ones; and if I had exhibited to you drawings of some others of these nebulæ, as seen by previous observers with inferior telescopic power, it would have been still more obvious to you how necessary are telescopes with large and perfectly ground mirrors for the development of the real character of these astonishing and enigmatical aggregations of stars.

It is for this reason that it has been thought desirable to have the nebulæ of the southern hemisphere examined with higher telescopic power than has hitherto been brought to bear upon them. You are aware with what a noble devotion to science Sir J. Herschel spent several years at the Cape of Good Hope in the examination of the southern heavens; but his telescopic power was limited to that of a reflector of $18\frac{1}{2}$ inches aperture. It is now proposed to send out to some convenient station in the southern hemisphere a reflecting telescope, with a mirror of 4 feet aperture. Mr. Grubb, of Dublin, has undertaken to construct such an instrument (should the plan proposed be adopted) under the general superintendence of Lord Rosse, Dr. Robinson, Mr. Lassell, and one or two other gentlemen. The general construction of the instrument, and the best mode of mounting it, have been decided on with careful deliberation, after consulting all the best authorities on the subject.

These important preliminaries being agreed upon, and an estimate of the whole expense of the instrument having been made by Mr. Grubb, the deputation appointed for the purpose proceeded to wait on Lord Aberdeen, to ascertain whether the Government were willing to bear the expense which the plan proposed would involve. His Lordship expressed himself, without hesitation, as favourable to the undertaking; but said that, since it involved a grant of money, it would be necessary to consult the Chancellor of the Exchequer, who, supposing him to take a favourable view of the subject, would probably bring it before the House of Commons among the estimates of the ensuing year. With this answer the deputation could not be otherwise than perfectly satisfied, nor could they fail also to be gratified by the perfect courtesy with which they were received. Judging from all we know respecting Mr. Gladstone's enlightened views on subjects of this nature, and the favourable manner in which the House of Commons has always received propositions for the advancement of science, we have, I think, every reason to hope that my successor in this Chair may have the satisfaction of announcing to you another instance of the liberality of the Government in their acceptance of the plan proposed to them. In such case, the result, I doubt not, will afford another proof that the Association is doing effectively what it professes to do as an Association for the Advancement of Science.

The refinement of modern methods of astronomical observation has become so great, that astronomers appear very generally to think that a higher degree of refinement in the calculations of physical astronomy than has yet been attained is becoming necessary. Mr. Adams has been engaged in some important researches of this kind. He has corrected an error in Burckhardt's value of the moon's parallax; and he has also determined to a nearer approximation than that obtained by Laplace, the secular variation in the moon's mean motion. The former investigation is published in an Appendix to the Nautical Almanac for 1856; the latter has been very recently presented to the Royal Society.

Before I quit this subject, I may state that an 'American Ephemeris and

Nautical Almanac for 1855' has been published this year. It is the first American Nautical Almanac, and is considered to reflect great credit on the astronomers of that country. It is under the superintendence of Lieut. C. H. Davis, assisted in the physical department by Professor Peirce.

No one has contributed more to the progress of Terrestrial Magnetism during the last few years than my distinguished predecessor in this Chair. Formerly we owed theories on this subject much more to the boldness of ignorance than to the just confidence of knowledge; but from the commencement of the systematic observations which Colonel Sabine has been so active in promoting, this vague and useless theorising ceased, to be succeeded, probably ere long, by the sound speculative researches of those who may be capable of grappling with the real difficulties of the subject, when the true laws of the phænomena shall have been determined. Those laws are coming forth with beautiful precision from the reductions which Colonel Sabine is now making of the numerous observations made at the different magnetic stations. In his Address of last year, he stated to us that the secular change of the magnetic forces was confirmed by these recent observations, and also that periodical variations depending on the solar day, and on the time of the year, had been distinctly made out, indicating the sun as the cause of these variations. During the present year, the results of the reduction of the observations made at Toronto have brought out, with equal perspicuity, a variation in the direction of the magnetic needle going through all its changes exactly in each lunar day. These results with reference to the sun prove, as Colonel Sabine has remarked, the immediate and direct exercise of a magnetic influence emanating from that luminary; and the additional results now obtained establish the same conclusion with regard to the influence of the moon. It would seem, therefore, that some of the curious phænomena of magnetism which have hitherto been regarded as strictly terrestrial, are really due to solar and lunar, as much as to terrestrial magnetism. It is beautiful to trace with such precision these delicate influences of bodies so distant, producing phænomena scarcely less striking either to the imagination or to the philosophic mind, than more obvious phænomena which originate in the great luminary of our system.

New views which have recently sprung up respecting the nature of heat have been mentioned, though not in detail, by my two immediate predecessors in the chair of the Association. They are highly interesting theoretically, and important in their practical application, inasmuch as they modify in a considerable degree the theory of the steam-engine, the air-engine, or any other in which the motive power is derived immediately from heat; and it is correct theory alone which can point out to the practical engineer the degree of perfection at which he may aim in the construction of such machines, and which can enable him to compare accurately their merits when the best construction is arrived at.

A theory which proposes to explain the thermal agency by which motive power is produced, and to determine the numerical relations between the *quantity* of heat and the *quantity* of mechanical effect produced by it, may be termed a *Dynamical theory of heat.* Carnot was the first to give to such a theory a mathematical form. His theory rested on two propositions which were regarded as axiomatic. The first embodied the abstract conception of a perfect thermo-dynamic engine, and has been equally adopted by the advocates of the new theory of heat. Again, suppose a given quantity of heat to enter a body by any process, and thereby to change its temperature and general physical state; and then, by a second process, suppose the body to be restored exactly to its primitive temperature and condition,—Carnot's second fundamental proposition asserts that the quantity of heat which passes out of the body into surrounding space, or into other bodies, *in the form of heat*, during the second operation, is precisely the same as that which passed into the body during the first operation. This view does not recognise the possibility of heat being lost by conversion into something else, and in this particular is at variance with the new theory, which asserts that heat may be lost by conversion into *mechanical effect*. To elucidate this distinction, suppose a quantity of water to be poured into an empty vessel. It might then be asserted, that, in emptying the vessel again, we must pour out just as much water as we had previously poured in. This would be equivalent to Carnot's proposition with respect to heat. But suppose a part of the water while in the vessel to be converted into *vapour*; then it would not be true that in emptying the vessel, the same quantity of water, *in the form of water*, must pass out of the vessel as had before passed into it, since a portion would have passed out in the form of *vapour*. This is analogous to the assertion of the new theory with regard to heat, which may be lost, according to that theory, by conversion into mechanical effect, in a manner analogous to that in which water may be said to be lost by conversion into vapour. But the new theory not only asserts generally the convertibility of heat into mechanical effect, and the converse, but also more definitely, that, whatever be the mode of converting the one into the other—and whether heat be employed to produce mechanical effect, or mechanical force be employed to produce heat—the same quantity of the one is always the equivalent of the same quantity of the other. This proposition can only be established by experiment. Rumford, who was one of the first to adopt the fundamental notion of this theory as regards the nature of heat, made a rough attempt to determine the relation between the force producing friction and the heat generated by it; but it was reserved for Mr. Joule to lay the true foundation of this theory by a series of experiments, which, in the philosophical discernment with which they were conceived, and the ingenuity with which they were executed, have not often, perhaps, been surpassed. In whatever way he employed mechanical force to produce heat, he found, approximately, the same quantity of heat produced by the same amount of force, the force being estimated in *foot-pounds* according to the usual mode in practical mechanics, *i. e.* by the motive power employed in raising a weight of 1 lb. through the space of 1 foot. The conclusion adopted by Mr. Joule is that 1° Fahr. is equivalent to 772 *foot-pounds*.

These results are unquestionably among the most curious and interesting of those which experimental research has recently brought before us. When first announced some ten or twelve years ago, they did not attract the attention which they deserved; but more recently their importance has been fully recognized by all those who cultivate the department of science to which they belong. Of this Mr. Joule received last year one of the most gratifying proofs, in the award made to him by the Council of the Royal Society, of one of the medals placed annually at their disposal. It may not be known to many of you that we have in Mr. Joule a pupil, a friend, and fellow-townsman of Dalton.

This theory is in perfect harmony with the opinions now very generally entertained respecting *radiant heat*. Formerly light and heat were regarded as consisting of material particles, continually radiating from luminous and heated bodies respectively; but it may now be considered as established beyond controversy, that light is propagated through space by the vibrations of an exceedingly refined ethereal medium, in a manner exactly analogous to that in which sound is propagated by the vibration of the air; and it is now supposed that radiant heat is propagated in a similar manner. This theory of radiant heat, in accordance with the dynamical theory, of which I have been speaking, involves the hypothesis, that the particles of a heated body, or a particular set of them, are maintained in a state of vibration, similar to that in which a sonorous body is known to be, and in which a luminous body is believed to be. At the same time there are remarkable differences between light and heat. We know that light is propagated with enormous velocity, whether in free space or through transparent media; sound also is propagated with great rapidity, and more rapidly through most media than through air. Heat, on the contrary, whatever may be the velocity with which it may radiate through free space, is usually transmitted with extreme slowness through terrestrial media. There appears to be nothing in light analogous to the slow *conduction* of heat. Again, the vibrations which render a body sonorous have no tendency to expand its dimensions, nor is there reason to suppose that luminous vibrations have any such tendency on luminous bodies; whereas, with the exception of particular cases, heat does produce expansion. It is principally from this property of heat that it becomes available for the production of motive power, as, for instance, in the expansion of steam. These phænomena of the slow conduction of heat, and the expansion of heated bodies, are proofs of differences between light and heat not less curious than the analogies above indicated. They must, of course, be accounted for by any perfect theory of heat. Mr. Rankine has written an ingenious paper on a molecular theory of heat; but before any such theory can be pronounced upon, it will be necessary, I conceive, to see its bearing on other molecular phænomena, with which those of heat are in all probability intimately connected. Prof. W. Thomson has also given a clear and compendious mathematical exposition of the new dynamical theory of heat, founded on Mr. Joule's principle of the exact equivalence of heat and mechanical effect. This is not, like Mr. Rankine's, a *molecular* theory, but one which must henceforth take the place of Carnot's theory.

Before leaving this subject, I may add that Prof. Thomson and Mr. Joule are now engaged in further experiments, which will serve to elucidate the new theory of heat. Some account of the commencement of these experiments has already been brought before the Royal Society.

Many years ago Gay-Lussac made an ascent in a balloon for the purpose of making observations on the air in the upper regions of the atmosphere; but it is only very recently that systematic observations of this kind have been attempted. Last autumn four balloon ascents were made by Mr. Welsh, under the guidance of the distinguished aëronaut Mr. Green. Attention was chiefly directed to the determination of the pressure, temperature, and moisture of the air at different altitudes. The decrease of temperature in ascending was very irregular, being changed even, in some cases, to an increase; but the mean result gives a decrease of 1° Fahr. for every 348 feet of ascent, agreeing within 5 or 6 feet of the result obtained by Gay-Lussac. The latter gentleman ascended 23,000 feet; the greatest height attained by Mr. Welsh was 22,940 feet. A repetition of similar observations in ascents made from different points of the earth's surface could scarcely fail to lead to valuable information for the science of Meteorology.

An immense contribution, of which brief mention was made by my predecessor, has been made within the last few years to this science, by the publication of Prof. Dove's Isothermal Maps, giving us the temperature of the lowest portion of the atmosphere (that which determines the *climate* of every region) for nearly all accessible points of the earth's surface. An immense number of thermometric observations had been made at fixed stations, or by travellers in almost every part of the globe, but were lying comparatively useless for want of adequate discussion. This task was undertaken some years ago by M. Dové. It was not merely a task of enormous labour, but one requiring great critical acuteness and sound philosophical judgement, and these qualifications M. Dové brought to his work, which has resulted in the excellent maps alluded to, accompanied by a considerable amount of letter-press, full of interesting generalizations, and written in the genuine spirit of inductive philosophy.

His maps present a great number of isothermal lines, *i.e.* lines passing through all those places which, at an assigned period of the year, have the same temperature, each line indicating a particular temperature differing by a few degrees from those of the adjoining lines. Besides a large map giving these lines for January and July, the months of extreme winter and summer temperature, there are smaller ones giving similar lines for all the different months. An English edition of these maps has been just published.

We may easily conceive how a great ocean current of warm water from the tropics may affect the temperature of the atmosphere in the colder regions into which it may penetrate, but it is only since the publication of these maps that we have had any adequate idea of the extent of this influence, or been able to appreciate fully the blessings conferred on the shores of North-western Europe, and especially on our own Islands, by the Gulf-stream. This great current, though not always under the same name, appears, as you are probably aware, to traverse the Atlantic in a north-westerly direction till it reaches the West India Islands and the Gulf of Mexico. It is then reflected by the American coast, and takes a north-easterly direction to our own shores, extending beyond Iceland into the North Sea. It is to the enormous mass of heated water thus poured into the colder seas of our own latitudes that we owe the temperate character of our climate; and not only do the maps of M. Dové enable us to assert distinctly this general fact, but also to make an approximate calculation of the amount to which the temperature of these regions is thus affected. If a change were to take place in the configuration of the surface of the globe so as to admit the passage of this current directly into the Pacific across the existing isthmus of Panama, or along the base of the Rocky Mountains of North America into the North Sea—a change indefinitely small in comparison with those which have heretofore taken place—our mountains, which now present to us the ever-varying beauties of successive seasons, would become the unvarying abodes of the glacier, and regions of the snow storm; the beautiful cultivation of our soil would be no longer maintained, and civilization itself must retreat before the invasion of such physical barbarism. It is the genial influence of the Gulf-stream which preserves us from these evils. Among its effects on our climate I may mention one which may not be without its local interest along this coast, especially for those who may wish to visit it during the winter for health as well as for pleasure. The temperature of the atmosphere to the north of this island is so ameliorated by the Gulf-stream in the depth of winter, that the isothermal lines for the month of January along the whole eastern coast of Great Britain and the opposite western coast of the continent run north and south instead of following their normal east and west direction, thus showing that Scarborough, or any watering-place on the same coast much further to the north, enjoys as temperate a climate in the depth of winter as the coast of Kent. In the early spring, however, it becomes considerably colder than on the latter coast.

My predecessor in his Address informed us of an application made to our government by that of the United States, to adopt a general and systematic mode of observing phænomena of various kinds at sea, such as winds, tides, currents, &c., which may not only be of general scientific interest, but may also have an important bearing on navigation. The plan proposed by Lieut. Maury, and adopted by the American government, is to have the required observations regularly made by the commanders of vessels sent out to sea. I am happy to be able to state to you that our Admiralty have given orders for similar observations to be made by those who have command of English vessels; and we trust also that proper persons will be appointed without delay for the reduction of the mass of observations which will thus soon be accumulated.

The science of Geology may be regarded as comprising two great divisions—the physical and the palæontological portions. The former may be subdivided into its chemical and dynamical branches. The chemical department has never made any great progress, though abounding in problems of first-rate interest—such, for instance, as the formation of coal, the segregation of mineral matter constituting mineral veins of all descriptions, the processes of the solidification and crystallization of rocks, of the production of their jointed and laminated structure, and many others. Interesting experiments are not altogether wanting on points such as these, but not such as to constitute, as far as I am aware, a positive foundation and decided progress in this branch of the science. The problems, doubtless, involve great difficulties, both as regards the action of the chemical agencies themselves and the varied conditions under which they may have acted. The accomplished chemist alone can combat the difficulties of the former kind, and the geologist those of the latter. Both these characters must be united in any one who may hope to arrive at the true solution of these problems. We cannot too earnestly invite attention to this branch of geology on the part of those best qualified to contend with its difficulties.

The dynamical, or, more strictly, the mechanical department of the science, has received a much larger share of attention. In fact, almost all theories and speculations of geologists, independently of organic remains, belong to it, and a large portion of the work of geologists in the field has been devoted to the observation of phænomena on which it treats. *Phænomena of elevation*—those immediately resulting from the action of the subterranean forces which have so wonderfully scarred and furrowed the face of our globe—have been made the objects of careful research. It is to this probably violent and desolating action that we owe the accessibility of the mineral sources of our mining districts, as well as all those exquisite beauties of external nature which the mountain and the valley present to us. The absence of all order and arrangement would seem, on a superficial view, to be the especial characteristic of mountainous districts, and yet the nicer observations of the geologist has detected, in such districts, distinct approximations to general laws in the great dislocations and upheavals in which the mountains and the valleys have originated. The more usual law in these phænomena consists in the approximate parallelism of all those great lines of dislocation and chains of mountains, the formation of which can be traced back to the same geological epoch. That this law is distinctly recognizable throughout districts, sometimes of many hundred miles in extent, is clearly established, but some geologists contend that it may also be recognized as prevailing over much larger geographical areas than any single geological district presents to us. M. Elie de Beaumont was the originator, and has been the great advocate of this extension of the theory of parallelism. He extends it, in fact, to the whole surface of the earth, using the term *parallelism* in a certain modified sense, to render it applicable to lines drawn on a spherical instead of a plain surface. His theory asserts that all great lines of dislocation, and therefore all mountain chains originating in them, wherever situated, may be grouped into *parallel systems*, and that all the lines or mountain chains belonging to any one system were produced simultaneously by one great convulsion of the earth's crust. This theory has been advocated by him many years, but he has recently published his latest views respecting it, and has made an important addition, which may, in fact, be regarded as an independent theory. Each of the parallel systems already mentioned will have its *characteristic direction*, to which all the lines of that system are parallel. This new theory asserts that these characteristic directions are not determined, as it were, by accident or chance, but that they have certain relations to each other, so that the respective systems to which they belong are disposed over the earth's surface, according to a distinct symmetrical arrangement. For the details of this curious theory I can only refer to the author's work, or to the analysis which I gave of it last February, in my address to the Geological Society. I feel it right, however, to add, that after an attentive examination of the subject, the evidence adduced by M. de Beaumont in support of the last-mentioned theory has failed to convey conviction to my own mind. With reference to the parallelism of contemporaneous lines of elevation, no one, I conceive, will deny the truth of M. de Beaumont's theory in its application to many geological districts of limited extent; but it will probably be the opinion of most English geologists, that, in attempting to extend it to districts far remote from each other, he has overstepped the bounds of legitimate induction from facts with which we are at present acquainted. Every one, however, who studies M. de Beaumont's work, in whatever degree he may be disposed to adopt or reject the theoretical views of that distinguished geologist, will admit the ability and the knowledge which he has brought to bear on the subject, and the advantages which must result from the ample discussion which he has given it.

One favourite subject of speculation in the physical branch of geology has been, at all times since the origin of the science, the state of the interior of our planet, and the source of the high temperature observed at all considerable depths beneath its surface. The terrestrial temperature at a certain depth in each locality (about 80 feet in our own region) remains constant during the whole year, being sensibly unaffected by the changing temperature of the seasons. The same, of course, holds true at greater depths, but the lower we descend the greater is this invariable temperature, the increase being proportional to the depth, and at the rate of 1° Fahr. for about every 60 or 70 feet. Assuming this rate of increase to continue to the depth of 50 miles, we should arrive at a temperature about twice as great as that necessary to fuse iron, and sufficient, it is supposed, to reduce nearly the whole mass of the earth's solid crust to a state of fusion. Hence the opinion adopted by many geologists is, that our globe does really consist of a solid shell, not exceeding 40 or 50 miles in thickness, and an interior fluid nucleus, maintained in a state of fusion by the existing remains of the heat to which the whole terrestrial mass was originally subjected. It might, at first sight, appear that this enormous mass of molten matter, enclosed in so thin a shell, could scarcely be consistent with the general external condition and temperature of our globe; but it is quite certain that the real external temperature and this supposed internal temperature of the earth are not inconsistent with each other, and that no valid argument of this kind can be urged against the above hypothesis.

The above estimate, however, of the thickness of the earth's solid crust entirely neglects the possible effects of the enormous pressure to which the terrestrial mass at any considerable depth is subjected. Now this pressure may produce effects of two kinds bearing directly on the question before us. In the above calculation, terrestrial matter, placed at the depth of 40 or 50 miles, with a pressure of more than 200,000 pounds on the square inch, is assumed to be fusible at the same temperature as if it were subjected merely to the ordinary atmospheric pressure; whereas the temperature of fusion may possibly be very much increased by such immense pressure as that I have mentioned. In such case, the terrestrial matter may be retained in a solid state at much greater depths than it otherwise would be—*i. e.* the solid crust may be much thicker than the above estimate of 40 or 50 miles. Again, in this estimate, it is assumed that heat will pass as easily through the most superficial portion of the earth's mass, as through the compressed portions at considerable depths. Now, in this assumption there is, I think, a great *à priori* improbability, and especially with reference to those superficial rocks in which observations on the increase of terrestrial temperature in descending have generally been made; for these rocks are, for the most part, sedimentary strata, which in general, independently of the effect of pressure, are doubtless worse conductors than the older, more compact, and more crystalline rocks. But if heat passes through the lower portions of this terrestrial mass with more rapidity than through its uppermost portion—*i. e.* if the *conductive power* be greater at greater depths—the temperature at considerable depths must increase *more slowly* as we descend, than it is observed to increase at the smaller depths to which we can penetrate, and consequently it would be necessary, in such case, to descend to a greater depth before we should reach the temperature necessary to produce fusion. On this account therefore, as well as from the increased temperature of fusion, the thickness of the earth's crust may be much greater than the previous estimate would make it.

It has been for the purpose of ascertaining the effects of great pressure, that Mr. Fairbairn, Mr. Joule, and myself have undertaken the experiments in which we have for some time been engaged at Manchester. The first object in these experiments is the determination of the effect of pressure on the temperature of fusion of as many substances as we may be enabled to experiment upon. We expected to meet with many difficulties in the use of the enormous pressures which we contemplated, and these expectations have certainly been fully verified; but we were also satisfied that those difficulties might be overcome by perseverance and patience, and in this also we have not been disappointed; for I may now venture to assert that our ultimate success, with respect to a number of substances, is beyond doubt. Without the engineering resources, however, at Mr. Fairbairn's command, success would have been hopeless.

At present our experiments have been restricted to a few substances, and those of easy fusibility; but I believe our apparatus to be now so complete for a considerable range of temperature, that we shall have no difficulty in obtaining further results. Those already obtained indicate *an increase in the temperature of fusion proportional to the pressure to which the fused mass is subjected.* In employing a pressure of about 13,000 lbs. to the square inch on bleached wax, the increase in the temperature of fusion was not less than 30° Fahr., about one-fifth of the whole temperature at which it melts under the pressure of the atmosphere. We have not yet ascertained the degree in which the conductive power of any substance may be increased when solidified under great pressure. This point we hope to investigate with due care, and also to determine the effects on substances thus solidified, with respect to their density, strength, crystalline forms, and general molecular structure. We thus hope to obtain results of general interest and value, as well as those which may bear more directly on the questions which first suggested the experiments.

Among researches for determining the nature of the earth's crust at depths greater than those to which we can penetrate, I must not omit mention of Mr. Mallet's very elaborate Report on Earthquakes, contained in the two last volumes of the Reports of the Association. His *Earthquake catalogue* is preceded by an account of some very interesting and carefully conducted experiments on the transmission of vibrations through solid media. These results will be found of great value whenever the subject of earthquakes shall receive that careful attention which it so well deserves. Insulated observations, and those casual notices which are now frequently given of earthquake phænomena, are utterly useless for scientific purposes. There are no observations which more require to be regulated by system and combination than those of the phænomena in question; and I should rejoice to see the influence of the Association exerted for this purpose, when some efficient mode of proceeding shall have been devised.

Some of the most interesting of recent discoveries in Organic Remains are those which prove the existence of Reptilian life during the deposition of some of our oldest fossiliferous strata. An almost perfect skeleton of a reptile belonging to the Batrachians or Lacertians, was lately found in the old red sandstone of Morayshire. The remains of a reptile were also discovered last year, by Sir Charles Lyell and Mr. Dawson, in the coal-measures of Nova Scotia; and a Batrachoid fossil has also been recognized in British coal shale. But the most curious evidence of the early existence of animals above the lower orders of organization on the face of our globe, is that afforded by the footprints discovered a short time ago in Canada, by Mr. Logan, on large slabs of some of the oldest fossiliferous rocks—those of the Silurian epoch. It was inferred from the more imperfect specimens first brought over, that these footmarks were those of some reptile, but more perfect examples, afterwards supplied by Mr. Logan, satisfied Prof. Owen that they were the impressions of some animal belonging to the Articulata, probably a crustacean. Thus the existence of animals of the reptile type of organization during the Carboniferous and Devonian periods is clearly established, but no evidence has yet been obtained of the existence of those animals during the Silurian period. After the discoveries I have mentioned, however, few geologists will perhaps be surprised should we hereafter find that higher forms of animal life were introduced upon the earth during this early period than have yet been detected in its sedimentary beds.

Many of you will be aware that there are two theories in geology which may be styled the theories of *progression* and *non-progression* respectively. The former asserts that the matter which constitutes the earth has passed through continuous and progressive changes from the earliest state in which it existed to its actual condition at the present time. The earliest state here contemplated may have been a fluid, or even a gaseous state, due to the enormous primitive heat of the mass, and it is to the gradual loss of that heat that the progressive change recognized by this theory is chiefly attributed. The theory of *non-progression*, on the contrary, recognizes no primitive state of our planet differing essentially from its existing state; the only changes it does recognize being those which are strictly periodical, and therefore produce no permanent alteration in the state of our globe. With reference to organic remains, the difference between these theories is exactly analogous to that now stated with reference to inorganic matter. The theory of *progression* asserts that there has been a general advance in the forms of organic life, from the earliest to the more recent geological periods. This advance must not be confounded, it should be observed, with that progressive development, according to which animals of a higher organic structure are but the improved lineal descendants of those of the lowest grade, thus abolishing all distinction of species. It is merely meant to assert that the higher types of organic being are far more generally diffused at the present time, and far more numerous and varied, than they were at the earlier geological periods; and that, moreover, at the earliest of those periods which the geologist has been able to recognize, some of these higher types had probably no existence at all. The theory of non-progression does not recognize the gradual advance here spoken of.

Each successive discovery, like those I have mentioned, of the remains of animals of the higher types, in the older rocks, is regarded by some geologists as an addition to the cumulative evidence by which they conceive that the theory of *non-progression* will be ultimately established; while others consider the deficiency in the evidence required to establish that theory, as far too great to admit the probability of its being supplied by future discovery. Nor can the theory derive present support, it is contended, by an appeal to any properties of inorganic matter or physical laws, with which we are acquainted. Professor W. Thomson has recently entered into some very interesting speculations bearing on this subject, and suggested by the new theory of heat of which I have spoken. The heat of a heavenly body placed under the same conditions as the sun, must, it has been said, be ultimately exhausted by its rapid emission. This assertion assumes the matter composing the sun to have certain properties like those of terrestrial matter with respect to the generation and emission of heat; but Professor Thomson's argument places the subject on better grounds, admitting, always, the truth of the new theory of heat. That theory asserts, in the sense which I have already stated, the exact equivalence of heat and motive power; and that a body, in sending forth heat, must lose a portion of that internal motion of its constituent particles on which its thermal state depends. Now we know that no mutual action of these constituent particles can continue to generate motion which might compensate for the loss of motion thus sustained. This is a simple deduction from dynamical laws and principles, independent of any property of terrestrial matter which may possibly distinguish it from that of the sun. Hence, then, it is on these dynamical principles that we may rest the assertion that the sun cannot continue for an indefinite time to emit the same quantity of heat as at present, unless his thermal energy be renovated from some extraneous source. The same conclusion may be applied to all other bodies in the universe which, like our sun, may be centres of intense heat; and hence, recognizing no adequate external supplies of heat to renovate these existing centres of heat, Professor Thomson concludes that the dispersion of heat, and consequently of physical energy, from the sun and stars into surrounding space without any recognizable means of reconcentration, is the existing order of nature. In such case the heat of the sun must ultimately be diminished, and the physical condition of the earth therefore altered, in a degree altogether inconsistent with the theory of non-progression.

Mr. Rankine, however, has ingeniously suggested an hypothesis according to which the reconcentration of heat is conceivable. Assuming the physical universe to be of finite extent and surrounded by an absolute *vacuum*, radiant heat (supposing it to be propagated in the same way as light) would be incapable of passing into the *vacuum*, and would be reflected back to foci corresponding to the points from which it emanated. A reconcentration of heat would thus be effected, and any of the heavenly bodies which had previously lost their heat, might, on passing through these foci, be rekindled into bright centres of radiant heat. I have alluded more particularly to this very ingenious, though, perhaps, fanciful hypothesis, because some persons have, I believe, regarded this view of the subject as affording a sanction to the theory of *non-progression*; but even if we should admit its truth to the fullest extent, it may be deemed, I think, entirely inconsistent with that uniformity and permanence of physical condition in any of the heavenly bodies which the theory just mentioned requires in our own planet. The author of this hypothesis did not possibly contemplate any such application of it; nor am I aware how far he would advocate it as really applicable to the actual constitution of the material universe, or would regard it as suggesting a possible and conceivable, rather than a probable, mode of counteracting the constant dispersion of heat from its existing centres. He has not, I think, attempted to work out the consequences of the hypothesis as applied to *light*, to which it must, I conceive, be necessarily considered applicable if it be so to heat. In such case the foci of the reflected heat would be coincident with those of the reflected light, proceeding originally from the same luminous bodies. These foci would thus become visible as the images of stars; so that the apparent number of stars would be constantly increasing with the increasing number of images of each star produced by successive reflexions. This will scarcely be considered the actual order of nature. It would be easy to trace other consequences of the application of this hypothesis to light; but I would at present merely state that my own convictions entirely coincide with those of Prof. Thomson. If we are to found our theories upon our knowledge, and not upon our ignorance of physical causes and phænomena, I can only recognise in the existing state of things a passing phase of the material universe. It may be calculated in all, and is demonstrably so in some respects, to endure under the action of known causes, for an almost inconceivable period of time; but it has not, I think, received the impress of eternal duration, in characters which man is able to decipher. The external temperature and physical conditions of our own globe may not, and probably cannot have changed in any considerable degree since the first introduction of organic beings on its surface; but I can still only recognise in its physical state, during all geological periods, a state of actual though of exceedingly slow progression from an antecedent to some ultimate state, on the nature of which our limited powers will not enable us to offer any conjecture founded on physical research. The theories, even, of which I have been speaking, may probably appear to some persons as not devoid of presumption; but for many men they will ever be fraught with deep speculative interest; and, let me add, no charge of presumption can justly lie against them, if entered upon with that caution and modesty which ought to guide our inquiries in these remote regions of physical science.

I feel how imperfect a view I have now submitted to you of recent scientific proceedings. I have given no account of the progress of Chemistry, Practical Mechanics, or of the sciences connected with Natural History; nor have I spoken of Ethnology, a science, which, though of such recent date, is become of great interest, and one which is occupying the minds of men of great learning and profound research. I can only hope that the chair which I have now the honour to occupy, will, from time to time, be filled by men qualified to do full justice to these important sciences. What I have now said, however, may serve to convey to you some idea of the activity which pervades almost every department of science.

I must not conclude this address without some mention of what appear to me to be the legitimate objects of our Association, or without some allusion to circumstances, calculated, I think, to give increased importance to its general working and influence.

There are probably few among us of whom the inquiry has not been made after any one of our meetings—whether any striking discovery had been brought forward; and most of us will also probably have remarked that an answer in the negative has frequently produced something like a feeling of disappointment in the inquirer. But such a feeling can only arise from a misapprehension of what I conceive to be the real and legitimate objects of the British Association. Great discoveries do not require associations to proclaim them to the world. They proclaim themselves. We do not meet to receive their announcement, or make a display of our scientific labours in the eyes of the world, or to compliment each other on the success we may have met with. Outward display belongs not to the proceedings, and the language of mutual compliment belongs not to the language of earnest-minded men. We meet, Gentlemen, if I comprehend our purpose rightly, to assist and encourage each other in the performance of the laborious daily tasks of detailed scientific investigation. A great thought may possibly arise almost instantaneously in the mind, and the intuition of genius may almost as immediately recognise its importance, and partly foresee its consequences. Individual labour may also do much in establishing the truth of a new principle or theory; but what an amount of labour may its multifarious applications involve! Nearly two centuries have not sufficed to work out all the consequences of the principle of gravitation. Every theory, as it becomes more and more perfectly worked out, embraces a greater number of phænomena, and requires a greater number of labourers for its complete development. Thus it is that when science has arrived at a certain stage, combination and co-operation become so essential for its further progress. Each scientific society effects this object in a greater or less degree, but much of its influence may be of a local character, and it is usually restricted by a limited range of its objects. Up to a certain point no means are probably so effective for the promotion of science as these particular societies, which devote themselves to one particular branch of science; but as each science expands, it comes into nearer relations with other sciences, and a period must arrive in this general and progressive advance, which must render the co-operation of the cultivators of different branches of science almost as essential to our general progress, as the combination of those who cultivate the same branch was essential to the progress of each particular science in its earlier stages. It is the feeling of the necessity of combination and facility of intercourse among men of science that has given rise to a strong wish that the scientific memoirs of different societies should be rendered, by some general plan, more easily and generally accessible than they are at present—a subject which I would press on your consideration. It is by promoting this combination that the British Association has been able to exert so beneficial an influence by bringing scientific men together, and thus placing, as it were, in juxtaposition every society in the country. But how has this influence been exercised? Not assuredly in the promotion of vague theories and speculative novelties, but in the encouragement of the hard daily toil of scientific research, and by the work which it has caused to be done, whether by its influence over its individual members, or on the Government of the country. Regarding our Association, Gentlemen, in this point of view, I can only see an increased demand for its labours, and not a termination of them, in the future progress of science. The wider the spread of science, the wider will be the sphere of its usefulness.

We should do little justice to the great Industrial Exhibition, which two years ago may be literally said to have delighted millions of visitors, or to the views of the illustrious Prince with whom it originated, if we should merely recollect it as a spectacle of surpassing beauty. It appears destined to exercise a lasting influence on the mental culture, and therefore, we may hope, on the moral condition, of the great mass of our population, by the impulse which it has given to measures for the promotion of general education. We may hope that those whose duty it will be to give effect to this impulse, will feel the importance of education in Science as united with education in Art. An attempt to cultivate the taste alone, independently of the more general cultivation of the mind, would probably fail, as it would deserve to do. I trust that the better education which is now so universally recognized as essential to preserve our future pre-eminence as a manufacturing nation, will have its foundations laid, not in the superficial teaching which only aims at communicating a few curious results, but in the sound teaching of the fundamental and elementary principles of science. Art ought assuredly to rest on the foundation of science. Will it, in the present day, be contended that the study of science is unfavourable to the cultivation of taste? Such an opinion could only be based on an imperfect conception of the objects of science, and an ignorance of all its rightful influences. Does the great sculptor or historical painter despise anatomy? On the contrary, he knows that a knowledge of that science must constitute one of the most valuable elements of his art, if he would produce the most vigorous and characteristic expression of the human figure. And so the artist should understand the structure of the leaf, the tendril, or the flower, if he would make their delicate and characteristic beauties subservient to the objects either of decorative art, or to those of the higher branches of sculpture and painting. Again, will the artist appreciate less the sublimity of the mountain, or represent its characteristic features with less truthfulness, because he is sufficient of a geologist to trace the essential relations between its external form and internal constitution? Will the beauty of the lake be less perfectly imitated by him, if he possess a complete knowledge of the laws of reflexion of light? Or will he not seize with nicer discrimination all those varied and delicate beauties which depend on the varying atmosphere of our own region, if he have some accurate knowledge of the theory of colours, and of the causes which govern the changeful aspect of mist and cloud? It is true that the genius and acute powers of observation of the more distinguished artists may compensate, in a great degree, for the want of scientific knowledge; but it is certain that a great part of the defects in the works of artists of every description, may be traced to the defect of scientific knowledge of the objects represented. And hence it is that I express the hope that the directors of the important educational movement which is now commencing with reference to industrial objects, will feel the necessity of laying a foundation, not in the complicated details of science, but in the simple and elementary principles which may place the student in a position to cultivate afterwards, by his own exertions, a more matured acquaintance with those particular branches of science which may be more immediately related to his especial avocations. If this be done, abstract science will become of increased estimation in every rank of society, and its value, with reference at least to its practical applications, will be far better understood than it is generally amongst us at the present time.

Under such circumstances, Gentlemen, the British Association could not fail to become of increased importance, and the sphere of its usefulness enlarged. One great duty we owe to the public is to encourage the application of abstract science to the practical purposes of life—to bring, as it were, the study and the laboratory into juxtaposition with the workshop. And, doubtless, it is one great object of science to bring more easily within reach of every part of the community, the rational enjoyments, as well as the necessaries of life; and thus not merely to contribute to the luxuries of the rich, but to minister also to the comforts of the poor, and to promote that general enlightenment so essential to our moral progress and the real advance of civilization. But still, Gentlemen, we should not be taking that higher view of science which I would wish to inculcate, if we merely regarded it as the means of supplying more adequately the physical wants of man. If we would view science under its noblest aspects, we must regard it with reference to man, not merely as a creature of physical wants, but as a being of intellectual and moral endowments, fitting him to discover and comprehend some part at least of the laws which govern the material universe, to admire the harmony which pervades it, and to love and worship its Creator. It is for science, as it leads to this contemplation of Nature, and a stronger sense of the beauties which God has spread around us, that I would claim your deeper reverence. Let us cultivate science, Gentlemen, for its own sake, as well as for the practical advantages which flow from it. Nor let it be feared lest this cultivation of what I may term contemplative science, if prosecuted in a really philosophic spirit, should inspire us with vain and presumptuous thoughts, or disqualify us for the due appreciation of moral evidence on the most sacred and important subjects which can occupy our minds. There is far more vanity and presumption in ignorance than in sound knowledge; and the spirit of true philosophy, be it ever remembered, Gentlemen, is a patient, a modest, and a humble spirit.

REPORTS

ON

THE STATE OF SCIENCE.

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Report on Observations of Luminous Meteors, 1852–53. *By* the Rev. Baden Powell, *M.A., F.R.S., F.R.A.S., F.G.S., Savilian Professor of Geometry in the University of Oxford.*

In submitting to the British Association a Sixth Report on Luminous Meteors, I have to acknowledge the valuable contributions of the same scientific friends who have on former occasions so extensively aided the objects of the Association in keeping up this record; which, it is to be hoped, may eventually prove of some service, by the accumulation of facts to illustrate the laws, and thence the origin and nature, of these remarkable phænomena.

I could indeed have wished that it were in my power now to have entered upon some kind of classification, at least, of these perplexing appearances, on which to have founded perhaps some conjectural hints towards their theory; but the pressure of other avocations has for the present hindered the prosecution of a design, which I, nevertheless look forward to taking in hand at no distant period.

August 31, 1853.

I. *Older Observations*

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1839. Nov. 8	h m 1 0 a.m. Local mean solar time.	When first seen = 2 diam. of ☽; increased and lengthened till it vanished.	Golden yellow, so bright that small type could have been read by its light; continued nearly uniform.	Sparks issuing from the top, as shown in the sketch, into which the object ultimately resolved itself.	Duration about sec. or a lit more.
1851. Aug. 26	8 25 p.m. Dresden time.	= to Venus............	Rather brilliant.	Drew a short and not very brilliant tail.	Described an arc about 60° in 3 se

II. *Continuation of Catalogue of*

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852. Aug. 8	h m s 10 16 0	= to Arcturus	Colour of Arcturus.	Long continued streak ...	0·5 sec., rapid ..
9	9 45 0	= 1st mag.	Colourless ...	Long continuous train ...	0·5 sec., rapid ..
	9 38 10	= 1st mag.	Blue	Train	2 seconds........
	9 39 3	= 3rd mag.	Blue	....	1½ second .....
	9 40 7	= 2nd mag.............	Blue	....	About 3 secs. ..
	9 48 0	= 3rd mag.	Blue	....	2 seconds........
	9 53 30	= 4th mag.	Pale blue	....	2 seconds........
	10 0 5	= 1st mag.	Bright	Considerable train	3 seconds........
	10 0 31	= 3rd mag.	Blue	....	2 seconds........
	10 5 21	= 3rd mag.	Blue	....	2½ seconds .....
	10 14 0	= 4th mag.	Blue	....	1 second ....
	10 16 30	= 1st mag.	Bright	Train	3 seconds........
	10 17 10	= 1st mag.	Very brilliant.	Bright train, visible 5 secs. after meteor had disappeared.	4 seconds........
	10 22 0	= 2nd mag.............	Bright	Train	3 seconds........
	10 23 30	= 1st mag.	Bright	Considerable train	2½ seconds .....

of Luminous Meteors.

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
rection N. by E. Greatest altitude about 50°.	Apparent motion, as seen from Gibraltar House, vertically upwards. As seen by Dr. Myrtle, from a point near Hope Park Chapel, almost perpendicularly downwards from N. to S.	Gibraltar House, near Edinburgh.	David Rankine and Mrs. D. Rankine.	MS. comm. See Appendix No. 1.
oved in a nearly horizontal direction at an elevation of about 50°, first appearing at a little S. of E.	....	Dresden. (Observed at the north end of the old bridge over the Elbe.)	J. W. Mallet, Ph.D.	MS. comm.

Luminous Meteors from the Report of 1851–52.

om direction of Polaris, starting at χ Bootis, passing across γ and ϵ Bootis.	Greenwich mean time is given.	Blackpool	E. J. Lowe	Mr. Lowe's MS.
om 1° above φ Andromeda, passing across ϑ Andromeda to near 78 Pegasi.	....	Ibid...............	Id.	Ibid.
eteor from star marked H 19 Camelopardalis, on Bardin's globe, to near Polaris.	....	Castle Donington, Lat. 52° 51′ 23″·75 N., Long. 1° 18′ 42″ W.	Mr. W. H. Leeson	Ibid.
om near ζ to η Ursæ Majoris.	....	Ibid...............	Id.	Ibid.
om Polaris perp. to point 3° above horizon.	....	Ibid...............	Id.	Ibid.
om 2½° above Polaris towards W. point of horizon.	....	Ibid...............	Id.	Ibid.
om β Cephei to near γ Ursæ Minoris.	....	Ibid...............	Id.	Ibid.
om midway between α and β Ursæ Majoris to point 4° below η of same constellation.	....	Ibid...............	Id.	Ibid.
om δ Bootis to near Arcturus.	....	Ibid...............	Id.	Ibid.
om ϵ Ursæ Majoris to near Arcturus.	....	Ibid...............	Id.	Ibid.
om near ϵ Ursæ Majoris towards Arcturus 8°.	....	Ibid...............	Id.	Ibid.
om λ Lyræ to ¾ distance to Gemma Coronæ Borealis.	....	Ibid...............	Id.	Ibid.
om Deneb. to between λ and α Lyræ.				
om 4° below Polaris to ζ Ursæ Majoris.	....	Ibid...............	Id.	Ibid.
om β Cassiopeiæ to ζ Cygni..	....	Ibid...............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Aug. 9	10 30 0...	=2nd mag............	Very brilliant.	Train vis. 7 seconds after meteor had disappeared.	2 seconds...........
	10 31 0...	=2nd mag............	Blue...........	Train	2 seconds...........
	10 54 0...	=1st mag.	Reddish	Train vis. 2½ seconds	Slow................
	11 1 5...	=4th mag.	Blue...........	....	3 seconds...........
	11 3 0...	=2nd mag............	Very bright ...	Train	2 seconds...........
	11 9 0...	=1st mag.	Much brighter.	Considerable train	3 seconds...........
10	9 24 0...	=4th mag.	Red	....	1 second ....
	9 24 40...	=3rd mag.	Blue...........	....	1½ sec. ....
	9 36 0...	=4th mag.	Red	....	2 seconds...........
	9 38 10...	=4th mag.	Red	....	1 second ....
	9 40 0...	=4th mag.	Bluish	....	2 seconds...........
	9 48 0...	=2nd mag............	Blue...........	Small train	2½ seconds ....
	9 58 10...	=1st mag.	Very brilliant.	Considerable train	2½ seconds ....
	9 58 12...	=2nd mag............	Blue...........	....	2 seconds...........
	10 5 30...	=1st and 3rd mag....	Blue...........	First left a train	3 and 1½ seconds...
	10 33 0...	=1st mag.	Very brilliant.	Train visible 13 seconds...	3 seconds...........
	10 50 0...	=2nd mag............	Bright	Small train	2 seconds...........
	10 57 30...	larger than 1st mag. .	Dazzling	Train visible 41 seconds...	5 seconds...........
13	9 40 0...	=1st mag.	Very bright ...	Train visible 6 seconds ...	3 seconds...........
15	9 22 0...	=4th mag.	Blue...........	....	3 seconds...........
	9 41 0...	=1st mag.	Blue...........	Train visible 8 seconds ...	2½ seconds ....
	10 0 3...	=4th mag.	Blue...........	....	1½ second ....
16 or 17	3 0 p.m.	Sharp whistling sound. No explosion.	A dark object seen to fall.	....	....
21	9 8 p.m.	3rd mag.	Yellow	....	Very rapid ....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
From just above Polaris to α Draconis.	....	Castle Donington.	Mr. W. H. Leeson.	Mr. Lowe's MS.
From 2° West of Polaris to ζ Ursæ Majoris.	Three other meteors at the same instant and nearly in same direction.	Ibid...............	Id.	Ibid.
From α Lyræ perpendicular to horizon 15°.	During next 15 minutes no less than 20 meteors were seen.	Ibid...............	Id.	Ibid.
From α Lyræ to near Deneb ...	A flash of lightning at this instant.	Ibid...............	Id.	Ibid.
From ζ Ursæ Majoris to near Cor Caroli.	....	Ibid...............	Id.	Ibid.
From ε Ursæ Majoris towards Arcturus 30°.	Two others at the same time, small.	Ibid...............	Id.	Ibid.
From ζ Draconis to midway between ξ and γ Draconis.	....	Ibid...............	Id.	Ibid.
From 4° West of Polaris to near γ Ursæ Majoris.	....	Ibid...............	Id.	Ibid.
From 2° above Polaris to near γ Ursæ Majoris.	....	Ibid...............	Id.	Ibid.
From 5° below β Ursæ Majoris perpendic. to horizon.	....	Ibid...............	Id.	Ibid.
From Arcturus to near γ Serpentis.	Another at the same instant.	Ibid...............	Id.	Ibid.
From near ε Ursæ Majoris to near Cor Caroli.	....	Ibid...............	Id.	Ibid.
From just below Altair, down Milky Way about 9°.	....	Ibid...............	Id.	Ibid.
From β Cygni down Milky Way 10°.	20 others in less than 5 minutes.	Ibid...............	Id.	Ibid.
Two from near Deneb towards η Ursæ Majoris. Former disappeared just below that star, latter at about ⅓ distance.	26 others were seen in the next 15 minutes.	Ibid...............	Id.	Ibid.
From 4° below Polaris to near δ Ursæ Majoris.	25 others during next 7 minutes.	Ibid...............	Id.	Ibid.
From just below Polaris to near α Ursæ Majoris.	....	Ibid...............	Id.	Ibid.
From ϑ Cassiopeiæ to near Deneb.	8 others during next half hour.	Ibid...............	Id.	Ibid.
From midway between η and θ Draconis to η Herculis.	....	Ibid...............	Id.	Ibid.
From γ Bootis to midway between Arcturus and Cor Caroli.	....	Ibid...............	Id.	Ibid.
From γ Draconis to midway between α and β Herculis.	....	Ibid...............	Id.	Ibid.
From 3° East of α Lyræ to near μ Serpentarii.	....	Ibid...............	Id.	Ibid.
At $<35°$ to the ground from N.E. to S.W., supposed about 60 or 80 yards distant.	After a thunderstorm and rain had ceased.	Wendlebury, Oxfordshire.	Rev. W. L. Brown.	MS. comm. to Prof. Powell.
From about 23 Pegasi and travelled about 12° towards Delphinus, passing 2° South of χ Pegasi.	....	Observatory, Stone Vicarage, Lat. 51° 47′ 57″·03 N. Long. 0° 52′ 16″·35 W.	F. V. Fasel, Esq.	Mr. Lowe's MS.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Aug. 22	9 30 p. m.	1st mag.	Orange		Moderate
	9 44 p.m.	4th mag.	White	Short train	Rapid
	10 13 30...	2nd mag.	Blue		Rapid
27	10 8 p.m.	A splendid meteor, brighter than a star of the 1st mag.	White	Long train which did not disappear for 2 seconds.	Slow
29	9 35 p.m.	2nd mag.	White		Moderate
31	9 19 p.m.	As large as Capella...	Yellow		Moderate
Sept. 3	8 26 15...	1st mag.	Yellow	Long train	Slow
	8 31 p.m.	3rd mag.	Blue		Rapid
	8 36 15...	2nd mag.	White	Train	Moderate
	....	3rd mag.	Colourless ...	Train	
5	8 0 p.m.	2nd mag.	Red		Rapid
	8 17 p.m.	3rd mag.	White		Rapid
	8 26 p.m.	2nd mag.	White	Long train	Moderate
	9 49 p.m.	3rd mag.	Orange		Rapid
6	9 14 p.m.	1st mag.	Yellow		Moderate
	9 18 30...	As large as Mars	Red	Train which did not disappear for 2 or 3 seconds.	Moderate
8	7 26 p.m.	3rd mag	White	Train	Rapid
9	9 2 p.m.	Very bright, 1st mag.	Blue	Train	Moderate
	9 34 p.m.	3rd mag.	White		Rapid
	9 36 p.m.	2nd mag.	Blue		Rapid
	9 47 p.m.	4th mag.	White		Very rapid
	9 50 p.m.	2nd mag.	Orange		Moderate
	10 22 p.m.	3rd mag.	Blue	Short train	Rapid
	10 25 p.m.	3rd mag.	Blue		Rapid
	11 1 30...	1st mag.	Orange	Long train	Moderate

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
rom 2° S. of λ Pegasi, passed within 4° E. of Markab and disappeared at 82 Pegasi.	....	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
rom γ to β Andromedæ	....	Stone	Rev. J. B. Reade	Ibid.
rom near β Cygni down towards S.	....	Highfield House Observatory.	A. S. H. Lowe, Esq.	Ibid.
rom α Cassiopeiæ to γ Ursæ Minoris.	Bright train	Hartwell	Rev. C. Lowndes	Ibid.
rossed Cassiopeia from W. to E.	....	Stone	F. V. Fasel, Esq.	Ibid.
rom η Ursæ Majoris to 15 Canis Venaticorum, or within 3° E. of Cor Caroli.	....	Ibid...............	Id.	Ibid.
rom η Pegasi, crossed Lacerta and vanished in the Milky Way about π Cygni.	It increased in size as it proceeded.	Ibid...............	Id.	Ibid.
rom Delphinus and went about 3° northward.	....	Ibid...............	Id.	Ibid.
rom about 4° N.W. of Polaris and proceeded in a direct line to the Pointers; it vanished within 5° of α Urs. Maj. and about 1½° N.E. of λ Draconis.	....	Ibid...............	Id.	Ibid.
rom β across η Pegasi	....	Highfield House.	E. J. Lowe, Esq.	Ibid.
rom α to very near ε Cephei...	....	Stone	F. V. Fasel, Esq.	Ibid.
rom π Pegasi to Scheat	....	Ibid...............	Id.	Ibid.
rom α Cygni to nearly γ Draconis.	....	Ibid...............	Id.	Ibid.
rom β to γ Andromedæ	....	Ibid...............	Id.	Ibid.
rom about 4° E. of α Lyræ to γ Draconis.	....	Ibid...............	Id.	Ibid.
rom midway between α Andromedæ and Scheat, and proceeded about 4° south, when it entered a cloud.	The train was beaded, and, after its entering the cloud, appeared very much like a rocket; it was of a bright red colour.	Ibid...............	Id.	Ibid.

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
rom α Andromedæ and proceeded 2° south.	....	Ibid...............	Rev. J. B. Reade	Ibid.
rom η Aquarii and went about 4° S.S.W.	....	Ibid...............	Mrs. Reade	Ibid.
From Delphinus to β Aquarii...	....	Ibid...............	F. V. Fasel, Esq.	Ibid.
From Scheat to Markab.........	....	Ibid...............	Id.	Ibid.
From γ Aquarii, and proceeded a few degrees S.E.	....	Ibid...............	Id.	Ibid.
From λ Andromedæ to half-way between α Andromedæ and Scheat.	....	Ibid...............	Id.	Ibid.
From 4° above the Pleiades and went to the Pleiades.	....	Ibid...............	Rev. J. B. Reade	Ibid.
From a few degrees E. of Fomalhaut and went towards it.	....	Ibid...............	Id.	Ibid.
From 3° W. of Algenib to nearly γ Piscium.	....	Ibid...............	F. V. Fasel, Esq.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Sept. 9	8 40	4th mag.	Orange	Streak	Moderate
	8 50	4th mag.	Orange	Streak	Moderate
	8 52	4th mag.	Orange	Streak	Moderate
	8 56	4th mag.	Orange	Streak	Moderate
	9 0	4th mag.	Orange	Streak	Moderate
	9 4	4th mag.	Orange	Streak	Moderate
	9 10	4th mag.	Orange	Streak	Moderate
	9 15	4th mag.	Orange	Streak	Moderate
10	8 39	3rd mag.	Orange	Streak	Moderate
	8 30	2nd mag.	Orange	Streak	Moderate
	8 42	1st mag.	Red	Long tail	2 seconds
	8 42 30...	Small	Colourless	Train	Rapid
	8 44	Small	Colourless	Train	Rapid
	8 58	Small	Colourless	Train	Rapid
	9 0	= α Arietis	= α Arietis	Without train	1 second
11	4 15 a.m.	Luminous appearance round; increased in size for 30 or 40 seconds, then decreased and disappeared for a minute, then reappeared of same size as at first and disappeared 2 or 3 times.	Bright white; another observer blue; another observer says it tinged the dark part of the moon with a reddish light.	Surrounded by luminous haze, but no rays.	Stationary. Vanished finally at 4·45
12	8 28	3rd mag.	Yellow	Tail	0·5 second
	8 59 45...	2nd mag.	Yellow	Long continuous tail	2 seconds, slow
	9 8 30...	=3rd mag.	Blue		2 seconds
	9 8 35...	=3rd mag.	Blue		2 seconds
	9 9	=3rd mag.	Deep red		1 second
	9 16	=3rd mag.	Blue		$1\frac{1}{2}$ second
	9 28 30...	=4th mag.	Blue		1 second
	9 32	=4th mag.	Blue		$1\frac{1}{2}$ second
	9 35 10...	=4th mag.	Blue		$1\frac{1}{2}$ second
	9 40	=3rd mag.	Blue		1 second
	7 56 p.m.	1st mag.	White	Train	Slow
	8 1 p.m.	3rd mag.	Bluish white		Moderate
	9 2 p.m.	3rd mag.	Bright blue		Rapid

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
Through β Pegasi	Many small meteors; the point from which they diverged was near ϑ Cassiopeiæ.	Highfield House.	E. J. Lowe, Esq.	Mr. Lowe's MS.
Near α Andromedæ............	....	Ibid..............	Id.	Ibid.
Near γ Andromedæ	....	Ibid..............	Id.	Ibid.
Near α Cassiopeiæ	....	Ibid..............	Id.	Ibid.
Near β Cassiopeiæ	....	Ibid..............	Id.	Ibid.
Near η Pegasi	....	Ibid..............	Id.	Ibid.
Near α Persei	....	Ibid..............	Id.	Ibid.
Near Aquila.....................	....	Ibid..............	Id.	Ibid.
From π Andromedæ through τ Piscium.	....	Ibid..............	Id.	Ibid.
Perpendic. down from 30′ E. of η Aquarii, passing E. of χ Aquarii.	....	Ibid..............	Id.	Ibid.
From f Cassiopeiæ across near Polaris and above η Ursæ Minoris.	....	Ibid..............	Id.	Ibid.
Upwards through γ Cassiopeiæ	....	Ibid..............	Id.	Ibid.
Perpendicular down from υ Aquilæ.	....	Ibid..............	Id.	Ibid.
Perpendicular down through γ Aquarii.	....	Ibid..............	Id.	Ibid.
Fell perpendic. down through α Arietis.	Broke into two and then disappeared.	Ibid..............	Id.	Ibid.
Altitude estimated at 30° or 35° at a little distance from the moon (estimated altitude probably too great).	After the disappearance one observer saw ♀ occupy nearly the same place, but there were many clouds.	Four Oaks, Staffordshire.	Several friends of Lord Wrottesley.	MS. communicated from Lord Wrottesley to Prof. Powell. See Appendix, No. 2.
From α Coronæ Borealis to about 5′ N. of ε Bootis.	....	Observatory, Beeston.	E. J. Lowe, Esq.	Mr. Lowe's MS.
Immediately below γ Andromedæ to φ Piscium.	....	Ibid..............	Id.	Ibid.
....	Other small ones...	Ibid..............	Id.	Ibid.
From η Herculis to near Ras Algethi.	Greenwich Mean Time is given.	Castle Donington Lat. 52°51′23″·75 N.	Mr. W. H. Leeson.	Ibid.
From ε Aquilæ to near γ Tauri Poniatowski.	....	Ibid..............	Id.	Ibid.
From Algenib to ε Pegasi	....	Ibid..............	Id.	Ibid.
From near ξ Draconis to 3½° below η Draconis.	....	Ibid..............	Id.	Ibid.
From Delphinus to near Altair	....	Ibid..............	Id.	Ibid.
From θ Tauri Poniatowski to α Serpentarii.	....	Ibid..............	Id.	Ibid.
From ζ Cygni to near β Cygni.	....	Ibid..............	Id.	Ibid.
From β Bootis to θ Coronæ Borealis.	....	Ibid..............	Id.	Ibid.
From Algol, and went 7° S.W.	....	Stone	H. Smith, Esq. .	Ibid.
From α Urs. Min. to α Urs. Maj.	....	Ibid..............	J. Oliver, Esq....	Ibid.
From 18 Persei to α Persei ...	....	Ibid..............	Rev. J. B. Reade	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Sept. 12	9 5 p.m.	Larger and brighter than α Lyræ.	Red	Train	Rapid ....
	9 31 p.m.	1st mag.	Red	....	Moderate............
	9 40 p.m.	3rd mag.	White	....	Rapid ....
	10 8 p.m.	3rd mag.	Orange........	....	Rapid ....
13	11 59 45...	= ♃. Ill-defined edge.	Blue............	Long streak..................	1 second ....
	12 2	= 3rd mag.	Yellow.........	Streak	Instantaneous ......
	12 3	Small	Yellow.........	Streak	Instantaneous ......
	8 30 p.m.	3rd mag.	Yellowish......	A few above it..............	A few seconds......
	10 15 p.m.	2nd mag................	White	Train	Moderate ....
	10 19 p.m.	1st mag. and brighter than α Aquilæ.	Red	Train	Moderate ....
16	8 16 p.m.	2nd mag................	Orange.........	Train	Very rapid ....
	8 35 p.m.	2nd mag................	Red	....	Rapid ....
	9 12 30 p.m.	2nd mag................	Yellow	Train	Rapid ....
	9 55 45 p.m.	2nd mag................	Orange.........	Train	Rapid ....
	10 4 30 p.m.	2nd mag................	Bright blue ...	Train very much like the brush of a fox's tail.	Rapid ....
	10 11 25 p.m.	3rd mag.	Yellow	....	Moderate..........
17	7 46 p.m.	1st mag. and as bright as α Lyræ.	Orange.........	Train	Very slow..........

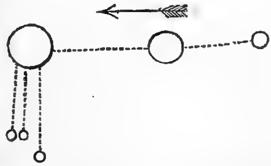
Direction or altitude.	General remarks.	Place.	Observer.	Reference.
om the head of Draco, and proceeded about 7° in a line, which, if produced, would pass between η and ζ Draconis.	....	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
om Algol to Algenib	Appeared to be very low.	Ibid...............	Rev. J. B. Reade	Ibid.
om about 12° N. of α^2 Capricorni and proceeded to α^2 Capricorni.	....	Ibid...............	F. V. Fasel, Esq.	Ibid.
om a little below Cassiopeia, and moved from S. to N.	....	Ibid...............	Rev. J. B. Reade	Ibid.
om 18 Piscium through ξ Andromedæ to just β Andromedæ.	Gradually increased in size, from a mere point to ♃ at opposition.	Beeston	E. J. Lowe, Esq.	Ibid.
rpendic. down from δ Capricorni.	....	Ibid...............	Id.	Ibid.
rpendic. down from η Ceti...	....	Ibid...............	Id.	Ibid.
out 45° from Canis Minor, whence it moved off horizontally towards S.E.	The evening was calm and clear. The Via Lactea formed a complete arch from S.E. to N.W. Fahrenheit 46°; Barometer 29·60.	North Dalton ...	Rev. Thomas Rankin.	MS. communicated to Prof. Powell.
om α Lyræ to π Herculis ...	....	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
om α Sagittæ to ϵ Aquilæ ...	....	Ibid...............	Id.	Ibid.
om about 5° N.E. of Aries, moved in a parallel line with, and passed just below α and β Arietis and η Piscium; it vanished at about 14° from the point it started from.	It appeared very low, and crossed a very low cloud.	Ibid...............	Id.	Ibid.
om 8° W. of Delphinus, and proceeded about 5° from W. to E.	....	Ibid...............	Id.	Ibid.
om Cassiopeia to γ Andromedæ.	....	Ibid...............	Id.	Ibid.
om 5° below Aries, and proceeded 20° from N. to S.	It appeared very low.	Ibid...............	Rev. J. B. Reade.	Ibid.
om α Persei to Algol	After the head had disappeared, the train remained visible for half a second, and the extremity of it disappeared last; it was rather high.	Ibid...............	Id.	Ibid.
om about α Aquarii, and went 5° S.	....	Ibid...............	F. V. Fasel, Esq.	Ibid.
om about 4° S.E. of α Cephei, and moved from W. to E. as far as 3 Lacertæ.	It appeared low ...	Ibid...............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852. Sept. 17	h m s 7 54 30 p.m.	2nd mag. and very bright.	Light orange..	Train	Moderate
	10 1 p.m.	3rd mag. and as bright as a star of the 2nd.	Orange	Long train	Moderate
	10 1 p.m.	3rd mag.	Bluish, but not very certain.	Train	Rather slow
	11 19 p.m.	2nd mag.	Red	Train	Very slow
18	8 55 p.m.	3rd mag.	Blue	Train	Rapid
	8 58 40 p.m.	2nd mag.	Orange		Moderate
	9 10 45 p.m.	2nd mag.	Blue	Train	Slow
	9 25 57 p.m.	As large as a tennis-ball, and with a perfect disc.	White	No train	Very slow, a[illegible] about 3 secs. d[illegible]ration.
	9 26 p.m.	3rd mag.	Yellow	Train	Moderate
	9 27 46 p.m.	Very bright, 1st mag.	Yellow	Train	Rapid
	9 32 40 p.m.	3rd mag.	Blue	Thin train	Moderate
	9 35 50 p.m.	3rd mag.	Yellow	Train	Slow
20	7 34 15 p.m.	1st mag.	Blue	Train yellow	Moderate
	9 5 p.m.	2nd mag.	White	Long train	1 sec. duration
	9 48 25	4th mag.	Bluish	Very thin train	Moderate
	10 3	2ce size of ♃	Colour of ♃	Long train	Slowly
23	9 56 p.m.	3rd mag.	Reddish	Train	Rather rapid
	10 56 p.m.	3rd mag.	White	Short train	Very rapid
24	7 20 50 p.m.	The head was a splash of flame, 4 times the size of Mars.	Red	Long train with sparks	Rather rapid

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
m about 5° S. of ι Urs. Min., and proceeded 14° due N.W.	When in the middle of its course it disappeared for about ½ a second; so that its train was divided into two parts.	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
m about 3° S. of ζ Andromedæ, passed below Algenib, and went as far as Piscium.	It was rather low...	Ibid...............	Id.	Ibid.
m about 6° S. of α Andromedæ passed above Algenib, and disappeared at about Piscium.	Appeared low. This evidently is the same meteor as the preceding one	Hartwell	Mrs. Reade	Ibid.
m χ Draconis to exactly ε Urs. Maj.	Its speed decreased as it proceeded.	Stone	F. V. Fasel, Esq.	Ibid.
m half-way between α Cygni and α Cephei, and went very near to δ Draconis.	....	Ibid...............	Rev. J. B. Reade	Ibid.
m ρ Draconis, passed between α and β Cephei, and disappeared at ξ Cephei.	....	Ibid...............	F. V. Fasel, Esq.	Ibid.
m ζ Pegasi, and went about 1° S.E.	Head blue; train orange.	Ibid...............	Rev. J. B. Reade	Ibid.
m about β Tauri, passed below the Pleiades, and disappeared a little below Saturn.	It was very low and described a line curved towards the earth.	Ibid...............	F. V. Fasel, Esq.	Ibid.
m ζ Draconis, passed through η, and vanished at Draconis.	....	Ibid...............	Rev. J. B. Reade	Ibid.
m α Draconis to θ Bootis ...	....	Ibid...............	Id.	Ibid.
m 37 Lyncis; moved in a N.E. direction, and disappeared behind the house.	....	Ibid...............	Id.	Ibid.
m η Urs. Maj., and went 10° towards Cor Caroli.	....	Ibid...............	Rev. J. B. Reade & F. V. Fasel.	Ibid.
m ι Bootis to Arcturus......	Train 7° in extent..	Stone	Rev. J. B. Reade	Ibid.
m α Aquilæ to within 10° of the horizon.	....	Hartwell	Rev. C. Lowndes	Ibid.
m 6° W. of β Cassiopeiæ, and went to β Cassiopeiæ.	....	Ibid...............	F. V. Fasel, Esq.	Ibid.
alt. of 45° horizontally from E. to S.	....	Highfield House Observatory.	A. S. H. Lowe, Esq.	Ibid.
m about α Cephei, and went about 10° due N. through a cirrus cloud.	It appeared high...	Ibid...............	Id.	Ibid.
m about 5° S. of β Cassiopeiæ, and went 6° W. of α Andromedæ.	It passed under a high cirrus cloud	Ibid...............	Rev. J. B. Reade & F. V. Fasel, Esq.	Ibid.
m α Coronæ Borealis to about π Bootis.	This magnificent meteor was very well seen.	Ibid...............	Id.	Ibid.

B. Mr. Fasel also saw the same at a station about 400 yards distant from that of Rev. Mr. Reade, and his account perfectly agrees with the above; he further adds, that, in the absence of the moon, which was then 11 days old, this meteor would have shown with as much light as our satellite when 3 or 4 days old.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852. Sept. 25	h m s 8 35 p.m.	Large meteor	Reddish	....	Slow ....
29	11 22 58 p.m.	Larger than a star of the 1st mag., and as bright as Capella.	Orange.........	Long *red* beaded train, in the shape of a double convex lens, or having a lenticular form.	Rather slow.......
Oct. 5	9 11 4 p.m.	3rd mag.	Light blue ...	Train	Rapid ....
	10 32 p.m.	1st mag.	Deep orange ..	Beaded train	Slow...............
6	7 48 p.m.	2nd mag..............	Orange red ...	Very long beaded train ...	Moderate ......
11	7 36 34 p.m.	2nd mag..............	Yellow	Train	Moderate ......
	8 9 17 p.m.	2nd mag.; it increased from the 2nd to the 1st mag.	White	No train	Slow...............
	8 22 31 p.m.	1st mag.	Yellow.........	Short train	Moderate ......
	10 42 26 p.m.	1st mag.	Red	Beaded train	Slow ....
12	8 22 p.m.	Small, 3rd mag.	Blue	....	....
	8 26	2nd mag...............	Blue; increased in brilliancy from a point.	Train of sparks emanated when at its greatest brilliancy.	Train soon vani[shed], and met[eor] diminished t[o a] point and dis[ap]peared.

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
est to South.	Was a very singular object; appeared at first as large as a star of the 1st magnitude; then shot some distance, and increased much in size; shot a second time, and still increased; then divided into and fell in 3 portions; gave a strong, brilliant, and sparkling light. Weather cloudy; drizzling rain, and very oppressive from heat.	St. Ives, Hunts.. 	J. King Watts...	MS. communicated to Prof. Powell.
om β Cassiopeiæ to very near α Cygni. B. This was very well seen, the observer happening just to look in that very spot when the meteor started.	The train appeared almost like the train of a rocket, and was visible for 2 secs. after the disappearance of the head.	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
om about 6° S. of α Arietis to about λ Ceti.	....	Ibid................	Id.	Ibid.
om about ϑ Urs. Maj., passed just below λ Draconis, and vanished between Mizar and α Draconis.	....	Ibid................	Id.	Ibid.
om about γ Urs. Min. to α Lyræ.	....	Ibid................	Id.	Ibid.
om Polaris to within 5° E. of γ Draconis, and 10° N. of α Lyræ.	....	Ibid................	Id.	Ibid.
om about φ Urs. Maj. to within 2° of λ Urs. Maj.	The first half of its course was a curve towards α Urs. Maj., and the other half was in a direct line to λ Urs. Min.; its path resembling a sickle.	Ibid................	H. Smith, Esq....	Ibid.
om about 1° S. of β Ophiuchi, and proceeded a short distance to the N.	....	Ibid................	C. V. Oliver, Esq.	Ibid.
om about 6° N. of γ Cassiopeiæ to Polaris.	....	Ibid................	F. V. Fasel, Esq.	Ibid.
om Lyra, passed between 3° and 4° W. of Altair.	....	Victoria Park, London.	W. R. Birt, Esq.	MS.
om β and γ Ursæ Minoris below head of Draco.	Path nearly parallel to last, and motion direct in both	Ibid................	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Oct. 12	8 40 p.m.	Fine globular meteor.	Gradually increasing in size and brilliancy from a point till = ♃, and of greater brightness. White tinged with yellow.	....	Motion slow ......
	8 42 p.m.	Small	Blue	....	....
13	6 58 p.m.	1st mag.	Orange........	Instantaneous flash........	....
14	0 21 a.m.	1st mag.	Blue	Long blue beaded train, which gradually disappeared.	Moderate.........
15	7 6 5 p.m.	3rd mag., but as bright as a star of the 1st.	Yellow	Train	Slow............
	7 21 45 p.m.	3rd mag.	Blue	Train of small blue beads..	Slow............
	7 31 21 p.m.	As large as Mars, and even rather larger.	The same colour as Mars.	A continuous train 2° in length, and of the same colour as Mars.	Slow............
18	7 9 58 p.m.	1st mag.	White	No train	Slow............
20	6 7 30 p.m.	1st mag.	White	Long beaded train	Rapid ....
23	9 22 10 p.m.	1st mag.	Orange........	Train	Slow............
	9 44 p.m.	1st mag.	Red	Train	Slow............
Nov. 3	6 11 44 p.m.	3rd mag.	Reddish	Train	Moderate ......
	6 18 44 p.m.	1st mag.	Yellow	No train	Very slow.........
	6 22 35 p.m.	2nd mag.	Orange........	Train	Moderate ......
	9 8 47 p.m.	2nd mag.	Deep orange...	....	Slow............
	9 11 57 p.m.	1st mag.	Yellow	Long train	Slow............
	9 15 7 p.m.	1st mag.	Orange	Train	Rapid ....
	9 21 8 p.m.	1st mag.	Yellow	Train	Slow............
	9 23 38 p.m.	1st mag.	Red	Train	Slow............
	10 5 9 p.m.	3rd mag.	Blue	No train	Rapid ....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
ssed across ι Persei towards Capella, eclipsing the star; uddenly disappeared.	Motion direct, very similar to meteor of Aug. 10, 1849.	Victoria Park, London.	W. R. Birt, Esq.	MS.
ne distance above Pleiades.	Retrograde	Ibid.	Id.	Ibid.
m δ Urs. Maj. to the chord f the arc formed by η and γ Jrs. Maj.	....	Stone	F. V. Fasel, Esq. & Rev. J. B. Reade.	Ibid.
m α Orionis to within a few egrees of Rigel.	The middle of the train vanished last.	Ibid.	Rev. J. B. Reade	Ibid.
m 3° E. of λ Draconis to vithin a degree of υ Urs. Iaj.	....	Ibid.	F. V. Fasel, Esq.	Ibid.
m exactly half-way between and ε Herculis to exactly alf-way between η and ζ Ierculis.	....	Ibid.	Rev. J. B. Reade	Ibid.
n about 2° W. of α Herulis to very near λ Serentarii.	....	Ibid.	Id.	Ibid.
n 1° N. of α Persei to Algol	....	Ibid.	C. Oliver, Esq....	Ibid.
n ζ Cephei to a little beyond Cephei.	....	Ibid.	Rev. J. B. Reade	Ibid.
n between α and ε Aurigæ ϑ Aurigæ.	....	Ibid.	F. V. Fasel, Esq.	Ibid.
n 55 Lyncis to within 2° of Geminorum.	....	Ibid.	Id.	Ibid.
n half-way between α and β ephei to half-way between and ξ Draconis.	....	Ibid.	Id.	Ibid.
n 35 Muscæ Borealis to 21 .H. 348.	....	Ibid.	C. Oliver, Esq....	Ibid.
n half-way between β and γ raconis to half-way between and η Herculis.	....	Ibid.	F. V. Fasel, Esq.	Ibid.
n γ Draconis to within 5° α Lyræ.	....	Ibid.	Id.	Ibid.
n about β Delphini to about beyond γ Aquilæ.	....	Ibid.	Id.	Ibid.
n Algenib to about 15° due outh.	....	Ibid.	Id.	Ibid.
n about ξ Cygni, passed etween γ and ε Cygni, and nished at φ Cygni.	....	Ibid.	Id.	Ibid.
n between ζ Persei and ι urigæ to η Aurigæ.	....	Ibid.	Id.	Ibid.
n Aldebaran to a few degrees outh.	....	Ibid.	Id.	Ib

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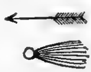
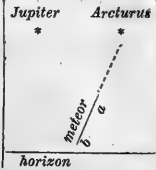
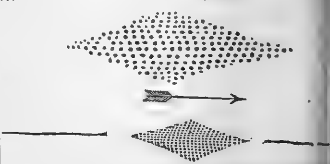
Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852. Nov. 3	h m s 10 23 10 p.m.	1st mag.	Blue	No train	Slow...............
	10 58 43 p.m.	Larger than a star of 1st mag., and as bright as Aldebaran.	Orange	Very long continuous train, which seemed to have a little swelling in the centre, like the vibration of a string.	Slow...............
	11 20 40 p.m.	3rd mag.	Blue	....	Slow...............
	8 20 p.m.	2nd mag.	Orange-red ...	Train	0·5 sec.............
4	8 9 p.m.	Seemed about the size of Jupiter.	....	....	Very rapid ....
7	10 32	Larger than Vega ...	Colour of Vega	Long streak..................	1 sec. ....
19	9 16 12 p.m.	1st mag.	Orange	Train	Slow...............
	12 23 36 p.m.	2nd mag.	Yellow	Short train	Very rapid ....
	12 26 15 p.m.	3rd mag.	Blue	Short train	Rapid ....
24	8 51 p.m.	1st mag.	Yellow	....	Rapid ....
27	9 3 12 p.m.	As large as α Lyræ ...	Brilliant red...	Short train	Slow...............
Dec. 8	10 49 p.m. (Dublin time.)	= to a star of the 1st mag.	Reddish, very bright.	No train or sparks	Passed over ab 15° in 1½ or 2 s
	10 57 p.m.	A mere spark	....	....	Lasted perhaps sec.; did move over n than 4° or 5°
11	10 0 p.m.	....	....	....	....
12	9 0	Small	....	....	Slowly ....
	10 20	1st mag.	Red	Streak	Slowly ....
	About 9 p.m. (Greenwich time.)	Apparent size of nucleus = Jupiter. 	Nucleus bright white; train reddish. Brightness steady.	Train of reddish sparks; diverging; length = distance between two of the three large stars in Orion's belt; breadth at end of train = one-third of length.	Moved about 9 2½ secs.
	A few secs. before the above.	Much smaller	....	None	Somewhat rapid than above.

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
om about 2° S. of γ Trianguli to α Arietis.	....	Stone	F. V. Fasel, Esq.	Mr. Lowe's MS.
om 2° S. of Aldebaran to α Ceti.	....	Ibid...............	Rev. J. B. Reade	Ibid.
om 3° E. of ν Tauri to π¹ Orionis.	....	Ibid...............	Id.	Ibid.
om direction of Vega, passing between β and γ Herculis.	Aurora borealis ...	Observatory, Beeston.	E. J. Lowe, Esq.	Ibid.
om ν Urs. Maj. in the direction of Capella through a cloud.	It disappeared about half-way in the thickest part of the cloud.	Stone	J. Oliver, Esq....	Ibid.
om between χ and ϑ Cygni, passing through ξ Lyræ.	....	Observatory, Beeston.	E. J. Lowe, Esq.	Ibid.
om between α and β Aurigæ to within 2° S. of δ Aurigæ.	....	Stone	F. V. Fasel, Esq.	Ibid.
om Polaris to δ Draconis......	....	Ibid...............	Rev. J. B. Reade	Ibid.
om Markab to ζ Pegasi	....	Ibid...............	Id.	Ibid.
om 4° N. of δ Aurigæ, and went 5° due N.	In the absence of the moon this would have proved a fine meteor.	Ibid...............	F. V. Fasel, Esq.	Ibid.
om 1° N. of ι Urs. Maj. to 1° N. of ζ Urs. Maj.	....	Ibid...............	J. Oliver, Esq....	Ibid.
peared at an elevation of about 45°, and moved downwards in a path forming an angle of 8° or 10° with the vertical, and slightly curved *towards* the vertical.	....	Near Glasnevin, about ½ a mile to the north of Dublin.	J. W. Mallet, PhD.	MS. com. to Prof. Powell.
titude 70° in the W.; moved vertically.	....	Ibid. (*In the village of Glasnevin.*)	Id.	Ibid.
....	Several small	Highfield House Observatory.	A. Lowe, Esq....	Mr. Lowe's MS.
titude 15° from S.W. towards W.	....	Ibid...............	Id.	Ibid.
titude 20° due E. perpendicular down to within 5° of horizon.	Several small ones..	Ibid...............	Id.	Ibid.
titude when it first made its appearance past the angle of a house, between 25° and 30°; direction East; moved nearly in a great circle towards the S. point of the horizon, and disappeared behind some trees.	....	Rosebank, 4 miles S.E. of Glasgow	Mrs. David Rankine.	MS. com.
urse nearly the same as the above.	....	Ibid...............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1852.	h m s				
Dec. 12	A few min. after the large meteor.	Much smaller	....	Doubtful	Very rapid
17	4 50	A remarkable cloud in S.E. emitting red flashes with a hissing sound, advancing towards N.W., scintillations more rapid.	....	....	....
	5 0	Ball of light in middle of cloud = ½ diameter of ☽.	Dull red	Tail 5 or 6 times diameter, emitting flashes.	Descended rapidly, detonating and hissing.
	5 3	....	....	....	Approached the shore throwing off portions; nucleus suddenly exploded, giving out bright light.
1853.					
Mar. 8	8 5 p.m.	Large meteor	White	Sparks	Quick
	7 44	= 4th mag.	Yellow	....	0·2ˢ, slow
	8 0	= 4th mag.	Orange	....	0·5ˢ, slow
11	12 15	twice mag.	Straw-colour	Long continuous light	0·2ˢ, rapid
	12 to 13	....	....	....	....
21	11 34 30	= size Sirius	twice as bright as Sirius, blue	Long train	2·5 secs.
29	8 23 p.m.	1st mag. and as bright as Capella.	Bluish-white	....	Moderate
	7 55 p.m.	Small luminous meteor.	Very faint	....	....
30	2 20 p.m.	Large meteor	White	No sparks	Slowly
May 5	11 14	= 1st mag.	Orange-red	Without stars	0·5 sec., slowly
	10 15	= 1st mag.	Colourless	....	....
17	8 57	= 3 times ♃	Bluish	Without appendages	1 second
June 6	11 20 p.m.	....	White	No sparks	Slow
July 5	11 50 p.m.	Small	White	No sparks	Rapid
	10 15	Much larger than ♃	Very bright blue.	No tail	Motion slow

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
ppeared in S.W. at an altitude of about 45°; moved towards the N.W. point of the horizon.	....	Rosebank, 4 miles S.E. of Glasgow.	David Rankine, Esq.	MS. com.
....	....	Near Dover	F. Higginson, Esq., R.N.	
....	....	....	....	Proceedings of the Royal Society, vol. vi. No. 94, p. 276.
....	Mass fell into the sea, causing great spray, &c.	....	....	
mediately below pointer of Ursa Major 10° North.	....	St. Ives, Hunts.	J. King Watts, Esq.	MS. communicated to Prof. Powell.
er 20′ in space, from 16 Argo Navis towards Sirius.	....	Observatory, Beeston.	E. J. Lowe, Esq.	Mr. Lowe's MS.
er 3° in space, from β Andromedæ towards Saturn.	....	Ibid...............	Id.	Ibid.
om direction of Arcturus through δ Bootis to γ Draconis.	....	Ibid...............	Id.	Ibid.
pparently meteors at great distance.	There were several spurts of light moving over 2′ to 3′ of space and under a 6th mag. star.	Ibid...............	Id.	Ibid.
owly from ψ Cancri, passed 1° N. of ϑ Cancri through η Hydræ to 1° S. of 31 Monocerotis.	Passed beneath a nearly full ☾.	Ibid...............	Id.	Ibid.
om about 3° N. of ϱ Cancri to about η Hydræ.	....	Stone	J. Oliver, Esq....	Ibid.
om Gemini to Leo	....	Victoria Park, London.	W. R. Birt, Esq.	MS. comm.
om Ursa Minor to west	....	St. Ives, Hunts	J. King Watts, Esq.	Ibid.
om ε Hydræ northward towards horizon for 5° at an angle of 45°.	....	Highfield House Observatory.	E. J. Lowe, Esq.	Mr. Lowe's MS.
an angle of 45° easterly from N.E., altitude 15°.	....	....	A. S. H. Lowe, Esq.	Ibid.
rpendic. down from ψ Bootis	A globe meteor ...	Observatory, Beeston.	E. J. Lowe, Esq.	Ibid.
om zenith down to south ...		St. Ives, Hunts.	J. King Watts, Esq.	MS. comm.
om Ursa Major downwards...		Ibid...............	Id.	Mr. Lowe's MS.
path produced backwards would pass through Arcturus.		Long Whatton, near Loughborough, Leicestershire.	Rev. K. Swann .	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1853.	h m s				
July 5	10 15	= ♃	Very bright blue.	No tail	....
28	11 29	= 3rd mag.	Very bright blue.	Streak	Rapid ....
	11 30	= 4th mag.	Very bright blue.	Tail	Rapid ....
	11 31	= 3rd mag.	Very bright blue.	Tail	Rapid ....
	11 32	= 3rd mag.	Very bright blue.	Tail	Rapid ....
	11 33	= 3rd mag.	Very bright blue.	Tail	Rapid ....
Aug. 3	10 18	= 2nd mag.	Orange	Streak	1·5 second ....
7	9 48 35...	= 1st mag.	Blue	Train, 3 seconds	$1\frac{1}{2}$ second ....
	9 58	= 3rd mag.	Blue	....	1 second ....
	10 12 31...	= 4th mag.	Blue	....	$2\frac{1}{2}$ seconds ....
	10 30 p.m. (Greenwich time.)	One-third of the moon's apparent diameter. About as bright as the moon's surface.	White	None	Visible for less tha[n] one second, du[ring] which it de[scribed] an arc o[f] about 15°, disap[pearing] behin[d] some trees.
	9 22 p.m.	Small, 3rd mag.	Piercingly bright.	....	....
8	9 41 p.m.	Very small	Faint	....	....
	9 53 p.m.	Very small	Faint	....	....
	9 56 p.m.	3rd mag.	Fluctuating in its brilliancy.	....	....
	9 58 p.m.	Between 3rd and 2nd mag.	Bright	....	....
	10 19 p.m.	Larger than ♂, at opposition nearly = ♃.	Very bright with yellow tinge at its extinction; it commenced as a small star, increasing rapidly in brilliancy.	.... 	Rather slow.....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
rpendic. down due S., alt. when first seen 45°.	....	Highfield House Observatory.	A. S. H. Lowe, Esq.	Mr. Lowe's MS.
om midway between α and ξ Pegasi towards ε Pegasi.	....	Observatory, Beeston.	E. J. Lowe, Esq.	Ibid.
om 67 Pegasi towards ϑ Andromedæ.	....	Ibid..............	Id.	Ibid.
om above β Cassiopeiæ	....	Ibid..............	Id.	Ibid.
om 1° S. of ξ Bootis perpendic. down.	....	Ibid..............	Id.	Ibid.
e S.E. perpendic. down......	....	Ibid..............	Id.	Ibid.
om the direction of τ Cassiopeiæ starting from above α Andromedæ, passing down with a S. inclination and passing 1° N. of α Andromedæ.	....	Ibid..............	Id.	Ibid.
om γ Ursæ Majoris, half-way to Delphinus.	....	Castle Donington	Mr. W. H. Leeson, Esq.	Ibid.
om β Ursæ Minoris to ½° above Polaris.	....	Ibid..............	Id.	Ibid.
om β Cassiopeiæ to ε Lyræ...	....	Ibid..............	Id.	Ibid.
st seen at an altitude of about 40°, moved downwards nearly along a portion of a great circle, connecting the pole with the S.W. point of the horizon.	The above angles were estimated by the eye.	Rosebank House, Cambuslang, about 4 miles S.E. from Glasgow.	David Rankine, Esq.	MS. com.
om near α Cassiopeiæ towards α Andromedæ.	....	Victoria Park, London.	W. R. Birt, Esq.	MS. communicated to Prof. Powell. See App. No. 3.
dway between Polaris and α Persei towards Ursa Major.	This star appeared as if it just impinged on the earth's atmosphere.	Ibid..............	Id.	Ibid.
ross the same line about three-fourths of its length from Polaris and one-fourth from α Persei.	The path of this star sensibly inclined to that of the former, the two very similar in character.	Ibid..............	Id.	Ibid.
om Camelopardalis about 2° above or south of Polaris to the body Ursa Minor.	....	Ibid..............	Id.	Ibid.
Polaris, where it became extinguished. It shot from a point some distance below and to the east.	....	Ibid..............	Id.	Ibid.
om about midway between α Cassiopeiæ and α Persei towards the south, parallel with the horizon.	Globular; just previous to its extinction it appeared to bend towards the horizon, a common feature in this kind of falling star.	Ibid..............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1853.	h m s				
Aug. 8	10 28 p.m.	Small, 3rd mag.			
	10 38 p.m.	Between the 3rd and 2nd mag.	Brightest as it crossed the meridian, diminishing in brightness at either end of its course.	A very faint train	Very rapid
	10 46 p.m.	3rd mag.			
9	9 13 p.m.	2nd mag.			
	9 20 p.m.	3rd mag.			
	9 25 p.m.	5th mag.			
	9 43 p.m.	= ♃ ; it increased *rapidly* from a mere point.	Bright	Sparks	
	10 0 p.m.	5th mag.	Very faint		
	10 2 p.m.	Between 3rd and 2nd mag.		Train	
	10 9 p.m.	= Mars	Red		
	10 21 p.m.	3rd mag.			Rapid
	10 25 p.m.	2nd mag.	Bright		
	10 34 p.m.	2nd mag.	Bright		Rapid
	10 43 p.m.	3rd mag.			
	10 43 p.m.		Faint		
	10 49 p.m.	3rd mag.		Faint train	
	10 54 p.m.	1st mag.	Very bright	Faint train	

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
om the line joining Polaris and α Persei to the body of Ursa Major near α Ursæ Majoris.	....	Victoria Park, London.	W. R. Birt, Esq.	MS. communicated to Prof. Powell. See App. No. 3.
om Cassiopeia through Cepheus to the head of Draco.	....	Ibid..................	Id.	Ibid.
om the northern meridian towards α Ursæ Majoris an upward motion.	....	Ibid..................	Id.	Ibid.
om the tail of Ursa Major towards Arcturus.	....	Ibid..................	Id.	Ibid.
om Polaris to β and γ Ursæ Minoris.	....	Ibid..................	Id.	Ibid.
om β and γ Ursæ Minoris to ζ Ursæ Majoris.	....	Ibid..................	Id.	Ibid.
ear the line joining ε Cassiopeiæ and α Persei about 5° below ε Cassiopeiæ towards the star.	This star appeared as if almost approaching the earth and quickly separated into sparks.	Ibid..................	Id.	Ibid.
etween δ and ε Cassiopeiæ upwards.	....	Ibid..................	Id.	Ibid.
bout 2° below or north of Polaris towards Ursa Major.	....	Ibid..................	Id.	Ibid.
om Algol directly towards the horizon.	This meteor burst and separated into two portions, thus— 	Ibid..................	Id.	Ibid.
om Cassiopeia through Cepheus to η and θ Draconis.	....	Ibid..................	Id.	Ibid.
cross α and γ Ursæ Majoris to Canes Venatici.	....	Ibid..................	Id.	Ibid.
om γ Cassiopeiæ, between α and β Cassiopeiæ, towards Cygnus.	Serpentine path ...	Ibid..................	Id.	Ibid.
ust below α Persei downwards.	....	Ibid..................	Id.	Ibid.
rossed the line joining Cassiopeia and α Persei.	An instant after the last.	Ibid..................	Id.	Ibid.
Camelopardalis, about 10° below Polaris towards Ursa Major.	....	Ibid..................	Id.	Ibid.
om ζ Ursæ Majoris towards ε Bootis.	Curved path very low in the atmosphere.	Ibid..................	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1853.	h m s				
Aug. 9	11 2 p.m.	=Jupiter		Fine train	
	11 7 p.m.	3rd mag.	Faint		
	11 8 p.m.		Bright	Sparks only	
	11 12 p.m.	4th mag.	Faint		
	11 18 p.m.	3rd mag.			
	11 26 p.m.	4th mag., small			
	11 32 p.m.	3rd mag.			
	11 42 p.m.			Faint train	
Aug. 10	9 45 30	=3rd mag.	Blue	Train	2 seconds
	10 52 10	=1st mag.	Very bright	Train, 7 seconds	3 seconds
	10 59 50	=1st mag.	Very brilliant.	Train	2 seconds
	10 7	=3rd mag.	Blue		2 seconds
	10 18 31	=4th mag.	Blue		3 seconds
	10 22 30	=4th mag.	Blue		2 seconds
	10 36	=1st mag.	Very brilliant.	Train, 8 seconds	3 seconds
	From 10 5 to 11 5	55 meteors		One with train	
	From 10 30 till 12 0 p.m.	17 meteors were noticed, 3 or 4 were of 1st mag.			
	10 30 p.m.	1st mag. and as large as Jupiter.			
	10 28	=2nd mag.	Bluish	Streaks	Instantaneous
	10 29	=2nd mag.	Bluish	Streaks	Instantaneous

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
om a line joining Polaris and Capella, two-thirds from Polaris to Ursa Major.	Curved path lost behind the houses.	11 A Wellington Street, Victoria Park, London.	W. R. Birt, Esq.	MS. communicated to Prof. Powell. See App. No. 3.
om Polaris towards Capella to the east of the line joining them.	....	Ibid..............	Id.	Ibid.
oout midway on a line between Cassiopeia and Perseus towards a line joining Polaris and Capella.	....	Ibid..............	Id.	Ibid.
om about midway between Polaris and Capella towards Ursa Major.	....	Ibid..............	Id.	Ibid.
om the zenith, between Cygnus and Cepheus across the head of Draco to Bootes.	....	Ibid..............	Id.	Ibid.
om Polaris across η and θ Draconis towards Hercules.	....	Ibid..............	Id.	Ibid.
oout midway between Polaris and α Persei towards α Persei.	....	Ibid	Id.	Ibid.
oout half a degree under or north of Polaris to about the same distance under β Ursæ Minoris.	....	Ibid..............	Id.	Ibid.
om α Cassiopeiæ to near α Andromedæ.	....	Castle Donington	Mr. W. H. Leeson.	Mr. Lowe's MS.
om ζ Cygni to near Altair ...	Another at same instant, as if in continuation.	Ibid..............	Id.	Ibid.
om μ Lyræ perpendic. towards horizon about 15°.	....	Ibid..............	Id.	Ibid.
om η to κ Cygni	....	Ibid..............	Id.	Ibid.
om β Aquilæ to Scutum Sobieski.	....	Ibid..............	Id.	Ibid.
om α Andromedæ to near β Cassiopeiæ.	....	Ibid..............	Id.	Ibid.
om μ Pegasi to 3° below Delphinus.	2 others at same instant, nearly in same path.	Ibid..............	Id.	Ibid.
....	....	Haverhill........	W. W. Boreham, Esq.	MS. See App. No. 4.
ese 17 meteors were chiefly under Cassiopeia and between Urs. Maj. and Pegasus.	A greater number would have been noticed if there had been more observers.	Stone	Rev. J. B. Reade	Mr. Lowe's MS.
sappeared near α Persei...... N.B. It is probable that this eteor will have been noticed d observed at other stations.	It was accompanied with a distinct report on its disappearance.	Ibid..............	Id.	Ibid.
om o through α to i Aquilæ .	....	Beeston Observatory	E. J. Lowe, Esq.	Ibid.
rpendic. down with slight inclination to S. passing through α Pegasi.	....	Ibid..............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1853.	h m s				
Aug. 10	12 50	=2nd mag.	Bluish	Streaks	Instantaneous ....
	12 51	=2nd mag.	Bluish	Streaks	Instantaneous ...
	12 51 30...	=1st mag.	Bluish	Streak	0·2 second ......
	12 59	=4th mag.	Bluish	Streak	Instantaneous ...
	13 0 30...	=2nd mag.	Bluish	Train	Instantaneous ...
	13 1	=2nd mag.	Bluish	Train	Instantaneous ...
	13 1 20...	=3rd mag.	Bluish	Train	Instantaneous ...
	13 2	=3rd mag.	Bluish	Train	Instantaneous ...
	13 3	=5th mag.	Bluish	Train	Instantaneous ...
	13 3 30...	=3rd mag.	Bluish	Stream.........................	0·3 second .....
	13 10	=3rd mag.	Bluish	Tail	Instantaneous ...
	13 14	=1st mag. having increased from a point as it progressed.	Blue	Streak	0·3 second, dis peared at m brightness.
	13 15	=3rd mag.	Blue	Streak	Instantaneous ...
	13 19	=3rd mag.	Blue	Tail	Instantaneous ...
	13 22	=1st mag.	Blue	Tail	Instantaneous ...
	13 24	=2nd mag.	Blue	Tail	Instantaneous .
	13 30	....	....	....	....
11	9 15	=1st mag.	Blue	Tail	Instantaneous .

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
om 15′ N. of Capella through ϑ Aurigæ.	All meteors diverged from a point situated near β Cassiopeiæ. Those meteors near Cassiopeia much shorter tracts. All fell down except near Cassiopeia, where some were horizontal. From W. of Delphinus they inclined W., and from S. of Delphinus inclined to S. The meteors not so bright as usual. Many spurts of light, probably very distant meteors.	Beeston Observatory.	E. J. Lowe, Esq.	Mr. Lowe's MS.
om slightly S. of Polaris perpendic. down.	....	Ibid................	Id.	Ibid.
rough Vega towards μ Herculis.	....	Ibid................	Id.	Ibid.
rpendic. down from 1° W. of Polaris.	....	Ibid................	Id.	Ibid.
rough Vega towards μ Herculis.	....	Ibid................	Id.	Ibid.
om γ through δ Aquilæ	....	Ibid................	Id.	Ibid.
om γ Cygni towards β Cygni.	....	Ibid................	Id.	Ibid.
rpendic. down from 1° N. of γ Delphini.	....	Ibid................	Id.	Ibid.
rpendic. down through α passing W. of χ Cygni.	....	Ibid................	Id.	Ibid.
om χ to τ Cassiopeiæ.........	....	Ibid................	Id.	Ibid.
om η through 25 Pegasi......	....	Ibid................	Id.	Ibid.
om ο through μ Aquilæ	....	Ibid................	Id.	Ibid.
om 1° W. of α Delphini nearly perpendic. down inclining W.	....	Ibid................	Id.	Ibid.
me path as the last meteor .	....	Ibid................	Id.	Ibid.
om Vega through χ Lyræ ...	Much cloud, being nearly overcast until 10^h, and quite overcast after $13^h\ 45^m$.	Ibid................	Id.	Ibid.
me path as last meteor	....	Ibid................	Id.	Ibid.
ight flash in E. under clouds, probably a meteor.	....	Ibid................	Id.	Ibid.
rpendicular down inclining W., and passing 2° N. of ☾.	Most meteors gave point of divergence near β Cassiopeiæ, yet several showed another point near Polaris.	Ibid................	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1853.	h m s				
Aug. 11	10 10	=3rd mag.	Blue	Tail	Instantaneous
	11 2	=3rd mag.	Blue	Tail	Instantaneous
	12 10	=3rd mag.	Blue	Tail	Instantaneous
	12 14	=3rd mag.	Blue	Tail	Instantaneous
	12 19	Increased rapidly from 6th to 1st mag.	2ˢ, as bright as 1st mag. star, yellow.	Many streaks, being 30′ long and 10′ broad.	Streak remained f[…] 10 secs.
	12 19 15	=3rd mag.	Blue	Streak	Instantaneous
	12 19 30	=3rd mag.	Blue	Streak	Instantaneous
	12 22	=3rd mag.	Blue	Streak	Instantaneous
	12 25	=3rd mag.	Blue	Streak	Instantaneous
	12 28	=4th mag.	Blue	Streak	Instantaneous
	12 28 2	=4th mag.	Blue	Streak	Instantaneous
	12 28 3	=4th mag.	Blue	Streak	Instantaneous
	12 33	=2nd mag.	Blue	Streak	Instantaneous
	12 34	=2nd mag.	Blue	Streak	Instantaneous
	12 41	=2nd mag.	Blue	Streak	Instantaneous
	12 41 15	=2nd mag.	Blue	Streak	Instantaneous
12	10 12 5 p.m.	4th mag.	Yellow		Moderate
	11 4 p.m.	1st mag.	Red	Short train	Moderate
	12 0				
23	9 40	=♃	=♃, blue	Separate stars	1·2 sec.
	9 41 30	=1st mag. star	Blue	Separate stars	0·7 sec.
28	10 25 p.m.	=♃	Bright bluish	Train	Rapid

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
erpendicular down through ϑ Cassiopeiæ.	....	Beeston	E. J. Lowe, Esq.	Mr. Lowe's MS.
ame path as last meteor	....	Ibid.	Id.	Ibid.
om ξ Pegasi through η Aquarii.	....	Ibid.	Id.	Ibid.
erpendicular down from β Cassiopeiæ.	No brilliant meteors	Ibid.	Id.	Ibid.
om ι Ursæ Majoris to about No. 11 Canis Venatici: appearance of streak left in the sky.		Ibid.	Id.	Ibid.
erpendicular down from Polaris.	... .	Ibid.	Id.	Ibid.
om ν Draconis to τ Herculis..	... .	Ibid.	Id.	Ibid.
om χ Draconis towards δ Ursæ Majoris.	....	Ibid.	Id.	Ibid.
om ν through φ Ursæ Majoris.	....	Ibid.	Id.	Ibid.
om η Draconis, moved 5° in direction of β Bootis.	....	Ibid.	Id.	Ibid.
same track	....	Ibid.	Id.	Ibid.
third in same track	....	Ibid.	Id.	Ibid.
om ϵ to φ Cassiopeiæ	....	Ibid.	Id.	Ibid.
om 1° N., and 1° above α Persei horizontally towards β Trianguli.	....	Ibid.	Id.	Ibid.
om midway between ϵ and α Aurigæ through λ Aurigæ.	....	Ibid.	Id.	Ibid.
om direction of Polaris, passing across Capella.	....	Ibid.	Id.	Ibid.
rossed α Cephei.	....	Stone	Rev. J. B. Reade	Ibid.
om 1° W. of μ Andromedæ to λ Andromedæ.	It rose upwards, and seemed to describe an orbit convex to the earth.	Ibid.	F. V. Fasel, Esq.	Ibid.
everal small meteors	Much cloud	Beeston Observatory.	E. J. Lowe, Esq.	Ibid.
ell slowly perpendicular down, passing *exactly* across Jupiter 	This was an assemblage of separate bodies, constantly becoming larger and brighter, disappearing at maximum brightness at about 3° immediately beneath Jupiter.	Ibid.	Id.	Ibid.
ell slowly perpendicular down, passing nearly across ζ Ursæ Majoris.	Much cloud and haze.	Ibid.	Id.	Ibid.
iagonally across Ursa Major, from α to γ, a little below them.	....	Stanhope Street, Hyde Park.	Miss C. E. Powell	Verbal statement.

APPENDIX.

No. 1.—Extract of two letters to Professor Powell from W. J. Macquorn Rankine, Esq., enclosing one from Dr. Myrtle.

"59 St. Vincent Street, Glasgow, June 6, 1853.

"Sir,—Enclosed I beg leave to transmit to you a register of three luminous meteors observed on the 12th of December 1852; and also a register of one observed in 1839, which I have prepared from some sketches and memoranda that had lain forgotten amongst other papers until now. It is evident that the latter was an object near the surface of the earth, and indeed, less than a quarter of a mile from the place of observation.

"The sketch is as nearly as possible a fac-simile of a pen-and-ink sketch made by one of the observers on the same morning, which I have now in my possession.

"I am, &c.,
"W. J. Macquorn Rankine."

"59 St. Vincent Street, Glasgow, 6th July, 1853.

"Dear Sir,—Enclosed I beg leave to send you Dr. Myrtle's account of the luminous object seen near Edinburgh on the 8th November, 1839. .... It is difficult to determine the real path of the object. I formerly came to the conclusion, that it must have moved nearly in a parabola, situated in a plane passing through Gibraltar House, and must have gone almost directly over the house; but the appearance described by Dr. Myrtle, of an object moving almost vertically downwards, is inconsistent with this supposition.

"With respect to the fact of its having seemed to Dr. Myrtle to disappear behind Salisbury Crags, I may mention, that the ridge on which Gibraltar House stands, as shown in the enclosed plan, might readily be confounded with part of Salisbury Crags when seen from the westward during the night.

"The apparent size of the object, as seen by Dr. Myrtle, viz. somewhat larger than Venus, compared with its apparent size as seen from Gibraltar House (nearly twice the diameter of the moon), shows that it must have been very near the latter point.

"I am, &c.,
"W. J. Macquorn Rankine."

"*The Rev. Professor Powell.*"

Enclosure.—Extract of a letter from Dr. Myrtle to Mr. Rankine.

"Edinburgh, 24 Rutland Street, July 5th, 1853.

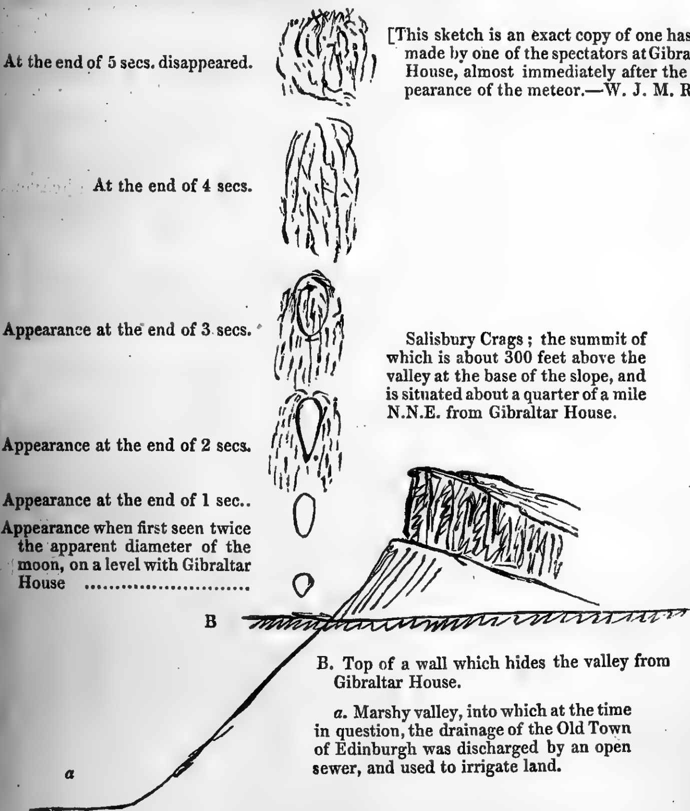
"I was returning about one o'clock in the morning from Newington, when on looking towards Salisbury Crags I observed a bright luminous meteor, to appearance more than twice the altitude of the Crags, falling in a somewhat perpendicular direction with considerable velocity towards the Queen's Park and the valley eastward from the Crags: it had for a short time, though somewhat larger, very much the colour and appearance of the planet Venus, and I really took it for a planet till I observed its motion: when it had fallen to about the third part of its course as observed by me, it suddenly began to emit sparks, which was continued throughout the remainder of its course, decreased in size, and at last disappeared behind the Crags.

"John Young Myrtle."

"*W. J. M. Rankine, Esq.*"

Mr. Rankine's Sketch of the appearance of the Meteor, Nov. 8, 1839.

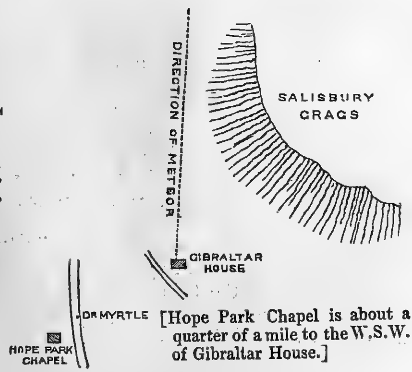
[This sketch is an exact copy of one hastily made by one of the spectators at Gibraltar House, almost immediately after the appearance of the meteor.—W. J. M. R.]



B. Top of a wall which hides the valley from Gibraltar House.

a. Marshy valley, into which at the time in question, the drainage of the Old Town of Edinburgh was discharged by an open sewer, and used to irrigate land.

Sketch of ground plan.

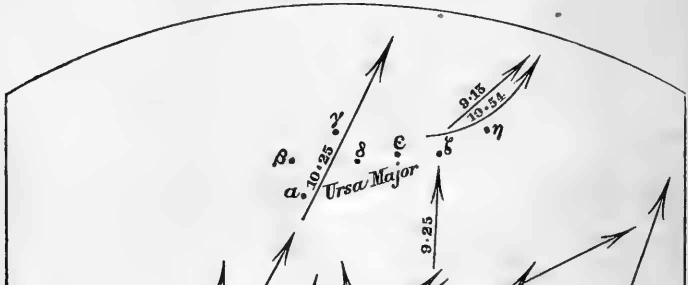


[Hope Park Chapel is about a quarter of a mile to the W.S.W. of Gibraltar House.]

No. 3.—Projection of the paths of 22 shooting stars, observed between 9 and 12 P.M., of the 9th of August 1853, at 11A Wellington Street, Victoria Park, London.

On inspecting the projections, it will be seen that the *line* of divergence extended from the Pole towards the constellation Cassiopea, and between this constellation and Perseus; all the paths in the neighbourhood of these constellations were *short*. The general sweep *from* Cassiopea and Perseus is across the Pole to Ursa Major and Bootes, which agrees with the passage of the Earth through a group of cosmical bodies, the observer commanding a view of those *on the left of the Earth's path*; those in that part of the heavens towards which the Earth was advancing, were seen, as might be expected, to move in different directions.—W. R. Birt.

Mr. Birt's diagram of meteors, August 9, 1853.



No. 4.—Letter from W. W. Boreham, Esq. to Professor Powell.

"Haverhill, Sept. 1, 1853.

"Dear Sir,—I send a diagram of the approximate paths of 55 meteors seen in one hour on the evening of the 10th of August; there was nothing remarkable seen during that time either by myself or Mrs. Boreham, except perhaps that the meteor marked * left a train of light which was visible for

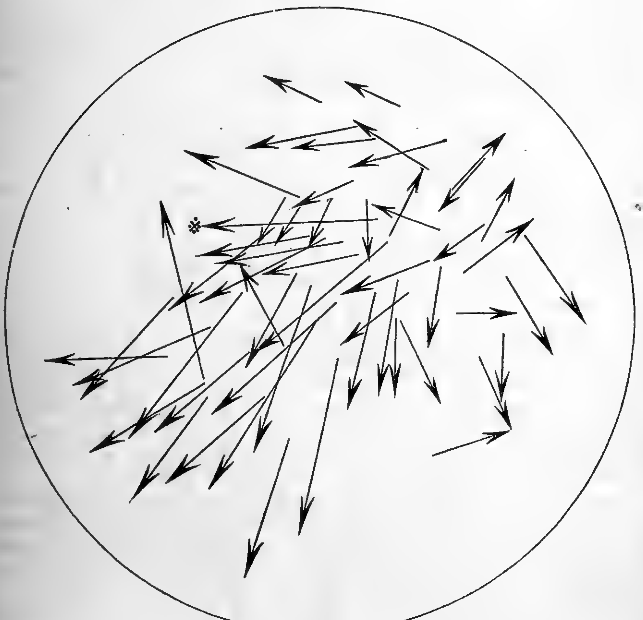
30 or 40 seconds, at $10^h\ 40^m$; and that it faded away at both ends some time before it became invisible in the middle.

"I am, dear Sir, yours most truly,
"W. W. BOREHAM."

"*Prof. Baden Powell, &c. &c.*"

Mr. Boreham's diagram of meteors, August 10, 1853.

North.

W.  E.

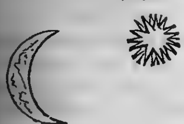
South.

55 meteors, Aug. 10, 1853, from $10^h\ 5^m$ to $11^h\ 5^m$: the right ascension of the zenith$=19^h\ 52^m$.

No. 2.—Extract of a letter from Lord Wrottesley to Professor Powell, October 12, 1852.

". . . . On finding that Venus occupied nearly the position assigned to the meteor, I at first felt tolerably well satisfied that Venus was the object seen; but then there can be little doubt that it must have presented very extraordinary appearances to excite so much notice; besides, (G. W.'s) account is inconsistent with an ordinary appearance, however brightly it may have shone.

Meteor.



Again, the drawing of (W. H.) (annexed) adds to the difficulty, and makes me doubt whether it could be Venus at all. It appears by the Nautical Almanac, that the time specified, or $16\frac{1}{2}^h$ on the morning of the 10th, astronomically,

☽'s $Æ = 8^h\ 59^m$ D$=+20°\ 15'$

♀ $Æ = 8^h\ 22^m$ D$=+15°\ 44'$.

Assuming these quantities, I find roughly by a celestial globe, that the two were 10° apart, or a distance about equal to that between α and δ, the two upper stars of the Great Bear, ... which does not at all accord with the drawing, or with the description of J. C. H. .... I think there is little doubt that the time was later than that mentioned, ... for otherwise the moon's altitude would have been much less than that mentioned. .... At the time mentioned, the moon had only about 12° of altitude. .... There can be little doubt also, that all the observers saw Venus; and I think the descriptions may be reconciled with each other, and with the fact that it was really a meteor, by supposing that when the meteor vanished they saw Venus and took it for the meteor they had been observing; of course, however, there is great doubt about this, and the balance of probability is in favour perhaps of Venus having been the object seen, with some peculiar halo surrounding her; but, as I said, the drawing is decidedly opposed to this supposition. ...."

On the Physical Features of the Humber.

By James Oldham, *Esq., Civil Engineer, Hull, M.I.C.E.*

[A communication ordered to be printed among the Reports.]

In consenting to prepare a paper to be read before the British Association, I have felt some degree of hesitation, believing that there are many gentlemen who, from their learning, research, and leisure are much better qualified to do justice to the subject than myself. However, as a paper of this description may be a text or theme on which to ground a discussion, and thereby call forth the views and opinions of others, I the more willingly venture to submit my remarks.

The Humber is properly an estuary or arm of the sea, in which the tide reciprocates, and forms the mouth of some extensive rivers. Its length is about 40 miles; 9 miles of which at its entrance from the sea, average about 6 miles in width, and the remaining 31 miles a little more than 2 miles. It contains a total tidal area of about 80,000 acres.

From Hull to the sea, the direction is about S.E., and from Hull inland its course is about W.

For the purposes of navigation, the Humber possesses great advantages; and notwithstanding the extensive sand-banks and shoals, the main channel as high as Hull is good and capable of admitting ships of the largest class. The depth between Hull and the sea at low water, spring-tides, is from 10 to about 4 fathoms. Above Hull, to the confluence of the Trent and Ouse, the depth varies from 4 to 1 fathom.

The spring-tides rise about 22 feet, and neap-tides 15 feet, on an average; and according to a note on Mr. Hall's Chart of the Humber, the former run at the rate of 4 to 5 knots per hour, and the latter from $2\frac{1}{2}$ to 3 knots per hour.

I do not intend to touch upon the chemical properties of the water of the Humber, as that subject will be treated by a gentleman well qualified to do it justice; but I may remark, that the water of the Humber is charged to a great density with the alluvial mud of its shores, even to saturation. This brings me to the geological formation of the Vale of the Humber, which consists of clay, silt, chalk, lias, and gravel. The clay and silt formations prevail to the greatest extent, being found on the whole of the shores, except at Hessle and Barton, where the chalk appears*; at Brough and Whitton, where we have the lias; and at Paull, where a fine bed of gravel exists. Where the alluvial formation exists on the shores of the Humber, it also extends, more or less, for several miles inland; and from observations I have made, I find that the average level of the surface of the shores of the Humber is about the average surface rise of all tides, and that the average fall of tides below the surface of the land is about 17 feet.

I may remark here, that we find land in the Vale of the Humber much lower than that immediately adjoining its shores; for instance, the Sutton and Waghen Carrs, where changes have taken place very different to any that we find in other low districts. Being engaged in drainage works on these Carrs, I had an opportunity more particularly of noticing the peculiarities of the district. The upper surface is peat, to the depth of 2 or 3 feet; and below this, to a considerable depth, occurs a dense mass of trees of almost every description, but particularly alders, yews, and other varieties, which it is impossible could have grown and flourished in swamps. Some were erect as when growing, but the greater portion were lying in every possible position. Some were in so perfectly sound a condition, as to be capable of being converted into walking-sticks, while others fell to dust on being exposed to the air. The only conclusion that I can come to is, that this district was once high land, but by some great convulsion of nature, the whole had settled down to its present level, and for a long period of time formed an extensive lake. These Carrs were not thoroughly drained until 1835. That the tides of the Humber extended over a much greater surface at one period of time than they do now, there is not a doubt; for during the operation of cutting some of our large drains, which discharge into the Humber, the tidal deposits were very obvious; and I would particularly allude to the Holderness drain, some of the works of which I have just referred to, and which discharges itself into the Humber at Marfleet. The section in this drain was most remarkable in illustration of the fact.

The Humber is not only important as a navigation, but it is also the great outlet or natural drain of a very extensive portion of England, receiving the waters of the Trent, the Ouse, and other rivers and streams; and the low point to which the tide falls, gives facilities for the perfect and natural drainage of nearly all the land in its vicinity; for we have comparatively little land the surface of which is not above low-water mark; and I can state with confidence, that were the drains of sufficient capacity, and their beds and sluices placed low enough, we have no lands in the neighbourhood of the Humber, or any part of the East Riding of Yorkshire, that might not be perfectly drained. At the present moment there are districts of many thousands of acres, within a few miles of Hull, utterly disgraceful to the present state of science and agriculture. I need only name the neighbourhood of the Market Weighton Canal, and the Vale of the Foulney, which might be perfectly drained at a comparatively small cost per acre.

Great changes have taken place, and are now taking place on the shores of the Humber. In some districts large tracts of land have been encroached upon by the tide, and have totally disappeared, whi st in other parts considerable accretions are forming.

* The chalk at Hessle appears above high-water. At the entrance of the Humber Dock at Hull it is 110 feet below the surface. At the "Cato" Mill, a quarter of a mile north of the entrance of the old dock, it is about 64 feet below the surface. At Mr. Hodge's mill, a mile north-east from the north bridge on the Holderness road, and three-quarters of a mile from the bank of the Humber, it is 84 feet below the surface; and at Sunk Island Church it is 110 feet below the surface. A section of a boring made at this place by Easton and Amos in 184[illegible] is shown in Pl. II.

First, as to the waste of land. It is difficult now to form an idea of what was once the greatest extent of the tidal waters of the Humber; but no doubt they flowed over districts at present in fertile cultivation, forming deep bays only limited by hills and rising ground; and it is equally difficult to tell what have been the narrowest limits of its channel. We have living witnesses to testify of a much more contracted channel than now exists, and tradition, if not maps, can verify still greater changes.

Commencing at A on the Lincolnshire side at the confluence of the Trent, and proceeding to Whitton at B, the land is alluvial, and easily affected by the action of the water, and therefore subject to continual change; at one time accretions of hundreds of acres forming in a few months, and then being as speedily washed away. Whitton is, for some short distance, protected by the lias formation, and therefore is not liable to rapid change, except that of deposits of sand-banks along its frontage, so as occasionally to prevent entirely the approach of vessels to its landing. From a point near to Whitton, to another a little to the east of Ferriby at C, including a distance of about six miles of coast, very extensive ravages have taken place; and in my own recollection and knowledge of the shore, and from facts I have obtained, not less than 200 acres have been lost during the last forty or fifty years, so that the line of coast at this locality forms a considerable bay, but filled in, in some measure, by an island, to which I shall have again to refer. I met with one individual at Wintringham, who informed me, that in one field of 14 acres he had constructed, within the space of about twenty years, seven new banks, and only about $3\frac{1}{2}$ acres now remain. Another field, of about 17 acres, is now reduced to about 2 acres. It is a tradition, that about 100 years ago persons could make themselves heard and understood, between the ancient Roman Ferry at Brough and the Ferry opposite. It is now more than a mile from Brough to the nearest point on the opposite side. Of course, water being a better conductor of sound than land, some allowance should be made on that account. At a little more than a mile east of Ferriby Sluice, at D, the chalk of the Lincolnshire Wolds appears, and for a short distance protects the foreshore. Here are two very extensive quarries for procuring chalk, where it is shipped for the purpose of being used for protecting the banks of the Humber, as well as for forming the foundations of roads and other works. From the Barton chalk quarry, throughout the whole of the remaining line of the Lincolnshire coast, it is, with scarcely an exception, alluvial, and liable to, and undergoing changes, except where protected by engineering works: and that part of the coast of the Humber is not without its massive and magnificent works of art; as at Ferriby Sluice, New Holland, and Grimsby.

Having thus noticed at something like railway speed the Lincolnshire coast of the Humber, from the Trent to the sea, we will now go back to the confluence of the Ouse, and survey in like manner the Yorkshire shore to the sea at Spurn.

Starting, then, at Faxfleet at E, we pass the entrance to the Market Weighton Canal, Bromfleet, &c., to Brough at F, a distance of about $5\frac{1}{2}$ miles, the line of coast forming a rather deep bay to the north. The formation is rich alluvial soil, and is easily washed away by the action of the tide and the somewhat rough seas of the Humber; and during the last sixty or seventy years, it is well known that a large area of land has been lost in this district, and there is now great danger of still more serious destruction, as the sea-banks are all but undermined. For many years an island existed along nearly the whole extent of the bay, to which I shall have to refer hereafter. The land for many miles adjacent to the Market Weighton Canal is remarkable for its fine beds of clay, having a depth of from 30 to 40 feet, with scarcely a pebble, or other foreign matter of any kind, to be found. Near the surface is a stratum, varying from 5 to 8 feet in thickness, from which the beautiful white stock bricks are made, and which are now becoming so celebrated. Clay suitable for white bricks is found in other parts of England, but I believe neither so extensive in quantity nor so fine in quality; and shortly the clay of this district will be more fully developed by the introduction, through an enterprising gentleman, of Beart's patent process of brick-making. At Brough, the old Roman Ferry, we have the oolite and lias, which for a short distance more effectually repel the action of the water, and thereby preserve that part of the Yorkshire coast, and give to it somewhat of a projecting form; and for the next 4 miles, although there is the light alluvial formation, yet generally the coast is of a harder and more gravelly character, and, owing to a somewhat better natural protection, it suffers less than almost any other part of the Humber, except where we have rock formations. At G, at Hessle, we find along a small extent, the white chalk, similar to that on the opposite coast of Lincolnshire. From the Hessle chalk quarry to H at Hull, a distance of about 5 miles, we have the low alluvial coast, and, like the rest, subject more or less to waste. Along this district, in the year 1357, an order was made to raise the road from Hull to Anlaby, as a tide of unusual height had taken place. I quote from Thompson's 'Ocellum Promontorium' the following remarks:—

"In the year 1357 (30th Edward III.), the king, being informed that the tides of the river of Humber and Hull did flow higher by 4 feet than they had wont to do, by which the road and the lands between Hull and Anlaby were overflowed and consumed, directed an old ditch to be cleansed and made wider, and from thence a new ditch to be made of 24 feet in breadth, to extend through the pasture of Miton unto the town of Hull, by which ditches the said waters at every tide might pass to and fro; and he directed that the said road should be made much higher..... From this statement by Dugdale, founded on records of undoubted authority, to which he refers, it appears probable that the waters of the Humber at that time passed *to* and *fro*, over the lowlands, between Hull and Anlaby. It is certain, however, that the ditches were left open to the Humber, and that the waters at every tide passed to and fro in them."

"This æra deserves to be remembered, on account of the extraordinary rise of 4 feet in the flowing of the tides of the Humber. The destruction of the banks" (if there were any), "and the consequent overflowing and damage of the lands, for many miles on both sides of the Humber, in Lincolnshire and Yorkshire, must have caused great distress in the country. It does not appear that any special record is left of the sufferings of the inhabitants of the adjacent districts; but if the tides in the Humber were to rise at the present time 4 feet higher than usual, and continue to flow to that height, such persons as live on the low lands adjoining the Humber may form some judgment of the difficulties which they might find in saving their lives and their property." This clearly shows that at that time there were no banks to this part of the Humber, and that the high or spring-tides flowed freely over the marshes.

It is not necessary that I should enter into any statement of the noble works of the Hull Dock Company, as the members of the Association have had the opportunity of inspecting them. These act more or less as a defence against the ravages of the tide, and have also been the means of a very considerable accretion to the frontage of the port.

Proceeding onwards, we have for a distance of about 6 miles low alluvial land (protected in a very inefficient manner from the violence of the waves, which along this portion of the coast concentrate in great force), till we arrive at I, at Paull; and for a short length of coast, we find the excellent gravel frontage of High Paull giving again a firmer defence, and producing a prominence to the line of coast, thus acting very much as a breakwater for the softer land in its immediate vicinity. From Paull to the south-eastern extremity of Sunk Island at J, and thence to the north-eastern point of the island at K, comprising a distance of about 12 miles, the whole is a fine alluvial soil, and of comparatively new formation, but still subject to changes and damage by the tide, and in some places considerable loss has occurred.

The only remaining part of the coast of the Humber is by Welwick, Weeton, Skeffling, and Kilnsea, and thence by the long neck or promontory to the Spurn at L, being about 11 miles. From Welwick to Kilnsea, the coast under some circumstances of wind and tide is much exposed and damaged, and the banks are kept in repair at considerable expense. The neck of land from Kilnsea to the Spurn Head is exposed to the fury of the North Sea on the one side, and to the action of the Humber on the other side, and between the two is suffering materially, and will of necessity soon be entirely swept away, unless works of importance and efficiency are carried out. It would be out of place in this paper to enter into a description of engineering works already executed, or which may be required for the maintenance of so important a barrier; and instead of grants of tens, hundreds of thousands should be made, or to a certainty the whole of the Spurn Head will be swept away, and that speedily. Should there once be a low-water channel formed through the neck (which was very nearly the case a short time ago), I will not undertake to say what evil effect would follow to the navigation of the Humber, and the valuable tracts of land on its shores; and there is no doubt, that were an important change of this nature to take place, such as I have described, others perhaps equally disastrous would follow.

I now proceed to remark upon the islands, accretions, and deposits, and the changes that are continually taking place in the channels of the Humber. I shall commence at the upper or western extremity, and notice the principal accumulations as I pass down towards the sea.

For many years an island or mud-bank existed in the deep bay between Brough and the entrance to the Market Weighton Canal, between E and F, about 2 miles in length, and of considerable width, having a large portion of its surface covered with marine or salt-water grass, and leaving between the island and the Yorkshire shore a navigable channel for river craft at high water, called the Broomfleet Hope. For some years I had frequently noticed this island, and had devised a plan for attaching it to the main land, and silting up the channel, and by an embankment to shut out the tide, and thereby secure to the Crown a valuable tract of land. I reported the existence of this island to the Commissioners of Her Majesty's Woods, &c., and received directions, in conjunction with Mr. Thomas Page, the engineer, to examine and report thereon. On the 21st of August 1846 we proceeded to inspect the locality; but on our arrival we found that a great change had taken place, and that the island was fast disappearing. Mr. Leaper, a farmer living near to the island, informed us that during the last four months (prior to that time) 100 acres of the grass, or best part of the island, had disappeared, and that only about 30 acres remained. He also informed us that formerly persons were in the habit of driving cattle across the channel at low water to graze on the island; but when we visited the place, we found 27 feet in the channel at low water. In a very short time after this the whole of the island had disappeared, and had formed itself into two great masses in other parts of the Humber, one a little above Hessle, and the other at or along the foreshore at Whitton. Since then the whole of the Whitton portion has moved, and is forming on the old site of the island just described.

The next accumulation I have to name is the island formed on "Ferriby Sand or Old Warp," on the Lincolnshire side, a little above Ferriby Sluice. About the year 1820, I believe, no part of the island had appeared above ordinary tides; but soon after that time the island formed rapidly, and about thirteen years ago a person of the name of Read, finding it in a fit state to be embanked, (that is, the vegetation had so far progressed as to present such a surface of available land as to make it worth the expense of shutting out the high tides which then overflowed the surface) applied to the Commissioners of Woods, &c. for a lease to rent and occupy the island, and from that time to the present it has been under agricultural management. The surface within the embankment contains about 80 acres, but there is beyond the banks more than double that quantity, on which cattle can graze at low water. From the time the island assumed its present state, or rather its climax of magnitude, a very deep channel existed between it and the Lincolnshire coast, which was generally used by river steamers coming down at low water; and during all this time the current has impinged with great severity on nearly the whole of the coast from Wintringham to South Ferriby, causing a serious loss to Lord Carrington, Sir John Nelthorpe, and others. Here, again, changes are going on, and instead of the deep channel on the south of the island, the current has taken a direction from about Brough to Ferriby on the north side of the island, leaving the south channel comparatively shallow; and I am also sorry to add, considerable loss is taking place to the east end and north side of the foreshore of the island, and I shall not be much surprised if, before very long, the whole island should take its departure.

The upper part of the Humber is liable to and experiences great changes, both as regards the sand-banks and the channels; but as we descend and approach Hull, and below Hull towards the sea, we find fewer changes, and less liability to the sand-banks and channels shifting, and we have no accretions of importance on either side until we have passed High Paull; and the first I have to notice in order is what was formerly called Cherrycum Sand, but now Cherry Cobb Sand, about 5½ miles in length, and varying from about half a mile to three-quarters of a mile in width. This tract of land, which contains about 1800 acres, was embanked from the Humber about the year 1770, and is the property of Sir C. A. Constable, Bart., and the Corporation of the Sons of the Clergy. To the east of this lies the valuable estate of Sunk Island, the property of the Crown, containing about 7000 acres. It has a line of coast towards the Humber of about 6½ miles, extending from Stone Creek at M, to what is termed the North Channel at K. The first, or most early account we have of Sunk Island, is, I believe, at the time of Charles I., when it contained about 7 acres, and was then a mile and a half from the Yorkshire coast, having a navigable channel between it and the main land, through which ships of considerable burthen could pass. The earliest map showing Sunk Island is the one by Captain Greenvile Collins, Hydrographer to His Majesty, in his work called 'Great Britain's Coasting Pilot,' surveyed by order of Charles II.

Immediately after this period we find the island rapidly to increase, and I shall here make an extract from a Report made by the Commissioners of Woods and Forests a few years ago, which is as follows:—"This estate has been gradually formed by the accretion of the warp or soil deposited by the River Humber. It was first granted on lease, on the 18th of December, 1668, to Anthony Gilby, Esq., for a term of thirty-one years, at a rent of £5 per annum, when it was described as containing 3500 acres of drowned ground*," (that is, land over which the tide generally flowed,) "and a stipulation was inserted in the lease for the embankment by the lessee of 100 acres or more, within the first ten years of the term; but the difficulties attending the undertaking were so great, and the expense so heavy, that in the year 1675 the lessee presented a petition to His Majesty, stating his inability to proceed with the same (having then succeeded in embanking not more than 20 acres), unless he should have a grant made to him of the Crown's reversionary interest in the property, which fortunately was not complied with; but it was thought reasonable under the circumstances to accept a surrender of the lease, and to extend by a new grant the terms to ninety-nine years, at the same rent. Under that lease considerable progress was made in the embankment, particularly by the exertions of Mr. William Gilby, a descendant of the original lessee; as it appears by a survey that had been made of the estate in the year 1744, that 1500 acres had been embanked, and that the estate was divided out into farms. In the year 1755 a third lease of the estate was granted, on payment of a fine of £1050, at the old rent of £5; and in 1771 a fourth lease was granted to Mrs. Margaret Gilby, for a term expiring on the 15th of March, 1802, on payment of a further fine of £1550, and at a rent of £100 per annum. Some time before the expiration of the last-mentioned lease, a survey of the estate was made by order of the late Surveyor-General of Crown Lands, when it appeared that the quantity of land then embanked was only 1561 a. 0 r. 14 p., no addition having been made since the year 1744 to the quantity brought into cultivation; but the surveyor reported that above 2700 acres of new ground were fit for embankment, the expense of which was estimated to amount to £8940 18*s*. He certified at the same time, that when the work should be completed, the property would be worth about £3400 per annum; and it was finally agreed that the estate should be granted to the Rev. John Lonsdale and others, in trust for the representatives of the original lessees, subject to a stipulation on their part for the embankment, at their own expense, of the new ground, containing 2700 acres, above referred to (which was estimated to cost about £10,000), for a term of thirty-one years from the 5th of April, 1802, at a rent of £704 2*s*. 6*d*. for the first year of the term, which lease expired at Lady-day 1833. The Commissioners and the old lessees not agreeing on a new lease, an arrangement was made with the then tenants or under-lessees to become separate lessees under the Crown." The Report goes on to say, that "On the survey made of the estate in 1833, it was certified that the land in actual cultivation contained no less than 5929 a. 1 r. 13 p. of land of excellent quality, then divided into fifteen farms, beside some small holdings by cottagers and others. It is believed that further extensive embankments may shortly be undertaken with success."

Without quoting further from the Report, I will briefly state that a further embankment has taken place in 1850, under my direction as engineer to the Commissioners of Her Majesty's Woods and Forests, of nearly 700 acres of most excellent land; so that now we have altogether of land within the banks, secured from the tides, and also available grass beyond the banks, little less than 7000 acres, and a prospect of still further increase.

During the last few years great improvements have been made on the island, in constructing roads, drains, &c. The land is of the most valuable kind for agricultural purposes, and requires very little manure for many

* Seven acres of which only was then embanked.

years after it is embanked. Before dismissing the subject of Sunk Island, I would make a remark on the new accretions. When the land, or rather mud-bank, has nearly reached the usual surface elevation, the first vegetable life it exhibits is that of samphire, then of a very thin wiry grass, and after this, some other varieties of marine grass; and when the surface is thus covered with vegetable life, the land may at once be embanked; but if it is enclosed from the tide before it obtains a green carpet, it may be twenty years before it is of much value for agriculture, for scarcely anything will grow upon it. There is another feature of interest, particularly to agriculturists, which I will take the liberty of naming,—I refer to the productiveness of accretions in this locality, viz. that within a very few years after the land has been embanked, a natural and luxuriant covering of white clover makes its appearance, giving an undoubted proof of the richness and capability of the soil.

In addition to Cherry Cobb Sand and Sunk Island, about 400 acres of new accretions have been added to Patrington, and a considerable portion to Ottringham, Welwick, and other places in the immediate neighbourhood; and though I have not been able to ascertain the exact quantity added to those places, I know it to be considerable, so that in round numbers we have an increase between the year 1668 and 1850, when the last embankment was made at Sunk Island, of about 10,000 acres, accumulated between Paull and the Spurn. It is a question, Where does it come from? Some are of opinion that it is brought into the Humber by the flood-tide, being the soil washed down by the sea along the Holderness coast; while others are equally confident that the soil from the sea-coast never enters the Humber, but that it is brought down from the shores of the Humber itself. From the best observations I have been able to make, I find that the deposit does not take place either at the flood or at the ebb-tide, or yet at any time when the water is in motion; but only at high-water, when it is in a quiescent state, and the quantity left is just in proportion to the depth of the tide at the time. Now, if the deposit be brought down the river, the only quiescent state it could have when so brought down, would be at the turn of the tide at low water, and therefore no accumulation could take place such as we have been describing, at least from that direction; for immediately the current begins to form with the flood, the whole of the loose deposit is again set in motion.

Taking, therefore, Sunk Island as the point for consideration at the time of high water of spring-tides, where is it likely the mud could come from which is found in suspension above the surface of the land? We have seen that the ebb could not deposit it, because of the current and the lowness of the surface of the water; then finding that the deposit does take place, and can only take place at high water, if it does not come from the sea, whence can it come? Somewhat further to illustrate this theory, I will make one other observation. I have already shown that the accretions of Sunk Island and the immediate vicinity amount to about 10,000 acres. Now, according to the statement made in the valuable publication by Professor Phillips, 'On the Rivers, Mountains, and Sea Coast of Yorkshire,' $2\frac{1}{4}$ yards on an average are lost by the incursion of the sea annually, between the Spurn and Bridlington; and this I fully believe. I have during the present year tested the waste at Hornsea, and found that during the last forty-four years the average loss was 7 feet 1 inch and three-tenths. Taking the length of coast so acted upon at 40 miles, we have a loss during the 182 years prior to 1850 of upwards of 6000 acres; and making the allowance due to the difference in cubic contents, the cliff along the sea coast being much higher than the depth of the bed of the Humber, where the Sunk Island accretion has taken place, the 10,000 acres' gain within the Humber will very fairly account for the loss of 6000 acres on the sea coast. If, therefore, the great accretions of Sunk Island and its immediate neighbourhood are not formed by the loss of the land on the shores of the Humber, what becomes of the loss from the foreshores of the Humber thus washed away? My answer is, that a large amount of it may pass up the rivers Trent, Ouse, Don, &c., and find its way on to the extensive tracts of land so wonderfully improved of late years by what is termed "warping," *i.e.* by the process of admitting the tidal water by means of sluices on to the surface of the land, carrying with it a heavy charge of mud, which on the turn of tide is left on the land. By this process the most worthless land has been rendered the most fertile and valuable. When therefore we take into account that tens of thousands of acres have been thus improved by an average depth of 2 or 3 feet of this rich matter, the question of where does the lost land of the Humber go to is in some measure answered. I may mention that I have known land put under the process of warping, on which, in about two and a half years, an average depth of deposit of 3 feet has taken place; and within a year or two after the tides have been shut out, the land is brought into tillage, and crops of corn growing. By this process, thousands of acres of extensive swamps in the Vale of the Humber might, at a comparatively small cost, become valuable and profitable.

I have only now briefly to notice the currents and channels of the Humber; and as I have already stated that the principal changes taking place in the mud and sand-banks are above Hull, so also, and as a matter of course, is it with the currents and channels, and so rapid and frequent are they, that it can scarcely be told twenty-four hours beforehand where the channel may be. Below Hull the currents and channels are more fixed and steady, and it is only occasionally that any material change occurs. It may not prove uninteresting for a moment to trace the direction of the current, as it more generally proceeds *downward*.

The streams of the Trent and Ouse unite above Faxfleet Ness, having come in contact at about right angles with each other, and there being little difference in the volume and force of each, their united force would naturally produce an angle of about 45 degrees; and so we find it to be the case. The greater bulk of the stream passes along in front of Whitton, and finding a hard surface, can make very little impression on the beach,—continues in the direction of Brough, and again meeting with the same hard formation (lias), is pitched off in the direction of Ferriby, and again is repelled by the chalk of that district in the direction of Hessle, where meeting with another hard face it is again diverted, and proceeds in the direction of a little below Barton. Leaving on its north what is termed the Hessle middle, and passing New Holland, it takes the direction of Hull and the deep bend of Marfleet and Hedon, until it feels the hard gravel formation of High Paull, when it is directed again to the Lincolnshire shore close in by Kellingholme and Stallingborough, and thence to the north side of the Burcom, south of the Middle Sand, and north of the Bull to the sea. This is not an engineering subject for discussion, or a great deal might be said on the improvement of the navigation of the Humber by embankments and other works. Much has been said on the question of depositing mud in the Humber, dredged from the docks. As a general principle, I think it is right that nothing should be deposited in navigable rivers, or indeed rivers of any kind; but with reference to the mud taken out of our docks, I am of opinion that no part of it remains in the channel where discharged from the barges, for had this been the case and the deposit remained, we should have had an island opposite Hull before now; and I maintain that no particle of it either does or can remain in the channels of the Humber. But if, as persons affirm, it must settle somewhere, and the deposit does take place on the foreshores, it will do good instead of harm, for it would thereby tend to contract the capacity of the navigable space, and deepen the channels. The Humber is now too wide for the volume of water passing *down* it; but contract its width, and just in proportion as that is done, the depth will be increased. Some time ago I had an opportunity of closely examining the foreshore in front of the Pottery at Hull, where the Hull Dock Company had been in the habit for many years of depositing the mud from the docks; but instead of any accumulation, I found the hard blue clay, and in some places extensive beds of peat, but not the least deposit of mud, for at this part of the Humber we have a strong current which at once sweeps away such light matter.

This noble arm of the sea is no longer to be left to its own uncontrolled sway, but is now and will henceforth be under the vigilant eye of a conservator, whose chief business will be to see that *no damage is done to it.* It would have been more satisfactory had the powers of Captain Cator (who has the honour of being the first conservator) extended over its two *great fingers* also, the Trent and the Ouse, and that authority were given to execute extensive works for their improvement.

It is with great pleasure that I would refer to the admirable manner in which the beacons and buoys are arranged and managed by the Corporation of the Hull Trinity House; and I have heard it remarked by a Captain in the Royal Navy, that nothing can be more beautiful than the way in which the lights and buoys of the Humber are disposed for its safe navigation, even by perfect strangers.

The Map on Plate II. is constructed to include on a smaller scale the information preserved by a chart of the Humber from the sea to Barton, by Captain Greenvile Collins, Hydrographer to the King, surveyed about 1687, showing the site of Sunk Island as it then existed, and the Ordnance map of the Humber, with portions of the Ouse and Trent. On this are shown the accretions of Sunk Island, &c., the loss on the sea coast, the mud and sand-banks in the channel, and the dock works of Hull, Grimsby, and New Holland.

To this is added a section of a boring at Sunk Island, by Easton and Amos, 1846.

Hull, September 7, 1853.

On the Rise, Progress, and present Position of Steam Navigation in Hull. By James Oldham, *Esq., Civil Engineer, Hull, M.I.C.E.*

[A communication ordered to be printed among the Reports.]

In every new discovery, whether of Science or Art, it is seldom that the thought or idea is confined to one individual and to one place; but the all-wise Creator has caused the same thoughts and feelings to be at work, and to become developed in different minds, and it may be in widely separated places at the same time, so that it is often difficult to determine by whom and where the first discovery originated. It would appear as if some of those rich treasures were too precious to be entrusted to one single individual, a contrary arrangement securing to the world the benefits contemplated.

In the rise or commencement of steam navigation, like all other discoveries and inventions which have answered and succeeded in the application, many persons are found to claim the honour of that which may or may not be their due. Now, in reference to the first discovery of propelling vessels by steam-power, we have, amongst others, the following countries as claimants, viz. England, Scotland, America, and Italy. It is not my intention to enter into any lengthened statement of the claims of different places, but briefly so, in order to show that Hull was among the first.

On the 21st of December, 1736, Jonathan Hulls took out a patent for a steam-boat, which was, without doubt, the very first attempt that was ever made to apply steam for the purpose of navigation; at least we have nothing older on record. Hulls, as is well known, published his letters-patent, and a description of his invention, illustrated by a drawing, in 1737, which he entitled a "Description and Draught of a new invented Machine for carrying vessels or ships out of, or into any Harbour, Port, or River, against wind or tide, or in a calm."

It appears from a paper of Professor Renwick of New York, published in Weale's edition of "Tredgold on the Steam-Engine," that the first attempt to propel boats by steam in America was made in the year 1783, by Fitch and Rumsey; but it was not until 1807 that it was made to perform with success by Fulton. In Scotland, about the year 1788, a trial was made at Dalswinton to propel boats by steam, by Mr. Patrick Miller of that place; and again, an experiment was made on the Forth and Clyde Canal, by the same person, in 1789, and it is said with good results; but from some cause or other, Mr. Miller appears to have abandoned the thing altogether. About this time, a person in Italy, of the name of D. S. Serratti, also proposed the application of steam to the purposes of navigation.

In 1801 and 1802, Mr. William Symington constructed a steam-boat for towing vessels on the Forth and Clyde Canal, but nothing of importance resulted from the experiment.

To come a little nearer home, it will be gratifying to many to hear that in Hull, about the year 1787, experiments were made on the River Hull by Furnace and Ashton, in the propulsion of vessels by steam-power. Furnace and Ashton built a boat which plyed on the river between Hull and Beverley for some time, and answered exceedingly well. In consequence of the good results of their experiments, they built a much larger vessel and engine, and sent the whole to London to be put together and finished, after which it was subjected to the severest tests, and gave the greatest satisfaction. This vessel was bought by the Prince Regent (afterwards George IV.), who had it fitted and furnished as a pleasure yacht; but it was soon afterwards burnt, having, it is supposed, been set on fire by persons who were afraid that such an invention would be injurious to their calling.

The Prince was so much pleased with the invention and ingenuity of Furnace and Ashton, that he granted them a pension for life of £70 a year each. Furnace was a native of Beverley, and Mr. Ashton was a medical gentleman, having been articled to the father of the late W. and C. Bolton of this place, but I do not know whence he came.

The steamer was on the paddle principle, propelled by a steam-engine, to which was attached a copper boiler; and this, I regret to say, is all I can give in detail as to the construction, and I also regret to add, that all from whom I obtained information are now no more. My father, himself an engineer, who knew the vessel from personal inspection, gave me the best information. The late Mr. Matthew Collyford Banks (whose father, Roger Banks, made the principal part of the machinery), although a boy, witnessed the performance of the vessel, and assisted in the construction of the engine, &c., and he gave me information on the subject. The late Mr. William Bolton, to whom allusion has been made, and the late Captain Joyce, who had the command of the boat, were both well acquainted with the circumstances, and communicated to me facts relating to the invention and performance of the steamer.

Thus I hope I have, by this brief introduction, established the claim of Hull to be ranked amongst the first in the introduction of this wonderful invention, which has become so indispensable to the requirements of the world, and so beneficial to mankind. It was not before the 12th of October in the year 1814, that the first steam-boat began to ply on the Humber as a great palpable fact, when we were all in some degree excited by the novelty of seeing the "Caledonia" commence running regularly between Hull and Gainsborough.

Thus while all Europe was involved in war and confusion, and empires were rising and falling, Science was quietly at work; and this, one of the most important discoveries ever made for the worlds' benefit, was struggling into life and activity.

The following is the first notice I can find in the Hull papers on the subject of steam-boats, which I copied from the "Rockingham" of the 15th of October, 1814:—"The steam-boat Caledonia, lately arrived here, has during the week been exhibiting her capabilities on the Humber; and it appears that, with both wind and tide strong against her, her speed is considerable. On Wednesday she went off for Gainsborough, and the weather being favourable, reached Burton Stather in the space of an hour and a half, travelling at the rate of 14 miles an hour."

I also copied the following from the same paper of the 13th of May, 1815: —"The 'Caledonia,' a steam-packet, we understand last Saturday went from hence up the River Ouse to Naburn, about 4 miles from York, with intention of proceeding to that city, but the lock was not sufficiently wide to admit of her passing through it. The packet had arrived from Hull on the same day, making the whole distance in that time, 122 miles." No doubt it is intended to convey the fact, that the whole distance from Hull to Naburn Lock and back to Hull, traversed in one day, was 122 miles. The "Caledonia" was followed by others of a more improved construction; the "John Bull," the "Humber," the "British Queen," the "Mercury," "Dart," "Rockingham," and others. The "Humber" was advertised in the Hull papers on the 25th of August, 1815, to run between Hull and Selby in five hours, and to carry best-cabin passengers at 6*s*., and fore-cabin passengers at 4*s*. each.

Having established the safety and utility of steam-boats on rivers, the next idea was to try them on the sea, but many were the doubts and fears expressed at so perilous an undertaking. However, notwithstanding the warnings and prejudices of nautical men, in the year 1821 our highly respected and enterprising townsmen, Messrs. Brownlow and Co., were the first to send out sea-going steamers from Hull, to run between Hull and London; and the first ship they despatched was the "Kingston," the engine of which was made by the late Overton and Smith of this place. This is supposed to have been the first sea-going steamer plying on the east coast of England. The owners had great anxiety and expense at the commencement, but they persevered, and have triumphed in no small degree, for they have now of one kind or another about fourteen steamers*. The "Kingston" was followed by the "Yorkshireman," "Prince Frederick," "London," &c. From that time to the present the fleet of both river and sea-going steamers has con-

* Ten sea-going; four river.

tinually increased, and we have now a goodly number plying in almost every direction; those within the Humber running to the following places, viz. Grimsby, New Holland, Barton, Ferriby Sluice, Gainsborough, Goole, Thorne, Selby, and York; coasters, to London, Yarmouth, Lynn, Wisbeach, Newcastle, and Leith; foreign parts, St. Petersburgh, Christiania, Gottenburg, Hamburg, Zwolle, Rotterdam, Antwerp, &c.

Many of our finest steamers, both of wood and of iron, have been built in Hull; and in justice to my scientific fellow-townsmen, I must say that they have displayed so much talent in the art of steam-ship building, as to secure for themselves a large amount of respect and commendation. There is, however, with some exceptions, a great want of public spirit and bold enterprise in Hull, or I do not fear to say, it might have become one of the first places in Britain for shipbuilding; but it is never too late to amend. As a locality, there is every facility for carrying on an extensive business; its position in reference to the north of Europe cannot be surpassed. The fine level shores of the Humber give facility for constructing building-yards and patent slips to any extent, and the ready communication with the iron, timber, and coal districts all combine to point out the advantages we possess, almost beyond any other place in the United Kingdom.

Many important improvements in the form and construction of steamers in Hull have taken place since the commencement here; and although we cannot boast of a John Scott Russell, a Robert Napier, and a John Laird, yet we have the advantage of their experience and science in many fine specimens of their build belonging to our port; and I may assert, that the lessons of those gentlemen will not be lost upon us.

Hull, too, has contributed its share in the improvement of the steam-engine, as applied more particularly to navigation; for it was the late Mr. Witty, of the firm of Todd and Witty of Hull, who first adapted the oscillating cylinder to practical uses, which is now so generally applied to steam-boats. I do not mean to say that Mr. Witty applied his oscillating engine to steam-boats, but he did upwards of thirty years ago set one to work in a manufactory at Hull of six or eight horse-power, which continued for several years, fully answering the purpose. After this it was that the invention was applied to marine purposes by Penn of Greenwich, and others. Some of Penn's beautiful engines may be seen on board the "Harlequin," "Columbine," and "Atalanta," running between Hull and Gainsborough; also, on the same principle by Robinson and Russell, on board the "Manchester," and by Messrs. Rennie on board the "Sheffield," Hull and New Holland steamers; and by our own townsmen, Brownlow and Pearson, on board the beautiful new ship the "Eagle;" and Messrs. Earle, on board the "Minister Thorbecke." I have been more particular in giving this detailed statement as a tribute to the memory of poor Witty, who, like many others, had few to support and encourage him in his just claims while living.

I have great pleasure in referring to another highly important invention by a townsman, which, although not yet applied to marine engines, no doubt shortly will, and must be, and which bids fair to take an important stride in their improvement,—I mean Messrs. Locking and Cook's patent rotary-valve, the invention of William Cook of this place, a working engineer. It is already fitted to a pair of engines, and fully answers, if it does not exceed, the most sanguine expectations formed upon its merits. As the principle will be fully explained by Mr. Locking, I will not at present say more about it, except that I hope to see it in general use, applied to marine, locomotive, and fixed engines.

Looking back at what has been done in steam navigation, and the rapid strides effected during the last forty years, what may we not anticipate a few years hence? When the first trials were made ordinary land-engines were applied; now we have the most compact engine imaginable: then paddles were the only system of propulsion; now the screw in a variety of forms is rapidly taking the lead: formerly we had only wooden boats, now iron ones. Thus year after year we are advancing and improving. I think it probable that the time is not very far distant when steam-boats, of one descrption or other, will almost if not entirely supersede sailing vessels.

Tables of Statistics.

The following tables show the present position of Hull in regard to the steamers which belong to, or trade from the Port:—

(A.) Sea-going steamers belonging to the port. Total tonnage, 9277; horse-power, 2799; averaging 3·31 tons per horse-power.

(B.) River steamers belonging to the port. Total tonnage, 2218; horse-power, 1135; averaging 1·71 ton per horse-power.

(C.) Sea-going steamers belonging to other ports, but trading to Hull. Total tonnage, 5909; horse-power, 2236; averaging 2·61 tons per horse-power.

(D.) River steamers trading to Hull, but belonging to other places. Total tonnage, 1156; horse-power, 426; averaging 2·71 tons per horse-power.

(E.) An account showing the progressive increase or decrease of tonnage on steam-vessels, foreign or coastwise respectively, from 1840 to 1852 inclusive.

The total number of steamers trading to Hull amounts to eighty-one, of the aggregate burthen of 18,560 tons, and 6596 horse-power; averaging on the whole 2·81 tons per horse-power; giving also an average on the total number of steamers of 229·38 tons each.

Note.—66 paddle-steamers and 15 screw steamers = 81.

Hull, 7th September 1853.

(A.)—List of Sea-going Steamers belonging to the Port of Hull.

Name of Steamer.	Iron or Wood.	Paddle or Screw.	Tonnage. Builders.	Tonnage. Register.	Horse-power.	Proportion of Tons to Horse-power	Where and by whom built.	Engines where and by whom made.
Emperor	Iron	Paddle	1320	914	400	3·30 to 1	Robert Napier, Glasgow	Robert Napier, Glasgow.
Lion	Iron	Paddle	846	626	320	2·64 to 1	Brownlow and Co., Hull	David Napier, Glasgow.
Queen of Scotland	Wood	Paddle	619	435	150	4·12 to 1	Duffles and Co., Aberdeen	Butterley Company.
Helen M'Gregor	Iron	Paddle	601	435	230	2·61 to 1	John Laird, Birkenhead	Forrester and Co., Liverpool.
Rob Roy	Wood	Paddle	538	355	170	3·16 to 1	Edward Gibson, Hull	Butterley Company.
Eagle	Iron	Screw	628	423	100	6·28 to 1	Brownlow and Co., Hull	Brownlow and Co., Hull.
Transit	Wood	Paddle	497	331	140	3·55 to 1	Pearson and Co., Thorne	Fenton and Co., Leeds.
Swanland	Iron	Screw	480	347	100	4·80 to 1	Napier and Crichton, Glasgow	Napier and Crichton, Glasgow.
Camerton	Iron	Screw	474	333	100	4·74 to 1	Napier and Crichton, Glasgow	Napier and Crichton, Glasgow.
Scandinavian	Iron	Screw	423	253	106	4·00 to 1	Thomas Wingate, Whiteinch	Thos. Wingate and Co., Whiteinch.
Gazelle	Wood	Paddle	402	269	100	4·02 to 1	Murris and Co., Greenock	Caird and Co., Greenock.
Emerald Isle	Wood	Paddle	410	270	150	2·73 to 1	Motteshead and Co., Liverpool	Preston and Co., Liverpool.
Courier	Iron	Paddle	373	245	140	2·66 to 1	Thos. Wingate and Co., Glasgow	Thos. Wingate and Co., Glasgow.
Prince	Iron	Paddle	329	227	100	3·29 to 1	Brownlow and Co., Hull	Thos. Wingate and Co., Whiteinch.
Albatros	Wood	Paddle	248	176	90	2·75 to 1	Edward Gibson, Hull	Brownlow and Co., Hull.
London	Wood	Paddle	247	149	100	2·47 to 1	Furley and Co., Gainsborough	Overton and Smith, Hull.
Antelope	Wood	Paddle	231	162	100	2·31 to 1	Thos. Barclay and Co., Glasgow	David Napier, London.
Fairy	Iron	Screw	164	111	60	2·73 to 1	T. D. Marshall & Co., South Shields	T. D. Marshall & Co., South Shields.
Iris	Wood	Paddle	158	96	45	3·50 to 1	Brownlow and Co., Hull	Brownlow and Co., Hull.
Cambridge	Wood	Paddle	141	99	48	2·93 to 1	Henry Smith, Gainsborough	Overton and Wilson, Hull.
Jupiter	Iron	Screw	138	127	50	2·76 to 1	Brownlow and Co., Hull	C. and W. Earle, Hull.

(B.)—List of River Steamers belonging to the Port of Hull.

Name of Steamer.	Iron or Wood.	Paddle or Screw.	Tonnage. Builders.	Tonnage. Register.	Horse-power.	Proportion of Tons to Horse-power	Where and by whom built.	Engines where and by whom made.
Manchester	Iron	Paddle	292	175	150	1·94 to 1	Robinson and Russell, Blackwall	Robinson and Russell, Blackwall.
Sheffield	Iron	Paddle	244	148	150	1·63 to 1	H. Smith and Sons, Gainsborough	G. and J. Rennie, London.
Leeds	Wood	Paddle	127	87	30	4·23 to 1	....	Fenton and Co., Leeds.
Pelham	Wood	Paddle	113	60	40	2·82 to 1	H. Smith and Sons, Gainsborough	James Overton, Hull.
Calder	Wood	Paddle	113	75	30	3·76 to 1	R. Pearson and Co., Thorne	Fenton and Jackson, Leeds.
Royal Albion	Wood	Paddle	91	36	40	2·20 to 1	Parkinson and Co., Hull	Overton and Wilson, Hull.
Falcon	Wood	Paddle	90	57	35	2·57 to 1	North Shields	J. and J. Waits, North Shields.

Magna Charta	Wood	Paddle	87	62	28	3·10 to 1	Darvie, North Shields	J. and J. Waits, North Shields.
Prince of Wales	Iron	Paddle	84	55	32	2·62 to 1	Ditchburn and Mare, Blackwall	Ditchburn and Mare, Blackwall.
Duncannon	Wood	Paddle	83	34	38	2·18 to 1	Cooper and Gardner, North Shields	J. P. Almond, North Shields.
Queen	Iron	Paddle	79	52	32	2·77 to 1	Ditchburn and Mare, Blackwall	Ditchburn and Mare, Blackwall.
Olive	Wood	Paddle	70	43	18	3·88 to 1	John Elliott, Newcastle	J. D. Marshall, South Shields.
Middlesboro'	Wood	Paddle	68	22	38	1·78 to 1		
Wilberforce	Wood	Paddle	67	23	36	1·86 to 1	Andrew Bell, North Shields	J. E. Harrison, North Shields.
Ebor	Wood	Paddle	67	28	34	2 to 1	Goole.	
Eliza	Wood	Paddle	54	20	29	1·86 to 1		
Black Eagle	Iron	Paddle	89	33	40	2·22 to 1	Gateshead	Hawks, Gateshead.
Isle of Thanet	Iron	Paddle	170	117	50	3·40 to 1		
Eclipse	Iron	Paddle	150	75	40	3·75 to 1		
8 other tug-boats	Wood	Paddle	380	...	245	1·55 to 1		

(C.)—List of Sea-going Steamers trading to Hull, but belonging to other Ports.

Leipsig	Iron	Paddle	700	497	250	2·80 to 1	Liverpool.	Liverpool.
Sea-Gull	Iron	Paddle	503	321	240	2·09 to 1	Coats and Young, Belfast	Coats and Young, Belfast.
Neptune	Wood	Paddle	253	173	100	2·53 to 1		
Mercator	Iron	Paddle	500	300	150	3·33 to 1		
Jupiter	Wood	Paddle	425	288	220	1·03 to 1	Scott, Sinclair and Co., Greenock	Scott, Sinclair and Co., Greenock.
Vivid	Wood	Paddle	368	228	180	2·04 to 1	...	Seaward and Co., London.
Waterwitch	Wood	Paddle	415	275	180	2·30 to 1	...	Seaward and Co., London.
Glenalbyn	Wood	Paddle	284	189	110	2·58 to 1	Scott, Sinclair and Co., Greenock	Scott, Sinclair and Co., Greenock.
Bold Buccleuch	Iron	Paddle	200	145	120	1·66 to 1		
Britannia (F.)	Iron	Screw	383	...	120	3·19 to 1	J. D. Marshall & Co., South Shields	J. D. Marshall & Co., South Shields.
Hammonia (F.)	Iron	Screw	228	...	80	2·85 to 1	J. D. Marshall & Co., South Shields	J. D. Marshall & Co., South Shields.
Archimedes (F.)	Iron	Screw	263	...	80	3·28 to 1	J. D. Marshall & Co., South Shields	J. D. Marshall & Co., South Shields.
Sea Nymph	Wood	Paddle	166	105	60	2·76 to 1	William Furley, Gainsborough	J. Overton and Co., Hull.
Marshall (F.)	Iron	Screw	215	...	80	2·68 to 1	J. D. Marshall & Co., South Shields	J. D. Marshall & Co., South Shields.
Forager	Wood	Paddle	86	52	56	1·63 to 1	Furley and Co., Gainsborough	Thompson and Stather, Hull.
Minister Thorbecke (F.)	Iron	Screw	275	200	60	4·68 to 1	C. and W. Earle, Hull	C. and W. Earle, Hull.
Graaf van Rechteren (F.)	Iron	Screw	203	146	50	4·06 to 1		
Burgeemeester Huidekooper (F.)	Iron	Screw	221	171	50	4·42 to 1		
Gouverneur van Euyck (F.)	Iron	Screw	221	171	50	4·42 to 1		

Note.—Those steamers with the letter (F.) belong to foreign parts.

(D.)—List of River Steamers trading to Hull, but belonging to other Ports.

Name of Steamer.	Iron or Wood.	Paddle or Screw.	Tonnage. Builders.	Tonnage. Register.	Horse-power.	Proportion of Tons to Horse-power	Where and by whom built.	Engines where and by whom made.
Ariel	Iron	Paddle	158	70	28	5·64 to 1	T. and W. Pim, Hull	John Linton, Selby.
Eagle	Iron	Paddle	124	85	60	2·06 to 1	Aire and Calder Co., Goole	B. Hawthorne and Co.
Dart	Wood	Paddle	124	75	35	3·52 to 1	Smith and Son, Gainsborough	Overton and Smith, Hull.
Atalanta	Iron	Paddle	123	95	40	3·07 to 1	Henry Smith and Son, Gainsborough	Penn and Sons, Greenwich.
Harlequin	Iron	Paddle	113	85	40	2·82 to 1	Smith and Son, Gainsborough	Penn and Sons, Greenwich.
Atlas	Wood	Paddle	99	49	40	2·47 to 1	Furley and Co., Gainsborough	Butterley Company.
Ebor	Wood	Paddle	89	62	35	2·54 to 1	Smith and Sons, Gainsborough	Aydon and Read, Wakefield.
Columbine	Iron	Paddle	85	55	40	2·12 to 1	Smith and Sons, Gainsborough	Penn and Sons, Greenwich.
City of York	Iron	Paddle	84	65	38	2·21 to 1	John Linton, Selby	John Linton, Selby.
John Bull	Wood	Paddle	47	30	20	2·38 to 1	R. Pearson and Co., Thorne	Aydon and Co., Wakefield.
Judith	Wood	Paddle	43	11	25	1·72 to 1	T. D. Marshall, South Shields	T. D. Marshall, South Shields.
Fairing	Wood	Paddle	37	17	12	3·08 to 1	James Dowey, North Shields	Jas. and John Waits, North Shields.
Expedition	Wood	Screw	23	18	8	2·87 to 1	Joseph Sleight, Brigg	T. and W. Pim, Hull.
Mary	Iron	Paddle	17	9	5	2·40 to 1	Todd and Macgregor, Glasgow	Andrew Lambe, Southampton.

(E.)—An Account showing the progressive Increase or Decrease of Tonnage on Steam Vessels, foreign or coastwise respectively, from 1840 to 1852 inclusive, as furnished by the Dock Company, Hull.

Years.	Gross Tonnage, Foreign.	Gross Tonnage, Coastwise.	Increase, Foreign.	Decrease, Foreign.	Increase, Coastwise.	Decrease, Coastwise.
1840	42,929	131,903				
1841	46,745	122,742	3,816	....	....	9,161
1842	56,711	122,225	9,966	....	....	517
1843	58,083	126,804	1,372	....	4579	
1844	68,248	130,842	10,165	....	4038	
1845	67,760	132,907	......	488	2065	
1846	85,305	125,404	17,545	....	....	7,503
1847	102,784	117,498	17,479	....	....	8,000
1848	98,659	123,970	......	4125	6472	
1849	123,657	108,536	24,998	....	....	15,434
1850	181,555	112,810	57,898	....	4274	
1851	200,808	106,160	19,253	....	....	6,650
1852	193,658	111,363	......	7150	5203	

Experimental Researches to determine the Strength of Locomotive Boilers, and the Causes which lead to Explosion. By WILLIAM FAIRBAIRN, *F.R.S.*

[A communication ordered to be printed among the Reports.]

A DIFFERENCE of opinion having arisen between a gentleman high in authority and myself concerning the causes of an accident which took place through the explosion of a locomotive engine at Manchester, on the Eastern Division of the London and North-Western Railway, I deemed it necessary to institute a series of experiments, not for the purpose of confuting the arguments of others or confirming my own, but to determine the real causes of the explosion, and to register the observed facts for our future guidance in guarding against such fearful catastrophes.

After a careful examination of the boiler a few hours subsequent to the explosion, I found one side of the fire-box completely severed from the body of the boiler, the interior copper box forced inwards upon the furnace; and with the exception of the cylindrical shell which covers the tubes, the whole of the engine was a complete wreck, as exhibited in Plate I. fig. 1.

Mr. Ramsbottom, the Locomotive Superintendent, in his Report to the Directors, states that "the engine in question was made by Messrs. Sharp, Roberts and Co. in the year 1840, has been worked at a pressure of 60 lbs. per square inch, and has run in all a distance of 104,723 miles, a great part of which has been either entirely without load, or nearly so. As the cylinders are only 13 inch diameter, it has been for some time too light to work any of our trains; and has therefore been chiefly employed since 1849 in piloting the trains through Standedge tunnel, along with another engine of the same size, which is now at work.

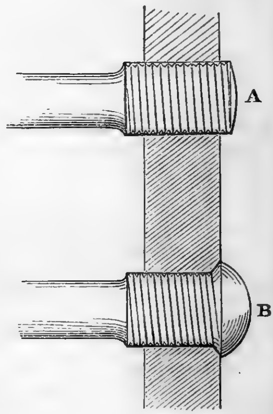
"The fire-box was originally $\frac{7}{16}$ths of an inch thick, and is now a little over $\frac{6}{16}$ths of an inch; and from its excellent condition, might well be supposed (as indeed it was by Mr. Sharp, of the firm of Sharp Brothers and Co., who inspected it a few days after the accident) to have been recently put in new. It is perfectly free from flaw or patch, and would certainly have run at least 100,000 miles. The same may also be said with respect to the outer shell, which is nearly of the original thickness. The engine had been in the repairing shop the three months previous to the accident; and the iron fire-box stays, about which so much has been said, were tested by the hammer in the usual way, and were considered, both by the workmen and the foreman, Wheatley, to be all sound. When originally made, they were $\frac{11}{16}$ths in diameter, and were equal to a strain of at least ten times the force they had to sustain. With the exception of one stay, which was on the top row, the one most reduced from oxidation was half-inch diameter; and supposing the hold on the copper box to have been good, it was capable of resisting a strain of rather more than $6\frac{1}{2}$ times the working pressure, equal, say, to 390 lbs. per square inch. The only point therefore which could admit of doubt as to the safety of the boiler, was with respect to the hold which the stays might have in the copper box; but it appears, from experiments which I have since made, and which are about to be repeated by Mr. Fairbairn, that from the force required to pull some of the old stays out of a copper plate similar to the fire-box, into which they had been screwed by the *old threads only*, and *not riveted*, the boiler could not have burst under a pressure of less than 300 lbs. per square inch. One of the old stays, which had had the thread partially damaged from being ripped out of the copper box by the explosion, was screwed by hand into a copper plate, by the old thread, to a depth equal to the thickness of the fire-box plate, but not riveted, and it required a dead weight of 8204 lbs. to pull it out; and as each stay has to support a surface of 5 inches, $\times 5\frac{3}{8}$ inches, say 27 square inches only, it follows that a pressure of $8204 \div 27 = 303{\cdot}85$ lbs. per square inch would have been required to strip it.

"Another stay, which had not been stripped by the explosion, but which was screwed out of the old box, was similarly treated, and required a force of 9·184 lbs. to strip it, equal to 340 lbs. per square inch."

Since the experiments here referred to were made, I have repeated them with great care; and taking into account the tensile strength of the stays—in their corroded state—of the side of the fire-box, which to appearance was the first to give way, I find that a force of 380 lbs. upon the square inch would be required to effect rupture; and the results of the experiments on the resistance of stays screwed into the copper fire-box fully confirm those already made by Mr. Ramsbottom. Assuming therefore that the ends of the screws were riveted, and sound in other respects, we may reasonably conclude that a strain of not less than 450 to 500 lbs. upon the square inch would be required to strip the screws, or tear the stays themselves asunder. I have founded these facts upon the experiment of the resisting powers of the iron stay screwed into a portion of the copper cut out of the ruptured fire-box, and another experiment of a similar stay first and then riveted, as shown in the annexed sketch.

The stay marked A, $\frac{3}{4}$ths of an inch in diameter, in the first experiment required a force of 18,260 lbs.=8·1 tons to strip the screw, and draw it out of the copper; and the stay B, of exactly the same dimensions, but riveted over the end, required a force of 24,140 lbs.=10·7 tons before it was dislodged*. Taking therefore the mean of those experiments, including those of Mr. Ramsbottom, and we arrive at the results given above, namely, a resisting power of 785 lbs. on the square inch, to burst or produce fracture in the stays and side of the fire-box.

Fig. 2.



In locomotive engines of more recent construction, where the stays are thicker and formed into squares of 4 to $4\frac{1}{2}$ inches, the resisting powers will probably be increased to 850 or 900 lbs. on the square inch, that is, 7 or 8 times the working pressure.

On a careful examination of the fire-box and every other part of the boiler, it was found that the stays and copper were perfect, and that they were able to sustain a pressure much exceeding 207 lbs. upon the square inch, as given in the following table.

In these experiments, the top of the fire-box sank a little, owing to the breakage of a bolt of one of the cross-bars; but the fire-box stays were quite perfect, and to every appearance would have sustained nearly double that pressure. If the fire-box stays had been new and the top well-stayed, it is more than probable that a force from 800 to 900 lbs. on the square inch would have been required to cause rupture.

* *Vide* Experiments in the Appendix.

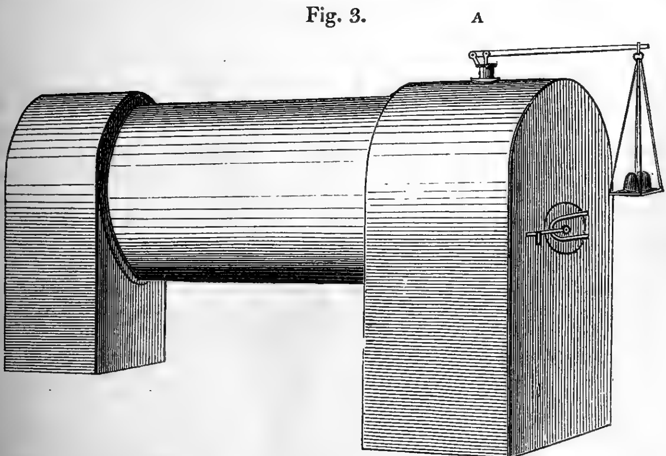
As much stress has been laid upon the weakness of the stays which unites the flat surface of the boiler to the sides of the fire-box, the following experiments clearly indicate that the fire-box stays are not the weakest parts of a locomotive boiler, and that we have more to fear from the top of the furnace, which under severe pressure is almost invariably the first to give way. Great care should therefore be observed in the construction of this part, as the cross-beams should not only be strong, but the bolts by which the crown of the fire-box is suspended should also be of equal strength, in order that no discrepancy should exist, and that all the parts should be proportioned to a resisting force of at least 500 lbs. on the square inch.

Finding our knowledge with regard to the power of resistance of locomotive boilers to strain exceedingly imperfect, I availed myself of the present opportunity to determine by actual experiment the laws on which these powers are founded; and for this purpose the Directors of the London and North-Western Railway Company placed in my hands an engine of the same age, constructed by the same makers, and in every respect a fac-simile of that which exploded. This engine was subjected to hydraulic pressure as follows:—

Experiment made May 4th, 1853, *to determine the Resisting Powers of the Fire-box and Exterior Shell of No. 2 Engine on the Eastern Division of the London and North Western Railway.*

In this experiment, the boiler was furnished with a valve, A, of exactly 1 inch area, and a lever of the annexed dimensions, as per sketch, fig. 3. This

Fig. 3.



lever, 15 : 1, gave as the weight upon the valve 35 lbs., and having suspended the scale, which indicated with the lever 50 lbs., the following results were obtained:—

TABLE I.

Number of pounds on scale.	Weights per square inch upon the valve.	Remarks.
Lever	35·0	
Scale	50·0	This engine was the same age, and had run about the same number of miles as the exploded engine. The fire-box was considerably sunk or bulged, and the rivets as well as the stays much weakened. The engine had been at work since 1840.
½	57·5	
1	65·0	
1½	72·5	
2	80·0	
2½	87·5	
3	95·0	
3½	102 5	
4	110·0	With this pressure a leakage was observed at some of the joints.
4½	117·5	
5	125·5	
5½	132·5	
6	140·0	Leakage increased.
6½	147·5	
7	155·0	
7½	162·5	
8	170·0	Leakage still increasing.
8½	177·5	
9	185·0	
9½	192·5	
10	200·5	
10½	207·5	With this pressure one of the bolts of the cross-bar over the fire-box broke, which caused the experiment to be discontinued, as the leakage was greater than the force-pump could supply.

From the above, it is evident that the boiler which led to these experiments could not have burst under a pressure of less than 300 to 350 lbs. upon the square inch, as the failure of a single bolt in one of the cross-bearers above the fire-box, under a pressure of 207 lbs. on the square inch, was not the measure of its strength, but one of those accidental circumstances which is calculated to weaken, but not absolutely destroy its ultimate powers of resistance. I have been led to this conclusion from the fact of finding the upper part of the fire-box in every respect perfect. After the removal of the pressure of 207 lbs. on the square inch, and comparing these experiments with the appearance of the crown of the ruptured fire-box, I am confirmed in the opinion that steam of high elastic force must have been present to cause the disastrous explosion which eventually occurred.

Again referring to Mr. Ramsbottom's Report, he states,—"That it has been objected that the steam could not have been raised from 60 lbs. per square inch, the pressure at which the safety-valve was blowing off before being screwed down, to the pressure stated by Mr. Fairbairn in twenty-five minutes; but although I do not go all the way with Mr. Fairbairn as to the strength of the boiler, I find, from experiments made upon a boiler of somewhat similar dimensions, and placed as nearly as possible under the same circumstances, that the steam was raised from 30 lbs. per square inch to 80 lbs., as shown by Bourdon's steam-gauge according to the following scale, namely,—

	h	m	s		
Safety-valve screwed down	3	1	20	=	30 lbs. per square inch.
... ...	3	2	30	=	35 ... ...
... ...	3	3	45	=	40 ... ..
... ...	3	5	00	=	45 ... ...
... ...	3	6	15	=	50 ... ...
... ...	3	7	20	=	55 ... ...
... ...	3	8	30	=	60 ... ...
... ...	3	9	30	=	65 ... ...
... ...	3	10	30	=	70 ... ...
... ...	3	11	30	=	75 ... ...
... ...	3	12	20	=	80 ... ...

These experiments, although perfectly satisfactory as regards the time required to raise the steam (under ordinary circumstances of the engine, standing with the fire lighted, and the usual quantity of coke in the furnace) from 30 up to 80 lbs. on the square inch—it was nevertheless considered desirable to repeat them through a still higher scale of pressure and temperature, and to ascertain, not only the exact time, but the ratio of increase, and the corresponding temperature of the steam in the boiler as the pressure progressively increased. For these objects, two delicately constructed thermometers were prepared by Mr. Dalgetti, and having adjusted Bourdon's pressure-gauge by a corresponding column of mercury, and an engine having been placed at my disposal, the following results were obtained:—

Experiment made May 7th, 1853, to determine the rate of Increased Pressure, Temperature of Steam, &c. in a Locomotive Engine with the Safety-valve screwed down and the Fire under the Boiler.

TABLE II.

Time.	Pressure.	Temperature, No. 1 gauge.	Temperature, No. 2 gauge.	Mean temperature.	Remarks.
h m		°	°	°	
2·44	11·75	243	243	243·00	
2·45	14·15	247	246½	246·75	
2·46	16·35	251	251	251·00	
2·47	19·25	255½	255	255·25	
2·48	22·35	260	259½	259·75	
2·49	25·75	264	264	264·00	
2·50	28·95	268½	268¼	268·37	
2·51	32·15	273	273	273·00	
2·52	35·75	277	277	277·00	
2·53	39·95	282	282	282·00	
2·54	44·25	286½	286¼	286·37	
2·55	48·35	291	291	291·00	
2·56	52·75	295½	295¼	295·37	
2·57	57·75	300	300	300·00	
2·58	63·75	304¼	304¼	304·25	
2·59	68·95	308½	309	308·75	
3·00	74·75	313	313	313·00	
3·01	80·35	318	317½	317·75	
3·02	87·25	322	322	322·00	
3·03	93·95	326¼	326	326·12	
3·04	101·15	331	331	331·00	
3·05	108·75	335½	335¾	335·62	
3·06	111·75	....	...	...	This experiment was lost, the thermometers not indicating a higher temperature.

Let us now endeavour from this table to discover the law expressing the relation between the time and pressure, or between the time and temperature *.

The observations being made at intervals of one minute of time, and the furnace being maintained at the same intensity, it may be presumed that the quantity of heat communicated to the water was uniform, or that there were equal quantities of absolute heat communicated to the boiler in equal times.

The column of pressures gives the successive augmentations of pressure at equal intervals, and the column of temperatures gives the corresponding augmentations of heat as indicated by the thermometer.

The column of pressures shows that the increments of pressure, in equal intervals of time, increase with the temperature; thus at or near 260° the average increment of pressure is at the rate of 3·1 lbs. per minute; at or near 282°, it is 5·4 lbs. per minute; and at or near 326°, it is 7·1 lbs. per minute.

Mr. Ramsbottom's table of experiments indicates a similar result; thus at or near 268° the average increment of pressure is at the rate of 4 lbs., whereas at or near 304° it is at the rate of 5 lbs. per minute.

The law, therefore, expressing the relation of time and pressure does not appear to admit of assuming a simple form. But the case is different with respect to the law expressing the relation of time and temperature. Thus if T=temperature in degrees, and t=the time in minutes at which this temperature is observed, estimated from the commencement of the experiments, then

$$T=a\times t+b \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

will give the relation between T and t with great precision where a and b are constants, whose values, derived from these experiments, are $a=4\cdot44$ and $b=-486$.

For example, let $t=166$, then

$$T=4\cdot44\times 166-486=251^\circ,$$

which exactly corresponds with the tabular value.

Again, let $t=180$, then

$$T=4\cdot44\times 180-486=313\cdot2;$$

in this case the tabular value is 313°.

Again, let $t=185$, then

$$T=4\cdot44\times 185-486=335^\circ\cdot4;$$

in this case the tabular value is 335°·6.

From this formula we find

$$t=\frac{T+486}{4\cdot44} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

If t_i=the number of minutes which elapse between the temperatures T and T_i, then we find from 29 (1),

$$T_i-T=4\cdot44\,t_i; \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

which shows that *the temperature increases with the time*; and presuming that the heat of the furnace remained constant, this formula also shows that

* I am indebted to my friend Mr. Tate for the mathematical analysis of this question.

equal increments of absolute heat produce equal increments of sensible temperature as indicated by the thermometer.

To determine the time, estimated from a given pressure, at which the boiler would burst,—

1st. Let the given pressure be that of the atmosphere, and let the boiler be able to sustain 240 lbs. pressure per square inch.

From an experimental table of pressures and temperatures, we find 240 lbs. pressure to correspond to 403° temperature, and 15 lbs. pressure to 212° temperature; hence we have by formula (3),

$$t_{,} - = \frac{403-212}{4 \cdot 44} = 43 \text{ minutes,}$$

which is the time in which the boiler would burst, estimated from the time at which the water begins to boil.

2nd. Let the given pressure be 60 lbs. per square inch, and the boiler-pressure 240 lbs. per square inch, then

$$t_{,} = \frac{403-296}{4 \cdot 44} = 24 \cdot 1 \text{ minutes.}$$

3rd. Let the given pressure be 60 lbs. per square inch, and the boiler-pressure 300 lbs., then

$$t_{,} = \frac{422-296}{4 \cdot 44} = 28 \text{ minutes,}$$

which is nearly the time in which the boiler experimented upon would burst.

These facts appear to be sufficiently conclusive to enable us to judge of the dangers to which people expose themselves under circumstances where the necessary precautions are not taken for allowing the steam thus generated with the fire under the boiler to escape. The great majority of accidents of this kind have arisen during the time the engines are standing, probably with the safety-valve fastened and a brisk fire under the boiler. How very often do we find this to be the case in tracing the causes of these melancholy and unfortunate occurrences!

The statements contained in the earlier part of this paper regarding the strength of the stays of the fire-box would have been incomplete if we had not put those parts of a locomotive boiler, comprised in the flat surfaces or sides of a fire-box, to the test of experiment.

This was done with more than ordinary care; and in order to attain conclusive results, two thin boxes, each 22 inches square and 3 inches deep, were constructed; the one corresponding in every respect to the sides of the fire-box, distance of the stays, &c., the same as those which composed the exploded boiler; and the other formed of the same thickness of plates, but different in the mode of staying, which, in place of being in squares of 5 inches asunder, as those contained in the boiler which burst, were inserted in squares of 4 inches asunder. In fact, they were formed as per annexed sketch (Figs. 4 and 5), the first containing 16 squares of 25 inches area, and representing the exploded boiler, or old construction; and the other, with 25 squares of 16 inches area, representing the new construction.

Fig. 4.

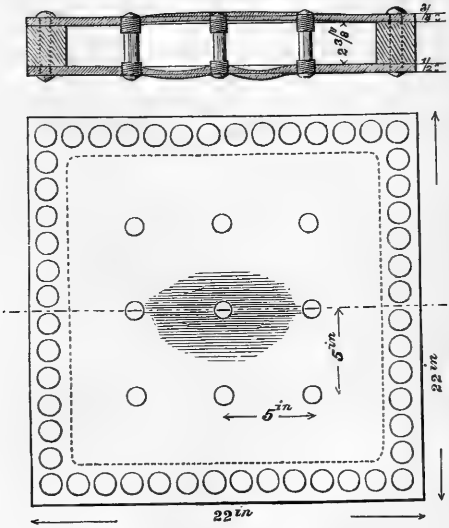
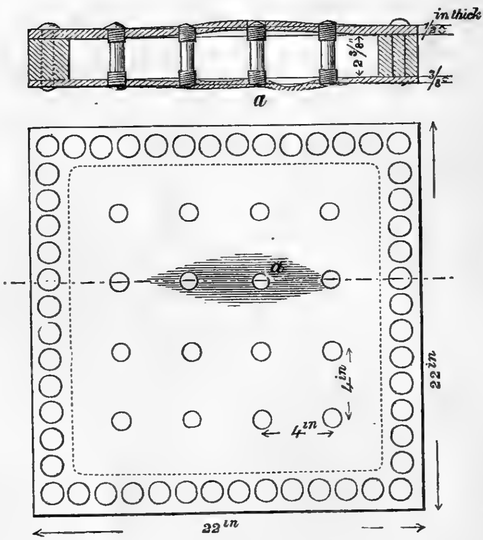

3/8
2 3/8
1/2
5 in
22 in
5 in
22 in

Fig. 5.


in thick
1/2
2 3/8
3/8
a
a
22 in
4 in
4 in
22 in

To the flat boxes thus constructed, the same lever, valve, and weight were attached as used in the previous experiments; and having applied the pumps of a hydraulic press, the following results were obtained:—

Table III.

Experiment 1*st*.—To determine the ultimate Strength of the Flat Surfaces of Locomotive Boilers when divided into squares of 25 inches area.

Number of experiments.	Pressure in pounds per square inch.	Swelling of the sides in inches.	Remarks.
1	245	+	
2	275	+	
3	305	+	
4	335	+	The box representing a portion of the flat surface of the side of the fire-box of a locomotive boiler was composed of a copper plate, on one side half an inch thick, and an iron plate on the other three-eighths of an inch thick, being the same in every respect as the boiler which exploded, and according to the dimensions exhibited in the drawings, fig. 4.
5	365	+	
6	395	+	
7	425	+	
8	455	·03	
9	485	·03	
10	515	·04	
11	545	·05	
12	575	·05	
13	605	·06	
14	635	·06	
15	665	·06	
16	695	·07	
17	725	·07	
18	755	·07	
19	785	·08	
20	815	...	Burst by drawing the head of one of the stays through the copper, which from its ductility offered less resistance to pressure in that part where the stay was inserted.

The above experiments are at once conclusive as to the superior strength of the flat surfaces of a locomotive fire-box, as compared with the top, or even the cylindrical part of the boiler; but taking the next experiment, where the stays are closer together, or where the areas of the spaces are only 16 instead of 25 square inches, we have an enormous resisting power; a force much greater than anything that can possibly be attained, however good the construction, in any other part of the boiler.

Table IV.

Experiment 2nd.—To determine the ultimate Strength of the Flat Surfaces of Locomotive Boilers when divided into squares of 16 inches area.

Number of experiments.	Pressure in pounds per square inch.	Swelling of the sides in inches.	Remarks.
1	245		
2	275		
3	305		
4	335		The flat box on which these experiments were made has the same thickness of plates as that experimented upon in the preceding table, viz. one side of copper half an inch thick, and the other of iron three-eighths thick. The only difference between the two is the distance of the stays, the first being in squares of 25 inches area, and the other in squares of 16 inches area.
5	365		
6	395		
7	425		
8	455		
9	485		
10	515	·04	
11	545	·04	
12	575	·04	
13	605	·06	
14	635	·06	
15	665	·07	
16	695	·07	
17	725	·07	
18	755	·08	
19	785	·08	
20	815	·08	
21	845	·08	
22	875	·08	
23	905	·08	
24	935	·08	
25	965	·09	
26	995		From 995 to 1295 lbs., the swelling or bulge on the side was inappreciable.
27	1025		
28	1055		
29	1085		
30	1115		
31	1145		
32	1175		
33	1205		
34	1235		
35	1265		
36	1295	·09	
37	1325	·09	
38	1355	·10	
39	1385	·11	
40	1415	·11	
41	1445	·12	
42	1475	·13	
43	1595	·14	
44	1535	·16	
45	1565	·22	
46	1595	·34	
47	1625	...	Failed by one of the stays drawing through the iron plate after sustaining the pressure upwards of 1½ minute.

In the above experiments, it will be observed that the weakest part of the box was not in the copper, but in the iron plates, which gave way by stripping or tearing asunder the threads or screws in part of the iron plate at the end of the stay marked *a*, fig. 5.

The mathematical theory would lead us to expect that the strength of the plates would be *inversely as the surfaces between the stays*; but a comparison of the results of these experiments shows that the strength decreases in a higher ratio than the increase of space between the stays. Thus, according to the mathematical theory, we should have—

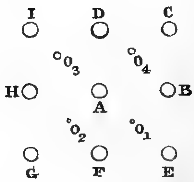
$$\text{Ult. strength 2nd plate per sq. in.} = \text{strength 1st plate} \times \tfrac{25}{16}$$
$$= 815 \times \tfrac{25}{16} = 1273 \text{ lbs.}$$

Now this plate sustained 1625 lbs. per square inch, showing an excess of about one-fourth above that indicated by the law.

This is in excess of the force required to strip the screw of a stay $\frac{11}{16}$ths of an inch in diameter, such as those which formed the support of the flat surfaces in the exploded boiler.

It will be found that a close analogy exists throughout the whole experiments, as respects the strengths of the stays when screwed into the plates, whether of copper or iron; and that the riveting of the ends of the stays adds to their retaining powers an increased strength of nearly 14 per cent. to that which the simple screw affords. The difference between a fire-box stay when simply screwed into the plate and when riveted at the ends is therefore in the ratio of 100 : 76, nearly the same as shown by experiment in the Appendix.

Fig. 6.



It is desirable, therefore, that we should ascertain the strain exerted on each stay or bolt of the fire-box.

Let A, B, C, D, E, F represent the ends of the bolts or stays; O_1, O_2, O_3, O_4 the centres of the squares formed by the bolts. Suppose a pressure to be applied at each of the points O_1, O_2, O_3, O_4 equal to the whole pressure on each of the squares, then the central bolt A will sustain one-fourth of the pressure applied at O_1, also one-fourth of the pressure applied at O_2, and so on; so that the whole pressure on A will be equal to the pressure applied to one of the square surfaces. Hence we have—

$$\text{Strain on the stay of Table III.} = \frac{815 \times 25}{2240} = 9 \text{ tons.}$$

$$\text{Strain on the stay of Table IV.} = \frac{1625 \times 16}{2240} = 11\tfrac{1}{2} \text{ tons nearly.}$$

The stay in the latter case was $\frac{13}{16}$ths of an inch in diameter; hence the strain upon one square of section would be about 13 tons, which is considerably within the limits of rupture of wrought iron under a tensile force.

In the experiments here referred to, it must be borne in mind that they were made on plates and stays at a temperature not exceeding 50° of Fahrenheit; and the question naturally occurs, as to what would be the difference of strength under the influence of a greatly increased temperature in the water surrounding the fire-box, and that of the incandescent fuel acting upon the opposite surface of the plates.

This is a question not easily answered, as we have no experimental facts sufficiently accurate to refer to; and the difference of temperature of the furnace on one side, as compared with that of the water on the other, increases the difficulty, and renders any investigation exceedingly unsatisfactory.

Judging, however, from practical experience and observation, I am inclined to think that the strengths of the metals are not much deteriorated. My experiments on the effects of temperature on cast iron* do not indicate much loss of strength up to a temperature of 600°. Assuming therefore that copper and wrought iron plates follow the same law, and taking into account the rapid conducting powers of the former, we may reasonably conclude that the resisting powers of the plates and stays of locomotive boilers are not seriously affected by the increased temperature to which they are subject in a regular course of working. This part of the subject is, however, entitled to future consideration; and I trust that some of our able and intelligent superintendents will institute further inquiries into a question which involves considerations of some importance to the public, as well as to the advancement of our knowledge in practical science.

Appendix.

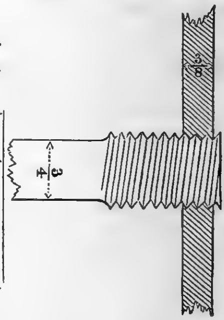
In order to test with accuracy the tensile power of the different descriptions of stays used in locomotive boilers, and to effect a comparison between those screwed into the plates and those both screwed and riveted, it was deemed expedient to repeat Mr. Ramsbottom's experiments on a larger scale; and by extending the tests to copper stays as well as iron ones, it was considered that no doubt could exist as to the ultimate strength of those simply screwed, the tensile powers of the stays themselves, and the relative difference between those and the finished stays when screwed and riveted on both sides of the fire-box.

The large lever and requisite apparatus being at hand, the experiments proceeded as follows:—

Experiments to determine the Ultimate Strength of Iron and Copper Stays generally used in uniting the flat surfaces of Locomotive Boilers.

Experiment I.—Iron Stay, $\frac{3}{4}$ths of an inch in diameter, screwed into a copper plate $\frac{3}{8}$ths of an inch thick.

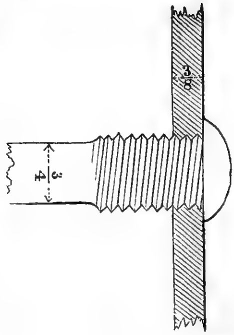
No. of experiment.	Weight in pounds.	Remarks.
Lever 1	9,860	With the last weight, 18,260 lbs. = 8·1 tons, the threads in the copper plate were drawn out or stripped after sustaining the weight a few seconds.
2	11,540	
3	13,220	
4	14,900	
5	16,580	
6	18,260	



* *Vide* the Transactions of the British Association for the Advancement of Science, vol. vi. p. 406.

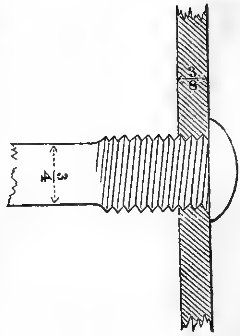
EXPERIMENT II.—Iron Stay, $\frac{3}{4}$ths of an inch in diameter, *screwed and riveted* into a copper plate $\frac{3}{8}$ths of an inch thick.

No. of experiment.	Weight in pounds.	Remarks.
Lever 1	9,860	
2	11,540	
3	13,220	When the last weight, 24,140 lbs. =10·7 tons, was laid on, the head of the rivet was torn off; and the stay, along with the threads in the copper, was drawn through the plate.
4	14,900	
5	16,580	
6	18,260	
7	19,940	
8	21,620	
9	23,300	
10	24,140	



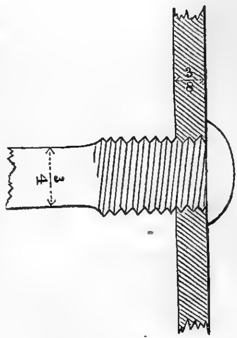
EXPERIMENT III.—Iron Stay, $\frac{3}{4}$ths of an inch in diameter, *screwed and riveted into an iron plate* $\frac{3}{8}$ths of an inch thick.

No. of experiment.	Weight in pounds.	Remarks.
Lever 1	9,860	
2	13,220	
3	16,580	
4	19,140	With the last weight, 28,760 lbs. =12·5 tons, the stay was torn asunder through the middle, both screw and plate remaining perfect.
5	20,780	
6	23,300	
7	25,980	
8	26,660	
9	27,940	
10	28,760	



EXPERIMENT IV.—Copper Stay, $\frac{3}{4}$ths of an inch in diameter, screwed and riveted into a copper plate $\frac{3}{8}$ths of an inch thick.

No. of experiment.	Weight in pounds.	Remarks.
Lever 1	9,860	With 11·540 lbs. the body of the stay was slightly elongated.
2	11,540	
3	13,220	Elongation considerably increased with 14,900 lbs.
4	14,900	
5	16,265	Broke with 16,265 lbs. = 7·2 tons, after sustaining the load upwards of three minutes. Ultimate elongation, 0·56 inch in a length of 3 inches.



It will be observed, on comparing the results obtained from the above experiments, that iron plates and iron stays are considerably stronger than those made of copper. It may not be advisable to have the interior fire-box made of iron, on account of its inferior conducting powers and its probable durability; but so far as regards strength, it is infinitely superior to that of copper, as may be seen by the following

Summary of Results.

No. of experiment.	Breaking weight in tons.	Resistance per square inch in tons.	Ratio, Experiment III., the iron stay and iron plate taken as 1000.
III.	12·5	27·7	1000 : 1000 Iron and iron.
I.	8·1	18·8	1000 : 648 Iron and copper screwed.
II.	10·7	23·6	1000 : 856 Iron and copper screwed and riveted.
IV.	7·2	16·1	1000 : 576 Copper and copper screwed and riveted.

On the above data, it will be found that the iron stay and copper plate (not riveted) have little more than one-half the strength of those where both are of iron; that iron stays screwed and riveted into iron plates are to iron stays screwed and riveted into copper plates as 1000 : 856; and that copper stays screwed and riveted into copper plates of the same dimensions, have only about one-half the strength of those where both the stays and plates are of iron. These are facts in connexion with the construction of locomotive, marine, and other description of boilers having flat surfaces, which may safely be relied upon, and that more particularly when exposed to severe strain, or the elastic force of high-pressure steam.

Provisional Report on the Theory of Determinants. *By* J. J. Sylvester, *F.R.S.*

I trust that I may stand acquitted of any want of respect to the British Association, in having failed to be ready with the Report which last year they did me the honour of confiding to me, on the Theory of Determinants. A circumstance has occurred since the last meeting, which seems to render such report less necessary or useful than at that time it appeared to be, as I have been informed that a complete compendium of all the methods and results of this theory is shortly forthcoming from the hands of a fellow-countryman, Mr. Spottiswoode, in the journal of M. Crelle, which is accessible to the whole mathematical world. This and the pressure on my mind attendant upon multifarious occupations and numerous original researches, may, I hope, serve as a sufficient apology for being unprepared with the report. The much vaster subject of Invariants, which includes the theory of Determinants as its simplest case, has at present no chronicler or editor; and if the Association would think it desirable that a summary of the progress so far made in it should be collected, and be not unwilling to commit to my charge the execution of it, I should have pleasure in accepting the task, provided the period for its completion were previously understood to be not necessarily limited to the period of a single year from the present time.

26 Lincoln's Inn Fields, September 3, 1853.

Report on the Gases evolved in Steeping Flax, and on the Composition and Œconomy of the Flax Plant. By Professor HODGES, *M.D.*

THE investigations directed by the Association at the Belfast Meeting with respect to the gases evolved in the steeping of flax and the composition of flax straw are in progress, and will be reported at the next meeting. The gases of the fermenting vat have been analysed by the methods of Professor Bunsen, and have been found to consist of carbonic acid, hydrogen, and nitrogen. No sulphuretted hydrogen has in any case been detected. Several analyses of the proximate constituents of the dressed fibre and of its inorganic ingredients have been made, which show that a considerable amount of the nitrogenized and other constituents of the plant are retained in the fibre, even after steeping and dressing have been employed to remove the structures unsuitable for textile purposes.

Thirteenth Report of a Committee, consisting of H. E. STRICKLAND, *Esq.,* Professor DAUBENY, Professor HENSLOW, *and* Professor LINDLEY, *appointed to continue their Experiments on the Growth and Vitality of Seeds.*

THE portions of each kind of seed set apart for this year's sowing were from those gathered in 1845, and are consequently of kinds which have been twice, previously, subjected to experiment, first in 1846, and secondly in 1848.

The circumstances under which they were sown were similar to those annually resorted to; nevertheless many have failed and appear to be exhausted, or nearly so, as will be seen by reference to the annexed Register:—

Name and Date when gathered.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
1845.								
1. Ailantus glandulosa	50	......	......	8	......	......	30	Weakly and yellow.
2. Alnus glutinosa	150	2	......	2	95	......	30	
3. Alonsoa incisa	100							
4. Beta vulgaris	75	2	7	14	20	16	15	
5. Browallia elata	50							
6. Chrysanthemum coronarium	150	1	......	2	45	......	30	
7. Cytisus albus	100	9	4	......	30	24		
8. Eccremocarpus scaber	100	......	......	1	......	......	27	Weakly.
9. Fagus sylvatica	100							
10. Fumaria spicata	100							
11. Gaillardia aristata	100							
12. Gleditschia triacanthos	20	3						
13. Iris, sp.								
14. Knautia orientalis	50							
15. Lopezia racemosa	150							
16. Lymnanthes Douglasii	50							
17. Petunia odorata	150	......	4	......	......	16	......	Weakly.
18. Schizopetalon Walkeri	50	......	......	2	......	......	32	Weakly.
19. Secale Cereale	200							
20. Spartium Scoparium	200	51	6	23	40 to 100	25	29	
21. Tagetes lucida	150							
22. Viscaria oculata	150	3	......	6	40	......	32	
23. Xeranthemum annuum	100	......	......	3	......	......	27	Weakly.
24. Zea Mays	100							
25. Zinnia grandiflora	100							

On the Chemical Action of the Solar Radiations. *By* Robert Hunt.

[Second Report.]

Note.—[In the former Report a division was made between the analytical examination of the solar spectrum by absorbent media, and the chemical results obtained from the spectra which had been thus subjected to absorption. It has been found inconvenient, in the examination of the woodcut illustrations, to have constantly to refer from page to page when comparing the chromatic with the chemical effects. This arrangement has, therefore, been altered in the present Report, and the chemical spectrum is given immediately after the description of the luminous spectrum. In all other respects the same order of arrangement is maintained; the numbers attached to the glasses, &c. remain unaltered, and where new specimens have been introduced they have been numbered in continuation. This remark applies also to the paragraphs, so that reference from one to the other, when required, will be made without difficulty. The uncertain state of the present summer, and the small amount of sunshine with which we have been favoured, has greatly retarded the progress of this investigation.]

(70). The Chemical preparation employed in the series of experiments which I have now to describe, was the iodide of silver as obtained on the ordinary iodized paper, rendered sensitive by the mixture of gallic acid and nitrate of silver. As, however, I find that nearly every variety of paper, and certainly, every different manipulation, gives rise to an alteration in the scale of sensibility, it becomes important that I should describe exactly the character of the paper employed.

A very hard and uniform paper of Turner's was selected; its surface being beautifully pressed, and presenting a fine ivory character. It was first washed with a solution of sixty grains of nitrate of silver to the fluid ounce of distilled water, and dried; then with a solution of thirty grains of the iodide of potassium to the fluid ounce of water. After standing for a few minutes, each sheet was placed in a large vessel of water, and allowed to soak for about half-an-hour. After this, being hung by one corner, it was allowed to dry in a warm room; if the atmosphere was moist, at a short distance from the fire.

This paper was placed upon the screen on which the spectrum obtained fell, after it had been submitted to the action of the medium under examination. Everything being carefully adjusted, the paper was washed rapidly by a wide flat brush, with the following mixture:—

Saturated solution of gallic acid	40 drops.
Nitrate of silver, thirty grains to fluid oz. of water..	10 drops.

The action was, in most cases, allowed to continue for a few seconds only, and the image developed itself slowly in the dark, without any subsequent application of the developing fluid.

(A.) *Series of Yellow Glasses* (continued).

(71) 60. Pure yellow. *Colouring matter Carbon.*—The visible spectrum is reduced by the violet and indigo rays; the orange blends with the yellow, which is consequently much extended (a slight extension arises also

from the reduction of the green space); the illuminating powers of the outstanding rays are but very slightly diminished.

(72) 60. Chemical action commences in the mean yellow ray about ·20 above a'; it extends, in the first instance, over a space equal to ·10, forming a patch of a semi-metallic lustre with an olive-grey colour; this action is continued for another equal space, but the impressed space has more of a brown hue; these gradually blend into one nearly circular spot. From about ·30 above a', a second action commences, independently of that already described; and indicating, as it appears to me, a set of rays of distinct character. Beyond this, at about ·60, another oval forms, which continues and extends to ·15, or sometimes, if the sun is very bright, to ·20 beyond a. This space, equal to ·60, is in every respect very broadly distinguished from that which is produced between the lines C and F of Fraunhofer. It is characterized by a light, cloudy brown colour, which deepens a little in colour beyond the luminous rays of the ordinary spectrum, when it is somewhat suddenly shaded off. The action may be well represented by two ovals, one considerably larger and longer than the other, which overlap; and it would appear that the change of colour observed in the upper section of the lower space is due to this involved action of two sets of rays. In the chemical spectrum described (52), obtained after the absorptive action of a medium yellow glass (6), No. 13, an indication of precisely similar peculiarity was obtained on the collodion plate, although at that time sufficient importance was not attached to the difference.

Fig. 35.

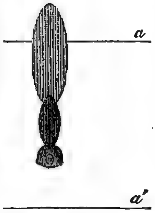
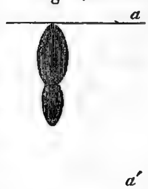


Fig. 36.

(73) 74. Yellow, *by Iron*.—The least refrangible rays are scarcely at all influenced by this glass; the orange is slightly extended upon the red; and the yellow in a similar manner encroaches on the green rays. The green rays are, however, very decided, and beyond them there still appears an outstanding line of blue, or rather dark indigo; but beyond these no further rays are visible.

(74) 74. At the most refrangible edge of the yellow rays the chemical action begins; and it may be at once described as extending to the very edge of the space occupied by the visible rays of the unabsorbed spectrum. In this, as in the spectrum from the carbon yellow glass (71. 72), a like dissimilarity was observable between the action of the two ends of the chemically active rays, although not to the same extent. The lower space, which commences about ·40 above a' and extends to above ·60, is a pale gray spot, with a well-defined outline. The upper space, commencing at ·55 above a' and extending completely up to a, is much broader than the first, less perfectly defined, and of a brown colour of the same character as that already described. After several experiments, in which the periods of exposure were much varied, it was proved that no chemical action took place actually in the yellow rays when this glass was employed.

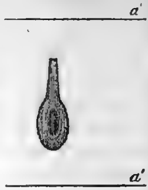
Fig. 37.



(75) 65. Lemon Colour, *by Silver*.—This very transparent glass does not exert any peculiar influence on the most luminous rays of the spectrum, beyond giving a peculiar whiteness to the yellow ray; but produces a very decided effect upon those which are least luminous at the most refrangible end. Beyond the green rays a broad fringe of clear dark blue is still evident, being the whole of the indigo ray, slightly altered in its colour by this absorptive medium; the violet, however, being entirely wanting.

(76) 65. The chemical change is confined to a space between the mean yellow ray of the spectrum, near the line E, or ·25 above a', and the upper verge of the green ray, or ·70 above a'; the oval being usually from ·42 to ·45 in length, a narrow neck extending upwards. Upon close examination, it is apparent that, even in this shortened chemical spectrum, we obtain indications of the two actions already described.

Fig. 38.



(77) 66. Pure bright yellow, *by Silver*.—By this glass the blue rays are completely obliterated, and the green rays somewhat shortened; but all the least refrangible rays are preserved in their purity, with the exception that the orange rays are somewhat reduced, and appear as a well-defined band, of more brilliancy than when seen without the interposition of this medium; and much white light is seen in the yellow ray. In observing natural colours through this glass, the absorption of all the blue rays, and those beyond, becomes very sensible.

(78) 66. In this case the chemical change occurs over the space covered by the most luminous rays, the orange, yellow, and the least refrangible green. It is comprehended within a space equal relatively to the corrected length of the spectrum of about one-third of an inch, and within these limits are discoverable three defined actions, differing in the intensity of the effect produced, and of the resulting colour of the impression; the lower space corresponding with the upper orange ray being several shades lighter than that darkened by the yellow ray, and again, the action of the green is far less intense. Where the gradations of shade are very slight, it is not easy to speak decidedly as to their character; but the least refrangible space may be described as *gray*; the next in order, and by far the most intense, as an *iron-gray* or *bronze*; and the next as a *pure brown*. There were sometimes indications obtained of a central line of action, extending from the green up into the blue rays; but this was always exceedingly faint, and only to be found when the atmosphere was clear and the sun very bright.

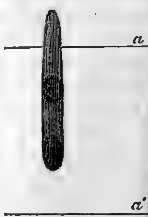
Fig. 39.

(79) 15. Straw-yellow. *Silver stain upon one surface only.* (Par. 5, First Report, 1852.)—It will be seen, by reference, that this glass cuts off a considerable portion of the violet rays, leaving the other rays without any considerable change.

An impression of this spectrum on collodion was not obtained, therefore the present one on iodized paper is not comparable with any previous impression.

(80) 15. Action commences at ·20 above a', and extends over the more luminous space with the greatest intensity; then the action suddenly weakens over the limits of the green rays, growing more intense under the action of the blue and indigo rays. A still more decided weakening of chemical activity occurs at about ·18 below a, from which space unto ·20 beyond a, a faint indication of action is continued. Thus we have here two very remarkable maxima and minima; the former in the yellow and blue rays, and the latter in the green and violet rays, and beyond them.

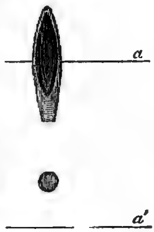
Fig. 40.



(81) 16. Deep yellow, *Carbon*.—For chromatic analysis see Par. 4, First Report; and for chemical action, Par. 51; the preparation then employed being a highly-sensitive collodion plate.

(82) 16. The chemical action is weak, and the resulting impression after long development is far from strong. The changes are, however, remarkable. In the very centre of the yellow ray a faint spot is produced; then all action ceases until about ·60 above a', a faint indication of chemical change again begins to be visible. This is continued as a mere long oval stain, of pretty uniform intensity, to 1·30, when all action terminates. On the collodion plate we have a very striking example of protective action, which is not apparent on the iodized paper; and on the former preparation the action is continuous from the point at which it commences to that at which it terminates.

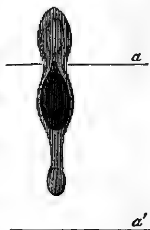
Fig. 41.



(83) 17. Deep yellow, *Iron*, fig. 3, par. 8, First Rep.—The obliteration of the blue, the violet still continuing visible, is the most remarkable characteristic of this glass.

(84) 17. A slight indication of chemical change commences in the yellow ray, ·18 above a'. This forms eventually a well-defined oval equal to ·12; from this point extends a narrow neck, over which the chemical change is exceedingly slight; then a well-defined oval extends to 1·30, with a slight interruption to its intensity and contraction at the extreme edge of the violet. Slight differences of colour are observable along this oval; its general tone is a bright pure brown; but where the blue rays should have fallen, there is a tendency to a gray; and along the longitudinal centre of the image, it would appear as if some more energetic power had been in operation.

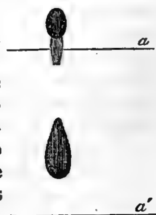
Fig. 42.



(85) 18. Medium yellow, *Charcoal*, par. 6, First Report; and for chemical action on collodion plate, see fig. 21, which shows a most extraordinary amount of action beyond the visible spectrum, par. 52.

(85) 18. The chemical action on the iodized paper is limited to two well-defined spaces; one, the most intense, a dark oval over the point of greatest luminous intensity, equal to ·20, commencing at ·15 above a' and terminating at ·35 a'. Between this point and the most refrangible violet there is no effect, the paper remaining quite unchanged; then at the extreme verge of the luminous spectrum a weak chemical action commences, which extends to 1·20. This is singularly weak, except in the mean space about ·10 above a, where the influence of the chemical rays is more decided.

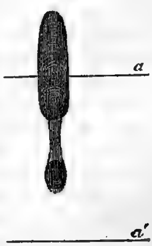
Fig. 43.



(86) 67. High orange, *Silver*.—The luminous spectrum is nearly reduced to red and green, a faint line of yellow alone appearing between these two; the orange rays are completely absorbed, and the green losing much of its blue, appears of a peculiar pale colour; no rays visible beyond the green.

(87) 67. Although this chemical spectrum differs in some respects from others already described, yet it exhibits peculiarities which are, to a certain extent, common to all the actions which have yet been obtained through yellow media. The chemical change commences and is most decided in the yellow ray, where an olive-brown oval is rapidly formed. At ·70 above a' the second chemical change occurs, forming a brown oval, which extends to 1·30. These two ovals are connected by a very faint neck, which is only

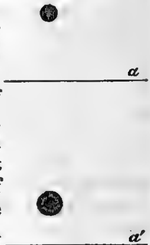
Fig. 44.



visible when the exposure to the spectrum has been prolonged, or the sunshine is very intense, and the atmosphere clear, after rain.

(88) 68. *a.* Orange, *Silver.*—All the more refrangible ordinary rays are very decidedly obliterated, and even the green somewhat shortened; but in the place of the blue and violet rays there is observable some red. The yellow and orange are considerably reduced, the red standing out in great brilliancy.

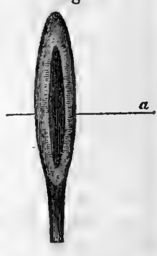
Fig. 45.



(89) 68 *a.* A very singular result is obtained when the prismatic rays are subjected to the absorptive action of this medium. A faint spot makes its appearance in the yellow space, and in the *point of maximum luminous intensity.* No other action than this occurs within the limits of the visible spectrum; but about ·40 beyond *a*, a yet fainter spot of chemical action makes its appearance. Thus we have in this example evidence of two sets of chemical rays which have a very much greater penetrating power, relative at least to the yellow media we have been examining, than any of the others situated in those parts of the spectrum which are usually referred to as possessing the greatest chemical power. Other examples of a similar description will be noticed.

(90). Yellow, *by Carbon.*—This glass, which is of a brownish colour, and without much brilliancy, allows the free permeation of all the rays below H. When the sun has been very brilliant, a slight shade of violet is visible beyond the line H. The red of the violet is, however, nearly obliterated.

Fig. 46.



This yellow medium gives a very decided and intense chemical spectrum. The action commences at ·25 above *a′*, and continues of an olive-brown colour to ·50, the oval formed at first gradually passing into a band. Then a larger oval is formed, which extends to 1·50, and sometimes still further. The overlapping of these, as previously noticed, is very apparent in this spectrum, and the colours of the upper oval and the lower prolonged space were as different as any which have yet been noticed. There were also some evidences of those internal actions which have been previously observed, but there was much uniformity in the colours and characters of the inner and outer images.

(91) 68. Orange-coloured glass, *Silver.*—Possessing in a remarkable degree the false dispersion observed by Mr. Stokes. It reflects from one side, when placed on a piece of black velvet, a peculiar bluish-green light; or when placed on a sheet of white paper, the scattered light partakes of that mixture of blue and brown which is ordinarily distinguished as a puce.

Of this variety of glass, Mr. Stokes makes the following remarks in his memoir 'On the Change of Refrangibility of Light':—"Orange-coloured glasses are frequently met with which reflect from one side, or rather scatter in all directions, a copious light of a bluish-green colour, quite different from the transmitted tint. In such cases the body of the glass is colourless, and the colouring matter is contained in a very thin layer on one face of the plate."

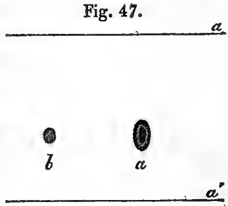
This is not always the case; in the glass with which the present experiment was made the colouring matter, silver, is diffused throughout the mass. The peculiarity in question is produced on one surface by exposing it to the influence of the flame of burning wood.

Mr. Stokes continues: "As this phenomenon was supposed by Sir John

Herschel to offer some analogy with the reflected tints of fluor-spar and a solution of sulphate of quinine, I was the more desirous of determining the nature of the dispersion. It proved on examination to be nothing but false dispersion, so that the appearance might be conceived to be produced by an excessively fine bluish-green powder contained in a clear orange stratum, or in the colourless part of the glass immediately contiguous to the coloured stratum. The phenomenon has therefore no relation to the tints of fluor-spar or sulphate of quinine. It is true that the very same glass which displayed a superficial reflexion of bluish-green, when examined by condensed sun-light, exhibited also, in its colourless part, a little true dispersion, just as another colourless glass would do. But this has plainly nothing to do with the peculiar reflexion which attracts notice in such a glass." The spectrum transmitted through this glass is shortened by the loss of the violet, indigo, and nearly all the blue rays; some rays are, however, still visible beyond the green, which assume a reddish colour. The orange rays are extended into the yellow, with which much white light is mixed, and the least refrangible rays lose some of their illuminating power.

(92) 68. The chemical action of the rays which permeate this glass is confined exclusively to the central space of the yellow rays. On the first exposure a mere indication of change was the only evidence which was obtained; by allowing the action, however, to continue for a few minutes, taking care that the spectrum still fell upon the same space, a decided olive-brown oval spot ·10 in length was obtained; this was deepened by still prolonged exposure, but not enlarged.

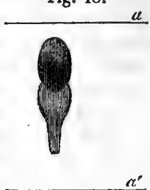
Fig. 47.



(93) 69. Yellow, *by Carbon* (?).—Beyond the green rays the blue rays are still very distinct, although much reduced in their intensity of illumination. The least refrangible rays are not much affected by the absorptive powers of this medium, although the pure brightness of the yellow is considerably diminished.

(94) 69. The changes which occur take place slowly, and even after a prolonged exposure of many minutes, they do not arrive at any considerable degree of intensity. A very faint action is observable in the space covered by the yellow rays; this action producing a weak gray patch of a similar character to those already described (72). This commences at ·20 above a', and extends to about ·50; but it here blends in so gradually with the broader brown oval, that it is not possible to determine exactly where the former ends. A second oval overlaps the first, and this one extends to the line H in the violet ray. There is no trace of any action beyond the luminous spectrum.

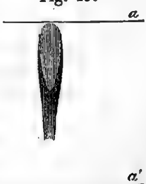
Fig. 48.



(95) 72. Yellow, *by Iron.*—This glass obliterates the violet and indigo rays, but the blue space is still visible of a reddish hue, but the light very faint; a thin line of pure blue is, however, still visible immediately at the edge of the green; the least refrangible rays suffer great loss of their illuminating powers.

(96) 72. This spectrum extends from ·30 above a' nearly up to the end of the luminous spectrum. The colour throughout is more nearly uniform than in the other examples. Still there is a reduction of the chemical force at ·60;

Fig. 49.

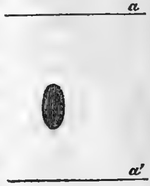


near which, around the edges, an action is again indicated by a colour somewhat different from that produced at the lower end.

(97) 70. Yellow, *by Carbon.*—This glass obliterates all the rays above the green, and reduces the illuminating power of the least refrangible rays very greatly; the red rays alone pass the glass with tolerable intensity.

(98) 70. An exposure to a very concentrated spectrum for three minutes is insufficient to produce any change upon the iodized paper. By prolonging the exposure to five or eight minutes, taking precautions to secure the fixedness of the solar image, a space corresponding to the mean yellow and the green rays becomes faintly coloured; and upon examination, even within this slight impression, variations in the intensity of action are apparent.

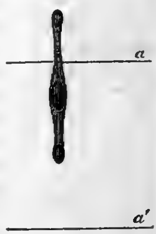
Fig. 50.



(99) 73. Deep Yellow, *by Iron.*—The illuminating power of the outstanding rays is very much reduced; the red, yellow, and green rays are alone distinctly seen; the green passes through various shades until it reaches a black, far up in the space previously occupied by the blue rays.

(100) 73. Chemical change commences at ·70, and extends both upward and downward from this point with nearly equal degrees of intensity, the centre of action continuing well defined. At ·50 above a' another action is established, and a similar well-defined spot at ·50 beyond a. Over the space occupied by the violet and Sir J. Herschel's lavender rays, there is a space upon which no chemical change takes place for a long time; but about ·20 beyond a a faint spot makes its appearance, which is followed after a while by another a short distance above it. This breaking up, as it were, of the spectrum into small circles of chemical action cannot but be regarded as curious. At present we are not in a position to offer any explanation of the phænomena. At length the three principal spots become united by continuous necks, over which, however, the chemical action is weak.

Fig. 51.



(101) 76. Yellow, *by Carbon.*—Red, yellow, and green are the only colours of the spectrum which pass this glass, and these are considerably reduced in brilliancy. Beyond the green, the space of the other rays is distinguishable rather by its blackness in contrast with the other illuminated spaces, than by any other indication.

(102) 76. We have here another example of the chemical action being confined to the *most luminous rays*; the whole space darkened being equal to ·10, and with the exception of some slight shading off at the edges of the oval, the colour is uniform.

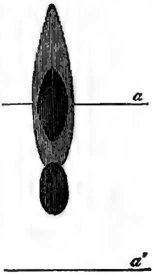
Fig. 52.

(103) 77. Yellow.—The blue rays are changed by the blending with them of the red of the violet, which are but little altered. The green rays are still visible, but they lose much intensity by the loss of their blue. The yellow ray also suffers considerably in its intensity, and indeed the red and orange are lowered in intensity. So that all the spectrum suffers rather in its general illuminating power, than in any actual destruction of a particular ray.

(104) 77. The impressed spectrum in this instance bears a close resemblance to others obtained, after the incident beam has permeated yellow media. At the least refrangible end the colour is an olive-brown, and an

elongated oval is well made out. This effect is produced by the yellow and the lower green rays, and occupies a space of about ·30; then a fainter impression is visible on the paper, and over the space upon which the blue and indigo falls there is an enlargement in width of the image, and the colour is a pure brown. The action is continued over the violet and lavender spaces as an interior dark oval, and it extends in diminished intensity to 1·50, when it suddenly ceases.

Fig. 53.



(105) 78. Yellow, *by Coke*.—The entire length of the spectrum is scarcely at all reduced, but the blue and violet rays blend, forming one band of a faint reddish blue; the green rays are somewhat lengthened; the yellow rays are mingled with the orange.

(106) 78. The difference between this and the former spectrum (104) is rather in degree. The image is as nearly as possible the same in all its parts, but that the chemical action extends to the lower point; it can indeed be traced down into the orange ray.

(107) 79. Uranium glass, *Canary-yellow*.—This is the peculiar yellow glass which is employed in the manufacture of toilet bottles and other ornamental articles, which transmits a pale yellow light, and disperses an unusual green light. Upon this quality depends its extensive use in ornamental glass manufacture. In my experiments I have employed a slab of this glass, the thickness of which is 1 inch, its width $2\frac{4}{10}$ inches, and its length $4\frac{1}{2}$ inches; and independently of some striæ, the glass was of a pretty uniform character throughout. This slab enabled me to operate respectively through the several thicknesses of 1, or $2\frac{4}{10}$ or $4\frac{1}{2}$ inches, and thus to determine with very great exactness the thickness of this medium through which the chemical rays would pass. If a block of this glass, which is a canary-yellow when we look through it, is placed upon a piece of black velvet, and we look at it, it appears of a fine yellowish green colour; this green light wanting, however, transparency, and exhibiting more the character of a gleam of monochromatic light piercing through a mist.

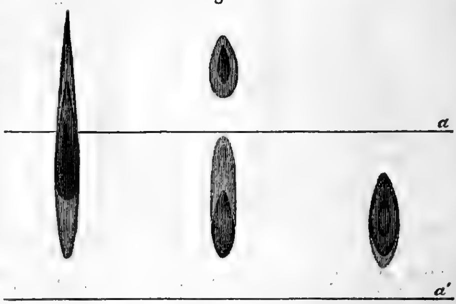
If we throw upon the face of this glass a condensed pure spectrum, and look through the sides of it, so as to observe the passage of the rays, its powers of internal dispersion become distinctly visible. From the fixed line *b* we find this dispersion commences, but few of these rays are enabled to penetrate through the 1-inch thickness of the glass. A little above F a minimum point is very observable, and from this point the dispersion of the rays becomes very decided; and some of these green rays, when the light is good, penetrate the glass. This green-dispersed light is visible for a considerable distance beyond the ordinary spectrum; the entire space which has usually been designated as the invisible chemical rays, is rendered luminous. [For a more detailed examination of the optical properties of this glass, I must refer to Professor Stokes's Memoir 'On the Change of Refrangibility of Light,' in the Philosophical Transactions for 1852.]

The ordinary spectrum which permeates this glass is but slightly altered in its character, the condition of the rays after having undergone absorption by this medium being as follows:—Beyond the green ray appears a band of a brownish hue, from the mixture of red with blue; then the blue appears again with considerable brightness. On looking at the coloured fringes produced by the prism, and interposing the uranium glass, it is evident that both blue and violet rays do permeate.

(108) 79. The chemical effect produced by the solar spectrum after it has

undergone absorption and dispersion by the uranium glass is not a little remarkable, and requires to be studied with much care. Before each experiment with this glass, it was my practice to obtain an impression from a very pure concentrated spectrum which had not been subjected to any absorption; the object of this being to determine exactly the relation which the chemical spectrum after absorption and dispersion bore to the unabsorbed image. This was necessary, as it was found there were many variations, from day to day, in the chemical powers of the several spaces corresponding with the coloured rays. Under all circumstances there was the same general character in this impressed spectrum after absorption as in many of those already described. The action was divided into two well-defined spaces. The rays which are chemically active from the mean yellow rays up to the blue produce a well-defined image varying in intensity: first a dark-olive oval, and above this we have a second brown oval. This, however, stops short of the end of the visible spectrum, terminating in the mean violet ray. Measurement according to the scale I have adopted throughout gives the following result. The first image in the figure represents the normal chemical spectrum:—

Fig. 54.



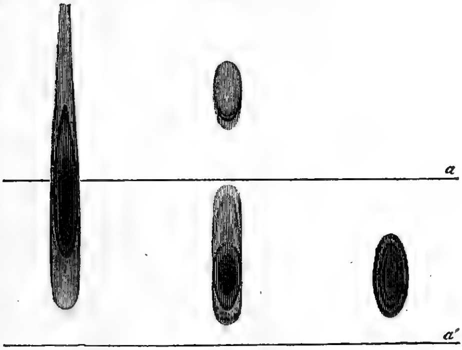
First indication of chemical action above a'		·15
Point of termination of the first oval	,,	·55
Commencement of second oval	,,	·50
Termination of second oval	,,	·90
Entire length of the image formed within the limits of the visible spectrum		·75

A space without any chemical change, equal to ·45, then occurs. This appears to agree with the extreme violet ray and the lavender ray of Sir John Herschel, and the lines of Becquerel and Stokes beyond. Beyond this, that is, at ·45 above a', the most refrangible limits of the known spectrum, a third oval forms, the entire length of which is ·40; so that the whole length which undergoes chemical change is ·115, with the interruption of the action above H to about Mr. Stokes's lines l. If the spectrum is made to pass through the width of the block of uranium glass, which is $2\frac{4}{10}$ inches, the action beyond the spectrum is entirely obstructed; but over the space covered by the most luminous rays chemical action goes on, with an intensity nearly equal to that which is produced when the thickness of the slab about 1 inch only is used for absorption. The third figure in the woodcut represents the result which is obtained.

(109) 79. *Bromide of Silver* instead of the iodide of silver was employed. The differences are not remarkable between those impressions and those already described, as being obtained on the iodized paper. The first oval of the spectrum after absorption descends rather lower, and shows a very decided action, due to the yellow rays, superior to that shown when the iodide is employed. When the rays are made to pass through $2\frac{4}{10}$ inches of the

uranium glass, although all the more refrangible rays are absorbed, these rays, corresponding with the most luminous, still continue very energetic.

Fig. 55.



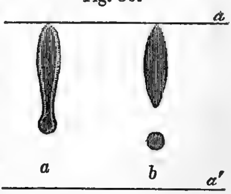
RED SERIES.

Pale ruby, by Gold.

(110) 81 *a*. The lower rays of the prismatic spectrum are but little changed; the upper portion of the green rays become a dark olive, passing into a brown, and having but very small illuminating power; then the blue again comes out in much brilliancy, and the violet rays are unaffected, except that the red is rendered superior in intensity to the blue of those rays.

(111) 82. PALE RUBY, *by Gold*.—The action on the luminous spectrum is as nearly as possible that exhibited by 81*a*.

Fig. 56.



(112). The chemical action of the glass 81 is shown in *a*, fig. 56. It commences in the blue rays, and extends upwards to the end of the violet, and downwards by a slight neck to the yellow ray, where it extends slightly in width. There are indications of a protecting action around the entire spectrum. The chemical actions of the rays which permeated 82 were somewhat different, as is shown in fig. *b*. The spot corresponds with the yellow ray; above this, over the green, there is no action for a space equal to nearly ·20, when it again commences, and entirely ceases at the end of the luminous spectrum. In this the protecting band is entirely wanting.

(113) 83. RED, *by Copper*.—The spectrum appears reduced to red and yellow, both well-marked and broadly separated by dark spaces; beyond the yellow a broad dark band appears, and then a set of green rays of slight illuminating power. After long examination, some red violet rays appear visible beyond the green.

(114) 83. After the most prolonged exposure, it is impossible to detect any evidence of chemical action.

(115) 84. Reduces the spectrum to the red rays with a faint line of yellow, and beyond this a line of a dark green, quite a dark olive. The spectrum being projected on a screen having passed this glass, appeared merely as one red spot.

(116) 84. No chemical action even after the longest exposure.

(117) 85. RED, *by Copper*.—This glass reduces the spectrum to a band of red of considerable brilliancy, and a band of yellow light; by carefully

excluding all extraneous light from the eye and gazing at the spectrum fixedly for some time, a trace of the green ray, nearly black, is rendered evident.

(118) 85. Neither of these three glasses show the slightest transparency to the chemical rays. Not only is there no effect produced by the action of the most concentrated spectrum, but the most sensitive calotype paper may be exposed for many hours to an intense sunshine under them, without showing the least signs of chemical change.

(119). To the photographic artist this fact is of considerable importance, since it gives him the means of excluding absolutely all the chemically active rays, still allowing a sufficient quantity of light to pass to enable him to work without any inconvenience. Yellow glasses have frequently been employed; —the results shown, however, in this Report prove the necessity of examining with great care the yellow glass which is used, as it is not the question of intensity of colour, but of the physical character of the colouring agent, that regulates the transparency or opacity of the glass to the chemical rays.

Quinine Solution.

(120). From the interest attached to the peculiar property of the solution of sulphate of quinine in water by means of dilute sulphuric acid, to bring into view a set of rays beyond the violet, of a beautiful celestial blue colour, corresponding with those produced by the canary-yellow glass, I became anxious to examine the influence of it on the chemical rays. This became the more important, since it had been asserted that the ordinarily dark chemical rays had been rendered visible, and this brought forward as an additional proof of the identity of the rays producing luminous and chemical phænomena.

(121). The solution employed was that recommended by Mr. Stokes, as the best for observing the peculiar phænomena of *fluorescence*, as it has been named, consisting of one part of the sulphate of quinine to 200 parts of water. For the purpose of ascertaining if any greater degree of absorption was produced by using a more concentrated solution than this, experiments were made with such as contained as much as six times this quantity of quinine; but unless this is distinctly stated, it will be solutions of the first-named strength which were employed.

(122). A plate-glass trough was used, and being first filled with distilled water, the length and general character of the prismatic spectrum were carefully observed and determined. The trough was then filled with the before-mentioned solution of sulphate of quinine, the result of which was sufficiently remarkable. The ordinary rays of the Newtonian spectrum passed the solution freely, and formed a well-defined image upon a screen placed to receive them. According to the strength of the solution employed, so more or less of the violet ray was cut off. The absorptive action on the other rays was quite inappreciable. From the mean violet ray diminishing, however, towards the end of the ordinary spectrum, the fluorescent rays penetrate the solution 1 inch in thickness, forming a stream of a beautiful celestial blue passing across the fluid; beyond this, over a space often nearly equal to the length of the ordinary spectrum, the new rays continue in view, but in no case penetrating the fluid. Mr. Stokes's observations may be quoted in confirmation of these conditions:

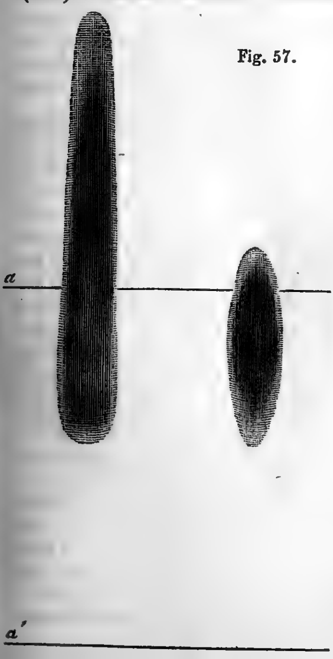
"In the case of a solution of sulphate of quinine of the strength of one part of the disulphate to 200 parts of acidulated water, it has been already stated that a portion of the rays which are capable of producing dispersed light passed across a thickness of 3 inches. On forming a pure spectrum, the fixed line H was traced about an inch into the fluid. On passing from H towards G, the distance that the incident rays penetrated into the fluid increased with great rapidity, while on passing in the contrary direction it diminished no less rapidly, so that from a point situated at no great distance beyond H to where the light entirely ceased, the dispersion was confined to the immediate neighbourhood of the surface. When the solution was diluted so as to be only one-tenth of the former strength, a conspicuous fixed line, or rather band of sensible breadth, situated in the first group of fixed lines beyond H, was observed to penetrate about an inch into the fluid. On passing onwards from the band above-mentioned in the direction of the more refrangible rays, the distance that the incident rays penetrated into the fluid rapidly decreased, and thus the rapid increase in the absorbing energy of the fluid was brought into view in a part of the spectrum in which, with the stronger solution, it could not be so conveniently made out, inasmuch as the posterior surface of the space from which the dispersed light came almost confounded itself with the anterior surface of the fluid."

(123). The mode of operating was the same as that already described, but that the experiments were made with very diffused, and exceedingly concentrated spectra. The object of this was to determine if the less powerful rays were more liable to absorption than those the energy of which had been exalted by concentration. Hence the various spectra obtained varied in length from 1 inch to 6 inches.

(124). The annexed woodcut (fig. 57) has been copied by the wood engraver with very great care from the actual spectra obtained. [This indeed has been done with all the figures of spectra in this, the quinine series.] The space from *a′* to *a* was the exact length of the visible ordinary spectrum, and under the conditions of the experiment, *i. e.* a weak sun and a diffused image at a great distance from the slit through which light was admitted, the chemical impression obtained through the trough filled with distilled water was precisely that represented. When the quinine solution was substituted, the second image was the result.

(125). A weaker solution of the sulphate of quinine was employed, and with a brighter sun than the former, with a less diffused spectrum and longer exposure; the singular elongation of the image down into the orange rays, as shown in fig. 58, was the result. My arrangements for keeping the solar image fixed being imperfect, there was some motion in a horizontal direction, which has given an increased thickness to the impressed spectrum.

Fig. 57.



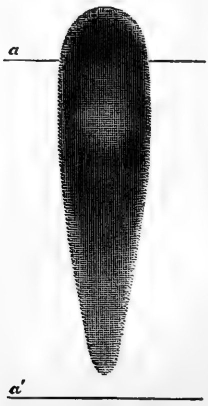
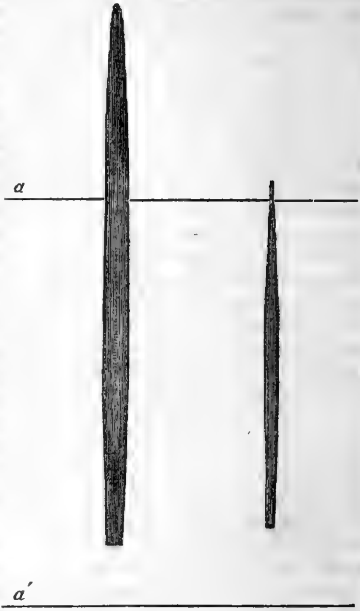


Fig. 58.

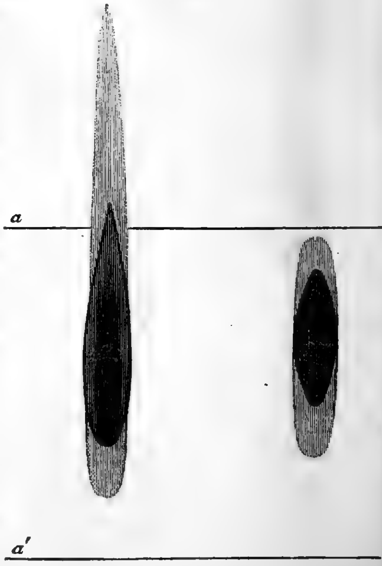
(126). A very intense spectrum was produced by a good achromatic lens employed in my camera obscura for photographic purposes. The resulting chemical spectrum without the interposition of any absorbed medium was that shown in fig. 59; the second image being the result of the interposition of the quinine screen, the exposure in each case being precisely one minute. Upwards of twenty spectra were obtained in the same morning, and, as a constant result, the above woodcut may be regarded as a faithful representation.

Fig. 59.



(127). I was anxious to ascertain the relative differences between the spectra obtained on the iodide of silver and those impressed on the bromide. The paper was first washed with a solution of bromide of potassium, 117 grs. to six ounces of water; then with nitrate of silver, 170·57 grains to three ounces of water. The spectrum being carefully thrown on the paper by nice adjustment of the prism, &c., it was washed with weak gallo-nitrate of silver, the spectrum being shut off by an opake screen. The screen being removed, the luminous image was allowed to act for one minute, and was then again obstructed. Fig. 60 shows the chemical image of the spectrum which had not undergone any absorption, and the second that which was obtained when the quinine trough was interposed.

Fig. 60.



(128). It has been repeatedly stated that the rays at the most refrangible end of the luminous spectrum were rendered chemically inactive by the quinine solution. When bromide of silver is employed, this, as is shown in fig. 60, has been a constant result; but in no case where the iodide of silver has been employed has this been found to be the case.

(129). In conclusion, I may state, that with a view of determining by another method the extent to which the chemical action of the solar radiations were obstructed by the quinine solution and the uranium glass, the following experiments were made:—

My photographic camera was carefully adjusted to embrace a somewhat extensive view, comprehending a granite-wall and trees in the foreground, the sea in the middle distance, and a town with an extensive range of hills beyond.

The first view, a very perfect one, was obtained on calotype paper in fifteen minutes. The glass trough filled with water was then placed in front of the lens, and the paper exposed for the same time as before. The view was not so intense, the radiations from the distant objects and the green leaves of the trees suffering the most by absorption; a very distinct image nevertheless resulted.

The glass trough was filled with the quinine solution. There was very little difference between this and the image obtained when the water was employed, although it was exposed no longer than the others (fifteen minutes). The impression was somewhat redder, and the foliage less perfectly made out: the distant town and land was well made out. The block of uranium (canary-yellow glass) was now interposed, expecting, since through this medium the extra spectral rays are very active, that an equally good result with that obtained through the quinine would have been secured. The image obtained in fifteen minutes was very imperfect; it required a considerable time for its development, and the picture eventually was little more than an outline of the objects.

Some peculiarities, which are not easily explainable, are indicated here; for an examination of which I must, however, wait until sunshine and leisure enable me to resume my researches.

(130). M. E. Becquerel has stated, "The most refrangible rays are the most absorbable," and "that when any part of the *luminous spectrum* is absorbed or destroyed by any substance whatever, the part of the chemical rays of the same refrangibility is equally so" (Comptes Rendus, tom. xvii. p. 883).

The results I have recorded show that this is not a constant result. This, and the peculiarities, *now first observed, of the influence of absorbent media in developing a chemical force in the most luminous rays*, are left for further examination with this passing remark.

Observations on the Character and Measurements of Degradation of the Yorkshire Coast. By JOHN P. BELL, *M.D., Hull.*

(A Communication ordered to be printed among the Reports.)

IN speaking of the degradation of land on the Holderness coast, it is not my intention to construct a lengthened history of its former condition, neither shall I enter into a detail of theoretical plans proposed for preventing its further waste. There cannot be a doubt that the process of waste and destruction of this remarkably fertile district had been going on long antecedent to any traditional or written history. We find, however, on record a lamentable catalogue of losses on this coast; one field after another has been swept away, and one township after another has disappeared. The village of Auburn has gone, the towns of Hartburn and Hyde, both at one period flourishing places, exist no longer. Owthorne has lately yielded to the same fate; the *ancient* church of Withernsea has long since disappeared, and its successor, built in 1434, is dilapidated and deserted. Further southward, Kilnsea Church exists no longer; the last portion of the fabric (being part of the tower), according to the parish register, "fell down the cliff into the sea, February 1, 1831," and the village itself is rapidly following. Camden mentions Pennismerk and Upsal, townships or hamlets in Holderness, neither of which remains at the present day. Nor have the encroachments of the deep been confined to the sea coast of Holderness, for within the Humber we find that considerable tracts of land have been swept away, as for instance, Redmare, Frismerk, Tharlesthorpe, Potterfleet, Ravenser, &c. The *whole* of the Yorkshire coast, south of Flamborough Head, is being continually wasted by the encroachments of the sea; and it is a startling consideration, that in the course of a few years, if the same process continue, other towns and villages now flourishing and fertile are doomed to follow. The rate of loss, however, throughout the line is not uniform; the physical features, and the geological composition of the cliffs, the set of the tide, and other minor causes influence the degradation to a greater or less degree.

Unfortunately there exist but few scanty records of actual measurement from certain and existing points to the sea.

In Tuke's Map of Holderness there are however a few such admeasurements taken in the year 1786, and I have been able to collect from authentic sources others of later date; namely, some made in the year 1836 by my late lamented friend George Milner, Esq., F.S.A., on whose accuracy I can most implicitly rely; and I have also been kindly furnished with others made a few days ago, by my friend John Malam, Esq. of Holmpton Lodge, Holderness.

I have endeavoured to obtain measurements in a due easterly direction from the different fixed objects to the edge of the cliff; in cases where such measurement is not specified, the line most direct to the sea has been taken.

From these records it would appear that the cross at Atwick in 1786, was distant from the edge of the cliff 946 yards. In December 1836 it was 814 yards, thus showing a loss of 132 yards in fifty years, or an annual average loss of rather more than $2\frac{1}{2}$ yards. At the present time it is but 770 yards distant from the edge of the cliff; so that during the last seventeen years there has been a waste of 44 yards. The annual average loss therefore has continued at the same rate. The entire loss during the last sixty-seven years has been 176 yards, giving an average of rather more than $2\frac{1}{2}$ yards annually.

Tuke says the east end of Hornsea Church in 1786 was distant from the sea 1133 yards. In 1836 it was only 1000 yards distant from high-water mark, showing a deficiency in fifty years of 133 yards, and making an average loss in this immediate neighbourhood of $2\frac{2}{3}$ yards, or 8 feet annually. It is now but 942 yards from high-water mark, so that there has been a loss of 58 yards in seventeen years, being at the rate of about $3\frac{1}{2}$ yards per annum; or taking the loss of the last sixty-seven years, there will be found to have been an annual average waste of nearly 3 yards.

Aldborough Church in 1786 was 2044 yards from the sea; it is now 1910 yards, so that 134 yards have disappeared in sixty-seven years, giving a loss of exactly 2 yards annually.

Tunstall Church in 1786 was 924 yards distant from the cliff; it is now 758 yards. The loss therefore in sixty-seven years has been 166 yards, giving an annual average waste of about $2\frac{1}{2}$ yards.

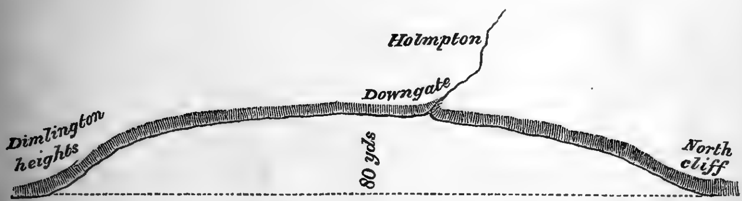
Holmpton Church in the year 1786 was distant from the sea 1200 yards; it is now 1120, so that in sixty-seven years 80 yards have gone, averaging about $1\frac{1}{5}$ yard annually.

The most rapid waste, however, is that going on at Kilnsea. The greater part of the church fell in the year 1826, and the last fragment totally disappeared in 1831. In April last I visited this place, and found the sea then making great ravages; several houses had gone, others were partly destroyed, and quite unfit for habitation.

The Blue Bell Inn in that village, which was built in the year 1847, was, according to a stone which I saw, and which had been fixed in the wall of that building (during the course of its erection), 534 yards from the sea; but when I visited Kilnsea on the 15th April last, it was only 491 yards from the edge of the cliff; thus showing that 43 yards had been swept away during the last six years, giving a yearly average loss of land of about $7\frac{1}{6}$ yards.

The other day I received a letter from Mr. Malam, in which he says, that since I was there the cliff has been carried away considerably; that he has remeasured the distance from the inn to the cliff, and finds it now but 488 yards! It would thus appear that a considerable difference exists in the amount of waste of land along this coast, it being the greatest at Kilnsea and the least at Holmpton.

The line of coast to which my remarks apply, extends about forty miles, and is now losing an amount of rich agricultural soil of $2\frac{1}{4}$ yards annually. If, however, we take the rapid waste of Kilnsea into account, the yearly loss would average 3 yards. My friend, who resides at Holmpton, attributes the comparatively small amount of loss at that place to the height of the cliffs north and south of Holmpton, which project and break the force of the tide; the beach is also of a concave form.



He says, "the fall of the clay or earth at the base of the high cliffs is to the extent of hundreds of thousands of tons more than where the cliffs are low." The removal of this fallen cliff must necessarily take a much longer period (and so protect the coast for a greater length of time) than where the land is low, and the sea does not meet with such an opposition. In fact, the falling of the high cliffs acts in the same manner as the intentional deposit of earth would do in preventing the encroachments of the sea. A farmer named Blushill, who has resided at Holmpton for the last forty years, told me that more land had been washed away in that locality during the past year (1852) (especially between the months of October and December), than had ever been the case in so short a time during his recollection.

He is the owner of some fields close to the sea, and calculates that something like 25 yards have been lost from his fields within the last *two* years, and he believes that equally large quantities have been lost towards the south of Holmpton.

Whilst speaking of this immense loss, I would incidentally remark, that such statements as the foregoing should be received with great caution, and not without thorough investigation. However honest in themselves such statements may be, they may nevertheless lead to very erroneous conclusions. The source of fallacy I conceive to be this:—the base of the cliff first yields to the attrition of the gravel and washing of the ocean; thus an undermining or scooping process necessarily takes place, and for many months or years a very large portion of what may be called table-land, is held by an exceedingly precarious tenure; so that it not unfrequently happens that one or two severe storms take off several yards of surface from any particular farm or district, and these losses are then recorded as having occurred within a very limited time; whereas, in truth and fairness, they ought to have been spread over a number of years, commencing with the washing away of the base.

First Report of the Committee, consisting of the Earl of Rosse, *the* Rev. Dr. Robinson, *and* Professor Phillips, *appointed by the General Committee at Belfast, to draw up a Report on the Physical Character of the Moon's Surface, as compared with that of the Earth.*

I. The Committee, having received their instructions in September 1852, lost no time in assembling, by invitation of the Earl of Rosse, at Parsonstown, where with the assistance of Colonel Sabine, at that time President of the Association, they made preliminary examinations of the moon, by the powerful telescopes of the Earl of Rosse, and formed plans of further proceeding in conformity with the results of these examinations, and the individual experience of the members of the Committee.

II. Taking as a general basis for the work to be done, the much-valued maps and treatise of Mädler and Beer, it appeared to the Committee desirable to procure a new set of drawings or surveys of selected parts of the lunar disc; to suggest certain conditions of representation, with reference to the illumination of these parts, and to propose a uniform scale for the drawings.

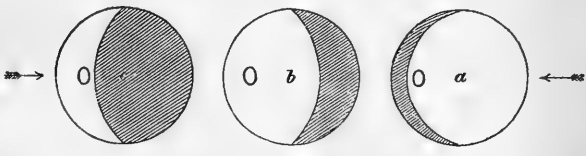
The suggestions offered, as some help to observers on this subject, were the following:—

"1. For the acquisition of correct ideas regarding the form of any part of the lunar disc, an examination of it under at least three aspects appears indispensable.

a. A little (one hour?) after the sun rises on that part of the spherical surface.

b. When the sun is on the meridian of that part.

c. A little (one hour?) before the sun sets upon it.



"By this arrangement each part of the surface may be delineated and described under three directions of incident sun-light, two of them (*a* and *c*) suited by long shadows to discover the inequalities of level, and the other (*b*) aiding by a vertical incidence to make apparent the unequal reflective powers and different colours which characterize the different lunar regions, and the systems of brilliant stripes which are connected with certain lunar forms.

"2. The 'age of the moon,' when a drawing is made, should be stated to the second decimal of the day, because a knowledge of this epoch is essential to a right estimation of the angle of incident light under which the observations are made. Probably the observer will find it convenient to prepare beforehand a table of the moon's age, corresponding to each hour of mean solar time. The mean solar time of the place at the beginning and end of each observation should also be stated.

"3. Among the chief points to be attended to are—

a. The steepness of slopes, which may perhaps be best determined by noting the time at which they began or ceased to be illuminated generally.

b. In ring mountains the difference of level between their exterior and interior bases.

c. The curvature of their interior, whether greater or less than that of the general surface. Some of them are much raised in the centre, as is evident by the shadows which these parts throw.

d. Whether the brilliant stripes are elevated above the ground where they pass, and the angle of illumination at which they disappear.

e. Slopes, height, and breadth of the soft ridges in the Maria.

f. External fragments round ring mountains.

g. Relation between mass of wall and area of depression (*i. e.* would the wall fill up the hollow).

"4. In delineating the appearances on the moon's surface, the Committee think the observer must be encouraged to employ various methods. For a general view of the proportional areas, more accurate than any sketch, Photography may be employed. To steady the work, and reduce it to a uniform scale, micrometrical measures will be required. In some cases, where these cannot be supplied by the observers separately, they may be obtained at one of the observatories. In drawing by the eye the Camera lucida is available, if the telescope has an equatorial movement by clock—a condition not only desirable, but perhaps indispensable for perfect delineation.

"5. For convenience of comparison, it appears desirable to recommend that one uniform scale should be employed in the delineations. Though it may seldom be practicable to employ on the moon a power of 1000, the Committee recommend that the *drawings* should in no case be made on a smaller scale. If the distance of the paper from the eye be assumed at 10 inches, a circular space on the moon's surface one mile across will be represented with only a diameter of about one-twentieth of an inch. For objects which require larger representation, the ordinary scale may be doubled or tripled.

"6. Both in drawing and describing it appears desirable to employ the method of Beer and Mädler, who *draw* the moon as she appears in the inverting telescope, but *describe* the relative situation of her parts by reference to her poles as northern and southern, and sides as east and west, in correspondence to the nearest cardinal points of the earth.

"7. It is found by trial that Sepia drawings are well-suited for representations of the peculiarities of the moon's surface."

It is requested that the drawings and descriptions, which may be prepared in conformity with these suggestions, may be forwarded by post to Professor Phillips, Assistant-General Secretary of the British Association, St. Mary's Lodge, York.

III. The Committee next endeavoured, by circular, to obtain the cooperation of a limited number of gentlemen, whether in the British Islands or in foreign parts, who by their possession of instruments of adequate optical power, habits of astronomical observation, and available leisure, might be able and willing to undertake definite parts of the great task which they hoped to see accomplished.

IV. To these letters, the replies which have been received offer in general very satisfactory assurances of cooperation; and in some cases useful additional suggestions and notices of interesting facts are added. In particular, the author of "Der Mond," besides assuring the Committee of a general desire to cooperate in their labours, states the degree in which, since his appointment to the Observatory at Dorpat, he has been able to extend his former observations on the "light streaks" of the moon, an object to which the Committee had ventured to specially direct his attention, and instances the distinction which he has already made between the "light spots" which vanish in lunar eclipses, and those which remain visible and even grow more distinct in the shadow, except where it is deepest.

The Committee do not, however, feel it to be proper now to report the special views and limited progress of their members, beyond placing before the Association one drawing of the Mountain Gassendi—on the scale proposed for the whole survey—made from a telescope mounted at York by one of their members.

Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments. By R. Mallet, *C.E., M.R.I.A.* (*In a Letter to the Assistant-General Secretary.*)

The grant of £50 made in 1850, for measurement of earthquake wave-transit, has been wholly expended, in addition to a sum a good deal exceeding its amount, upon the experiments on transit made at Killiney Bay and Dalkey, as reported in the last volume but one of our Transactions. Prior to the conclusion of the above experiments I had made some progress in the construction of a self-registering seismometer, upon principles already placed before the Association.

Within the last year other unavoidable occupations, and the work of preparing and discussing the large Earthquake Catalogue, have much interfered with the progress of the seismometer: I expect to be able at the meeting succeeding the present to exhibit the instrument, or perhaps to have had it previously set to work for a time.

Galvano-telegraphic combinations recently brought into use, and especially the beautiful arrangements for simultaneous astronomical transit observations adopted by the Astronomer Royal, leave no room to doubt that any difficulties in applying such methods to seismometry may be fully overcome.

The great Earthquake Catalogue, due almost wholly to the devotion and labour of my eldest son, Dr. John William Mallet, has been entirely completed and discussed, and the results reduced to curves. The first portion of the catalogue is already printed in the last volume of our Transactions, and all the remainder is ready for press, and with the discussional results can appear in the volume for 1853.

At the meeting of the Association, September 1852, a grant of £50 was made to me for the purpose of extending experiments upon earthquake wave-transit, availing myself of the mining operation sin progress at the quarries of Holyhead Harbour. With a view to carrying out this design, I have been in communication with James M. Rendell, Esq., V.P. Inst. C.E., the Engineer-in-Chief of the Works, and have derived from him every aid that could be desired. I have also been in communication with the Astronomer Royal, with a view to obtaining the use of some time-measuring instruments, and derived some useful suggestions from his experience in arrangements analogous to those proposed. I expect therefore early next spring to proceed with these experiments at Holyhead.

I cannot close this brief report without congratulating our fellow-workers in Physical Geology upon the increased attention now given to seismological observation and research, to which the several reports published by the British Association, and by various authors, have no doubt been instrumental; the arrangements, now understood to be in progress under the Board of Ordnance for earthquake observations in the Mediterranean, are a welcome sign of progress.

On the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration. By WILLIAM FAIRBAIRN, *F.R.S. &c.*

THIS inquiry was undertaken at the request of the British Association, to determine certain anomalous conditions which present themselves in castings when produced from the same iron in successive meltings. It is a generally acknowledged opinion, that iron is improved up to the second, third, and probably the fourth meltings; but that opinion, as far as I know, has not been founded upon any well-grounded fact, but rather deduced from observation, or from those appearances which indicate greater purity and increased strength in the metal.

Those appearances have, in almost every instance, been satisfactory as regards the strength; and the questions we have been called upon to solve in this investigation, are, to what extent can these improvements be carried without injury to the material; and what are the conditions which bear more directly upon the crystalline structure, and the forces of cohesion by which they are united.

In the following research I have endeavoured to supply these desiderata; and having in the course of the inquiry made a careful selection of the material, the subjoined experiments were instituted, and from which some curious and interesting results were obtained. In preparing the iron, coke, and flux requisite for ensuring sound castings, it was found necessary, for the sake of comparison, to have them cast under circumstances precisely the same; and in order to ensure, as nearly as possible, perfect uniformity in the castings, a furnace was prepared for the express purpose, and from 18 cwt. to a ton of No. 3 Eglinton Hot-blast iron was melted and run into bars and pigs with 588 lbs. of coke, and 224 lbs. of lime as a flux.

The proportions of coke and flux were carefully observed in the first and throughout the whole of the subsequent meltings. They were accurately weighed every time the furnace was charged, and each charge was made under the same circumstances, and as nearly as possible with the same quantity of blast. In the first melting, three or four bars, each 5 feet long and 1 inch square, were cast, and the remainder of the iron fused was run into pigs, and preserved for re-melting along with the fractured bars used in the first experiment. In the succeeding experiments, the bars and pigs were prepared and re-melted in the same way; and thus, by a continued succession of remeltings, ne constant reproduction of the same metal was carefully preserved, and that under the same circumstances of fusion, as respects coke and flux, as those previously melted, until the whole of the metal was exhausted.

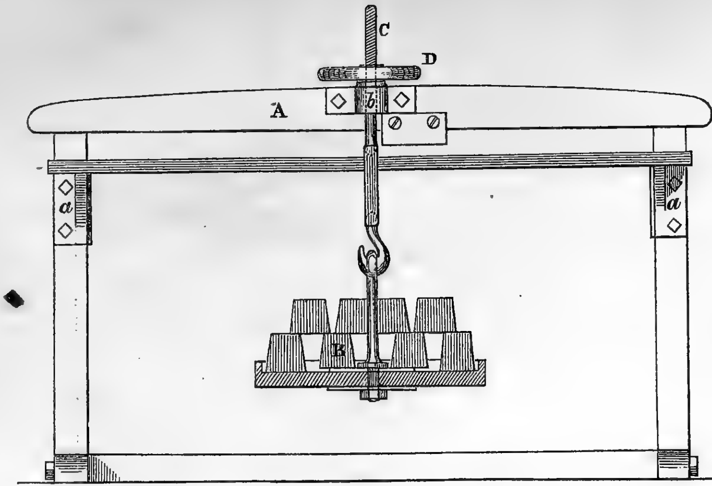
In these consecutive meltings, it will be observed that the same quantity of coke and limestone was used, but at each separate process the quantity of iron was diminished until the waste and the abstraction of a few specimen bars—reserved each time for the succeeding experiments—had exhausted the quantity with which the furnace was originally charged. These precautions became the more essential, as any admixture, or any change in the furnace might alter the conditions under which the castings were produced, and thus render them to some extent abnormal for those researches and points of comparison which, under all the circumstances, it was necessary to observe. To avoid these discrepancies, the furnace was retained of uniform dimensions, of nearly the same temperature, and having the coke and limestone carefully weighed at every charge; the castings were, by these means, obtained from a uniform system of treatment maintained from the beginning to the end of the process.

The bars derived from each successive melting were placed upon two iron brackets, *a*, *a*, exactly 4 feet 6 inches apart, screwed to the sides of a wooden frame of the form and dimensions shown in the annexed figure.

On the centre of the cross bar A the socket *b* was fixed, and through this socket the rod *c*, screwed on the top end, was passed. This rod had a slit at the bottom to admit the bar; and the wheel D having a nut in its centre and fitting the screw, the scale with the weights B could be raised or lowered upon the middle of the bar according as the weights were successively laid on to measure the deflection, or taken off to ascertain the defects of elasticity or permanent set.

The pig iron used in these experiments, and from which the following results were obtained, was No. 3 Eglinton Hot-blast. From its blue tinge and large crystalline structure, it had the characteristics of No. 1 more than No. 3; and judging from its appearance, it indicated a ductile and superior quality of iron; probably of more value for its working properties than its powers of resistance to strain. This property in the metal was not however objectionable, as it enabled us to continue the experiments through a longer series of meltings before it arrived at the point of maximum strength, and those chemical changes which affected the formation of its crystalline structure. Under the circumstances, and considering the objects to be attained in the research, it was probably as good a selection as could have been made for such an inquiry.

For the purpose of ascertaining progressively the effect of the load upon the bars, it was considered expedient to lay on weights not exceeding 56 lbs. at a time, and by careful attention to the gauge and the scale made in the form of a wedge, and divided into the tenths and hundredth parts of an inch, the deflection produced upon the bar was ascertained with the utmost accuracy. Reading off the deflections was accomplished with great care; and in order to indicate the amount of permanent set produced by the different weights as they were laid on, the scale was screwed up at every second or third increase of the load, and applying the scale to the gauge, the defects of elasticity were easily determined, and recorded in the Tables in the usual way. Having thus selected the metal and prepared the apparatus, the experiments were proceeded with as exhibited in the following Tables.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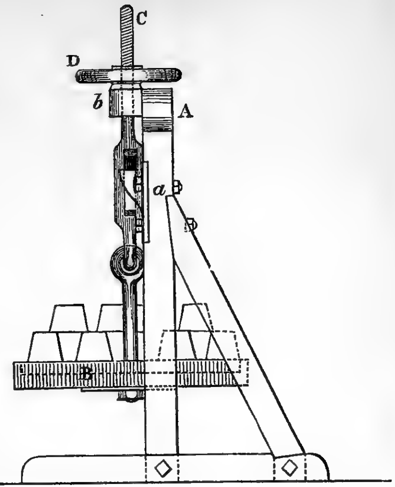
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Experiments to determine the resistance of Cast-Iron bars obtained from repeated Meltings to a transverse strain.

Table I.—Eglinton Iron, No. 3, Hot-blast. First Melting.

Experiment I.			Experiment II.			Experiment III.		
Section of bar 1×1·02 in. Distance between the supports, 4 ft. 6 in. Weight of bar 16 lbs.; 5 ft. long.			Section of bar 1×1 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·01×1·01 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·12	+	32	·12	......	32	·10	......
88	·23	+	88	·25	+	88	·24	+
144	·35	·02	200	·55	·01	144	·39	+
200	·52	+	312	·85	+	200	·56	+
256	·66	·03	368	1·01	+	256	·74	+
312	·81	+	403	1·14	+	312	·93	+
368	1·04	·04	424	1·20	+	368	1·13	·01
396	1·14	·043	452	1·26	·03	424	1·34	·03
424	1·20	+	473	1·33	·04	480	broke.	
438	1·23	+	487	1·38	+			
452	1·25	·044	501	1·43	·05			
466	1·26		522	1·48				
473	broke.		536	broke.				
Ultimate deflection 1·28. Broke near the centre when laying on the last weight, 473 lbs.			Ultimate deflection 1·54. Broke in two places at the centre, and at 7½ inches from that point.			Ultimate deflection 1·51. Broke at the centre after sustaining the load two minutes.		

The fractured ends of these bars (when viewed with a microscope) are remarkable for great uniformity of texture. In the first melting they had changed their appearance entirely from the pig in their crystalline structure, the crystals being much more minute and of greatly increased density, as may be seen on reference to the column of *specific* gravity below.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	463	1·27	588 8
Experiment 2, bar 4 ft. 6 in. between supports	6·969	536	1·54	825·4
Experiment 3, bar 4 ft. 6 in. between supports	......	470	1·51	709·7
Mean......	6·969	489·2	1·44	705·6

TABLE II.—On the same Iron. Second Melting.

Experiment 1. Section of bar 1×1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar ·99×1 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1×1 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·11	......	32	·12	+	32	·08	+
88	·21	+	88	·26	+	88	·22	+
144	·42	+	144	·45	+	144	·38	+
200	·59	+	200	·64	+	200	·56	+
256	·76	+	256	·81	+	256	·73	+
312	·95	+	312	1·01	+	312	·91	+
368	1·16	·02	368	broke	+	368	1·11	+
396	1·26	+				438	1·37	·01
424	1·37	·03				466	1·51	·04
452	1·39	broke after the load had remained on 5 min.				487	1·58	·06
						494	1·62	......
						508	broke	......
Ultimate deflection 1·48. Broke near the centre on laying on an additional 28 lbs., or 452 lbs.			Ultimate deflection 1·19. Broke 16½ in. from centre when the last weight was laid on; a flaw in the casting.			Ultimate deflection 1·67. Broke at the centre after sustaining the weight about a minute.		

The above bars have nearly the same appearance in their fractured sections as those experimented upon in the last Table: the same uniformity in their granulated structure was observable; as also in the appearance and colour of the crystals, which were nearly the same in every respect.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	443·1	1·48	655·7
Experiment 2, bar 4 ft. 6 in. between supports	6·970	374·7	1·19	445·2
Experiment 3, bar 4 ft. 6 in. between supports	......	508	1·67	848·3
Mean......	6·970	441·9	1·446	639

TABLE III.—Third Melting.

Experiment 1. Section of bar 1×1 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1×1 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1×1·01 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·08	+	32	·10	+	32	·11	+
88	·26	+	88	·27	+	88	·27	+
144	·44	+	144	·46	+	144	·46	+
200	·65	+	200	·66	+	200	·67	·02
256	·85	+	256	·87	·01	256	·84	+
312	1·06	·01	312	1·18	+	312	1·10	·04
340	1·17	·015	368	1·32	·05	340	1·22	+
368	1·30	+	396	broke		368	1·38	·08
382	1·37	+				382	1·44	·10
396	broke					396	1·51	+
						403	1·55	+
						417	broke	......
Ultimate deflection 1·42. Broke 6 in. from the centre as soon as the last weight was laid on.			Ultimate deflection 1·43. Broke at the centre in a few seconds after the weight was laid on.			Ultimate deflection 1·61. Broke near the middle of the bar when the last weight was laid on.		

No change was observable in the crystallization of these bars, excepting only in the colour, which is a dull grey, with less lustre than the first and second meltings; in other respects the constituents of the iron appear to be the same.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b\times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	396	1·42	562·3
Experiment 2, bar 4 ft. 6 in. between supports	6·886	396	1·43	566·2
Experiment 3, bar 4 ft. 6 in. between supports	......	412·9	1·61	664·7
Mean......	6·886	401·6	1·486	596·7

TABLE IV.—Fourth Melting.

EXPERIMENT 1. Section of bar 1·01×1·05 in. Distance between the supports, 4 ft. 6 in.			EXPERIMENT 2. Section of bar 1×1·02 in. Distance between the supports, 4 ft. 6 in.			EXPERIMENT 3. Section of bar 1·×99 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·09	+	32	·06	+	32	·06	+
88	·22	+	88	·19	+	88	·21	+
144	·37	+	144	·34	+	144	·39	+
200	·54	+	200	·51	+	256	·75	+
256	·70	+	256	·69	+	340	1·04	+
312	·86	+	284	·77	+	368	1·14	·01
368	broke	+	326	·88	·02	382	1·20	·02
			354	·98	+	396	1·26	+
			382	1·08	·03	410	1·30	·03
			396	1·13	+	431	1·40	·04
			410	1·18	+	452	1·50	·05
			424	broke	+	466	broke	
Ultimate deflection 1·01. Fracture showed a large air-bubble.			Ultimate deflection 1·22. Broke 7 in. from centre; not very sound.			Ultimate deflection 1·55. Broke near the middle; quite sound.		

These bars gave indications of greater hardness, particularly at the corners, where the crystals were more compact, and rather more porous in the centre of the fracture. Colour the same as the last bars.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	347	1·01	350·4
Experiment 2, bar 4 ft. 6 in. between supports	6·938	415·6	1·22	508·0
Experiment 3, bar 4 ft. 6 in. between supports	......	477·7	1·55	740·4
Mean......	6·938	413·4	1 26	520·8

TABLE V.—Fifth Melting.

Experiment 1. Section of bar 1·1 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·01 × 1 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar ·99 × 1·1 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·06	+	32	·08	+	32	·08	+
88	·19	+	88	·23	+	88	·29	+
144	·36	+	144	·38	+	144	·40	+
200	·53	+	200	·57	+	200	·58	+
256	·70	+	256	·75	+	256	·75	+
312	·86	+	312	·95	·02	312	·91	+
368	1·07	+	368	1·14	+	368	1·15	·02
396	1·18	·03	396	1·26	+	424	1·37	·04
438	1·37	·05	424	1·39	·05	452	broke	
452	1·43	+	452	1·52	·07			
459	1·46	·06	459	1·55	+			
466	broke		466	broke	......			
Ultimate deflection 1·48. Broke at the middle; quite sound.			Ultimate deflection 1·57. Broke at the middle; fracture clean and sound.			Ultimate deflection 1·46. Broke as soon as the last weight was laid on; fracture sound and good.		

The fracture from these bars—fifth melting—presented rather more lustre, accompanied with a bluish tinge. The interior crystals larger than those at the corners and round the edges, which were firm and more compact.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	418·5	1·48	619·3
Experiment 2, bar 4 ft. 6 in. between supports	6·842	461·3	1·57	724·2
Experiment 3, bar 4 ft. 6 in. between supports	......	415	1·46	605·9
Mean......	6·842	431·6	1·503	648·6

Table VI.—Sixth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1 × ·99 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1 × ·98 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·03 × ·98 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·07	+	32	·08	+	32	·06	+
88	·21	+	88	·24	+	88	·19	+
144	·37	+	144	·39	+	144	·34	+
200	·54	+	200	·57	+	200	·50	+
256	·70	+	256	·73	+	256	·68	+
312	·87	+	312	·91	+	312	·85	+
368	1·05	+	368	broke	+	368	1·04	+
410	1·22	·02				396	1·14	+
445	1·35	+				410	1·20	+
459	1·41	·04				424	1·26	+
473	1·48	·05				438	1·31	+
487	broke					452	broke	+
Ultimate deflection 1·54. Broke in the middle after sustaining the weight for about two min.; very sound.			Ultimate deflection 1·07. Broke 2 in. from centre; slight flaw.			Ultimate deflection 1·35. Broke when laying on the last weight; slight flaw.		

The whole of the bars from the first up to the sixth meltings are soft, and work freely under the file. The crystalline structure of those in the above table exhibit a closely granulated texture round the edges and corners of the bars, the same, or nearly so, as those in the last tables.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	491·9	1·54	757·5
Experiment 2, bar 4 ft. 6 in. between supports	6·771	375·5	1·07	401·7
Experiment 3, bar 4 ft. 6 in. between supports	......	447·7	1·35	604·4
Mean......	6·771	438·7	1·32	579·0

TABLE VII.—Seventh Melting.

Experiment 1. Section of bar 1·04 × 1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·025 × 1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1·02 × 1·02 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·07	+	32	·06	+	32	·06	......
88	·21	+	88	·18	+	88	·19	+
144	·37	+	200	·49	+	144	·34	+
200	·53	+	284	·72	+	200	·51	+
256	·69	+	340	·90	+	256	·68	+
312	·87	+	382	1·03	·02	312	·87	+
340	·97	·02	417	1·15	+	368	1·07	+
368	broke		438	1·23	+	396	1·19	·01
			459	1·31	+	424	1·30	
			487	1·44	·04	452	broke	
			536	1·64	·1			
			592	broke				
Ultimate deflection 1·04. Broke at centre; slight flaw in one corner.			Ultimate deflection 1·90. Broke in the middle; very sound.			Ultimate deflection 1·38. Broke 2½ in. from centre; slight flaw.		

The general appearance of these irons is increased density in the fracture, with finely granulated edges, and increased hardness at the corners. On comparing these bars with those from the first and second meltings, an evident change has taken place in the closeness of the granulated structure and increased hardness of the iron over the whole of the exterior surface of the bars. Colour the same as the last.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	346·9	1·04	360·7
Experiment 2, bar 4 ft. 6 in. between supports	6·879	566·2	1·90	1075·7
Experiment 3, bar 4 ft. 6 in. between supports	......	434·4	1·38	599·4
Mean......	6·879	449·1	1·44	646·7

TABLE VIII.—Eighth Melting.

Experiment 1. Section of bar 1·02×1·01 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·02×1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1·01×1·02 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·08	+	32	·06	+	32	·07	+
88	·22	+	88	·19	+	88	·20	+
144	·38	+	144	·35	+	144	·37	+
200	·54	+	200	·51	+	200	·54	+
256	·72	+	256	·70	+	256	·71	+
312	·91	·01	312	·86	+	312	·91	+
368	1·14	·03	368	1·08	·02	368	1·12	+
410	1·30	+	424	1·31	·03	424	1·38	·04
438	1·42	·07	452	1·44	·05	480	broke	
466	1·55		480	1·57	·08			
494	1·74	·15	508	1·70	·13			
522	broke		522	broke				
Ultimate deflection 1·88. Broke in the middle, fracture very sound.			Ultimate deflection 1·82. Broke after sustaining the weight rather more than one minute; sound.			Ultimate deflection 1·56. Bar sound; broke in the middle.		

In the eighth melting there appears to be no particular change from those in the two last tables. The bars continue to retain their compact form, with probably some slight increase in the densities of the exterior surfaces of the bars. No perceptible change in the colour.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b\times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	506·6	1·88	952·4
Experiment 2, bar 4 ft. 6 in. between supports	7·025	501·7	1·82	913
Experiment 3, bar 4 ft. 6 in. between supports	......	465·9	1·56	726·8
Mean......	7·025	491·3	1·753	861·2

Table IX.—Ninth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·01×1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·01×1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·02×1·01 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·08	+	32	·06	+	32	·07	+
88	·21	+	88	·19	+	88	·22	+
144	·33	+	144	·32	+	144	·34	+
200	·47	+	200	·47	+	200	·49	+
312	·75	+	256	·62	+	256	·64	+
396	1·00	+	312	·77	+	312	·80	+
424	1·1	·01	368	·96	+	368	·97	+
480	1·29	·02	424	1·15	+	424	1·15	+
508	1·38		508	1·46	·03	480	1·34	+
522	1·43	·04	536	1·56		508	1·45	+
556	1·53	·06	571	1·75	·07	536	broke	
564	broke		578	broke				
Ultimate deflection 1·56. Broke as soon as the weight was put on; sound.			Ultimate deflection 1·77. Broke 2½ in. from middle as soon as the weight was laid on; sound.			Ultimate deflection 1·53. Very slight flaw.		

The cohesive texture appears to increase, as the granulated surface of the fracture in all the three bars seem to indicate. There is greater uniformity in the crystals, which in these bars are very compact. No material change in the colour, which is gray, with a slight tinge of blue.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (*b*).	Ultimate deflection (*d*).	Product *b*×*d*, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	552·8	1·56	862·5
Experiment 2, bar 4 ft. 6 in. between supports	7.102	566·6	1·77	1002·8
Experiment 3, bar 4 ft. 6 in. between supports	......	520·2	1·53	795·9
Mean......	7·102	546·5	1·62	885·3

Table X.—Tenth Melting.

Experiment 1. Section of bar 1·01 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·03 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1·05 × 1·01 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·06	+	32	·06	+	32	·05	+
88	·19	+	144	·31	+	88	·15	+
144	·32	+	256	·58	+	144	·29	+
200	·49	+	312	·72	+	200	·41	+
256	·63	+	368	·85	+	256	·58	+
312	·77	+	424	1·00	+	312	·72	+
368	·93	+	480	1·19	+	368	·87	+
452	1·21	+	536	1·35	+	424	1·04	+
508	1·40	+	578	1·49	·02	480	1·22	+
536	1·51	·015	613	1·64		536	1·41	0·1
550	1·57	+	634	1·73	·05	564	1·52	
564	broke	+	641	broke		broke		
Ultimate deflection 1·62. Broke in the middle after sustaining the weight half a minute; sound.			Ultimate deflection 1·74. Broke in the middle while putting on the weight; sound.			Ultimate deflection 1·52. Broke in the middle after sustaining the weight half a minute; sound.		

This melting and the next present perfect uniformity throughout the whole surface of the fracture. The porosity in the centre has entirely disappeared, and the remarkable feature of these castings is, that of a firm grained iron, rather hard, but susceptible of being worked under the chisel and file.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	552·9	1·62	895·6
Experiment 2, bar 4 ft. 6 in. between supports	7·108	616·1	1·74	1072·0
Experiment 3, bar 4 ft. 6 in. between supports	......	531·8	1·52	808·3
Mean......	7·108	566·9	1·626	921·7

TABLE XI.—Eleventh Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·03 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·04 × 1·03 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1 × 1 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·05	+	32	·04	+	32	·06	+
144	·24	+	144	·32	+	88	·15	+
256	·54	+	256	·58	+	144	·23	+
368	·78	+	368	·85	+	200	·42	+
424	·93	+	424	·97	+	256	·54	+
480	1·08	+	480	1·09	+	312	·68	+
536	1·23	+	536	1·24	+	368	·83	+
592	1·39	+	592	1·38	+	424	·95	+
620	1·48	+	648	1·53	·01	480	1·12	+
648	1·55	+	662	1·57	+	564	1·34	+
662	1·58	+	683	1·65	+	634	1·57	+
676	broke	+	690	broke	+	662	broke	+
Ultimate deflection 1·61. Broke in the middle after sustaining the weight 40 seconds.			Ultimate deflection 1·66. Broke after sustaining the weight one minute.			Ultimate deflection 1·64. Broke in four places just as the weight was laid on.		

The bars from this melting are so nearly similar to those from the tenth as scarcely to require a description. They present the same uniformity in their crystalline structure, accompanied with rather a lighter gray colour.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	649·8	1·61	1046·1
Experiment 2, bar 4 ft. 6 in. between supports	7·113	644·1	1·66	1069·2
Experiment 3, bar 4 ft. 6 in. between supports	......	662	1·64	1085·6
Mean	7·113	651·9	1·636	1066·5

TABLE XII.—Twelfth Melting.

Experiment 1. Section of bar 1·01 × 1·03 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·03 × 1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1·03 × 1·02 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·07	+	32	·06	+	32	·06	+
144	·18	+	144	·26	+	144	·26	+
256	·57	+	256	·49	+	256	·52	+
312	·70	+	368	·72	+	368	·79	—·02
368	·82	+	480	·97	+	424	·90	+
424	·97	+	592	1·23	—·08	480	1·02	+
480	1·11	+	676	1·43	+	536	1·17	—·05
536	1·25	+	711	1·57	+	592	1·30	+
592	1·39	+	739	1·62	+	648	1·45	—·08
620	1·46	+	760	1·68	+	676	1·56	+
648	1·54	+	781	1·72	+	690	1·60	+
676	broke		795	broke	+	704	broke	
Ultimate deflection 1·60. Broke in the middle; quite sound.			Ultimate deflection 1·77. Broke in two places; one fracture at the middle, the other 8 in. from that point.			Ultimate deflection 1·63. Broke while testing the deflection.		

There is a marked difference in these bars when compared with those from the earlier meltings. Their resisting powers to strain have been nearly doubled, when compared with those obtained direct from the pig, or from the second, third, or fourth meltings; and upon a careful examination of the fracture by the microscope, the same indications of a strong adhesive force is observable, accompanied with a finely-grained texture, which the fracture of each bar presents. The colour is a light gray.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (*b*).	Ultimate deflection (*d*).	Product *b* × *d*, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	649·8	1·60	1039·6
Experiment 2, bar 4 ft. 6 in. between supports	7·160	756·7	1·77	1339·3
Experiment 3, bar 4 ft. 6 in. between supports	......	670	1·63	1092·1
Mean......	7·160	692·1	1·666	1153

Table XIII.—Thirteenth Melting.

Experiment 1. Section of bar 1·03×1·03 in. Distance between the supports, 4 ft. 6 in.			Experiment 2. Section of bar 1·03×1·02 in. Distance between the supports, 4 ft. 6 in.			Experiment 3. Section of bar 1·03×1·03 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·06	......	32	·05	......	32	·06	......
144	·28	......	144	·27	......	144	·30	......
256	·55	......	256	·51	......	256	·58	......
368	·82	......	368	·75	—·04	368	·87	—·04
424	·95	......	480	1·03	—·08	424	1·02	......
480	1·10	......	564	1·28	......	480	1·18	......
536	1·25	......	592	1·34	......	536	1·34	—·02
592	1·40	—·05	620	1·42	......	564	1·42	......
648	1·56	......	648	1·52	......	592	1·51	......
676	broke	......	662	1·57	......	620	1·61	0·00
			676	1·61	......	634	1·65	......
			690	broke		648	broke	......
Ultimate deflection 1·62. Fracture 2½ in. from centre; sound.			Ultimate deflection 1·64. Broke in the middle; very sound.			Ultimate deflection 1·68. Broke in the middle on taking the weight; sound.		

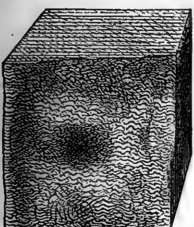
This iron presents a singular admixture of exceedingly sharp angular crystals, closely packed upon each other, and so tightly compressed as to give indications of great hardness. This is, however, not the case, as it yields to the action of the file, but not without difficulty, by taking the sharp edge of the teeth. In other respects it is a strong close-grained iron, but inferior to the twelfth melting, which is rather more ductile and more elastic.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b\times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	637·1	1·62	1032·1
Experiment 2, bar 4 ft. 6 in. between supports	7·134	656·6	1·64	1076·8
Experiment 3, bar 4 ft. 6 in. between supports	......	610·7	1·68	1025·9
Mean......	7·134	634·8	1·646	1044·9

Table XIV.—Fourteenth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·03 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·06 × 1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·01 × 1·03 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·05	+	32	·05	+	32	·07	+
144	·26	+	144	·25	+	144	·31	+
256	·52	+	256	·46	+	256	·57	+
368	·78	—·04	368	·71	—·04	368	·87	+
424	·92	+	480	·97	+	452	1·10	+
480	1·05	+	536	1·12	+	508	1·25	+
536	1·21	—·05	564	1·19	+	536	1·35	+
564	1·29	+	592	1·28	+	550	1·39	+
592	1·37	+	606	1·31	+	578	1·47	+
620	broke	+	620	1·34	+	592	1·52	+
			634	1·37	+	620	1·59	+
			648	broke	+	634	broke	+
Ultimate deflection 1·43. Broke in two places; one sound, the other faulty.			Ultimate deflection 1·49. Bar sound; broke in the middle.			Ultimate deflection 1·62. Broke in the middle as soon as the weight was put on.		



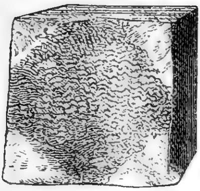
The bars from this melting are something like their predecessors in the last table, close and hard, with pointed angles rising on the surface of the fracture. This is a hard iron, very difficult to work, and indicates brittleness when subjected to blows from a hammer. In its powers to resist impact it is however more ductile than might otherwise be supposed, as the deflections were considerable, and not much inferior to those in the last two tables. Colour a light sparkling gray, as exhibited in the annexed figure.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	595·8	1·43	852
Experiment 2, bar 4 ft. 6 in. between supports	7·530	605·2	1·49	901·7
Experiment 3, bar 4 ft. 6 in. between supports	......	609·4	1·62	985·4
Mean......	7·530	603·4	1·513	912·9

Table XV.—Fifteenth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·03×1·03 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·04×1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·03×1·02 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·04	+	32	·05	+	32	·05	+
144	·18	+	144	·21	+	88	·15	+
256	·37	+	200	·32	+	144	·25	+
368	·56	−·05	256	·41	−·02	200	·35	+
424	broke		312	·49	+	256	·45	+
			368	·60	−·03	284	·51	+
			396	·64	......	312	·56	+
						326	·59	+
						340	·61	+
						354	·65	+
Ultimate deflection 0·64. Bar sound; broke in the middle while laying on the weight.			Ultimate deflection 0·64. Broke 1 inch from the middle; sound.			Ultimate deflection 0·65. Broke in the middle after carrying the weight 40 secs.		



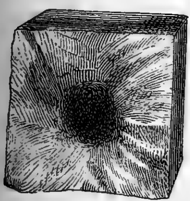
On comparing the resisting powers of the iron from this melting with that of the last, it will be found that a sudden and rapid decline of nearly one-half the strength has taken place. Referring to the drawing of this iron, it will be observed that all the four corners have become silvered with a fine white frosted surface, which fully accounts for the brittle nature of the bars, and the consequent loss of adhesion in those parts furthest from the neutral axis; and in which, when exposed to a transverse strain, is the principal strength of the bar. Colour a light gray, surrounded with four triangles of white silvery iron at each corner, as seen in the figure.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	399·6	0·64	255·7
Experiment 2, bar 4 ft. 6 in. between supports	7·248	376·9	0·64	241·2
Experiment 3, bar 4 ft. 6 in. between supports	......	336·9	0·65	218·8
Mean......	7·248	371·1	0·643	238·6

Table XVI.—Sixteenth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·03×1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·0×1·01 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·02×1·03 in. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·03	+	32	·04	+	32	·04	+
88	·10	+	88	·14	+	88	·10	+
144	·21	+	144	·24	+	144	·18	+
200	·29	+	200	·33	−·01	200	·26	+
242	·35	+	228	·38	+	228	·34	+
270	·39	−·03	256	·42	+	256	·38	+
298	·41	+	284	·46	−·03	284	·42	+
305	·44	+	312	·51	+	312	·46	+
319	·47	−·05	326	·54	+	326	·48	+
333	·49	+	340	·57	+	340	·49	+
347	·52	+	347	·59	+	354	·52	+
368	broke	+	354	broke		368	broke	......
Ultimate deflection 0·56. Broke in the middle; bar sound.			Ultimate deflection 0·60. Broke in the middle after sustaining the weight half a minute.			Ultimate deflection 0·53. Broke 2 inches from the middle while laying on the weight; sound.		



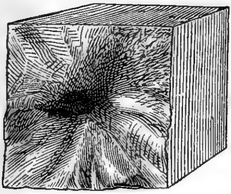
In this melting the process of deterioration goes on rapidly; the whole surface of the fracture (with the exception of a circle of closely granulated gray iron, about one quarter of an inch in diameter) is a white silvery formation pressing hard upon the internal core of gray iron, as shown in the figure. The most remarkable feature of the process is the fine frosty appearance of the external surface of the bars, and the extreme hardness of this portion of the metal, on which the best cast-steel makes no impression.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	353·7	0·56	198
Experiment 2, bar 4 ft. 6 in. between supports	7·330	350·4	0·60	224·2
Experiment 3, bar 4 ft. 6 in. between supports	......	350·1	0·53	185·5
Mean......	7·330	351·3	0·566	198·8

Table XVII.—Eighteenth Melting.

Experiment 1.			Experiment 2.			Experiment 3.		
Section of bar 1·03×1·02 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·03×1·03 in. Distance between the supports, 4 ft. 6 in.			Section of bar 1·03×1·04. Distance between the supports, 4 ft. 6 in.		
Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.	Weight in lbs.	Deflection in inches.	Deflection, load removed.
32	·03	+	32	·04	+	32	·03	+
88	·10	+	88	·11	+	88	·08	+
144	·18	+	144	·18	+	144	·14	+
200	·27	+	200	·26	+	200	·20	+
256	·35	+	256	·34	+	256	·28	—·03
270	·38	+	284	·39	+	284	·34	+
284	·40	+	298	·41	+	298	·36	+
298	·42	+	312	broke	......	305	·37	+
312	·45	+				312	·38	+
326	·47	+				319	·39	+
340	·48	+				326	·41	+
354	broke	......						
Ultimate deflection 0·49. Broke 2 inches from the middle while laying on the weight; sound.			Ultimate deflection 0·43. Broke 3 inches from the middle while laying on the weight; sound.			Ultimate deflection 0·41. Broke in the middle after sustaining the weight 2 minutes; sound.		



The above completes the series on the transverse strengths as well as the working powers of this iron, which after these repeated meltings are really of little value. Such iron may be of some use in mixing with the finer and more fluid descriptions of iron; but its obdurate, brittle, and uncertain character renders it totally unfit for purposes in connection with the useful arts. Appearance white and silvery over the whole surface of the fracture. See figure.

Results reduced to those of bars 1·00 in. square.

	Specific gravity.	Breaking weight (b).	Ultimate deflection (d).	Product $b\times d$, or power of resisting impact.
Experiment 1, bar 4 ft. 6 in. between supports	......	336·9	0·49	165·0
Experiment 2, bar 4 ft. 6 in. between supports	7·385	294·0	0·43	126·4
Experiment 3, bar 4 ft. 6 in. between supports	......	307·2	0·51	156·6
Mean......	7·385	312·7	0·476	148·8

The slight deteriorations and loss of strength from the first up to the eighth melting, and the progressive and striking increase which took place from the eighth up to the maximum or the twelfth melting, indicate some curious and interesting phænomena in the fusion of cast iron. It will be observed that after the first melting, there is a steady and progressive decrease of strength till the fourth melting, when it again begins to rise and keeps steadily on the ascent till the thirteenth melting, when it again begins to decrease, at first progressively up to the fifteenth, when it suddenly falls from 603 to 371, and from this again downwards to the last or eighteenth melting, when it falls as low as 312; and at which time the iron becomes perfectly useless, from its flinty hardness and its obdurate nature in resisting the attacks of the hardest steel.

The general summary will, however, exhibit the peculiar properties of the irons produced from each melting. Some of them, but more particularly those towards the close of the experiments, presented appearances in their sectional fractures of an extremely curious character. These I have endeavoured to describe at the bottom of each table; and I now refer to the following summary, where the results of each experiment will be found tabulated in the order in which they were made.

General Summary of Results.

No. of melting.	No. of experiment and bar.	Specific gravity.	Breaking weight.	Mean breaking weight.	Ultimate deflection.	Mean ultimate deflection.	Mean power of resisting impact.
1.	1. 2. 3.	6·949	463·7 536 470	490	1·27 1·54 1·51	1·44	705·6
2.	1. 2. 3.	6·970	443·1 508·0 374·7	441·9	1·48 1·67 1·19	1·446	638·98
3.	1. 2. 3.	6·886	396 396 412·9	401·6	1·42 1·43 1·61	1·486	596·7
4.	1. 2. 3.	6·938	347 415·6 477·7	413·4	1·01 1·22 1·55	1·26	520·8
5.	1. 2. 3.	6·842	418·5 461·3 415	431·6	1·48 1·57 1·46	1·503	648·6
6.	1. 2. 3.	6·771	491·9 375·5 447·7	438·7	1·54 1·07 1·35	1·32	579·0
7.	1. 2. 3.	6·879	346·9 566·2 434·4	449·1	1·04 1·90 1·38	1·44	646·7
8.	1. 2. 3.	7·025	506·6 501·7 465·9	491·3	1·88 1·82 1·56	1·753	861·2
9.	1. 2. 3.	7·102	552·8 566·6 520·2	546·5	1·56 1·77 1·53	1·62	885·3
10.	1. 2. 3.	7·108	552·9 616·1 531·8	566·9	1·62 1·74 1·52	1·626	921·77
11.	1. 2. 3.	7·113	649·8 644·1 662	651·9	1·61 1·66 1·64	1·636	1066·5

General Summary (*continued*).

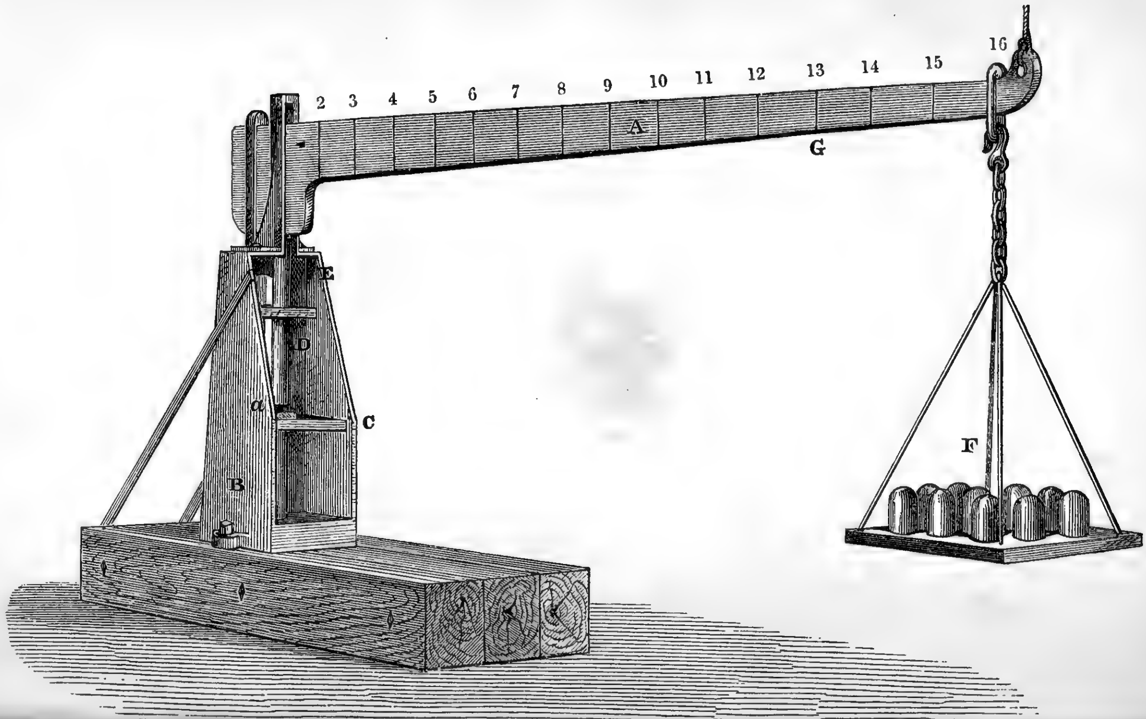
No. of melting.	No. of experiment and bar.	Specific gravity.	Breaking weight.	Mean breaking weight.	Ultimate deflection.	Mean ultimate deflection.	Mean power of resisting impact.
12.	1. 2. 3.	7·160	649·8 756·7 670	692·1	1·60 1·77 1·63	1·666	1153
13.	1. 2. 3.	7·134	637·1 656·6 610·7	634·8	1·62 1·64 1·68	1·646	1044·9
14.	1. 2. 3.	7·530	595·8 605·2 609·4	603·4	1·43 1·49 1·62	1·513	912·9
15.	1. 2. 3.	7·248	399·6 376·9 336·9	371·1	0·64 0·64 0·65	0·643	238·6
16.	1. 2. 3.	7·330	353·7 350·4 350·1	351·3	0·56 0·60 0·53	0·566	198·8
17.	The 17th melting was a failure, the iron being too stiff to run into bars.						
18.	1. 2. 3.	7·385	336·9 294·0 307·2	312·7	0·49 0·43 0·51	0·476	148·8

Forming an abstract of the above table, and taking the mean of the breaking weight, deflection, &c. of all the experiments, we arrive at the following results :—

Ultimate Results as derived from the whole of the meltings.

No. of meltings.	Specific gravity.	Mean breaking weight in lbs.	Mean ultimate deflection in inches.	Power to resist impact.
1.	6·969	490·0	1·440	705·6
2.	6·970	441·9	1·446	630·9
3.	6·886	401·6	1·486	596·7
4.	6·938	413·4	1·260	520·8
5.	6·842	431·6	1·503	648·6
6.	6·771	438·7	1·320	579·0
7.	6·879	449·1	1·440	646·7
8.	7·025	491·3	1·753	861·2
9.	7·102	546·5	1·620	885·3
10.	7·108	566·9	1·626	921·7
11.	7·113	651·9	1·636	1066·5
12.	7·160	692·1	1·666	1153·0
13.	7·134	634·8	1·646	1044·9
14.	7·530	603·4	1·513	912·9
15.	7·248	371·1	0·643	238·6
16.	7·330	351·3	0·566	198·5
17.	lost.			
18.	7·385	312·7	0·476	148·8

The above constitutes the results as obtained from the whole series of meltings, and it will be observed that the maximum of strength, elasticity, &c. is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&c. is only arrived at after the metal has undergone twelve successive meltings. It is probable that other metals and their alloys may follow the same law, but that is a question that has yet to be solved, and that probably by a series of experiments which would require a considerable amount of time and labour to accomplish.

Having effected the experiments on the resistance of these metals to a transverse strain, I next availed myself of a large wrought-iron lever and a strong cast-iron frame, mounted for other researches, to ascertain their relative powers of resistance to compression. This powerful apparatus had a lever 17 feet long, 12 inches deep, and $2\frac{3}{4}$ to nearly 3 inches thick, and tapered to about 5 inches deep at the extreme end, where the weights were suspended. This will, however, be better understood by the foregoing figure, which exhibits the iron frame, lever, scale, weights, &c. by which the experiments were effected, and the results in the following Tables obtained. A is the lever, B the cast-iron frame, and C the shelf with a solid column below, over which the specimen to be crushed was placed between two perfectly flat steel discs at *a*. The column D was inserted under the shoulder of the lever resting upon the specimen and upper disc, and retained in its vertical position by the guide-plate E; the metal cubes were crushed by adding weights of 56 and 28 lbs. at a time to the scale F.

In this way the whole of the specimens were crushed; and in order to prevent the weight falling so as to injure the fractured parts, a stop was placed under the lever at G to receive the fall of the lever and scale when fracture ensued.

On the Resistance of Cast-iron, derived from repeated Meltings, to the Force of Compression.

The extraordinary results obtained from the foregoing experiments on a transverse strain, induced a further extension of them to that of compression, or the resisting powers of the metals in their different stages of successive meltings to a force tending to crush them. This was a work of some difficulty, as we found by repeated trials that our apparatus was not sufficient to crush 1 inch cubes, and particularly those of the higher meltings, which required a force of upwards of 90 tons to the square inch to produce fracture. Finding the power of the lever inadequate for this purpose, the cubes were reduced from 1 inch to a base of three-fourths and five-eighths of an inch; and having fixed the fulcrum of the lever equivalent to a force of 100 tons, the experiments were proceeded with consecutively in the order of the meltings, as exhibited in the following Tables.

Experiments to determine the comparative resisting powers of cast-iron cubes derived from repeated meltings, to a force tending to crush them.

EXPERIMENT I.—First Melting.

No. of experiment.	Dimension of specimen in inches.	Weight laid on in pounds.	Resistance in tons.	Resistance per square inch in tons.	Remarks.
Lever 1	$\frac{3}{4}$ cube	9,940	....	....	Marked Experiment II.
2	,,	54,580			
3	,,	56,268			
4	,,	58,056	25·9	46·0	Crushed after sustaining the load a few seconds.

Experiment II.—Second Melting.

No. of experiment.	Dimension of specimen in inches.	Weight laid on in pounds.	Resistance in tons.	Resistance per square inch in tons.	Remarks.
Lever 1	¾ cube	9,940	....	....	From Experiment V.
2	"	54,580			
3	"	55,476	24·7	44·0	Crushed at once when the weight was laid on.

Experiment III.—Second Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment VI.
2	"	54,580	24·3	43·2	Crushed before the whole of the load was laid on; 54,000 lbs. would probably be nearer the crushing weight.

Having made two experiments on the second melting, it will be necessary to reduce them to the standard of one experiment = 43·6 tons per square inch, which may be taken as the mean resistance of the second melting.

Experiment IV.—Third Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment VII.
2	"	51,790	23·1	41·1	Crushed with this weight.

Experiment V.—Fourth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XII.
2	"	51,342	22·9	40·7	Crushed when laying on the last weight.

Experiment VI.—Fifth Melting.

Lever 1	¾ cube	9,40	....	....	From Experiment XIV.
2	"	51,342			
3	"	51,790	23·1	41·1	Crushed at once when the full weight was on the lever.

Experiment VII.—Sixth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XVIII.
2	"	51,790	23·1	41·1	Crushed in the same way as last experiment.

Experiment VIII.—Seventh Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXI.
2	"	51,342			
3	"	51,566	23·0	40·9	Crushed with this weight.

Experiment IX.—Eighth Melting.

No. of experiment.	Dimension of specimen in inches.	Weight laid on in pounds.	Resistance in tons.	Resistance per square inch in tons.	Remarks.
Lever 1	¾ cube	9,940	....	....	From Experiment XXIII.
2	„	51,790	23·1	41·1	This specimen gave evident signs of rupture with this weight, and ultimately gave way after sustaining it for about twenty seconds.

Experiment X.—Ninth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXV.
2	„	51,790			
3	„	69,430	31·0	55·1	Crushed with this weight.

The great weight required to fracture the specimens in this experiment gave rise to suspicion that something might be wrong with the apparatus or the weights on the lever. On careful inspection everything was found correct, and it appeared difficult to account for the discrepancy. On examination it was however found to be a closer and harder metal than its predecessor, and comparing this with Experiment XXIII. on the transverse strain, it will be found, from the deflection, that the former is softer and more ductile.

Experiment XI.—Tenth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXVIII.
2	„	51,790			
3	„	72,790	32·5	57·7	Crushed.

Experiment XII.—Eleventh Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXXII.
2	„	54,580			
3	„	87,060	38·3	69·0	Crushed.

Experiment XIII.—Eleventh Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXIII.
2	„	54,580			
3	„	89,076	39·7	70·6	Crushed.

The ultimate crushing force of the two last experiments, both from the eleventh melting, are

$$\left.\begin{array}{r}87{,}060 \text{ lbs.}\\ 89{,}076 \text{ lbs.}\end{array}\right\} \text{Mean, } 88{,}068 \text{ lbs.,}$$

which may be taken as the force required to crush the eleventh melting. If we compare the last three experiments with their respective tables, we shall find this iron of a high order as regards strength; whether viewed in its power of resistance to compression or a transverse strain, it is alike conclusive in its measure of strength. In both cases it was approaching its maximum power of resistance, as may be seen on comparing the three last experiments with those from which the iron was taken in the other.

EXPERIMENT XIV.—Twelfth Melting.

No. of Experiment.	Dimension of specimen in inches.	Weight laid on in pounds.	Resistance in tons.	Resistance per square inch in tons.	Remarks.
Lever 1	¾ cube	9,940	....	....	From Experiment XXXV.
2	„	54,580			
3	„	92,212	41·1	73·1	Crushed.

EXPERIMENT XV.—Thirteenth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XXXVII.
2	„	54,580			
3	„	83,252	37·1	66·0	Crushed.

In the three last experiments the specimens were indented to a depth of about the 40th part of an inch into the solid steel plates, and this may account for the comparative weakness of the thirteenth melting, as the specimen in the last experiment did not lie solid upon the plates.

EXPERIMENT XVI.—Fourteenth Melting.

Lever 1	¾ cube	9,940	....	....	From Experiment XLII.
2	„	54,580			
3	„	120,884	53·9	95·9	Crushed with this weight.

From the great weight required to fracture this specimen—nearly 100 tons to the square inch—I find on examining the fracture that the iron was so excessively hard as to make indentation into the steel plate to a depth of nearly one-twelfth of an inch. The colour was a whitish gray, and harder than cast steel.

EXPERIMENT XVII.—Fifteenth Melting.

Lever 1	⅝ cube	9,940	....	....	From Experiment XLIII.
2	„	54,580			
3	„	67,124	29·9	76·7	Crushed.

The increased weight required in the previous experiment induced a change in the size of the remaining specimens, which were reduced to five-eighth-inch cubes.

On examination we found this specimen to contain a band of exceedingly white hard iron, the interior of a bluish tinge, and much softer than the corners or the outer edges. This will account for the comparatively small weight which produced fracture in this when compared with the previous experiment.

Experiment XVIII.—Sixteenth Melting.

No. of Experiment.	Dimension of specimen in inches.	Weight laid on in pounds.	Resistance in tons.	Resistance per square inch in tons.	Remarks.
Lever 1	⅝ cube	9,940	....	....	From Experiment XLVII.
2	„	54,580			
3	„	61,748	27·5	70·5	This specimen was crushed; one side soft and the other hard.

The seventeenth melting failed in the casting, the metal being too stiff to run into bars.

Experiment XIX.—Eighteenth Melting.

Lever 1	⅝ cube	9,940			
2	„	54,580			
3	„	77,060	34·4	88·0	Crushed after making a deep indentation into the steel plates on both sides.

In this experiment the pressure was so great as to cause an adhesion of the two metals, the specimen being so closely incorporated with the plates as to require a hammer to effect the separation.

Collecting the results obtained from the foregoing experiments into a table of resistances to pressure, we have, in these resistances, derived from the different meltings a remarkable uniformity up to the ninth melting, and from that to the twelfth; which it will be observed is the maximum point of strength in the resistance to a transverse strain. From this point there is a steady increase of resistance to compression. This is again progressive, until it reaches the maximum, or the fourteenth melting, where its powers are doubled, and from this again to the eighteenth melting its resisting power decreases, as may be seen by the following abstract of results.

Abstract of Resistances from the foregoing Experiments.

Number of meltings.	Resistance to compression per square inch in tons.	Remarks.
1	44·0	
2	43·6	
3	41·1	
4	40·7	
5	41·1	
6	41·1	
7	40·9	
8	41·1	
9	55·1	
10	57·7	
11 } 11	Mean 69·8	
12	73·1	In this experiment the cube did not bed properly upon the steel plates, otherwise it would have resisted a much greater force, probably 80 or 85 tons per square inch.
13	66·0	
14	95·9	
15	76·7	
16	70·5	
18	88·0	

On a careful examination of the drawings which exhibit the line of fracture of the cubes derived from the different meltings, it will be observed that up to the thirteenth melting the whole of the specimens appear to yield at one and the same line of fracture, namely, by wedges which are split, or which slide off diagonally at an angle varying from 52° to 58°. This appears to agree with the experiments of Professor Hodgkinson on the mechanical properties of iron obtained from the hot and cold blast*. In speaking of the angle of the wedge he states, that "We have seen that when bodies are subjected to a crushing force, their fracture, if they do not break by bending, is caused by the operation of a cone or wedge, which seems, under various circumstances, to slide off at nearly a constant angle. If a prismatic body, as for instance a short cylinder, be subjected to a crushing force, there seems no reason why fractures should take place one way more than another; there is usually, too, in soft irons a bulging out in every direction round the cylinder, which shows that it is equally strained all round; a matter which is otherwise exemplified in fig. 8. If, then, the cylinder be longer than the wedge, or than the two cones, which are always in operation at the ends during crushing, it is evident that the angle of the wedge and cones, which is the same, will depend upon the nature of the material, and the cones must be isosceles. Cylinders longer than the wedge usually slide off in one direction without showing the cones."

The resisting powers of iron, stone, and other materials to a crushing force, have been ascertained by various writers; but the most accurate and extensive—excepting only those of recent date—are probably those by Mr. George Rennie. Rondelet made a considerable number of experiments on stone and wood of various kinds; but those by Mr. Rennie appear to be the most conclusive, and give evidence of the great accuracy with which Mr. Rennie's experiments were conducted. Professor Hodgkinson took up the subject where Mr. Rennie left off; and the experiments recorded in the preceding Tables are to a great extent analogous with those by Rennie and Hodgkinson. It may be interesting, for the sake of illustration, to compare them. Taking the mean of the different meltings as shown in the following Table, we have an approximate ratio of the forces required to crush cast iron under the separate forms which indicated the experiments made by Mr. Rennie, Mr. Hodgkinson, and myself.

	Crushing weight per square inch in tons.	Mr. Rennie's experiments. Crushing weight per square inch in tons.	Mr. Hodgkinson's experiments. Crushing weight per square inch in tons.
Mean of eight consecutive meltings	41·9	69·8 Mean of eight exps.	64·9. Devon No. 3. Hot blast.
Mean of five meltings, from eight to thirteen	64·3	79·3 Mean of five exps.	36·7. Coed-Talon No. 2. Hot and cold blast.
Mean of four meltings, from thirteen to eighteen, omitting the seventeenth	82·8	79·5 Mean of five exps.	55·5. Carron No. 3. Hot and cold blast.
Mean	63·0	76·2	52·3

The comparisons will therefore stand as the numbers 76, 63 and 52. The discrepancies observable in the different experiments may be accounted for

* See Report on the Properties of Hot and Cold Blast Iron, Transactions of the British Association for the Advancement of Science, vol. vi.

in those by Mr. Rennie, which were evidently made on small specimens, which being cast of such limited dimensions invariably produce a hard casting exceedingly difficult to crush; and as those of Mr. Hodgkinson were made, the first from Devon No. 3, an exceedingly hard and rigid iron, and the others from the Carron No. 3, a comparatively strong iron, and the Coed-Talon No. 2, hot blast, a soft, fine working iron, the differences under these circumstances may be easily accounted for.

The Eglinton No. 3 iron, from which the results of the different meltings were obtained, is very similar in character, but rather stronger than the Coed-Talon No. 2. Up to the eighth melting it will be observed that the ordinary power of resistance to a crushing force, namely, about 40 tons to the square inch, is indicated. Afterwards, as the metal increases in strength, from the eighth to the thirteenth melting, a very considerable change had taken place, and we there have 60 instead of 40 tons as the crushing force. Subsequently, as the hardness increases, but not the strength, double the power is required to produce fracture.

From these results we arrive, in round numbers, at the following conclusions, viz.—

	Crushing force in tons per square inch.
1st. In cast iron derived from consecutive meltings, we have up to the eighth melting the ordinary powers of resistance.	= 40
2nd. From the eighth to the thirteenth melting, or nearly the point of maximum strength, the power of resistance to strain has increased more than one half.	= 60
And, lastly, from the commencement of deterioration, from the thirteenth to the eighteenth melting, and in which the castings present a hard silvery fracture, the powers of resistance are doubled.	= 80

These facts are the more interesting as they exhibit some curious phænomena in connection with, not only the mechanical properties of iron, but their chemical affinities; and my friend Professor C. Calvert, of the Royal Institution of this city, having kindly undertaken to analyse a few of the most remarkable samples of the experiments, I attach the particulars as follows.

In the analyses of these irons, Mr. Calvert observes that the gradual increase of silica in the irons as they are progressively reunited are well deserving of attention; as also, the increased quantity of sulphur and carbon, of which it will be observed by the following results that the increase in all the three substances is progressive from the first to the last meltings, as under.

	Per-centage of Silicium.	Per-centage of Sulphur.	Per-centage of Carbon.	Remarks.
First melting.........	·77	·42	2·76	
Eighth melting......	1·75	·60	2·30	
Tenth melting	1·98	·26	3·50	
Eighteenth melting.	2 22	·75	3·75	

In the above analyses there appears to be this remarkable fact, that the increase in the quantity of silicium is much greater than appearances would indicate up to the tenth and twelfth meltings; but it is probably not more than what might naturally be expected from the number of meltings and the quantity of limestone used each time as a flux. This flux, when in contact with the iron at a high temperature, would part with a portion of its silica, or, what is equally probable, the iron would take up its equivalent at each melting, and thus bear out the fact recorded in the table of the increase and relative importance of this constituent.

As respects the sulphur, the surprise is that the increase is not greater, and that more particularly when the quantity contained in the fuel used is considered. In this constituent we are led to the conclusion that a gradual absorption from the coke must have taken place from the commencement to the end of the process, and in this view of the question the quantity taken up by the iron at the different meltings should have been nearly the same. This is, however, not the case, as we find the tenth melting of a purer quality by ·34 than the eighth, and ·49 less than those of the eighteenth melting.

In the relative increase of the quantity of carbon * there is not that discrepancy, as in the absorption of this constituent there is not a uniform but a variable increase; and from the first to the last melting there is an increase from 2·76 to 3·75, or nearly one per cent.

The chemical properties of these different meltings are somewhat peculiar in character, and appear to be entitled to further investigation, and that by abler and more intelligent heads than my own. On some future occasion I hope to induce some of my chemical friends to take up the subject, and nothing will give me greater pleasure than to furnish the necessary facilities for such an inquiry.

* Mr. Calvert states, in his note attached to the analyses, that the quantity of carbon contained in the specimens was determined in the usual way; but the process adopted, although the best in use, was not calculated, in his opinion, to enable him to state the real amount of carbon in each specimen.

Third Report on the Facts of Earthquake Phænomena (continued).
By Robert Mallet, *C.E., M.R.I.A.*

Catalogue of recorded Earthquakes from 1606 B.C. *to* A.D. 1850.

[Continued from Report for 1852, p. 176.]

1. Anno Domini.	2. *Locality.*	3. *Direction, duration, and number of shocks.*	4. *Phænomena connected with the sea.*	5. *Meteorological and other phænomena.*	6. *Authority.*
1755. Dec. 13. Between 2 and 3 P.M.	Strasburg, Hüningen, Bourg en Bresse, Dijon, Flavigny, Montbard, and many places in Franche Comté.	Slight tremblings ...	....	....	Coll. Acad.; Journ. Hist.
—— —— 15.	Brieg	Ditto	....	....	Phil. Trans.; Coll. Acad.
—— —— 17.	In the Aargau, and still at Brieg.	Ditto	....	....	Collection Académique.
—— —— 18.	The village of Glonsow, near the Wye in Herefordshire.	A violent shock	....	Accompanied by a frightful subterranean noise. About 500 yards from the village a piece of land of two acres in extent sank down. The hills near had been shaken in the month of March preceding. This account is obviously confounded with that of the 18th November. The latter appears likely to be the correct one.	Gazette de France, 10 Janv.; Journ. Hist. Fév. 1756, p. 134.
—— —— 19.	The same region of N. America which had been shaken on the 18th and 22nd November.	Renewed tremblings	....	....	Collection Académique.
—— —— 20.	Brieg in the Valais. Also	Another shock parti-	....	....	Philosophical Transactions, *loc. cit.*

	Also at Lisbon and the country round, with the kingdom of Algarbia.	two or three shocks were felt daily at Brieg, but at various hours. At Lisbon the disturbance was again violent.		shocks of this day. More than 300 persons perished under the ruins of houses which were thrown down, or in the waters of the Tagus, which overflowed its banks. A league of country was submerged by the sea in Algarbia. The extremity of Cape de la Bagne was carried away. The towns on the frontiers of Spain suffered least.	
——— 23.	In the mountains of Roussilon.	A trembling			v. Hoff quotes Kant.
——— 24. At night.	At Besançon, Lyons, and Geneva.	Sensible shocks		v. Hoff give the 23rd as date	Coll. Acad.; Journ. Hist.
——— 25.	Milan and in the Margravate of Ancona.	Two strong shocks		Great damage done. A thousand victims perished	Huot, *loc. cit.*; Gazette de France, 20 Fév. 1756; Journ. Hist. Avril, 1756, p. 304.
	Also at Lisbon	Shocks a little more violent than those which were constantly occurring, but have not been particularized. Slight shocks were felt almost every day from this up to the 6th January.		The Collection Académique gives the dates 27th and 29th December for the events here mentioned (on the authority of Perrey) on the 27th and 29th November.	Coll. Acad.; Gazette de France; Journ. Hist.
——— 26. 4 P.M.	Maestricht and Cologne	A slight shock, followed by another more violent at $4\frac{1}{4}$ P.M.			Ditto; Phil. Trans. &c.
$11\frac{3}{4}$ P.M. and at midnight.	In the district of the Lower Rhine, especially at Brussels, Liège, Maestricht, Nimeguen, and even as far as Arnheim and Breda. Also in Cologne, Bonn, some valleys of Alsace and Lorraine, in Picardy, and in the Alps.	Two shocks, at the hours mentioned. Both were undulatory. At Rocroy a shock was felt at $11^{h}\ 56^{m}$.		In the Alps some wells became salt. v. Hoff appears to have confounded those mentioned on the 26th and 27th November with these, as it is very improbable that they were really distinct events. All the dates about this period, especially those taken from the Philosophical Transactions, are most confused, and many of them obviously inaccurate.	

1.	2.	3.	4.	5.	6.
1755. Dec. 27. 15 min. after midnight of the 26th, and at 1 A.M. 30 min. past midnight (or 2 A.M.).	The region of the Lower Rhine, as before, at Maestricht, at Sedan, Liège, and Cologne.	At Maestricht two shocks at the time stated, the first stronger than the second. At Rocroy a second shock at 12 min. past midnight. At Sedan and Liège, two, and at Cologne four shocks were felt. Shocks were also felt at 4 A.M.	....	These shocks were preceded, at Rocroy and other places, by a dull noise, lasting but a short time. The heavens too appeared as if all on fire. No damage was done, except at Chesnée, a village near Liège, where the second of the two shocks threw down two houses and shook others. A prolonged noise like that of musquetry was heard there. In the Valais the shocks still continued, they were especially violent at $2\frac{1}{2}$ P.M.	Coll. Acad.; Gazette de France; Journ. Hist.; Phil. Trans., &c.
—— —— $3\frac{1}{2}$ A.M.	Roussilon, in the neighbourhood of Canigou, at the foot of the Pyrenees.	Six undulatory or balancing movements of the earth in the two hours after.	....	Each movement was preceded by a subterranean noise.	Ditto.
—— ——	At Cordova; Aix in Savoy.	Shocks were felt at these places. The hour not mentioned	....	....	Collection Académique.
—— —— 28. 6 A.M.	Brieg in the Valais	Two slight shocks ...	....	....	Phil. Trans. p. 616.
6ʰ (Italian time.)	Padua	One ditto	....	At the end of this month there was an eruption of Vesuvius.	Ditto, p. 615.
—— —— 30. 1 A.M.	Brieg again	The shocks recurred	....	Some portions of chimnies were thrown down. The Rhone was often troubled, and appeared to boil during these shocks.	Collection Académique, p. 640.
	Also at Madrid	One shock	....	....	v. Hoff.
—— —— 31. Shortly before 1 A.M.	At Glasgow, Greenock, Dumbarton, Inchinnan, and other places in Scotland.	Three consecutive shocks.	....	The shocks were felt in the different stories of the houses at Dumbarton, where birds appeared greatly frightened in their cages.	Phil. Trans. p. 509; Coll. Acad.; Gazette de France; Journ. Hist.
1756. Jan. 1.	Ancona	A smart shock........	....	But little damage done	Gazette de France, 20 Fév.
—— —— 2. About $7\frac{1}{2}$ P.M.	In the west of Ireland...	Ditto	....	A meteoric phænomenon (the heavens appearing like a sea of flame), which was probably an aurora, was observed from 4 to $7^h\ 18^m$ P.M., the latter 18 minutes were the most brilliant. This was soon followed by the shock, which did	Journal Encyclopédique, Février et Mars.

				mention is made of subterranean commotions.	
9h 30m P.M.	Brieg in the Valais. Also felt at Geneva.	Slight movements ...	....	....	Phil. Trans. &c., as quoted above.
Hour not given	Boston in Massachusetts	....	....	....	Keferstein.
1756. Jan. 3. Before 10 A.M.	Brieg	Ditto	....	....	Phil. Trans. &c.
—— 6. Before 8 P.M.	Ditto	A rather more violent shock.	....	....	Ditto.
—— 7. 5 P.M.	Ditto	Two ditto consecutively.	....	....	Ditto.
—— 8. 7h 30m P.M.	Ditto	One ditto	....	....	Ditto.
Hour not given.	Rimini in Italy	A slight shock	....	....	Gazette de France, *loc. cit.*; Journ. Hist.
—— 11. 3 and 11 A.M.	Brieg	Two more shocks at the hours stated.	....	....	Phil. Trans. &c.
—— 12.	Ditto	More slight movements.	....	....	Ditto.
	Prague, and on the frontiers of the kingdom of Bohemia, extending to Barrenstein, Zinnwald and Altenberg.	*Fresh* shocks. (This expression perhaps refers to shocks felt in this region on the 1st November before.)	....	The mines were inundated, and filled with a smell of sulphur. At Ofermissen near Herfort, during the night of the 13th–14th, during a violent tempest, the earth opened, forming a pit of 32 feet in diameter, and more than 50 toises deep, and full of water. This may have proceeded from an earthquake, but no shock is mentioned.	Gazette de France, 14 et 28 Fév. 1756; Journ. Hist.; Coll. Acad.; Kant, Géog. Phys.
—— 13.	Brieg	Slight motion	....	....	Phil. Trans. &c.
—— 14. 2h 30m A.M.	Ditto	Violent undulations, lasting but 3 or 4 secs.	....	No damage done........	Ditto.
	In the Saxon and Bohemian Erzgebirge, especially at Altenberg and Zinnwald. Also felt at Erfurt.	Tremblings	....	This is probably only the same event with that just reported on the 12th.	v. Hoff.
—— 15. 4h 30m A.M.	Brieg	A moderate shock in the direction S. to N., followed by others at various hours.	....	Three hours before the shocks the wind suddenly fell, and a slight trembling was felt. Bodies thrown to the ground were in the direction S. to N., and fissures in the same direction opened in the earth.	Phil. Trans. &c.

1.	2.	3.	4.	5.	6.
1756. Jan. 15. 4h 30m A.M.	Ancona	A violent shock		This event is only mentioned in the Journal Historique, and is probably the same as that of the 1st, one or other date being erroneous.	Journ. Hist.
	Amersfort in the province of Utrecht.			A shock which caused much consternation, but did no damage. v. Hoff mentions erroneously another shock at this place on the 15th of December before.	Phil. Trans. p. 513.
—— 18.	At Lisbon. Also this day at Casal-Maggiore, Ferrara, Spoleto, Albano, Fano, Orvieto, and Rimini.	A trembling, followed by many others, at Lisbon up to the 3rd of February.			v. Hoff.
At midnight.	Brieg	Another shake, rather violent, but very short.			Phil. Trans. &c.
"About this time."	In Peru	An earthquake			v. Hoff.
—— 19. 45m past midnight.	Brieg	A movement not so great as the last.		The air was very cold	Phil. Trans. &c.
—— 20. 12h 34m P.M.	Constantinople	Three rather strong shocks.		Probably at the same time as the last, the one reckoning it as the 19th, the other as the 20th.	Phil. Trans. *loc. cit.* p. 122.
	Lisbon	More violent shocks			Journal Encyclopédique, Mars 1756.
—— 21. About 11 P.M.	Brieg	Rather violent			Phil. Trans. &c.
—— 22. A little before midnight.	Ditto	Differing but little in violence from that of the 9th, but very short. Followed by other slighter ones.			Ditto.
—— 23. In the morning.	Ditto	Two shakings, the first the more violent of the two.			Ditto.
	Constantinople	Another shock			Ditto.
—— 24.	Brieg	Several slight movements.		Also felt at Berne, and at Demonte in Piedmont.	Ditto.
—— 25.	Ditto	Ditto		Some persons believed that they felt a shock at Berne.	Ditto.
—— 26.	Ditto	Ditto			Ditto.

$3^h 55^m$ A.M.	Bonn and Cologne	At Cologne a slight shake from E. to W., lasting 7 or 8 secs. At Bonn it resembled that of the 26th Dec.			Coll. Acad.; Journ. Hist.; Gazette de France.
11 P.M.	Brugg and throughout the lower Aargau.	More shocks		No damage done.	Ditto.
1756. Jan. 27.	Brieg	Slight ditto		From this until the 6th Feb. the shocks were feebler and less frequent in the Valais and Berne.	Phil. Trans. &c.
—— ——	Dalecarlia in Sweden	Some more shocks			Gazette de France, 28 Fév.
—— Feb. 1.	Aigle	More shocks			Bertrand.
2 and 5 A.M.	In Piedmont and Savoy	Slight ditto	At $8^h 45^m$ A.M. of this day an extraordinary agitation of the waters of Closeburn Loch, a little lake in Dumfriesshire, was observed; the water rising in the centre, and moving in currents in opposite directions for $3\frac{1}{2}$ or 4 hours. No shock is mentioned.		v. Hoff; Phil. Trans.
—— —— 2.	At Arau. Also on the same day in different parts of Switzerland and Italy.	Ditto			Bertrand; Coll. Acad.
—— —— 5.	Ancona	A trembling motion			Keferstein.
—— —— 6. 6 A.M.	Brieg	Another violent shock. Slight tremblings daily from this up to the 13th.			Phil. Trans. *loc. cit.* &c.
—— —— 13. $4\frac{1}{2}$ P.M.	Maestricht	A slight and short shock.	On the 12th and 13th irregularities were observed in the tides at Chatham, Sheerness, Woolwich, and Deptford. They were accounted for solely by the wind.		Coll. Acad.; Phil. Trans. &c.

1.	2.	3.	4.	5.	6.
1756. Feb. 13.	In the island of Corfu. And at Malta?	A smart shock. At Malta two ditto.	....	The shock at Malta was in February, and probably on this day.	Coll. Acad.; Gazette de France; Journ. Hist.
At night.	Naples	A shock lasting some seconds.	....	....	Gazette de France, 27 Mars.
—— 14. $3\frac{1}{4}$ A.M.	Maestricht	Another shock; strong and short.	....	....	Coll. Acad.; Phil. Trans. &c.
About midnight.	Brieg	Moderate agitation ...	....	Cold and snow prevailed at the time........	Phil. Trans. *loc. cit.*
—— 15. $2\frac{1}{2}$ and $5\frac{1}{2}$ A.M.	Ditto	Two violent shocks at these hours.	....	A strong wind was blowing at the time	Ditto.
—— 18. $1^h\ 30^m$ A.M.	Ditto	A violent shock	....	Preceded by a loud bellowing noise	Ditto.
—— —— About 8 A.M. In the morning Between 7 and 8 A.M. About 8 A.M. $7^h\ 56^m$ $8^h\ 8^m$ $8^h\ 6^m$ $8^h\ 30^m$ A little before 8	Very extensive shocks, felt in the Alps, some parts of France and Germany, in the Netherlands, and in England. Also about the same time in Portugal. In France, at Paris, Versailles, Beauvais, Rouen, Dieppe, Sedan, Metz, &c. Throughout the whole of Belgium, as at Brussels, Mons, Namur, Liège, &c. In Holland, at Leyden, Amsterdam, the Hague, &c. In Germany, they were felt at Bonn, Cologne, Arensberg, Worms, Mannheim, Darmstadt, Wetzlars, Cassel, Gotha, &c. In England, at London, Dover, Deal, Margate, Canterbury, and even	In France the shocks came from S.E. to N.W., or from W. to S.E. (?). At Aire and Sedan they lasted more than a minute. In Holland, where they were very violent, they lasted $1\frac{1}{2}$ min., and then recommenced in 10 or 12 minutes. At Bonn the shocks recurred at 9 A.M., and 20 minutes after. At Liège also at 9 and $9\frac{1}{2}$ A.M., and at $12\frac{1}{4}$ and $8\frac{1}{4}$ P.M., other shocks were felt. At Maestricht the shocks were slight, but recurred at $9\frac{1}{2}$ A.M. At Lisbon a shock which lasted nearly 3 mi-	The waters of the Rhine and Meuse were much agitated during the shocks.	At most of the towns in France the barometer was very low. At Aire and Sedan a subterranean noise was heard. At Metz chimnies were thrown down. The same happened at Aix-la-Chapelle, where the mineral contents of the waters appeared to be suddenly increased. At Cologne and Liège a good deal of damage was done to buildings. In the coal-pits near Liège, the miners, at the depth of 900 feet, heard a rumbling noise above their heads (and then felt the shock), while those above ground heard a similar noise under their feet. Near Stolberg the earth opened and closed again. The earth appears to have been somewhat agitated for an hour together, and during the whole time a low noise was heard. Some people supposed that some of the shocks were attended with flashes of light. The west wind had prevailed for a long time before, and at the time of the earthquake, the barometer, which at Berne was down to 25 in $5\frac{1}{2}$ lines, and magnetic needle were greatly agitated. In England the weather was calm, but soon after a violent tempest took place. All the dates as to hour are given in the time of the places to which they refer.	Coll. Acad.; Phil. Trans. vol. xlix.; Gazette de France; Journ. Hist.; Journ. Encyc.

	Glasgow. Many places, not mentioned, also experienced them.	nutes. Its direction appeared to be from E. to S. Many others had been felt there at the beginning of the month. At Brieg these shocks were also felt, and they recurred there at 1½ P.M.			
Hour not mentioned.	In Silesia. Also at Prague, and in Albania.	Shocks were felt at all these places on this day.	....	A terrible tempest all day in Silesia. It was also somewhat felt in Switzerland, and seems to have been most violent about 8 P.M.	Keferstein; v. Hoff.
1756. Feb. 19. 6 A.M.	Maestricht, and other places in Belgium.	A short but violent shock.	....	....	Phil. Trans. *loc. cit.*
Before 11½ A.M.	Brieg	More shocks	....	Stones and plaster fell from the walls of the houses.	Ditto.
—— —— 20. 4 A.M.	Maestricht, and the rest of Belgium.	A short and slight shock.	....	At Maestricht scarcely a day passed, until the beginning of April, without a shock. More than eighty distinct earthquakes were reckoned there. In general the shocks were felt more in the upper stories of the houses than on the pavement. They were felt *less* strongly in the upper part of the town. During some of the most violent lightning was observed. On every occasion a noise like that of a carriage in motion was heard. They occurred in all weathers, except that often it was calm before the shock, and the wind arose soon after. The barometer was high, and the weather very variable. Clouds and auroræ were often observed. Some persons felt a sensation like that of a strong electric discharge. Horses, cows and pigeons were much alarmed, often long before the shock. Igneous meteors were common in Switzerland for some time after.	Ditto; Coll. Acad.; Gazette de France, &c.
—— —— 23. Between 7 and 8 A.M.	Brieg	Shocks feebler than those of the 19th.	....	....	Phil. Trans.
—— —— 26.	Ditto	Two slight shocks ...	....	Here Bertrand's catalogue stops	Ditto.

1.	2.	3.	4.	5.	6.
1756. Feb. 27, 28, and at the commencement of March.	In the Tyrol; at Trente and Venice.	Several rather violent shocks. They continued more or less for three weeks.	On the 27th, at 6 P.M., at Ilfracombe in Devonshire, the sea rose 6 feet, as on the 1st November, and remained so for half an hour without ceasing to boil as it were in a remarkable manner. No shock is mentioned. During the whole course of the month the tides were very irregular at Chatham, Woolwich, Sheerness, and Deptford.	....	Coll. Acad.; Gazette de France, 30 Avril; Bertrand; 5th Mem. Journ. Hist. Mai; Phil. Trans. *loc. cit.*
—— —— At the end of the month.	At Rondhelem, twenty leagues from Drontheim in Norway.	....	....	A mountain is said to have fallen and interrupted the course of a river, thereby causing an inundation. No shock is mentioned. and it may have been only a landslip. v. Hoff, on the authority of the Coll. Acad., says in March.	Gazette de France, 10 Avril.
—— Mar. 1.	Lisbon	A more violent shock than any felt since the 21st December.	....	The earth had been perfectly still for some days, but this shock, which was followed by many others during March, produced fresh alarm in the city.	Coll. Acad.; Journ. Hist. Mai, p. 368.
—— —— 3.	At Brieg	Several shocks	....	At Berne, in the Pays de Vaud, in the bishopric of Bâle, and elsewhere, a brilliant meteor was observed at 7 P.M.	Coll. Acad.; Phil. Trans. &c.
—— —— 5.	Ditto	Ditto	....	A second meteor was observed this day at Aigle and Vevey, at which places, as also at Avignon, the former one was seen. At Avignon a third was observed on the 3rd of April.	Ditto.
—— —— 7.	Ditto. At Odivillas also, a village 2 leagues from Lisbon, on the same day.	Ditto. At Odivillas a rather violent shock.	....	At Odivillas the shock was accompanied by a loud noise like the report of a cannon, repeated many times by an echo.	Ditto; Gazette de France; Journ. Hist.
—— —— 8. 11½ A.M.	Turin	Two slight shocks, apparently from	....	....	Phil. Trans. p. 615.

		above downwards. Six minutes afterwards a slight oscillation from S. to N.			
	Belem near Lisbon	One shock		Occasioned considerable alarm	Gazette de France; Coll. Acad.; Journ. Hist.
1756. Mar. 11.	Lisbon	Ditto		Some houses were thrown down	Ditto.
—— —— 29. In the morning.	Ditto	A violent ditto	The waters of the Tagus were much swollen.	The shocks at Lisbon during this month were generally perceived either at sunrise or sunset.	Ditto.
—— April 13.	Venice, Padua, Verona, and Trevisa.	A shock lasting half a minute, followed by another at 3 P.M.		At Trevisa chimnies were thrown down and houses injured.	Coll. Acad. p. 644; Gazette de France; Journ. Hist.
—— —— 15.	Lisbon	Very violent shocks			Ditto.
—— —— 16. $2^h\ 10^m$.	Venice, Padua, &c., as above.	Another earthquake, consisting of two distinct shakes.		Preceded by a loud subterranean noise	Ditto.
—— —— Night of 18th to 19th.	Ditto	Another shock, from S.E. to N.W.		On the 24th, 25th, 26th and 27th, Vesuvius was in eruption. Loud subterranean noises were heard there.	Ditto.
—— —— 26. $3\frac{1}{2}$ P.M.	Breteuil. Also felt at Plessis and St. Just.	At Breteuil four shocks, the third the most violent. At the other places two shocks, longer, but less alarming.			Ditto.
—— —— 27.	Lisbon	More violent shocks			Ditto.
—— —— 30. $9^h\ 7^m$ P.M.	Paris, Versailles, and the Chateau du Plessis, four leagues from Montdidier.	At the château du Plessis, the shock, which was considerable at all the places, lasted fifteen minutes.		At the château du Plessis a noise was heard like the wind blowing through a high wood. At Breteuil the noise was heard every half-hour during the night.	Ditto.
	Lisbon	More shocks of equal violence with the last.		More than thirty violent shocks were counted at Lisbon in the course of the month. They were most remarkable on the three days noticed.	Ditto.
—— May 15. $1\frac{1}{4}$ to $2\frac{1}{4}$ and 7 A.M.	Sains near Breteuil. Also felt at Beauvais, Montdidier, and Clermont.	Three shocks at the hours mentioned.		Attended by a low noise, which recurred every half-hour until night. At Beauvais and Bonvillers exhalations in a state of inflammation were observed at the moment of the shock.	Collection Académique.

1.	2.	3.	4.	5.	6.
1756. May 22, and 25.	Ulm and Augsburg	The earth shook on these days.	....	....	v. Hoff.
—— —— 30.	Near Lisbon, in the mountains of Cintra.	A shock was felt, being the first for fifteen days.	....	A terrible tempest had raged over the country on the 24th, 25th, and 26th. The Collection Académique gives the date 29th June.	Journ. Hist. Août, 1756, p. 145; Gazette de France, 17 Juillet.
—— June 3.	Aix-la-Chapelle, Liège, Maestricht, Cologne, Duren, Sittart, and the whole country lying between the Rhine and Meuse, and which was shaken on the 18th and 19th of February.	The shock was much more violent at Duren than at Aix-la-Chapelle, and was followed by several others over the whole district shaken.	....	....	Coll. Acad.; Phil. Trans. vol. xlix. p. 893; Gazette de France, 19 Juin.
—— —— 7. 8^h 30^m A.M. 8^h 45^m.	In Neufchatel, at Colombières, and Chaux-de-Fond.	At Colombières it was an oscillatory movement from E. to W. Other shocks followed 18 minutes after. At Chaux-de-Fond there were four periods of disturbance from 8^h 45^m, and another at 11 P.M. The shocks, which were vertical at this place, appeared more violent than elsewhere.	....	....	Bertrand; Coll. Acad.; Acta Helvetica, vol. iii. p. 438.
—— —— 22.	Ditto	More shocks occurred	....	....	Ditto.
—— July. Beginning of the month.	Brieg in the Valais. Also felt in the bailiwick of Interläcken.	Shocks felt at both places.	....	....	Collection Académique.
—— —— 10 and 11.	Lisbon	Two violent shocks ..	....	On the 10th a cloud of smoke arose from the ground, which obscured the light of the sun. While this obscurity lasted a smell of sulphur pervaded the air.	Gazette de France, 4 Sept.; Journ. Hist. Nov. p. 385.
—— —— 18.	Ditto	Another but a slighter shock.	....	....	Ditto.

1756. Aug. 3.	Obedas in Portugal......	A very violent shock.	....	A cleft opened, from which a great quantity of water gushed out.	Gazette de France, 25 Sept.; Journ. Encycl. Oct.; Journ. Hist. Nov. p. 386.
—— —— 13. 9h 5m A.M.	In Piedmont, at Turin..	Slight shocks	....	....	Phil. Trans. 1757, p. 58.
—— —— 17. Some minutes before noon.	Padua	Several shocks	....	Preceded by a terrible tempest. Great injury done to the buildings by the earthquake, some, amongst others the town-hall, being ruined from top to bottom.	Gazette de France, 11 Sept.; Journ. Encycl. Oct. 1756, p. 303.
—— —— ——	Different places in Turkey.	Several shocks during the month.	....	....	Gazette de France, 4 Déc.; Coll. Acad.; Journ. Hist. Fév. 1757, p. 151.
—— Oct. 20.	Sicily, and in the Morea, especially in the gulfs of Lepanto and Corinth.	Violent shocks........	....	New islands were said to have appeared in the Grecian archipelago. The Collection Académique says that these shocks were felt at Naples; but the letters from that city, speaking of the earthquake of the 22nd, do not mention these.	Gazette de France, 24 Nov. et 11 Déc.; Journ. Hist. *loc. cit.* p. 149; Coll. Acad.
—— —— 22. 3h 30m P.M.	Naples	A violent shock lasting nearly 4 min.	....	Houses were injured and chimnies thrown down.	Ditto.
—— —— 29.	Lisbon	One rather smart shock.	....	Accompanied by loud subterranean noise.........	Coll. Acad.; Journ. Hist. *loc. cit.* p. 151.
—— Nov. 9. 20h 45m and 4m 30m at night (?).	Genoa	Two undulatory shocks from N. to S.	....	....	Phil. Trans. 1757, p. 58.
—— —— 16. 4 A.M.	Boston in N. America...	A slight shock for two seconds.	....	Felt more sensibly elsewhere........................	Silliman's Journal, vol. xl. p. 206.
—— —— 17. 11h 50m P.M.	Inverhallan in Argyleshire.	Lasted about 20 secs. Two other shocks were felt two days after.	....	Preceded by a rumbling noise like thunder	Gentleman's Magazine, vol. xxvi. p. 591.
—— —— 19. 3 A.M.	Cologne, Liège, Bonn, Malmedy, Maestricht, Limburg, and the whole district between the Rhine and Meuse.	A shock of thirty seconds duration.	....	....	Gazette de France, 4 Déc.; Coll. Acad.; Phil. Trans. vol. xlix. p. 893.
—— —— 28.	Barcellos in Portugal ...	A violent shock	....	During November shocks were frequent in many parts of Portugal, especially at Viren, towards the close of the month.	Gazette de France, 1 Janv. 1757; Mercure de France, Janv. 1757, p. 214.
—— —— and December.	The island of Sumatra	Several shocks during the two months.	....	....	Phil. Trans. 1758, p. 491.

1.	2.	3.	4.	5.	6.
1756. Dec. 4 to 9.	Cascaes, Cintra, Colares, Ozyrat, and Sezimbra in Portugal.	Several shocks		That of the 8th threw down some houses at Sezimbra. The Journal Historique reports these facts and those of the 28th Nov. on similar dates in August and September, but obviously erroneously.	Gazette de France, *loc. cit.*; Mercure de France, *loc. cit.*
——— 19. 10 P.M.	Boston in N. America	A slight shock			Silliman's Journal, vol. xl. p. 206.
——— 26.	Several places in Cornwall.	Several shocks			Collection Académique.
——	In the island of Luçon	An earthquake		And a volcanic eruption	Phil. Trans. 1756, p. 458.
——	In Kamtschatka	Ditto			v. Hoff.
1757. Jan. Night of 15-16.	Lisbon	One shock		Preceded some moments by a subterranean explosion like that of a cannon.	Gazette de France, 5 Mars; Journ. Hist. Avril, 1757, p. 309.
——— 18.	In Franche-Comté, and in Alsace.	Several shocks			Collection Académique.
—— Feb. 4.	Ansto and Aggerschow in Norway.	Two shocks		Preceded and accompanied by subterranean noises. Similar sounds had been heard during the latter end of January; on the 1st (or 21st?), 22nd, 23rd, 24th, and 25th. The Collection Académique gives the date 4th March. That here given is probably the correct one.	Gazette de France, 12 Mars, 1757; Journ. Encycl. Mars, 1757.
——— 8, 15 and 16.	Lisbon	More shocks		One of those on the 15th or 16th preceded by a loud noise.	Collection Académique, p. 646.
—— Mar. 1. 3 A.M.	Ditto	Another, rather violent.			Ditto.
——— 16. 11h 30m P.M.	Ditto	Undulatory ditto		Accompanied by loud subterranean noises	Journ. Encycl. Avril et Mai, 1757; Gazette de France, 16 Avril et 7 Mai; Journ. Hist. Mai, p. 376, et Juin, p. 467.
——— 17. 4 P.M.	Ditto			Ditto	Ditto.
——— 18. 5h 30m A.M.	Ditto	Ditto		Ditto. Some houses at Cascaes were thrown down by these shocks.	Ditto.
—— April (or May 15).	Salee on the coast of Morocco.	An earthquake of three minutes duration.		Some days before it had been learnt that Cape Cantain had been convulsed by subterranean motion, and that the earth had opened there into fissures in which buildings were swallowed up. v. Hoff says this earthquake at Salee took place on the 5th of April or May. In the month	Collection Académique.

				of April the volcano previously active in the island of Fuego (Cape de Verds) fell, and buried a village at its foot.	
1757. End of June or beginning of July.	Near Cascaes in Portugal.	Some more shocks ...	....	....	Gazette de France, 6 Août, quoting "la rubrique de Madrid" of July 19.
—— July 8. $2\frac{1}{4}$ P.M.	Boston in Massachusetts.	A considerable shaking, but lasting a short time only.	....	....	Silliman's Journal, vol. xl. p. 206.
—— —— 9. $11^h 45^m$ P.M.	Throughout the Azores.	A terrible shock, lasting about 2 mins. It was at first vertical, but soon changed to horizontal, in the direction W. to E.	The sea was in a state of great agitation, and came in violently on the land, in the direction W. to E. on the island of St. George, E. to W. on that of the Pic, and S. to W. on Graciosa.	All the houses of Angra (Terceira) were violently shaken. In the island of St. George (12 leagues from Terceira) 1053 persons were destroyed beneath the ruins of their houses.	Collection Académique; Mercure de Madrid, 1757, Dec.; Dulac-Mélanges d'Hist. Nat. t. iv. p. 333; v. Buch, *loc. cit.* p. 368; Journ. Hist.; Gazette de France; Journ. Encycl.
—— —— 10. About 10 A.M. and 4 P.M.	Ditto. But feebly felt in the island of the Pic, except in the quarter opposite to the island of St. George. The shocks were also slight in the islands of Fayal, St. Michel and St. Marie. In one or two of the islands nothing was felt.	Another shock at 10 A.M., followed by one at 4 P.M. as violent as that of the day before, but shorter. Slight shocks did not cease until the 2nd Sept.	....	Eighteen new islets made their appearance at 100 fathoms to the N. of the island of St. George. Immense ruins were caused in all directions. Great landslips took place, the detached masses sliding into the sea, and in some cases holding together with the houses, &c. on them, and appearing as islands above the surface. Monte Formoso, in the E.S.E. of this island, separated into two parts, of which one fell into the ocean, and was separated more than 100 fathoms from the remainder. In the island of Topo terrible devastation took place. The earth opened in several places, and a piece of land of nearly a quarter of a league in size slid into the sea. In some localities the hills changed their place, and in others they disappeared altogether. A part of the village of Norte Grande was separated to the distance of 150 fathoms from the rest, forming a new island. The *falling masses* of rock and the gaping chasms in the earth terrified the inhabitants so much that they lived solely in the woods.	Ditto.

1.	2.	3.	4.	5.	6.
1757. July 15. 6h 15m P.M.	In the Scilly Islands and Cornwall. Most violent in the island of St. Mary, and extending with diminished intensity to Penzance, Marazion, St. Ives (6 English miles from Penzance), Tohidy, Redruth, St. Coulomb, Bodmin, to Camelford, 90 English miles from the Scilly Isles. At Lostwithiel, Liskeard, and even at Loo and Plymouth, they were slightly felt.	The shocks lasted six seconds, in some places half a minute. They were apparently from S.W. to N.E.	Two young people of the parish of St. Just, who were bathing, were struck by the unusual agitation of the waves.	In some of the Cornish mines these shocks were very strongly felt. Rolling noises, like thunder, or waggons in motion, were heard in the mines, at depths varying from 18 to 70 fathoms. Moveable bodies were visibly shaken, but no damage was done. The weather had been very calm and hot for eight days before, the wind E. and N.E. On the 14th it changed to S.W., and a shower of rain fell. The barometer was rather high, but very unsteady. On the morning of the 15th a fresh N.W. wind blew, and the air was cold. On the strand at Penzance unusual marks were observed in the sand at 10 A.M. Where it was generally quite smooth a space of 100 square yards was covered with little elevations like mole-hills with holes in the tops, "as if something had issued thence," and separated by little depressions of equal diameter. From one of these depressions a jet of water of the size of a man's wrist issued, a phænomenon never observed before or after. The noise heard appeared to last half a minute, or, in the Scilly Isles, 40 seconds.	Phil. Trans. vol. l. pt. 2. p. 499.
—— Aug. 6.	At Milan and Syracuse. Also felt at Bâle.	A violent earthquake.	....	According to some authors half of the town of Syracuse was destroyed, and 10,000 persons perished. At the end of this month a violent eruption of Vesuvius.	Collection Académique; Merian quotes Prof. d'Annone's Meteorological Register; Gazette de France, 24 Sept.; Journ. Hist. Nov. p. 379.
—— —— 29.	In the island of Barbadoes.	A considerable earthquake.	....	Followed by a violent tempest	Collection Académique.
—— —— 30. 2½ A.M.	Florence	....	....	Preceded by a very high wind, which ceased immediately after the shock.	Gentleman's Magazine, vol. xxvii. p. 429.
—— Oct. 13.	Tornea in Lapland	....	....	The earthquake occurred at the time of full moon	Cotte in Journal de Physique, t. lxv. p. 331.
—— —— 27 and 28.	Havre and Pont-l'Evêque.	Two tremblings. The first lasted 3 mins., the second 2 mins.	....	....	Gazette de France, 5 Nov.; Coll. Acad.
—— Nov. 8. 9 A.M.	Bâle	A slight trembling	....	....	Acta Helvetica, vol. iii. p. 385; Merian quotes Prof. d'Annone's Meteorological Register.

About 20.	on the Tagus, and especially at Evora.	these places at the same hour.		…preceded by a loud subterranean noise.	Collection Académique; Gazette de France, 24 Déc.
—— Dec. 31. 6 A.M.	Lisbon …………………	A single shock lasting 30 or 32 secs. It was the most violent felt there since the 1st Nov. 1755, even than that of the 9th Dec. 1755.	………………………	Accompanied by a loud explosive noise. No damage was done.	Collection Académique; Gazette de France, 4 Mars; Journ. Hist. Avril, 1758, p. 309.
				Some time during this year a remarkable submarine eruption took place 3 leagues from Pondicherry in the East Indies.	
1758. Jan. Beginning of the month (or in Dec. 1757).	Province of Constantine in North Africa, and at Tunis.	*Fresh* shocks of earthquake, some very violent.	………………………	The province suffered very much, and at Tunis the houses fell in great numbers, several thousand people perishing in the ruins. This account is taken from a letter from Genoa of the 18th January; the shocks may therefore have taken place in 1757.	Journ. Hist. Mars, 1758, p. 238.
—— —— 24. 2 A.M.	In the parishes of Worth and East Grinstead in Sussex, Lingfield in Surrey, and Edenbridge in Kent.	A slight trembling, lasting but a moment.	………………………	Accompanied by a rolling noise. The windows were made to rattle.	Phil. Trans. vol. l. pt. 2. pp. 614 & 645.
Same day, in the daytime and at night.	At Herculaneum ………	An earthquake ……	………………………	v. Hoff erroneously gives the date 24th March…	Ditto, p. 622.
—— ——, and in Feb.	Lisbon …………………	More shocks in these two months.	………………………	………………………………………	Gazette de France, 29 Avril.
—— Feb. Beginning of the month.	At Naples. And about Vesuvius.	A trembling at Naples. On Vesuvius the shocks were violent.	………………………	………………………………………	Ditto, 25 Mars.
—— Apr. 13.	At sea, in 0° 20′ S. lat., and 23° 20′ W. long.	………………………	The frigate La Fidèle, Capt. Lehoux, experienced shocks here on this day.	………………………………………	Daussy's Memoir, as quoted above.
—— —— 24. 9½ P.M.	Annapolis in Maryland, and more feebly in Pennsylvania.	A trembling, lasting thirty seconds.	………………………	Preceded by subterranean noises, which increased by degrees.	Collection Académique, t. vi. p. 648.
—— July 3. 0h 45m A.M.	Lisbon …………………	A somewhat violent shock.	………………………	Preceded by subterranean noise. The shock was felt in all quarters of the city. In the month of May the island Bondico, or Pondico, and two other small isles near it (in the gulf of Zeitoun, near Negropont), sank suddenly into the sea. No earthquake is mentioned.	Coll. Acad.; Almanach de Dijon, 1759, p. 146.

1.	2.	3.	4.	5.	6.
1758. Aug. Beginning of the month.	Vesuvius	A slight shock		Followed by an eruption from the summit of the volcano.	Gazette de France, 30 Sept.
—— Nov.	Etna, in the direction of Bronte.	A violent ditto		Followed, after some time, by a slight eruption. A little lava flowed from the crater. Both Etna and Vesuvius, having been almost completely at rest since 1755, began to show symptoms of activity about this time.	Ferrara, Descrizione dell' Ætna, p. 121.
—— Dec. Night between 3 and 4.	Constantinople	A rather violent shock, lasting however only a short time.		Very little damage done	Gazette de France, 10 Fév. 1759; Journ. Hist. Mars, p. 223.
—— —— 6.	In Russian Lapland, along the White Sea, at Kola and the environs.	A considerable earthquake. It lasted three hours according to some, or only half an hour according to other accounts		A terrible tempest, which lasted the same time as the earthquake, accompanied it. The storm threw down many houses in Archangel, where the earthquake was not felt.	Coll. Acad.; Abh. d. Acad. v. Stockholm (German translation), 1759, p. 221.
—— —— 20. About midnt.	London and the neighbourhood.	A slight shock			Gazette de France, 6 Janv. 1759.
—— —— 31. About 11½ P.M.	In Kemi, Lapland. Also at the same time in England.	Two shocks		Preceded by a subterranean noise. Perrey suggests that the shock in England referred to may be that of the 20th.	Coll. Acad. t. xi. p. 13; Abh. d. Acad. v. Stockholm (German translation), *loc. cit.*
1759. Jan. 20.	Leghorn	A considerable shaking.		In the beginning of the month the mountain called General's Bergsand, near Stockholm, is said to have fallen. No mention is made of any earthquake shock being perceived.	Collection Académique.
—— Feb. 2. In the morning.	Boston in Massachusetts.	One shock		Preceded by a rumbling noise	Doddesley's Annual Register, vol. ii. p. 88.
—— —— 24. 10 P.M.	Liskeard in Cornwall	Ditto, of a vibratory character, lasting two or three secs.		Blood-red rays were observed, converging to one dark spot in the heavens. This phænomenon lasted fifteen minutes. (Probably an aurora.)	Ditto, vol. ii. p. 73.
—— —— End of the month.	In Berbice, Surinam, and the adjoining parts of S. America.	Violent shocks			Collection Académique, p. 649.
—— Mar. 18.	Pistoia in Italy	A strong trembling motion.			Ditto.
—— April 18.	Ditto	Another ditto		v. Hoff does not mention any shock on the 18th of March. It is probably a mistake. During	Ditto.

				this month, and until August next, Etna was in eruption, and Vesuvius recommenced its activity.	
1759. Apr. 25.	Lisbon	Rather heavy shocks			Ditto, p. 650.
—— May. Middle of the month.	The country around Etna.	Very sensible shocks		The volcano was in active eruption	Ferrara, Descrizione, &c. p. 121.
—— —— 20 and 26.	Naples, Milan, and several other cities of Italy.	Violent shocks		At Mareico-Nuovo (near Naples) the shocks were so violent that the people lived in the open country under tents.	Collection Académique.
—— June 10. In the morn^g.	Aleppo	Very slight shocks			Phil. Trans., vol. li. p. 529.
—— —— 22. 1 P.M.	Salonica	A very violent shock, followed by two others in the space of three hours.			Collection Académique.
—— —— 23.	Ditto	More shocks, of which one was very intense.			Ditto.
—— —— 29. 5h 45m P.M.	Ditto, and the town of Philippopoli near Salonica.	Two more violent shocks. Fifty-four had been counted up to this date, and more were felt in July, August and September.		Philippopoli suffered much from this earthquake	Ditto.
—— —— ...	In Mexico, near the station of S. Pedro de Xorullo.	Numerous shocks were felt for fifty or sixty days, up to the end of August.		Constantly accompanied by horrible subterranean explosions.	Sonneschmidt, Mineralog. Beschreib. d. vorzüg. Bergw. Reviere v. Mexico, 1804, S. 325; Humboldt, Versuch üb. Neu Spanien. Th. ii. S. 145; ditto, Ideen zur Geogr. d. Pflanzen. u.s.w. S. 154; Atlas Pittoresque, p. 243.
—— Aug. 10. $10\frac{1}{4}$ P.M.	Bordeaux. Also felt at Limoges and in the Limousin.	At Bordeaux two violent shocks from W. to N.E., each lasting two or three seconds. At Limoges but one shock, lasting about a minute, was felt.		Preceded by a loud rumbling noise for two or three seconds (or half a minute according to others). This noise continued during the shock. Although the weather was quite calm the lower region of the air was full of clouds in a state of agitation. Doors and windows shook violently, and one or two buildings were injured. At Limoges the subterranean noise was also heard.	Coll. Acad.; Gentleman's Magazine.

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1759 Aug. 23. 4½ A.M.	Brussels	Lasted about one minute.	....	The air became very calm immediately after the shock.	Gentleman's Magazine, vol. xxix. p. 391.
—— Sept. Night of 28–29.	The region around S. Pedro de Xorullo in Mexico.	Most violent shocks .	....	During these shocks the plain became convulsed and raised, flames bursting forth in many places, and six principal hills, besides many smaller ones, were upheaved, of which the highest attained the elevation of 1477 feet above the former level of the plain, or 5170 feet above the sea, and has since remained an active volcano, known as that of Xorullo. For a particular account of this eruption see Humboldt's works referred to.	Humboldt's works, as quoted above (under June).
—— Oct. 30. About 4 A.M.	Aleppo, Damascus, Tripoli, and along the coasts of Syria, over a space of about 100 leagues square, the centre being supposed to be Saphet.	*Very* violent shocks, followed by other slighter ones up to the 25th November.	At Acre the sea rose 7 or 8 feet above its ordinary level, inundating the streets.	Preceded by a rumbling noise. At Damascus, Latakieh, Saphet: many other towns, and all the villages of the mountain region of Libanus were greatly injured, vast numbers of houses and mosques being thrown down, and very many people killed. In the valley of Baalbeck 20,000 perished.	Phil. Trans. vol. li. p. 529; Hist. de l'Acad. de Paris, 1760, p. 23; Mercure de France; Gazette de France, &c.
—— Nov. 25. 7h 30m P.M.	Ditto	Another violent earthquake. The first shock lasted two minutes, and was followed by another, but feebler one, eight minutes after.	....	The motion was at first a trembling one, but soon changed to violent oscillations, which latter principally caused the fall of buildings, &c.	Ditto.
—— —— 26. 4h 30m A.M.	Ditto	At Aleppo a shock as violent as the first, followed by a slight undulatory one at 9 A.M., and by five others up to the following day.	....	....	Ditto.
—— —— 28. In the morng, and at 2 P.M.	Ditto	Two very violent shocks at the hours mentioned.	....	Numbers of houses were thrown down by these later shocks, which had escaped the former ones.	Ditto.
—— Dec. 22.	Gothenburg, Jön-köping, Œrebro, and Clu-[illegible] in Sweden	Several shocks	....	Chimnies were thrown down at Gothenburg ...	Gazette de France, 12 et 19 Janv. 1760; Coll. Acad.

1759. Dec....	In the regions of Syria shaken in October and November.	More shocks were felt during this month.	....	....	Phil. Trans., &c. quoted above.
1760. Jan. ...	Ditto, especially at Mardjorjos in Lebanon.	Ditto	....	In the beginning of this year a great fall of a mass of rock near Drontheim in Norway is recorded by the Gazette de France, but no earthquake shock is mentioned.	Ditto; Volney, Voyages, 2de édit. t. i. p. 270.
—— 11. $4\frac{1}{2}$ A.M.	Lisbon	Two shocks	....	Preceded by a subterranean noise........	Collection Académique.
—— 16. $1\frac{1}{2}$ P.M.	Aix-la-Chapelle	A vibratory motion, with several smart shocks.	....	Accompanied by great blasts of wind, increasing and decreasing with the shocks.	Doddesley's Annual Register, vol. iii. p. 69, 70.
—— 18, 19 and 20. 8 and $10\frac{1}{2}$ P.M.	Ditto	Ditto	....	....	Ditto.
—— 20. 7 P.M.	Wicklow in Ireland ...	Vibratory........	....	A noise like a heavy carriage driving along was heard.	Ditto; Gentleman's Magazine, vol. xxx. p. 99.
$10\frac{1}{4}$ P.M.	Amsterdam and Maestricht. (The Coll. Acad. says on the 19th, 20th and 21st, at Amsterdam, Leyden and Utrecht. The hour here given must refer to some of these shocks.)	Three shocks at Amsterdam.	....	Lightning and a slight trembling of the earth were observed before the shocks.	Doddesley's Annual Register, *loc. cit.*; Coll. Acad.
Hour not given	Paris and Versailles. And, same day, at Vézelay in Burgundy.	Slight shocks	....	The Annual Register says, *about the same time* as the shocks in Holland, others were experienced in France, Portugal and other parts of Europe. Antwerp is also mentioned as having felt these about the 20th, but the exact day is not given.	Ditto; Gazette de France, 2 Fév. et 8 Mars.
—— 21. Morning.	Cologne	....	....	....	Annual Register, *loc. cit.*
—— Night between 21 and 22.	Hamburg and Copenhagen.	One shock, followed by three less violent. Direction, N. to S. At Hamburg they lasted half a minute, at Copenhagen one minute.	The sea was much agitated at Elsineur.	....	Ditto.

1.	2.	3.	4.	5.	6.
1760. Jan. ...	In the Margravate of Ancona.	Several shocks.........	....	Some damage done at Cascia.........................	Collection Académique.
—— Feb. 3.	New England	....	....	....	Doddesley's Annual Register, vol. iii. p. 92.
—— —— 7.	Jamaica	A violent shock	....	No damage done.........................	Gazette de France, 3 Mai, 1760; Journ. Hist. Juin, p. 465.
—— April.	Truxillo in Peru	....	....	....	Annual Register, vol. iii. p. 108; Coll. Acad.
—— May 26.	Mezzo in the territory of the republic of Ragusa.	A trembling of 4 min. duration.	....	....	Coll. Acad.; Gazette de France, 28 Juin; Journ. Hist. Août, p. 151.
—— June 16. 4 P.M.	Beneath the sea at Portici.	A very violent earthquake.	The sea was so opened and divided by the disturbance that it left the bottom dry for 2 mins.	....	Journ. Encycl. 1 Juillet.
—— —— 20. About 11 A.M.	Brussels, some other places in Brabant, and at Cologne.	Shocks slighter than those of the 20th Jan. before.	....	....	Collection Académique.
—— July 16. 1h 47m A.M.	Brussels and several other towns of Brabant.	Three or four undulatory shocks.	....	....	Coll. Acad.; Phil. Mag. July 1828, p. 55; Annual Register.
—— Aug. 13. About 7 P.M.	Constantinople and Vienna.	A very slight shock felt at each place at the same hour.	....	....	Journ. Hist. Oct. 1760, p. 302.
—— —— 14.	Salonica	One shock	....	....	Gazette de France, 6 Déc., quoting a letter from Salonica of the 29th Aug.; Journ. Hist. Janv. 1761, p. 75.
—— —— 15. 1h 56m A.M.	Ditto	Ditto	....	Followed by a brilliant meteor	Ditto.
—— —— 17. 9 P.M.	Ditto	Ditto	....	Violent thunder, wind and rain immediately succeeded the shock.	Ditto.
—— —— 21. 11h 30m A.M.	Ditto	The last shock. All four appeared to act in a vertical direction.	....	....	Ditto.
—— ——	Lisbon	Two shocks	....	....	Collection Académique.
—— Oct. 13.	In Syria	Several shocks	....	....	Brewster's Encyclopædia, article Chronology.
—— Nov. 9.	Boston in Massachu-	A slight shock..........	....	More considerable in the country round Boston	Gazette de France, 31 Janv. 1761;

8 A.M.	setts, and the country for thirty miles round.			than in that place itself. In the country a subterranean noise was heard.	Journ. Hist. Mars, 1761, p. 230; Mercure de France, Mars, p. 205; Annual Register, vol. iii. p. 149.
1760. Dec. 21 and 22.	Vesuvius	Several shocks		Followed on the 23rd and following days by one of the most remarkable eruptions of Vesuvius.	Gaetano de Bottis, Ragionamento Istorico, &c., quoted by v. Hoff; Della Torre, Supplemento alla Storia del Vesuvio, Napoli, 1761; Hamilton's Campi Flegrei; Phil. Trans. vol. lii. pt. 1. pp. 39–44.
—— —— 27.	Ditto	Violent ditto			Ditto.
—— —— 28.	Ditto, and at Portici. Many of the shocks were felt as far as Naples.	Ditto, followed by tremblings more or less violent up to the 5th January.		The eruption continued with varying intensity up to the 6th January.	Ditto.
—— ——	Lima in Peru	Several shocks during the month.			Annual Register, vol. iv. p. 189.
1761. Jan. Night of 4–5.	Portici and Naples	Violent shocks		During the eruption of Vesuvius the houses were much shaken.	Gaetano de Bottis, &c., just quoted.
—— —— 8.	Lima in Peru				Annual Register, *loc. cit.*
—— —— Night of 11-12.	Naples	A violent shock		The summit of Vesuvius fell in at this time. The Journal Historique gives the date 11th Feb.	Gazette de France, 7 et 21 Fév.; Journ. Encycl. 1 et 15 Fév.
—— —— 18. 10 P.M.	Zuyglius near Grenoble.	Three shocks felt		During a terrible tempest the earth opened, and flames came out thence some days after.	Journ. Encycl. 15 Fév.
—— —— 24. 7 A.M.	Hermösand in Sweden	Violent shocks		Accompanied by a subterranean noise, and preceded by a terrible storm, which lasted up to 10 o'clock (of the night before?).	Gazette de France, 18 Avril, 1761.
—— —— 25.	Ditto	Another earthquake		At the same time an aurora borealis of great extent was observed. It had been remarked for some time before that auroras appeared after tempests and earthquakes.	Ditto.
—— Feb. Beginning of the month.	Boston in Massachusetts.	A slight shock			Journ. Hist. Juillet, 1761, p. 65.
—— —— 6. Between 11 and 12 P.M.	Sturminster			Attended with a rumbling noise	Annual Register, vol. iv. p. 69.
—— Mar. 12.	In North America	Violent shocks		Unattended by any damage	Journ. Encycl. 15 Mai, p. 163.
—— —— 16.	Boston in Massachusetts.	Two shocks from S.W. to N.E. The second of the two the greater. They lasted 20 secs.		The weather was perfectly calm. The sky overhead was clear, but the horizon all round was obscured by a whitish fog, looking as if there were a light behind it.	Annual Register, vol. iv. p. 117.

1.	2.	3.	4.	5.	6.
1761. Mar. 31. 5^m past 12, noon. 30^m past 12. $11^h\ 45^m$ A.M. Noon. 1 P.M. (?) $1\frac{1}{2}$ P.M. (?) $12\frac{1}{4}$ Noon. $11^h\ 35^m$ A.M. (=12 o'clock Lisbon time.)	At Lisbon, Setuval, Oporto, and all along the coast of Portugal; at Madrid, Aranjuez, &c. in Spain. Some vessels at sea off Lisbon (as H.M.S. Gosport, in lat. 44° 8′ N. and long. 5° 10′ W., and the convoy along with her) experienced the shocks. At Santa Cruz in Barbary; at Bayonne, Bordeaux and Roussillon in France; at Amsterdam in Holland; at Cork in Ireland; at Funchal and throughout the island of Madeira; and at the Azores.	At Lisbon a very violent earthquake (the most so since the 1st Nov. 1755), in a perpendicular direction from below upwards. The movement lasted 5 min., and was followed by another shock at midnight and three more during the night. (Others were said to have been felt before noon.) At Oporto the direction appeared to be N. to S. At Madrid the shock lasted $2\frac{1}{2}$ min., at Aranjuez 3 min. On board H.M.S. Gosport and the other vessels two shocks were felt, one at $11^h\ 45^m$, and the other at $11^h\ 50^m$. The first lasted $1\frac{1}{2}$ min., the second not so long. At Santa Cruz in Barbary a slight shock only, lasting a quarter of a minute. At Bayonne the duration of the motion was 3 min. At Cork the shocks were violent, undulatory,	An hour and a half after (or according to others, during) the shock the sea rose 8 feet at Lisbon, and continued to ebb and flow to this extent at intervals of 6 min. until evening. At Cape Finisterre an extraordinary flux and reflux of the sea occurred at 15 min. past 12. The shock was perceived on board a vessel near the coast here. Vessels in the harbour of Amsterdam were much agitated. At Cork no commotion of the sea was observed, though the shock was felt there, while at other places on the coast where it was not sensible the agitation of the water was very considerable. Thus at Kinsale (at about $5^h\ 30^m$ or 6 P.M.), at dead low water the sea suddenly rose 2 feet, and then retired in about 4 min. This occurred several times. At Carrick the waters of the river Suir rose about 4 P.M.	Owing probably to the perpendicular direction of the shock very little damage was done at Lisbon. At Oporto much injury of houses, &c. took place according to some, while other accounts say directly the reverse. St. Ubes suffered much. On board H.M.S. Gosport it felt as if the cables were running rapidly round the bits in letting go anchor. A submarine noise was heard, and after the shock several of the vessels of the convoy were found leaking. At Corunna no houses fell, though many were moved from their positions; one more than 4 feet towards the sea, and its front towards the sea was altered in aspect more than two points of the compass. Several chasms formed in various places in the earth, from which sand and shells were thrown up. In some of the churches of Amsterdam the chandeliers swung a foot from their former position. At Funchal in Madeira a noise like that of carriages was heard before the shock. On the eastern coast of this island rocks were detached from their places, and rolled into the sea. The wells were turbid, and walls of 2 feet thick, running N. to S., were damaged. $4^h\ 30^m$ Barbadoes time $=8^h\ 30^m$ Lisbon time; hence the agitation of the waves at Barbadoes occurred about $8\frac{1}{2}$ hours after the shock at Lisbon.	Phil. Trans. vol. lii. pp. 141 & 418; Gazette de France, 2, 9, 16 et 30 Mai; Journ. Encycl. Avril et Juin; Journ. Hist. Juin, p. 466; Annual Register, vol. iv. p. 92.

		from E. to W. and *vice versâ*, lasting a minute. At Funchal in Madeira a very violent earthquake. The vibrations were very rapid, and consisted of two periods, of increase and decrease. Their direction seemed to be E. to W., and their duration 3 min.	to the extent of 4 feet in the space of 5 min. At Dungarvan five ebbings and flowings of the sea were observed between 4 and 9 P.M. At Ross in co. Wexford, a violent agitation of the river there took place about 7 P.M., and at Waterford the sea advanced 30 feet on the shore. At Mount's Bay in Cornwall, about 5 P.M., the sea rose 6 feet five times in the space of an hour. At the same hour it rose 4 feet at the Scilly Isles, the motion lasting two hours. At Fort Augustus in Scotland the waters of Lough Ness rose and fell 2 or $2\frac{1}{2}$ feet for three quarters of an hour, about 2 P.M. At the islands of Madeira and Terceira violent agitation was observed, and at Barbadoes (no land shock), from $4\frac{1}{2}$ P.M. to 6 the next morning.		
1761. March. End of the month.	Thessalonica	Several shocks from S.W. to N.E.	....	Preceded by a sound like that of the wind rising in the distance, and accompanied by a rumbling noise. Very probably these shocks were connected with that at Lisbon just described.	Annual Register, vol. iv. p. 94.

1.	2.	3.	4.	5.	6.
1761. Apr. 9. 7½ P.M.	Santa Cruz in Barbary ..	Another shock, more violent than that of the 31st March.	....	The walls of most of the houses were split	Annual Register, vol. iv. p. 95.
—— —— 14.	Terceira in the Azores...	Three slight shocks...	....	....	Same authorities as for the 31st Mar.
—— —— 15. 1 A.M.	Ditto	A very violent shock. The earth continued to tremble slightly up to the evening of the 17th.	....	....	Ditto.
—— —— 17.	Ditto	Two more, very violent.	....	On the 18th a thick smoke appeared at 3 leagues to the N.W. of Angra. Subterranean noises like thunder had been heard for three days. On the 20th the earth opened, and three volcanoes formed, from which torrents of sulphurous and inflamed matter came forth. One village was almost completely reduced to ashes. Balbi (Essai, t. i. p. 102), as quoted by v. Hoff, gives a violent earthquake at Lisbon on the 30th of this month, but no other author mentions it, and in all probability v. Hoff is right in supposing it to be a mistake, the event of the 31st March being what is referred to.	Ditto.
—— June 9. $11^h\ 55^m$ A.M.	Sherborne, Shaftesbury, and the country for 13 miles round.	An earthquake	....	....	Annual Register, vol. iv. p. 121; Gazette de France, 11 Juillet; Journ. Hist. Août, p. 149.
—— July 5.	Madeira	Ditto	On the 28th of this month an extraordinary agitation of the sea was observed at Mount's Bay, Falmouth, Fowey and Plymouth, on the south coast of England. No land shock is mentioned.	....	Annual Register, vol. iv. p. 132; Phil. Trans. *loc. cit.* p. 507.
—— Aug. 14.	Guernsey	Ditto	A violent swell of the sea set in from the S.W., the wind being E. at the time.	Accompanied by a hollow rumbling noise	Gentleman's Magazine, vol. xxxi. p. 378.

1761. Aug.	Santa Cruz in Barbary	Two shocks felt in this month.			Annual Register, vol. iv. p. 154.
—— Oct. 16. Between 8 & 9 A.M.	At Verpillère and the adjoining villages, on the route from Lyons to Grenoble.	One shock		Accompanied by noise, which terrified various animals.	Gazette de France, 24 Mai, 1762.
—— Nov. 2. N.S. 1 P.M.	Fortin Nowikowski in Siberia.	A slight trembling motion.		Accompanied by a rolling subterranean noise. Lightning was observed the following day at 4 A.M.	Phil. Trans. vol. liii. p. 204.
—— —— 6.	Teruel in Portugal	Three shocks, of which the first lasted several minutes.			Gazette de France, 25 Janvier, 1762.
—— —— 13. 2^h 30^m A.M.	Geneva	A slight shock		Accompanied by a dull noise. A meteor of the form of an immense globe, which afterwards changed to a train of light and disappeared with an explosion, was observed at the same time.	Ditto, 28 Nov.
—— Dec. 9.	Carthagena	An earthquake	Two Spanish men-of-war were driven on shore by the sea.	Preceded by a violent storm from the south. Great floods came down from the mountains after the shock.	Annual Register, vol. v. p. 76.
—— —— —. N.S. Between 7 & 8 P.M.	North-west of the chain of the Altai. Felt at the mines of Koliwan, at forts Czagirsk and Inesk, at Ust-Kamenogorski, Schoulbinsk, Simpalat, Jamischeff and Barnaoul. The earthquake, therefore, extended about 1000 versts from E. to W., from Barnaoul to Ust-Kamenogorski, and from thence northwards, to Schoulbinsk and Semipalatnaja.	Direction of the earthquake = E. to W., and duration 3 min. at the mines of Koliwan. At Ust-Kamenogorski and all the environs on the Irtisch the duration was 20 minutes. At Schoulbinsk on the Irtisch it lasted 3 or 4 minutes in the direction S. to N. At Simpalat some said the direction was E. to W., others, S. to N. At Jamischeff the shock lasted 12 min., and at Barnaoul its direction was S.W. to N.E.		Preceded by a subterranean noise. At Ust-Kamenogorski the noise appeared to come from the east and to go towards the north. The bastions of the fort of Inesk were violently shaken.	Phil. Trans. *loc. cit.*
—— —— 12. About noon.	Ditto	Another shock, as violent, but shorter.		The Annual Register says merely, "Obi in Siberia," but it obviously refers to the same event.	Journ. Encycl. 1 Mai, 1762; Annual Reg. *loc. cit.*

1.	2.	3.	4.	5.	6.
1762. Jan. 11. In the evening.	Near Montfort l'Amaury (department Seine et Oise) in France.	Several shocks from E.S.E. to W.N.W.	....	Preceded by a severe storm during the day	Hist. de l'Acad. de Paris, 1762, p. 36; Coll. Acad. t. xii. p. 45.
—— —— ...	In the district of Albano in the Estates of the Church.	Tremblings which recurred for thirty-four days.	....	....	Preuss. Staatszeitung, 1829. No. 170.
—— March. Night between 14 and 15.	In Tuscany and the territory of Bologna.	Several shocks........	....	....	Gazette de France, 16 Avril.
—— —— 16. 6 A.M.	Wexford in Ireland......	A strong shock, but of short duration.	....	Preceded by a rumbling noise. A violent gale the same day threw many ships upon the coast.	Annual Register, vol. v. p. 74; Gazette de France, 9 Avril.
—— —— 20. $6^h 45^m$ A.M.	Shaftesbury in Dorsetshire.	One shock	....	Accompanied by a very considerable subterranean noise.	Gazette de France, 16 Avril.
—— April 2. 5 P.M.	Throughout Bengal, Arracan and Pegu. The region especially shaken was the northern part of the east coast of the Bay of Bengal, extending from the eastern bank of the Burramputra to Calcutta. Dacca, Ghirotty, Calcutta, Deep Gong, and many other places are mentioned as having suffered.	A very violent earthquake. The motion was at first gentle, but gradually increased, so that people walking could hardly keep their feet. At Calcutta it lasted ten minutes.	At Dacca the river was so violently agitated that some hundred boats were thrown out on dry land.	Islamabad, the capital of the province of Chittagong, suffered great injury. The earth opened in many places and threw out mud and water with a sulphurous smell, in some places to the height of 10 cubits. The earth sank also in many localities to a great depth (in one, 7 cubits), often forming chasms which filled with water, and in another place the course of a river was completely stopped by a large bank of sand which rose across it. Two volcanoes soon after opened in the Sceta Cunda hills. At Bakar Tschurak on the sea a piece of land with 200 men and all their cattle sank completely. This sinking of the earth seems to have been the most remarkable phænomenon connected with this earthquake.	Phil. Trans. vol. liii. p. 251; Annual Register, vol. vi. p. 60.
—— —— 9. 8 P.M.	Koliwanowofresenkoy in Siberia.	Lasted about three or four minutes.	....	Preceded by subterranean noises	Annual Register, vol. v. p. 80.
—— —— 12. Noon.	Ditto	Ditto	....	Ditto. Weather, during the first shock, calm and cloudy; during the second cold and very serene.	Ditto.
—— —— Night of 13 to 14.	In the Mugello in Italy	Eleven shocks, of which some were rather violent.	....	....	Gazette de France, 3 et 14 Mai; Journ. Encycl. 1 Juin.
—— —— 15. 6 P.M.	At Florence. Also in the Mugello.	Two slight shocks at Florence, more violent in the Mugello.	....	....	Ditto.

1762. April 17.	In the Mugello	Another shock		Several houses were thrown down	Ditto.
—— May 5. $9^h 28^m$ P.M.	Verpillère on the route from Lyons to Grenoble.	A shock lasting a minute.	At Bergen in Norway, on the 26th of May, the sea ebbed and flowed with preternatural violence. No earthquake mentioned.	Accompanied by subterranean noise. Animals appeared much frightened, and horses neighed.	Gazette de France, 24 Mai; Annual Register, vol. v. p. 87.
—— June 13.	Adrianople	A violent shock			Gazette de France, 9 Août.
—— —— ...	Foggia in Italy	Rather violent trembling.		A village was overwhelmed near Salerno	Ditto, 16 Juillet.
—— July 13. 2½ P.M.	Calcutta	Two (or three) oscillatory shocks, lasting a few seconds.			Phil. Trans. vol. liii. p. 258; Annual Register, vol. vi. p. 61.
—— —— 23. 7½ P.M.	Arles in France	A slight shock		The weather very serene and hot	Gazette de France, 6 Août.
—— —— Night of 28 to 29.	In the Mugello. In the islands of Ischia Commicchiola.	Eight shocks. In the two islands mentioned sixty-two were counted, of which some were very violent.		Little damage was done, except in the two islands spoken of, where considerable injury to houses, &c. occurred.	Ditto, 20 et 23 Août.
—— —— 31. 1 P.M.	Bonn	One shock, followed at midnight by others lasting 30 seconds.		On each occasion preceded by subterranean noises.	Ditto, 13 Août.
—— Aug. 1.	Ditto	Two more shocks			Ditto.
11 A.M.	Brussels	A trembling lasting 10 to 20 secs.			Communication of M. Quetelet to M. Perrey. (See memoir of the latter on earthquakes in France, Holland and Belgium.)
—— Oct. 6.	Rome, Aquila, and the environs.	A violent shock, especially at Aquila.	On the 27th of September the Thames rose suddenly in the midst of a dead calm, and dashed the ships violently against one another.	The principal buildings of Aquila were injured. The adjoining village of Poggio-Picenza was entirely ruined.	Gazette de France, 1 et 8 Nov.; Annual Register, vol. v. p. 105.
—— Nov. 2. Between 11 A.M. and noon.	At the Dardanelles	Two rather violent shocks.		A terrible storm took place on the 7th, which threw down many houses.	Gazette de France, 14 Janv.; Journ. Encycl. 15 Janv. 1763.

1.	2.	3.	4.	5.	6.
1762. Nov. 6.	Aquila in Spain	An earthquake		Several houses were thrown down, and the walls of the church cracked from top to bottom.	Annual Register, vol. v. p. 108.
—— —— 8.	Jamaica	A violent earthquake		The inhabitants quitted Port-Royal in alarm, but no considerable damage occurred.	Gazette de France, 25 Fév. 1763.
—— —— 13. 8h 45m A.M.	St. Jago de la Vega	Lasted 15 secs.			Annual Register, vol. vi.
—— Dec. 3.	Chili	An earthquake	On the night of the 28th and 29th of December the river Eden in Cumberland, near Armathwaite, fell suddenly 2 feet, and remained so until 11 o'clock the following morning, when the water gradually rose again, though neither rain nor snow had fallen. No shock is said to have been felt.	Accompanied by a volcanic eruption from a mountain near Peteroa, upon which a new crater formed. On a neighbouring height a cleft appeared in the earth of many miles long (?); and a mass of earth slid into the valley of the river Lontue, and thereby obstructed its course for ten days, forming a lake of no inconsiderable magnitude.	Lyell's Principles of Geology, vol. i. p. 438; Malina, Saggio della Storia Nat. del Chili, Bologna, 1810; Bibliot. Italiana, vol. i. p. 56; Phil. Trans. vol. liii. p. 7.
1763. Jan. 13. 5 P.M.	West Nordland in Sweden.	Earthquake shocks		Accompanied by subterranean noise, a hissing sound in the air, and luminous meteors.	Collection Académique, t. xi. p. 13.
—— —— —— 11 P.M.	Smyrna	A violent shock			Gazette de France, 18 Mars.
—— Feb. Beginning of the month.	Bronte and the country round Etna for thirty miles in circumference.	Many shocks, which became more violent daily. One especially so took place on the 6th at night.		Accompanied by an eruption, during which cracks opened in several places in the older lava, and fresh molten matter flowed out. Smoke, ashes and red-hot stones were ejected with the greatest violence from the crater. Towards the middle of the month the violence of the eruption diminished, but before the beginning of March it had not altogether ceased.	Ferrara, Descrizione del Ætna, p. 122.
—— Mar. 11. 10 P.M.	Bayonne	A very slight shock			Gazette de France, 8 Avril.
—— —— 12. Some minutes	Ditto	Another ditto			Ditto.

1763. Mar. 13. $1\frac{1}{2}$ A.M.	Pau in the Pyrenees ...	A rather strong shock	....	Accompanied by a subterranean noise which appeared to come from the Pyrenees.	Ditto.
—— May 22. $1\frac{1}{2}$ P.M.	Malta	A considerable trembling, lasting 1 min.	....	....	Journ. Encycl. 1 Juillet.
—— June 18	Around Etna	More shocks, which continued up to the 1st of July.	....	The eruption was renewed with great violence, and the volcano remained active for three months, during which time the crater itself was at rest; but huge clefts opened in the earth, from which so much solid matter was ejected, that a new hill, called Monterosso, was formed thereby.	Ferrara, Descrizione, &c. *loc. cit.*; Gazette de France, 1 et 12 Août.
—— —— 28. About $5\frac{1}{2}$ A.M.	Hungary. Felt at Comorn, Raab, Pesth, Buda, Kerepas, Temeswar, Belgrade, Schemnitz, Vienna; and extending even to Dresden and Leipzig.	Very violent. At Comorn the first shock took place at 5 A.M., and was followed by another at $5^h\ 22^m$ or 23^m. This second lasted $1\frac{1}{2}$ min., and was much more violent than the first. At Pesth the first shock at 5 A.M. was slight, but that at $5^h\ 45^m$ very severe. At Schemnitz shocks were felt at 2^h, 5^h, and $5^h\ 28^m$. At Vienna, at 5^h and $5^h\ 10^m$, but slight, as they were also at Dresden and Leipzig. Up to the 4th of July 90 shocks were counted at Comorn.	Two bastions of the fortress of Comorn, on the Danube, were destroyed by the violent agitation of the waters of the river. Water mingled with sand and having a sulphurous odour, were thrown up from the river to the height of 5 feet in jets as large as a man's arm.	The second shock at Comorn was accompanied by a subterranean noise, and did great damage, almost all the buildings being shaken, and several thrown down. At Pesth most of the houses were injured or thrown down altogether. A cross on one of the public buildings, and a large iron bar supporting the arms of Hungary were bent, the latter to the extent of 2 feet. Temeswar and Belgrade also suffered considerably. The earth opened, and an odour of sulphur came out. At Schemnitz it was remarked that the earthquake was not felt at all in the mines. A piece of iron was detached from a magnet here. Violent storms were experienced the day before at Vienna, and on the 30th in Bavaria.	Gazette de France, Juillet et Août; Journ. Encycl. Juillet et Août; Annual Register, vol. vi. p. 83.
—— July 11. $7^h\ 32^m$ A.M.	Nîmes in France	A slight shock from W. to E., lasting some seconds.	....	....	Gazette de France, 25 et 29 Juillet.
—— —— 12. 7 A.M.	Avignon, Aix and Tarascon.	A very perceptible shock, lasting 5 to 6 seconds.	....	Accompanied by subterranean noise	Hist. de l'Acad. de Paris, 1763, p. 19; Coll. Acad. t. xvii. (or xiii.?) p. 85.

1.	2.	3.	4.	5.	6.
1763. July 20.	Country round Etna ...	Another violent shock	....	Followed by an eruption the day after	Journ. Encycl. 1 Août.
—— —— 23.	Comorn in Hungary ...	Two more shocks, raising the total number felt there to 110 or 112.	....	....	Gazette de France, &c. as quoted above.
—— —— 29.	Ditto. Also felt, at the same time and with equal violence, at Raab.	Another. Other shocks were felt, from time to time, at Raab, up to the 4th of August.	....	At Comorn 1500 houses were overthrown, and 300 injured.	Ditto.
—— Aug. 9.	Raab	Another shock, more violent than any of those felt since the 28th of June.	....	Houses were thrown down at Raab	Ditto.
—— —— 21.	Augusta in Georgia, N. America.	A shock of earthquake	At Plymouth (England), on the 19th, about noon, a sudden flux and reflux of the tide, like that at the time of the great Lisbon earthquake, occurred during a tremendous storm of thunder, wind, rain and hail. No earthquake shock mentioned.	....	Annual Register, vol. vi. p. 96, and for Plymouth, p. 95.
—— Sept. 1. 5 P.M.	One of the Molucca Islands.	The first shock lasted 4 minutes, followed by seventeen others during the evening and night.	At the time of the first shock the sea fell 5 fathoms, and then rose suddenly, inundating a large tract of land.	At the same time a neighbouring volcano threw out vast quantities of stones, &c., and subterranean noises were heard like the firing of cannon. Great damage was done to the buildings.	Ditto, vol. vii. p, 96.
—— —— 18. 10 A.M.	In Westrobothnia, Sweden.	Two feeble shocks, with an interval of half an hour.	On this day the sea rose suddenly at Weymouth to the extent of 10 feet, and fell back as suddenly. No shock spoken of.	....	Mém. de l'Acad. de Stockholm, 1764, p. 24; Annual Register, vol. vi. p. 99.

From this time until May 1764.	land. These disturbances were principally felt from the valley of the Linth in the canton of Glaris, by the valley of the Sernf to Mühlihorn, thence by the Wallensee to the Quintenberg, by the upper Toggenburg in the district of Wildhaus, and further west through the seigneury of Sax.	during the period referred to, from E. to W.			v. Hoff quotes "Alpina v. Salis u Steinmüller, Th. iii. S. 311."
—— Oct. 3. About 6 A.M.	Constantinople	A rather energetic shock.	....	....	Gazette de France, 28 Nov.; Journ. Encycl. 15 Nov.
—— —— 11. 8h 15m A.M.	Lisbon. Also at Cadiz at the same hour.	Violent shock at Lisbon, though but feeble at Cadiz.	....	The Journal Historique records a shock in *November*, at the same place and hour. It obviously refers to this event.	Gazette de France, 4 et 11 Nov.
—— —— 30. 4h 15m P.M.	Philadelphia in N. America.	A violent shock	....	Service was interrupted in the churches, but no damage done. The Hist. de l'Acad. de Paris reports a *supposed* earthquake at Roussillon in France on the 18th of this month.	Ditto, 9 Janv. 1764.
—— Dec. 16, 17 & 18.	In Westrobothnia in Sweden.	Twelve shocks were felt.	....	The earth and houses were distinctly shaken. "A fire in the air" was seen during the earthquake. The following spring, clefts were found in the earth of 2 or 3 Norwegian ells deep, and several hundred fathoms long.	Mém. de l'Acad. de Stockholm, 1764.
—— —— 23. About 7 P.M.	Constantinople	A considerable shock	....	....	Gazette de France, 13 Fév.; Journ. Encycl. 15 Fév., 1764.
—— .	Parish of Logierait in Perthshire.	An earthquake shock from east to west, of 1 or 2 secs. duration.	....	....	Thomson's Annals of Philosophy, vol. viii. p. 366.
1764. Jan. 6.	Bâle	A trembling.........	....	The Gazette de France (20 Fév.) records the fall of a mountain 18 miles from Naples on the 19th Jan. Possibly caused by an earthquake, though none is mentioned.	Merian quotes Prof. d'Annone.
—— Feb. 14. 7h 4m P.M.	Tripolis in Syria	A rather violent shock, lasting 6 secs.	At Bristol and in the Bristol Channel irregularities were ob-	Some time before a shock had been felt at Aleppo.	Gazette de France et Journ. Encycl. 1 Juin; Phil. Trans. vol. liv. p. 83.

1.	2.	3.	4.	5.	6.
			served in the tides on the forenoon of the 11th Feb., but no shock was felt.		
1764. May 15.	Cocæna in East Bothnia, Sweden, and in the adjoining villages.	A slight shock	....	Accompanied by a noise like that of a carriage rolling on a pavement.	Gazette de France, 30 Juillet.
—— —— 19. In the even^g.	Albano in Italy, and the surrounding villages.	One shock	....	....	Ditto, 11 Juin; Journ. Encycl. 1 Juin.
—— June 4.	On the banks of the Ganges (whereabouts is not mentioned, probably near Calcutta).	Several violent shocks.	....	Many houses were overturned, and great numbers of men and cattle were killed.	Annual Register, vol. viii. p. 98.
—— July 3.	Florence	Two slight shocks	....	....	Gazette de France, 28 Juillet.
—— —— 21.	Berbice; S. America	A violent shock of 4 minutes' duration.	....	....	Ditto, 23 Nov.
—— Aug. 16.	Freiberg in Saxony	A violent shock	....	Felt both in the mines and on the surface	Ditto, 19 Oct.
—— Oct. 12.	In the Azores	One shock, from S.W. to N.E.	On the 18th of this month a disturbance of the waters of Lake Erie was observed. No shock mentioned.	Did considerable damage at Fayal	Annual Register, vol. vii. p. 103; Férussac, Bull. des Sc. Géol. t. xiii. Mai 1828, p. 130.
—— ——	Comorn in Hungary	Some more shocks during this month.	....	....	Gazette de France, 16 Nov.
—— —— or November.	In the district of the Lower Elbe.	An earthquake	....	A space of 30 acres was swallowed up, and a lake of 40 fathoms deep formed in its place.	Journ. Encycl., 1 Déc., quotes "La Rubrique" of Hamburg of the 30th Nov.
—— Nov. 6. 4¼ A.M.	At Oxford, and in other parts of Berkshire and Wiltshire.	One shock	....	The morning was calm, but, after the shock, the wind became tempestuous.	P. Cotte in Mém. Math. et Phys. prés. à l'Acad., &c. t. vii. p. 475; Annual Register.
—— Dec. Night of 2–3.	Peterwaradin in Hungary.	A violent shock	....	Some walls were thrown down	Gazette de France, 11 Fév. 1765.
—— —— 26. About 11 A.M.	Lisbon	An instantaneous, vertical shock, of great violence. Some feeble shocks had been remarked the night before.	The tide was very low at the time, and it was observed that the sea, which before had been quite calm, rose consi-	Accompanied by a subterranean noise. The weather was bad, thunder, wind and rain prevailing, but for a moment after the shock a sudden calm took place.	Journ. Hist. Mars, 1765, p. 235; Phil. Trans. vol. lv. p. 43.

	Lower Elbe, and in Saxony.			... with inundations ...	Journ. Hist. Fév. 1765, p. 147.
1765. Jan. 6.	Comorn and Raab in Hungary.	Slight tremblings ...	...	...	P. Cotte in Mém. Math. et Phys. prés. à l'Acad., &c. t. vii. p.475; Gazette de France, 11 Fév.
—— —— 13.	Pranden in Austria......	Three slight shocks...	...	Each shock accompanied by a noise like the report of a cannon.	P. Cotte, *loc.cit.*; Gazette de France, 15 Fév.
—— —— 18.	Sala in the duchy of Parma.	One ditto...	...	...	Cotte, *loc. cit.*; Gazette de France, 4 Févr.; Journ. Encycl. 1 Fév.
—— Feb. 9.	Along the Irtisch in Siberia, especially at the fortress of Jampschew.	Several violent shocks about this time, that of the 9th being the most remarkable.	...	Accompanied by a terrible noise ...	Cotte, *loc. cit.*; Journ. Hist. Juillet, p. 65.
—— —— 14.	Abbeville in France, especially from the side of Saint-Valery.	A slight shock...	...	To the north nothing was perceived but a low hollow noise, coming apparently from the sea.	Cotte, *loc. cit.*; Gazette de France, 8 Mars.
—— —— About the middle of the month.	Pistoia and San Gemignano in Italy.	Slight shocks ...	...	...	Gazette de France, 11 Mars.
—— March 9.	Antigua in the West Indies.	Violent shocks ...	...	...	Ditto, 14 Juillet.
—— —— 15, and following night.	Island of Dominica......	Shocks of more violence than any previously felt in this island.	...	More than 150 shocks were reckoned here in February and March. They continued up to the 30th June.	Ditto, 15 Juillet.
—— —— 21. 7h 40m A.M.	Karlstadt in Wermeland, Sweden.	Several shocks...	...	Accompanied by a noise like that of a carriage.	Ditto, 29 Avril; Journ. Encycl. 15 Avril; Cotte, *loc. cit.*
—— April. 1.	Bermuda ...	A shock of earthquake	...	...	Annual Register, vol. viii. p. 77.
—— —— 5.	Dominica...	More violent shocks..	...	...	Gazette de France, 19 Juillet.
—— —— 8. 10 P.M.	Limoges and the country round.	Three violent shocks.	...	The two last shocks accompanied by a prolonged noise like thunder.	Ditto, 19 et 21 Avril; Cotte, *loc. cit.*
—— —— 17.	Island of Grenada	Several ditto ...	...	...	Gazette de France, 2 Sept.
—— —— 20. In the afternoon.	Florence ...	A very slight shock...	...	...	Ditto, 17 Mai; Cotte, *loc. cit.*
—— —— 22. Between 5 and 6 A.M.	Genoa ...	Three shocks, of which the first was rather violent.	...	...	Gazette de France, 6 Mai; Journ. Encyl. 1 Mai; Cotte, *loc. cit.*

1.	2.	3.	4.	5.	6.
1765. May 19. $10^h 45^m$ A.M.	The country on the French side of the Pyrenees.	In the "pays de Foix" one shock lasting nearly two minutes, followed by two other slighter ones ten or twelve minntes after, and by many others for twenty-four hours. At $11^h 15^m$, one shock lasting three seconds was felt at Toulouse; direction =N. to S.	....	Buildings, furniture, &c. were much shaken and injured. The Journ. Encycl. of the 15th July records an earthquake extending seventeen leagues, in the Pyrenees, on the 19th *June*, at 11 A.M.; but it seems obvious that that of the 19th May is spoken of.	Gazette de France, 31 Mai; Journ. Encycl. 1 Juin; Mém. de l'Acad. de Paris, 1765, p. 23; Coll. Acad. t. xiii. p. 157; Annual Register, vol. viii. p. 89; Cotte, *loc. cit.*
—— —— 25. 8 (A.M. or P.M.?)	Lisbon	A rather violent shock	....	....	Journ. Encycl. 15 Juin.
—— —— End of the month.	Tiano and Migniano near Naples.	Earthquake shocks ...	At the end of this month the sea suddenly rose 30 feet near Canton in China, and swept away 10,000 of the inhabitants. No earthquake mentioned.	Three houses were thrown down, and two churches much damaged.	Annual Register, vol. viii. p. 92.
—— —— —	Jalas-järvi and Umola in Eastern Bothnia, Sweden.	Two shocks, lasting about a minute.	....	The Annual Register says at the end of June. The date here given however is the correct one.	Journ. Encycl. 15 Juin; Annual Register, vol. viii. p. 106.
—— June 22.	Rocca, Montepiano in the Abruzzo, Italy.	Some shocks felt, probably very slight.	....	Felt during tremendous rain. On the 24th an enormous rock fell and overwhelmed part of the village.	Gazette de France, 29 Juillet; Journ. Encycl. 1 Août.
—— —— 24.	Chieta in the Abruzzo...	An earthquake	....	Masses of rock fell, and water burst forth. Probably connected with, if not the same as the last account.	P. Cotte, *loc. cit.*
—— —— 29.	Trieste	Three shocks	....	....	Gazette de France, 9 Août.
—— July 14.	Pitea in West Bothnia, Sweden. Also, the	At Pitea the shock appeared to come	....	At Pitea the windows were shaken, and at Lulea a subterranean noise was heard.	Ditto, 26 Août; Journ. Encycl. 1 Sept.; Annual Register, vol. viii. p. 110; Cotte, *loc. cit.*

		At Lulea it was very slight, and apparently in the same direction.			
1765. July 23.	Ditto		The sea ebbed and flowed more than twenty times in a short space to the extent of 3 or 4 feet.	During a terrible storm of thunder, lightning, and rain. The Annual Register gives the date 26th July, as also v. Hoff, quoting Cotte, who places the earthquake at Lacknau.	Gazette de France, 28 Oct.; Journ. Encycl. 15 Oct.; Annual Register, *loc. cit.*; Cotte, *loc. cit.*
—— Aug. ...	Agnano in Italy	A strong shock			Gazette de France, 9 Sept.
—— In autumn.	Batavia in the island of Java.	An earthquake			H. Vogel's Seereisen. Th. 2. S. 151.
—— Oct. ...	Spoleto in Italy	Several very energetic shocks.			Gazette de France, 11 Nov.; Journ. Encycl. 15 Nov.
—— Nov. 13. 6h 30m P.M.	Lisbon	A shock		Cotte (*lec. cit.*) reports several shocks at Lisbon on the 13th *December*. The date must be mistaken for that here given.	Gazette de France, 20 Déc.
1766. Jan. 2.	In she Söndmör, Norway.	An earthquake		The houses, windows, &c. were shaken	Keilhau's Memoir in the Magazin fur Naturvidenskaberne, *loc. cit.*
—— —— 10.	Naples	Two slight shocks			Gazette de France, 10 Févr.; Cotte, *loc. cit.*
—— —— 24.	In the Söndmör, Norway.	Another earthquake shock.		Ditto	Keilhau, *loc. cit.*
—— Feb. 2.	Rhode Island and Massachusetts in N. America.	An earthquake		Accompanied by a remarkable meteor	Silliman's Journal, vol. xxxix. p. 336.
—— —— 10. 11½ P.M.	In Glamorganshire	A quaking, tremulous motion, lasting eight seconds.			Annual Register, vol. ix. p. 65.
—— —— 28. Between 3 and 4 A.M.	Harstoëff in the province of Halland in Sweden.	A shock of two minutes' duration.		Articles of furniture were thrown down. The Gentleman's Magazine gives the date 28th January.	Gazette de France, 10 Mars; Gentleman's Magazine, vol. xxxvi. p. 150.
—— Mar. 9.	Island of Antigua	A violent shock			Cotte, *loc. cit.*; Gazette de France; Mercure de France; Journ. Hist.; Journ. Encycl., &c., at various dates during this year and the next mention the numerous shocks in the West Indies; Mém. de l'Acad. de Paris; Humboldt, &c.

1.	2.	3.	4.	5.	6.
1766 Mar. 28.	About Vesuvius	Many violent shocks..	....	Accompanying an eruption of the volcano	Hamilton, Observations on Mount Vesuvius and Mount Etna, London, 1774, p. 5–15; Phil. Trans. vol. lviii. p. 2; Gazette de France, 28 Avril et 16 Juin; Journ. Encyl. 1 Mai.
—— April 4.	In Iceland	An earthquake	....	Followed on the 5th by an eruption of Hecla, which lasted until the 16th July. Krafle was also in eruption.	v. Hoff.
—— —— 17.	Island of Grenada	A violent shock	....	....	Cotte, *loc. cit.*; Gazette de France, &c.
—— —— 26.	On the south side of Etna.	Violent shocks, followed by others during the following night and day, and at intervals up to the beginning of June.	....	Accompanying a violent eruption of the volcano.	Ferrara, Descrizione del Etna, p. 124.
—— May 22. About 5^h 30^m A.M.	Constantinople. Several other towns also suffered severely.	Violent shocks from S. to N., continuing uninterruptedly for two minutes. They recurred several times during the day, and indeed were felt almost daily up to the 16th June, and at frequent intervals, to the end of that month. Those of the 10th and 14th were the greatest.	The sea was greatly agitated.	Accompanied by a loud subterranean noise in the same direction as the shocks. The damage done to buildings at Constantinople was valued at eleven millions of piastres. v. Hammer, in his History of the Ottoman Empire, (t. xvi. p. 143 of the French translation, quoted by Perrey) gives the date 22nd April. This seems to be certainly a mistake.	Gazette de France; Journ. Encycl.; Journ. Hist. Juillet et Août; Cotte, *loc. cit.*
—— June 11. At midnight.	Jamaica, especially at Port Royal. Also in Cuba.	In Jamaica a violent shock lasting $1\frac{1}{2}$ minute. In Cuba it lasted seven minutes; and the shocks recurred up to the 1st August.	Ships at sea, a league and a half from the coast of Jamaica, rolled so much that their gunwales were immersed in water.	In Cuba many houses were thrown down, but in Jamaica, though greatly shaken, very few fell. The Annual Register gives the date 9th June, but obviously erroneous.	Annual Register, vol. ix. p. 118; Cotte, *loc. cit.*; Gazette de France, &c.

1766. July 1.	Constantinople	One shock			Gazette de France; Journ. Hist.; Journ. Encycl.; Juillet et Août.
—— —— 5.	Ditto	Ditto		Accompanied by subterranean noise, and productive of some ruins.	Ditto.
—— —— 8. About 3 P.M.	Briançon and Mont Dauphin.	Two considerable shocks from N. to S.		Accompanied by noise	Gazette de France, 25 Juillet; Journ. Encycl. 1 Août.
—— —— 14.	Constantinople	Another shock			Ditto, and Journ. Hist. Juillet et Août.
—— —— Night between 14 and 15.	Ditto	Ditto; more violent than any of those in this month.		Accompanied by a loud bellowing noise	Ditto.
—— —— Middle of the month. During the night.	Ste Marie in S. America.	Very violent shocks, followed by slighter ones every day up to the 21st.			Gazette de France; Journ. Hist. &c.
—— —— 24.	Island of Cephalonia	A violent shock, lasting three minutes, and followed by three others the same day. The earth trembled more or less for fifty days.			Journ. Encycl. 1 Sept.; Gazette de France, 19 Déc.
—— Aug. 5. 6h 50m A.M. Half an hour after noon.	Vienna, and more violently on the frontiers of Hungary, and at Sta Marguerita. Also at Constantinople, Adrianople, Gallipoli, Salonica, Smyrna, Enos, Tenedos, &c., as far as Brussa in Bithynia.	At Vienna and in Hungary two shocks were felt. At Constantinople and other places in Turkey and Asia Minor, one very violent shock (the most so since the 22nd May), which lasted 40 secs. at Constantinople, and was there succeeded by two others at 8½ and 10 P.M. From the 5th to the 16th the shocks occurred daily at Constantinople, and were very frequent up to the 23rd.		At Constantinople fresh ruins were produced among the houses and mosques. At Adrianople also houses were thrown down, and the other towns mentioned suffered more or less injury. The Journ. Hist. and Annual Register give the date 8th Aug.	Gazette de France; Journ. Encycl. Août et Sept.; Journ. Hist. &c.

1.	2.	3.	4.	5.	6.
1766. Aug. 6. $15^h 30^m$ (Italian time).	Padua	One shock			Toaldo, Essai Météor. p. 270.
—— —— Beginning of the month.	In the margravate of Ancona.	Several shocks			Journ. Encycl. 15 Août.
—— —— 13. 10 P.M.	Island of Martinique in the West Indies.	An earthquake		During a terrible hurricane	Gazette de France; Journ. Hist. &c.
—— —— 16. $10^h 25^m$ P.M.	Vienna	A considerable shock, of five or six seconds' duration.		Accompanied by subterranean noise. The weather was perfectly calm.	Ditto; Annual Register, vol. ix. p. 136.
—— —— 17. 1 A.M.	Ditto. Also felt at Presburg.	A second, and less violent shock.			Ditto.
—— —— 25.	Newport (the capital of Rhode Island) in N. America.	A violent shock, lasting twenty-five seconds.		No damage done	Gazette de France, 7 Nov.
—— —— Towards the end of the month.	Martinique in the West Indies.	Another and very violent shock.		Houses were thrown down at St. Pierre	Gazette de France; Journ. Hist. &c.
—— Sept. 5. $5^h 30^m$ A.M.	Constantinople. All these shocks at Constantinople were scarcely perceptible at Smyrna, but extended to Vienna on the other side.	Another rather considerable shock, followed by slight ones up to the 24th, when they appear to have ceased for a month.			Gazette de France, 24 Oct. et 17 Nov. Journ. Encycl. 15 Sept. 1 et 15 Oct.
—— —— 18.	Guadaloupe in the West Indies.				Gazette de France; Journ. Hist. &c.
—— —— 23. 6 A.M.	Lyons. Also observed at the château de Fléchères, at la Croix-Rousse, St. Just, and other places in the environs.	A feeble trembling motion.			An extract from the registers of the observatory of Lyons, communicated by M. Aug. Bravais to M. Perrey. Also a communication of M. P. de Lacroix to the same.
—— —— End of the	Cuba	An earthquake		The city of St. Jago was overturned	Annual Register, vol. ix. p. 142.

[illegible] From this month until the new year.	[illegible]	Shocks recurred daily.		M. Perrey says that he can find no account of these shocks in any of the journals of the day.	Constitutionnel, 14 Sept. 1829.
—— Oct. 6.	Island of St. Eustache in the West Indies.	An earthquake........	....	Accompanied by a hurricane, according to Cotte.	Gazette de France; Journ. Hist. &c.; Cotte, *loc. cit.*
—— —— 21. 3 A.M.	Cumana and Caraccas in New Granada, South America. Also the island of Trinidad. Also at Surinam, and indeed all the north-eastern portion of S. America.	Very violent shocks. In the territory of Caraccas they recurred *hourly* (probably only at first) for 14 months; up to the end of 1767. According to tradition, the shocks were simple horizontal oscillations. At Surinam there were two other violent shocks felt besides the one here mentioned, viz. on the 24th at midnight, and 27th at 7 A.M.	....	The whole city of Cumana was ruined. Eruptions of sulphurous water frequently occurred, especially about Casanay, two leagues to the east of Coriaco. The inhabitants lived in the streets for the two years, 1766–67. The Indians celebrated by feasts the approaching destruction and subsequent regeneration of the world. During these shocks a little island in the Orinoco sank and disappeared beneath the waters, and in many places disturbances of the surface were produced. The first and third of the shocks at Surinam were attended with subterranean noise, as were the shocks at the mission station of Encaramado.	Ditto; Humboldt, Voyage, &c. (octavo), t. i. p. 307., t. ii. pp. 23 to 274, t. v. p. 56; Gili, Saggio di storia Americana, t. ii. p. 6.
—— —— 24. 7 A.M.	Constantinople	Another shock, lasting twenty seconds.	....	....	Gazette de France; Journ. Encycl. &c.
—— Nov. 9. 5 A.M.	Ditto	Another rather energetic shock.	....	....	Gazette de France, 12 et 29 Déc. et 16 Janv. 1767; Journ. Encycl. 15 Janv.; Mercure de France, Fév. 1767.
—— —— 23. 6 A.M.	Ditto	Ditto, followed by others up to the 1st December.	....	....	Ditto.
—— ——	Charleston in S. Carolina	....	....	Accompanied by a meteor	Silliman's Journal, vol. xxxix. p.336.
—— Dec. 12. 5 A.M.	Martinique	A slight shock........	....	....	Gazette de France; Journ. Hist. &c.
—— —— 17. 6h 48m P.M. (According to the Gaz. de Fr. the date was Dec. 13, at 6h 40m P.M.)	Portsmouth, and many adjoining places in New Hampshire, N. America.	A violent shock	....	Attended by a rumbling noise. The weather very calm and serene. No damage was done.	Annual Register, vol. x. p. 52; Gazette de France, 6 Mars, 1767.

1.	2.	3.	4.	5.	6.
1766.	In the Caucasus	An earthquake	....	....	Kerferstein.
1767. Jan. 12.	Constantinople	A rather violent shock	....	The spire of a minaret, which was just repaired, was thrown down.	Gazette de France, 27 Fév.; Journ. Encyl. 1 Mars.
—— —— Night between 18 and 19.	Bielefeld in Westphalia.	One shock	....	....	Gazette de France, 9 Fév.; Cotte, *loc. cit.*
—— —— 19. 10 A.M.	Hameln (in the basin of the Weser), and Hanover.	At Hameln, one shock At Hanoverit lasted but a few instants, and was so slight as to be perceptible only in the upper stories of the houses.	....	After the shock the wells at Hameln in which there had been no water were suddenly filled. The weather was excessively cold. The Annual Register gives the date 22nd January for Hanover.	Gazette de France; Journ. Encycl. Févr.
—— —— 20. $9\frac{1}{2}$ A.M.	Lipstadt, Rithberg, Guterslohe, Herfort, Munster, Osnabruck, and Paderborn.	At Lipstadt the shock was from W. to E., and lasted a few seconds.	The ice on the Lippe was cracked in many places.	Doors were burst open at Lipstadt	Annual Register, vol. x. p. 50; Gazette de France, 6, 16, et 20 Fév.; Journ. Encycl. 15 Fév.
—— —— 21. $8^h\ 30^m$ and $9^h\ 45^m$ A.M.	Parma. Also at Pisa...	Two shocks at Parma at the times mentioned, each lasting two seconds. They were more violent at Pisa, and had been preceded by some slighter ones.	....	....	Gazette de France, 9 et 20 Fév.; Cotte, *loc. cit.*
—— —— Between the 21st and the 4th February.	Finizzano in Tuscany ...	Thirty-six shocks were felt in this space of time.	....	Great damage was done to the buildings	Annual Register, vol. x. p. 67.
—— —— 22.	Genoa	Three successive shocks felt, succeeded by slight tremors for some time.	....	In all probability this account, with those of the 19th, 20th, and 21st, all refer to the same earthquake, and thus the dates are erroneous. Perrey, however, does not seem to think so.	Ditto.
—— —— About the end of the	Naples, and about Vesuvius.	Some slight shocks...	....	Fire appeared on the summit of Vesuvius on the 1st February.	Gazette de France, 23 Fév.; Hamilton.

5h 30m P.M.		shock.			de France, 20 Mars.
—— —— Night between 31 and Feb. 1.	Kisliar in the province of Dagostan, Caucasus.	Two shocks, the first lasting one minute, the second twenty seconds.	....	Several people were thrown down by the motion.	Journ. Encycl. 15 Avril.
—— Feb. 7. About 4 or 5 A.M.	Genoa and Turin, and indeed perceptible all through Lombardy.	At Genoa and Turin some rather violent shocks, lasting 30 seconds.	....	....	Gazette de France, 23 Fév., 16 Mars; Annual Register, *loc. cit.*
—— —— About same day.	Island of Scio	An earthquake........	....	Probably occurred at the same time with that next mentioned.	Annual Register, *loc. cit.*
—— —— 8. 8 A.M.	Constantinople	A rather violent shock, lasting as long as that of the 30th January. Slight shocks were felt up to the 16th.	....	....	Gazette de France, 27 Mars; Journ. Encycl. 1 Avril.
—— —— 9. 4 A.M. (According to the Annual Register, 4h 15m.)	Grasse in France. Felt also more strongly at Nice, Genoa, and especially at Venice.	Three considerable shocks, of which the first, the most violent one, lasted a few seconds, the others not so long.	....	During the shock a sound was heard like that of a gust of wind.	Annual Register, vol. x. p. 78; Gazette de France, 9 Mars.
—— —— 24.	Naples	....	....	....	Gentleman's Magazine, vol. xxxvii.
—— Mar. 17.	Comorn in Hungary ...	A violent shock	....	The inhabitants quitted the town........	Gazette de France, 20 Avril; Journ. Encycl. 15 Avril; Cotte, *loc. cit.*
—— —— 26. 4h 30m A.M.	Constantinople	Two more shocks ...	....	....	Gazette de France, 11 Mai.
—— —— 30. A little after midnight (of the 29th?).	Ditto	Another, as violent as the first.	....	....	Ditto.
—— April 7. 1h 30m A.M. 2 A.M.	At Bourgneuf (départ. Loire-Inférieure). Also at Nantes.	At Bourgneuf a violent shock. At Nantes the shock was but slight.	....	Accompanied at Bourgneuf by noise in the direction E.S.E. to W.N.W. Half an hour after a loud clap of thunder where the noise of the earthquake appeared to end. At Nantes the sound was like that of a chariot. There had been a high wind there the evening before.	Ditto, 17 Avril et 15 Mars.

1.	2.	3.	4.	5.	6.
1767. Apr. 13. 1 and 3 A.M.	Gotha. Also at Cassel, Göttingen, Helmstadt, and Mulhausen. Also the same day, at Rothemburg, and along the Fulda and Werra.	At Gotha two shocks at the hours mentioned, of which the first only was felt at Cassel, Göttingen, &c. At Rothemburg three violent shocks were felt (hour not mentioned).	....	At the moment of the first shock an oblong sulphurous cloud was observed at Vagelsburg on the side of Cassel. At Sondra (two miles from Gotha) a noise like the report of a cannon was heard. At Rothemburg chimneys were thrown down.	Gaz. de Fr., 1, 8, 25, 29 Mai; Journ. Encycl. 15 Mai; Mercure de France, Octobre; Poggendorff's Annalen, B. 19. s. 473; Cotte, *loc. cit.*
—— 15 (ought it not to be 13?). Between 2 and 3 A.M.	Gernsheim in Hesse Darmstadt.	Two smart shocks ...	....	Accompanied by a subterranean noise lasting one minute for each. On the 11th the thermometer had suddenly fallen 9°, in the evening it was very variable, and at 10 P.M. a violent wind arose, which lasted only five minutes.	Gazette de France, 15 Mai.
—— 20.	In different places to the west of Stirling, Scotland.	A slight shock........	....	....	Ditto, 22 Mai.
—— 24. 6½ A.M.	Surinam. Also in Martinique and Barbadoes.	At Surinam several shocks, of which two were rather violent. In Martinique also the shocks were violent. One particularly so was felt there about 7 A.M. in the mountains which separate the waters of the Oyapoc from those of the Marony.	At Martinique and Barbadoes the sea was much agitated, and ebbed and flowed in an unusual way.	The Journ. Hist. erroneously gives the date 14th April for Martinique.	Ditto, 17 Juillet, 4 et 21 Sept.; Journ. Hist. Oct. p. 318; Gentleman's Magazine, vol. xxxvii. p. 325.
—— May 26.	In the neighbourhood of Sandomir, Mimorsca, and Latyszew in Poland.	An energetic shock...	....	....	Gazette de France, 10 Juillet.
—— 27.	Turin and the valley of Lanzo.	At Turin some slight shocks; more violent ones in the valley of Lanzo.	....	Some buildings were injured in the valley of Lanzo. It was reported that the little hill of Sta Christina was seen to reel (chanceler) and smoke. The following day at 5 P.M. two villages of this district were struck by lightning.	Journ. Hist. Août, p. 153.

Beginning of the month.		since the beginning of the year.			Hist. Oct. p. 318.
—— 4. About 6 P.M.	Rome. Also at Spoleto.	A violent shock. At Spoleto several others were felt.	....	Houses were thrown down at Spoleto	Gazette de France, 29 Juin; Journ. Encycl. 15 Juin et 1 Juillet; Cotte, *loc. cit.*
—— —— 22. 3h 9m A.M.	Cologne and throughout the province of Cleves. Also felt at Sedan and Bouillon.	A violent shock	....	....	Gazette de France, 3 et 17 Juillet; Journ. Encycl. 15 *Juin* (the number did not appear until July according to M. Perrey); Cotte, *loc. cit.*
—— July. Night of 14 to 15.	In Upper Calabria. The shocks were felt as far as Gallipoli.	Several violent shocks from W. to E., followed by others up to the 18th.	....	Great damage done to buildings, &c. Cosenza, Luzzi, Sta Agatha, &c. suffered extremely. Forty persons were killed. An eruption of Vesuvius began on the 7th August.	Annual Register, vol. x. p. 125; Journ. Hist. Sept. p. 230.
—— —— End of the month.	Island of Cephalonia ...	Violent shocks	....	Sta Maura was much injured	Journ. Encycl. 15 Sept.
—— Aug. 24.	Ditto	Ditto	....	Many of the inhabitants swallowed up, and almost all the buildings ruined. Very probably the last account refers to this event.	Annual Register, vol. x. p. 123.
—— Sept. 2.	Spoleto	Seven more shocks...	On the 5th September at between 7 and 8 P.M., the sea at Ostend, and the Liffey at Dublin, ebbed and flowed suddenly and violently to the extent of 4 or 5 feet. No shock is mentioned.	Vesuvius continued in eruption........	Journ. Encycl. 1 Oct.; Annual Register, vol. x. p. 126–7.
—— —— 11. $1\frac{1}{2}$ and 5 A.M.	Constantinople	Two slight shocks ...	....	....	Gazette de France, 26 Oct.; Journ. Encycl. 1 Nov.
—— —— Night of 22, 23.	In the Söndmör, Norway.	Three considerable shocks in the space of a minute.	....	Each shock preceded by a noise, which appeared to come from the earth.	Keilhau's Memoir, *loc. cit.*
—— —— 26 and 27.	Spoleto	More shocks	....	On the 28th a hurricane unroofed almost all the houses.	Gazette de France, 26 Oct.; Journ. Encycl. 1 Nov.

1.	2.	3.	4.	5.	6.
1767. Oct. 19 to 22.	About Vesuvius, and as far as Naples.	Numerous and violent shocks.	....	Accompanying a violent eruption of the volcano, which did not entirely cease until the 27th. At Naples explosive noises were heard, and doors and windows opened of themselves. On the 13th and 14th there had been heavy rains.	Gazette de France, 16 Nov.; Journ. Encycl. 15 Nov.; Coll. Acad. t. xiv. p. 79; Journ. Hist. Déc. p. 473; Phil. Trans. vol. lviii. p. 1, vol. lix. p. 18; Hamilton, Observations, &c., pp. 19–44; Hamilton, Campi Flegrei, pp. 22–32.
—— —— End of the month.	Cephalonia and Zante...	A very violent shock, preceded by others less so.	....	Montgomery Martin (Hist. of the Brit. Col. vol. v. p. 431.) mentions an earthquake of great violence in Zante during this year, without giving the month or day. He doubtless alludes to this event.	Annual Register, vol. x. p. 142.
—— Nov. 13.	Constantinople	A moderate shock ...	....	....	Gazette de France, 28 Déc.
—— —— 20.	Strassburg in Carinthia.	A shock of 7 seconds' duration.	....	....	Ditto, 18 Déc.; Journ. Encycl. 15 Déc.
—— —— 21.	Clagenfurth in Carinthia.	A rather energetic shock.	....	....	Ditto.
—— —— 22. 9h 50m P.M.	Macao in China	A trembling motion, which lasted about a minute. Followed by a second, of less violence at $11^h 5^m$, and by a third and pretty strong one at 3 A.M. on the 23rd. Altogether five shocks were reckoned, of which the first was the most violent.	The ships lying in the harbour experienced the motion.	The first shock was strong enough to shake a house violently. A rolling noise and heavy gusts of wind were observed.	Phil. Trans. vol. lix. p. 71.
—— —— 23.	Clagenfurth in Carinthia. Also felt at Gratz, and in Styria.	Two other shocks, less violent than the former.	On the 28th November at 5 A.M., the tide at London ebbed and flowed twice in an hour and a half. No earthquake mentioned.	....	Gazette de France and Journ. Encycl. *loc. cit.*; Annual Register, vol. x. p. 151.
—— Dec. 8.	The island of Poulo Neira, belonging to the Banda group.	An earthquake	....	....	Vogel's Seereisen, Th. 2. S. 178.

Between midnight (of the 2nd) and 1 A.M.	shire, and other places near.				Annual Register, vol. ii. p. 59.
—— —— 21. 6h 30m P.M.	Cap Français in St. Domingo.	A slight shock from W. to E.	....	....	Gazette de France, 27 Mai.
—— Feb. 27. 2h 45m A.M.	Vienna. Also at Neustadt, Presburg, Bischoffswerder in Lusatia, and Freiberg.	At Vienna a rather violent shock from N.E. to S.W., lasting eight seconds. At Presburg the shock was less remarkable, and at Bischoffswerder and Freiberg it was very slight.	At Presburg the inundations were considerable.	The Annual Register gives the date, the 26th for Vienna, and says that it was there imagined that the earthquake originated in Italy. At Neustadt houses were thrown down, and in the mountains around Freiberg clefts opened in various places.	Annual Register, vol. ii. pp. 75 and 85; Gazette de France, 14 et 18 Mars; Journ. Encycl. 15 Mars.
—— March 5. 9h 30m A.M.	Vienna and the neighbourhood.	More shocks	....	....	Gazette de France; Journ. Encycl. *loc. cit.*
—— —— 18. (O.S.) 4 A.M.	Irkutsk and Selinginsk in Siberia.	A slight trembling ...	....	....	Pallas, Voyage, &c. t. iv. p. 394.
—— April 3.	Pan in the Pyrenees ...	A violent trembling for one minute.	....	v. Hoff, quoting Cotte, gives the date 13th April, and adds in a note that Palassou does not mention this earthquake.	Gazette de France, 18 Avril; Cotte, *loc. cit.*
—— —— 25.	At L'Orient in France...	An undulatory shock.	....	....	Cotte, *loc. cit.*
—— —— 30. Between 6 and 7 P.M.	Naples. Felt more perceptibly in several other parts of Italy.	A slight shock........	....	Followed on the side of Vesuvius by a considerable subterranean noise for two days.	Gazette de France, 30 Mai, 10 Juin; Cotte, *loc. cit.*
—— May 4.	Parma	Some slight lateral shocks.	....	....	Gazette de France, 23 Mai; Cotte, *loc. cit.*
—— —— 15. 4h 15m P.M.	Newcastle, Manchester, Darlington, Kendal, and some places in Yorkshire.	Twu shocks with an interval of half a minute. Direction supposed to be E. to W. One shock lasted nearly two seconds.	The river at Kendal was much agitated.	At Kendal a rumbling noise was heard before the shock, like the sound of a heavy carriage on rough ground. At Manchester some walls were moved in a right line, and the flagging of a kitchen was observed to heave. In Yorkshire a prolonged noise like thunder was heard.	Annual Register, vol. xi. p. 114; Cotte, *loc. cit.*; Gazette de France, 30 Mai et 6 Juin.
—— —— 19. Beginning of the night.	Genoa	A trembling	....	....	Gazette de France, 10 Juin; Journ. Encycl. 15 Juin.
—— June 9. 2h 30m P.M.	Lisbon	Several violent shocks, *said* to be from N.E. to S.E.	....	Accompanied by subterranean noise........	Gazette de France, 11 Juillet; Journ. Encycl. 15 Juillet; Cotte, *loc. cit.*

1.	2.	3.	4.	5.	6.
1768. June.... (Very probably same day as last.)	Gibraltar	A violent shock	....	....	Gazette de France, 4 Juillet.
—— Aug. 5. (O.S.) 2 P.M.	Irkutsk and Selinginsk in Siberia.	Another slight trembling.	....	....	Pallas, Voyage, &c. t. iv. p. 394.
—— Oct. 5.	Constantinople	A trembling	....	Did no damage	Renaudot, Annales Périodiques.
—— —— 12.	Ditto	Another slight trembling.	....	The Coll. Acad. mentions an earthquake at Constantinople in this year, which threw down three of the so-called seven towers. Can it refer to this event?	Ditto.
—— —— 19. Between 11 P.M. and midnight. At midnight.	Florence, and the country round. Also at Padua.	A rather violent shock, preceded by a slighter one, and followed by a third at 2 A.M. on the 20th.	....	The district of Sta Sophia in the Florentine Romagna was ruined by this earthquake. The moon was at the full at the time. Cotte gives the date 20th October.	Gazette de France, 18 et 21 Nov.; Journ. Encycl. 15 Nov.; Toaldo, *loc. cit.*; Cotte, *loc. cit.*
—— Nov. 30.	Castel, Fiorentino, Montale, and Gombassi in Italy.	Very smart shocks ...	....	Even the sick were brought out into the open country.	Gazette de France, 19 Janv.; Mercure de France, Fév. 1769.
—— Dec. 1.	Ditto	More shocks	....	....	Ditto.
—— —— Beginning of the month. 11 P.M. (day not given).	Santa-Sosia in Tuscany.	Two shocks, of which the second was the more violent.	....	Many houses were thrown down, and the large bridge of the place was split through the middle from end to end.	Annual Register, vol. xi. p. 195.
—— —— 21. Between 5 and 6 P.M.	Worcester, Gloucester, many other parts of England, and in the mountains of Scotland.	A violent shock of earthquake.	....	Gloucester cathedral was shaken to its foundations.	Annual Register, vol. xi. p. 201; Gazette de France, 13 Janv.; Mercure de France, Fév. 1769.
—— —— 29. 8 A.M.	Bytown in Herefordshire.	Apparently from E. to W.	During this year the sea was turbid off the Shetland Isles, and dead fish rose to the surface, phænomena ascribed by v. Hoff to submarine volcanic action.	Attended with a rumbling noise. A cleft opened in a neighbouring hill, and water gushed out. The two French periodicals merely say, in Herefordshire, and give the date 27th Dec.	Gentleman's Magazine, vol. xxxix. p. 50; Gaz. et Merc. de Fr. *loc. cit.*; Hibbert, Description of the Shetland Isles, p. 390.

59. 9 o'clock (Italian time).				... the time of new moon ...	Toaldo, Essai Météor. *loc. cit.*
—— Feb. 5.	Neustadt near Vienna...	Ditto ...	...	...	Gazette de France, 3 Mars.
—— —— 6. 2^h 30^m P.M.	Lisbon ...	A trembling...	...	Unproductive of damage ...	Renaudot, Annales Périodiques.
—— —— 20. 8^h 30^m A.M.	Constantinople ...	A violent shock ...	...	...	Gazette de France, 21 Avril; Journ. Encycl. 15 Avril.
—— Mar. 8. 8 o'clock (Italian time).	Padua ...	Another shock...	...	The moon was in her last quarter...	Toaldo, Essai Météor. *loc. cit.*
—— May 1. 2 P.M.	Bagdad ...	Several shocks...	...	Accompanied by a terrible hurricane. 2000 (or, according to others, 4000) houses were thrown down.	Journ. Hist. Déc. p. 474; Gazette de France, 3 Nov.; Richard, Hist. des Météores, t. viii. p. 504; Cotte, *loc. cit.*
—— Aug. 4. 4 P.M.	Augsburg, Nuremberg, Gunzburg, Ulm and Eischler.	Violent shocks for seventeen minutes.	...	...	Gazette de France et Journ. Encycl. 15 Août; Cotte, *loc. cit.*
—— —— 19. 19^h 45^m (Italian time).	Padua ...	Another shock...	...	The moon was at the full ...	Toaldo, Essai Météor. *loc. cit.*
—— Oct. 24. (N.S.) 7 P.M.	Irkutsk ...	Two violent shocks from S. to N.	...	The latter of the two shocks injured some buildings.	Gazette de France, 26 Fév.; Journ. Encycl. 1 Mars, 1770; Pallas, *loc. cit.*
—— Nov. Middle of the month.	Inverness...	...	...	Several houses were thrown down ...	Annual Register, vol. xii. p. 155.
—— —— 18. 4 A.M.	Avignon. More perceptible at two places near Roquemaure and Bedarrides.	Violent shocks from S. to N. and N. to S., lasting $1\frac{1}{2}$ minute.	...	Accompanied by a noise like that of a gust of wind. Followed in a quarter of an hour by extraordinary rain, and the same evening by much thunder and lightning. At Roquemaure and Bedarrides houses were overthrown.	Gazette de France, 15 Déc.; Richard, Hist. des Mét. t. viii. p. 505.
—— Dec. 1. A little after $6\frac{1}{2}$ P.M. (at Versailles 6^h 36^m). $10\frac{1}{2}$ P.M.	Paris, St. Cloud, Montmorency, Versailles, Elbeuf, Dieppe, Rouen, and Houlme, a village near Rouen.	A violent shock. At Houlme (one league from Rouen) two smart shocks were felt at the hour mentioned.	The Seine at Elbeuf boiled up with a bellowing noise.	At Rouen fears were entertained that the houses would fall, while in the neighbourhood the shock was little perceived. At Houlme a brilliant light was observed in the heavens. At Elbeuf, where the shocks were violent, a multitude of shooting stars with brilliant trains were seen.	Hist. de l'Acad. de Paris, 1769, p. 23; Cotte, *loc. cit.*; Gazette de France, 8 et 15 Déc.; Journ. Encycl. 15 Déc.; Coll. Acad. t. xiv. p. 124; Richard, Hist. des Mét. t. viii. p. 506.

1.	2.	3.	4.	5.	6.
1769.	Island of Zante	A violent shock	....	It is doubtful whether this event is not the same with that of 1767.	Montgom. Martin, *loc. cit.*
——	Syracuse	An earthquake	....	....	Keferstein.
1770. Jan. Beginning of the month.	Messina	A violent shock	....	Belfries were injured	Journ. Encycl. 1 Mars.
—— ——	S^{ta} Maura, one of the Grecian islands.	A violent earthquake.	....	Seven hundred houses were destroyed, and many of the inhabitants buried under the ruins.	Annual Register, vol. xiii. p. 69; Journ. Encycl. 5 Fév.
End of the month.				....	Phil. Trans. vol. lxxiii. p. 196.
—— Feb. ...	In Calabria, at Reggio, and also in Sicily.	An earthquake.........	....	....	Merian quotes the Meteorological Register of d'Annone.
—— Mar. 20.	Bâle	A trembling............	....	....	Renaudot, Annales Périodiques.
—— May 26. 6 A.M.	Lisbon	One shock	....	Followed by a subterranean noise	
—— June 3. 7h 15m P.M.	In the western part of St. Domingo, especially at Port-au-Prince.	A violent earthquake. The first shock (at 7h 3m) was from E. to W., and lasted 3 minutes. The other shocks (which continued at Port-au-Prince for four hours) were in all the various directions of the compass. The most severe lasted $2\frac{1}{2}$ minutes. Only four were felt at Cape Nicola Mole. The shocks were felt in the other parts of the island but feebly, but at Port-au-Prince they continued almost un- [illegible]	The sea inundated the country to the distance of a league and a half from the shore.	All the buildings at Port-au-Prince and many other places were destroyed. A river was completely choked up in one place, and in another a small volcano made its appearance. A noise like that of a cannon fired amongst hills was heard. Immediately before the shock a water barometer fell $2\frac{1}{2}$ inches =2 lines of the mercurial barometer. Great clefts opened in the earth in various places, from which mephitic vapours came and produced an epidemic. Hot springs also appeared, but ceased to flow after some time. On the 6th a violent hurricane occurred at Charleston.	Annual Register, vol. xiii. p. 130; Vivenzio (1788), p. 22; Humboldt, Voyage, t. ii. p. 285; Cotte, *loc. cit.*; Essai sur l'Hist. Nat. de l'Isle de St. Domingo, Paris, 1776; Gazette de France, 3 et 10 Août; Journ. Encycl. Août; Mercure de France, Sept.; Renaudot, Ann. Périod.; Richard, Hist. des Mét. t. ix. p. 419; Journal des Mines, No. 18. pp. 49 et 54.

[illegible]	[illegible] Arpino, Sora, Peperno, and several other places in the Terra-di-Lavoro.	[illegible] during this period. At Messina 30 shocks in a space of eight days. In the Terra-di-Lavoro but one shock.			Encycl. 1 et 15 Août; Renaudot, Ann. Période.
—— —— 9. 10ʰ 58ᵐ 45ˢ (A.M. OR P.M.?) 11ʰ.	At Cologne. Also felt at Maestricht.	Reiterated shocks for fourteen to sixteen seconds at Cologne. At Maestricht but one shock.	....	....	Gazette de France, 25 Juin.
—— July 22.	Messina	....	....	....	Annual Register, vol. xiii. p. 145.
—— —— 29. Some minutes past 5 P.M.	Belley, Bourg, Lyons, Mont d'Or, Geneva, and Grenoble.	Two or three shocks of thirty seconds, in *two parallel directions* from E. to W.	....	There was much rain during the month, so that almost all the rivers had inundated their banks.	Gazette de France, 17 Août; Register of the Observatory of Lyons, communicated to M. Perrey by M. Aug. Bravais. Communication of M. P. Lacroix to the same; Cotte, *loc. cit.*
—— Aug. 14.	Constantinople	Two shocks from N. to S. (Renaudot, Ann. Période. gives the opposite direction.)	....	....	Gazette de France, 8 Oct.
—— Oct. 9. 7ʰ 15ᵐ A.M.	Lyons, la Claire, Balmont, and Ambérieux (Bugey).	More slight shocks, less perceptible at Lyons than at the other places mentioned.	....	....	Register of the Observatory of Lyons, communicated to M. Perrey by M. Aug. Bravais.
—— —— ——	Bâle	A trembling	....	....	Cotte, *loc. cit.*
—— —— Day not mentioned.	Sora in the Terra-di-Lavoro, Italy.	Several shocks	....	....	Gazette de France, 30 Nov.; Journ. Encycl. 1 Déc.
—— —— 30.	In the Voigtland, Saxony; at Plauen and the adjoining villages, Adorf and its territory, Brunebach, Schomberg, Egra.	Numerous shocks from the 25th September to the 10th November, the most violent being those of the date here given.	....	It was remarked that the shocks appeared to go from Plauen to Adorf at first, and afterwards seem to take the opposite direction; that they were felt sometimes in the midst of a storm, sometimes in a perfect calm; and that they were sometimes unaccompanied by any noise, whilst on other occasions they were preceded, accompanied or followed by a terrible noise.	Gazette de France, 21 et 28 Déc., 4 Fév.; Journ. Hist.; Fév. 1771; Journ. Encycl. 15 Déc.

1.	2.	3.	4.	5.	6.
1770. Nov. 3. 3 P.M.	Schomberg in the same region.	The shocks recurred after an interval of quiet, and continued almost all the rest of the day. At 10 P.M. they became more violent.	....	Accompanied by a subterranean noise, which, with the shocks, became more violent at 10 P.M. Some persons were crushed in attempting to escape from a church.	Gazette de France, 21 et 28 Déc., 4 Fév.; Journ. Hist. Fév. 1771; Journ. Encycl. 15 Déc.
—— —— — Between 9 and 10 P.M.	Plauen in the same region.	The shocks recurred here also, followed by others at 4 A.M. on the 4th.	....	Accompanied by a dull noise like that of a heavily laden carriage.	Ditto.
—— —— —	Johann-Georgenstadt in Saxony also.	An earthquake	....	Followed by storms which did not cease for more than a month.	Ditto.
—— Dec. 6.	Lintz on the Danube ...	A rather energetic shock.	....	....	Gazette de France, 28 Déc.; Journ. Encycl. 1 Janv. 1771.
—— —— 27. Between midnight (of the 26th?) and 1 A.M.	Florence	A violent shock, followed by some others less considerable.	....	Some houses and villas were thrown down	Gazette de France, 25 et 28 Janv.; Journ. Encycl. 15 Janv. 1771.
—— —— — Hour not mentioned; in all probability the same as at Florence.	Sienna in Tuscany	A trembling..........	....	....	Merian quotes d'Annone's Meteorological Register.
——	At sea, on board a vessel which had left Lisbon the day before.	Lasted two or three minutes.	....	The cannon were shaken	Férussac, Bull. des Sc. Nat. t. ix. p. 21.
1771. Jan. 4. 8 P.M.	Johann-Georgenstadt ...	A violent shock, followed by two others in the space of a quarter of an hour.	....	The men at work in the mines perceived a disturbance, and heard a noise which they took for a signal.	Gazette de France, 4 Fév.
—— —— 5. 9 A.M.	Ditto	Another shock	....	....	Ditto.
—— —— 8. 4 A.M.	Leghorn	The first of a series of violent shocks, which lasted until	....	The inhabitants were much alarmed, the churches were kept open night and day, and all the theatres were closed.	Ditto, 8 Fév.; extract from the Manuscript Journal of Leghorn, of Bernardo Prato, t. i. p. 171 (communicated by Signor Pilla

		was very violent.			
1771. Jan. 12.	District of Belluna in the Venetian territory.	Several shocks........	....	Part of a mountain rolled down, being detached by these shocks.	Gazette de France, 18 Fév.; Journ. Encycl. 15 Fév.; Cotte, *loc. cit.*
—— —— 15.	Leghorn	The two most violent shocks of the period occurred on this day. The motion of the earth was felt, though feebly, until the 20th March.	....	....	Bernardo Prato's Journal, *loc. cit.*
—— —— 28 to April 20.	Albe (in Italy)	Daily shocks during this period, some of them very violent.	....	The shocks occurred in all states of the barometer, which varied $\frac{1}{2}$ or $\frac{3}{4}$ in. during the time.	Vassali-Eandi, Rapport, *loc. cit.* p. 128.
—— Feb. 1...	Luçon in the Philippine Isles.	An earthquake	....	Did great damage, especially at Hermita near Manilla.	Aragon, Descripc. Geogr. y Topogr. de la Ysla de Luçon, Manilla, 1819, t. ii. p. 19.
—— —— During the first half of the month.	Martinique	One shock	....	Did some damage to St. Pierre, Fort-Royal, and in various houses.	Gazette de France, 6 Mai; Journ. Encycl. 1 Mai.
—— —— 17.	Island of Vulcano (one of the Lipari group).	The island was violently shaken.	....	....	Ferrara, Campi Flegrei, pp. 233 and 234.
—— —— 18. (O. S.) 8 A.M.	Schlangenberg, Semenofsköi, Kouznetzköi, and over the whole extent of the Altai chain. Not felt *beyond Schlangenberg.*	A rolling motion from S. to N., but feeble at Schlangenberg. At Semenofsköi, however, it was very violent.	....	The day before, the barometer fell half an inch, and the wind blew strongly from the south all night. Snow fell in the morning, and very cold weather set in, which lasted until the 3rd of March. At Semenofsköi the shock was felt as well in the mines as on the surface. At Schlangenberg it was not perceived in the mines.	Pallas, Voyage, &c.; Trad. de Gauthier de la Feyronie, t. iii. p. 342.
—— Mar. 20. 9 P.M.	Florence	A slight shock........	....	....	Gazette de France, 19 Avril; Cotte, *loc. cit.*
—— —— 21. 5 A.M.	Ditto	Ditto	....	....	Ditto.
—— April 3. 7 o'clock (Italian time).	Padua	One shock	....	....	Toaldo, *loc. cit.*
—— —— 29. 5½ P.M.	Abingdon in Berkshire	A momentary, but rather violent shock.	....	Persons felt themselves lifted up, and saw the pavement move. There was a very little wind from the east.	Annual Register, vol. xiv. p. 100.

1.	2.	3.	4.	5.	6.
1771. June ...	Velletri and the environs	Rather energetic shocks.	....	....	Gazette de France et Journ. Encycl. 15 Juillet.
—— July. End of the month or beginning of August.	Scilly Isles	A violent shock	....	....	Gazette de France, 23 Août; Journ. Encycl. 15 Août.
—— —— 28. (O. S.) 9½ A.M. 12 noon.	Irkutsk, and at Verchangarsköi (9 wersts from Irkutsk), in the villages above Irkutsk, in the Ostrog of Balaganskoï (distant 184 wersts), at Selinginsk, and Kiakta (91 wersts from Selinginsk).	Two shocks, the first of which was feeble, and the second very violent, although scarcely felt in some localities. At Selinginska similar order was observed. At the other places the motion was slight. The shocks were from N. to S. (according to Pallas, the opposite), lasted 10 secs., and were more violent to the south of Irkutsk.	The Angora exhibited a species of flux and reflux.	The weather was very calm, and the wind westerly, in which direction it remained until the 30th.	Pallas, *loc. cit.* t. iv. p. 394; Gazette de France, 9 Déc. 1771 et 9 Mars 1772.
—— Aug. 6. 2 A.M.	Leghorn	A slight shock........	....	v. Hoff, quoting Cotte, gives the date 7th August	Gazette de France, 6 Sept.; Cotte, *loc. cit.*
—— —— 7. (O. S.)	The Ostrog of Tounkiskinskoi in Siberia.	A violent shock. This year is stated to have been most remarkable for the violence of the earthquakes in Central Asia.	....	Chimneys were thrown down. It is very remarkable that the previous shocks were not felt in this district. Pallas concludes that the centre of disturbance of the Altai chain is situated in the mountains of Zaïssan-Noor. See general observations on this district in Pallas, *loc. cit.*; Gmelin in Prévost, Hist. Gén. des Voyages, t. xviii. pp. 214 and 401, and t. xix. p. 340; Humboldt's Asie Centrale, t. ii. p. 110; and Erman, Reise, Th. ii. s. 179–184.	Pallas, *loc. cit.* t. iv. p. 394; Gazette de France, 9 Déc. 1771, 9 Mars 1772.
—— —— 8.	Smyrna	A violent shock	....	Service was interrupted in the churches; the priests left the altar.	Journ. Encycl. 15 Oct. Gazette de France, 9 et 11 Oct.

	of Augsburg, over a space of 60 leagues long and 40 wide, to the banks of the Rhine.				
1771. Aug. 13.	At Castiglione, and in the territories of Mantua, Ferrara, and Modena.	Violent shocks		Followed by a storm	Ditto, 23 Sept. et 11 Oct.; Journ. Encycl. 1 Oct.; Merc. de Fr. Oct.
—— —— 15. 2 A.M.	In the valley of Magna near Bergamo; and at the same moment the mountain of Brianza.	A very energetic shock		A mountain was thrown down and the debris covered several villages (!). A great quantity of water came from a cleft in the ground.	Ditto.
—— —— 17. 2 P.M.	Cagliari, and at the islands of St. Pierre, Tenedos, and Neutri.	Several shocks during 40 seconds.		Accompanied by a subterranean noise	Journ. Encycl. 15 Sept.
—— —— 24. 4 A.M.	Astbury in Cheshire	Lasted about 3 secs.			Gentleman's Magazine, vol. xl. p. 422; Gazette de France, 23 Sept.; Merc. de Fr. Oct.
—— —— ...	Island of St. Eustache in the West Indies.	A violent shock		Followed by a terrible storm	Gazette de France, 19 Oct.
—— Sept. 3. 8 A.M.	Jamaica	A violent shock, lasting 30 seconds.	Felt on board the vessels in port.	Did much damage	Ditto, 18 Déc. 1771; Journ. Encycl. 1 Janv. 1772.
—— Oct. 3. 8 P.M.	At sea 0° 42′ S. lat., and 22° 47′ W. long.	A trembling kind of shock.	The sea seemed greatly agitated. No bottom was found on sounding.	Felt on board the frigate "le Pacifique," Capt. Bonfils, from the Gold Coast for St. Domingo.	Daussy's Memoir, *loc. cit.*
—— —— — 9h 30m P.M.	Barcelona in Spain	Violent shocks from E. to W. for 5 or 6 seconds.			Gazette de France, 8 Nov.
—— —— 3 to 4.	St. Domingo	Fresh violent shocks.		A recently erected church was thrown down. Keferstein mentions this event without giving the month.	Ditto, 27 Déc.; Journ. Encycl. 1 Janv. 1772.
—— Nov. 7. 7h 15m P.M.	Barcelona	Violent shocks again for 5 or 6 seconds.			Gazette de France, 16 Déc.
—— —— 27. 1h 30m A.M.	Nice, Sospello, Monaco, and Menton in Italy.	A shock from E. to W.			Ditto, 24 Janv. 1772.
—— Dec. 10. At night.	In the Söndmör, Norway.	Several little shocks, for the most part from S.E. to N.W.		Followed by a warm south wind. Generally accompanied by a very temporary fall of the barometer to the extent of two to four millimètres.	Keilhau's Memoir, *loc. cit.*

1.	2.	3.	4.	5.	6.
1771	Island of Java............	Several shocks	....	The surface of the ground was upheaved in several places.	Raffles, History of Java, vol. ii. p. 234, and Appendix, p. 7.
1772. Jan. 2. Between 6 and 7 A.M.	Parthenay (department Deux-Sèvres) in France.	A violent shock	....	Furniture was thrown down	Gazette de France, 24 Janv.
——— 9. 7 A.M.	Ditto	Ditto, followed by a very slight one at 9 A.M.	....	Buildings were thrown down. Accompanied by a noise like that of carriages.	Ditto.
——— 10. 7 and 9 A.M.	Poitiers	Two rather violent shocks.	....	....	Ditto.
—— Feb. 18. 7 P.M.	In the neighbourhood of Kola, Russian Lapland.	An earthquake lasting about a minute, in the direction N. to S.	....	Preceded by a noise like that of a carriage upon pavement. The houses were shaken, and tiles fell from the roofs. The weather was cloudy and stormy all day. During the disturbance a quantity of snow fell, accompanied by a high wind.	Journ. Encycl. 1 Mai.
—— Mar. 8. About noon.	Brétignolles near Chinon (depart. Indre et Loire) in France.	Two shocks, in a vertical direction.	....	Accompanied by a low noise like a prolonged explosion.	Mém. de l'Acad. de Paris, 1772, p. 15; Coll. Acad. t. xv. p. 23.
——— 10. 3 o'clock (Italian time).	Padua	One shock	....	....	Toaldo, *loc. cit.*
—— April 5. Midnight.	Lisbon	Two violent shocks, of which the second and more violent lasted two minutes. The vibration appeared to be horizontal, from S. to N. This shock was also felt at $12^h\ 6^m$ at Cadiz, Sta Maria, San-Lucar-de-Barameda, &c.	....	The weather was calm and serene, and the sky clear. Before the shocks the dogs howled and cocks crew in a melancholy manner. Then there were heard subterranean noises, with whistling sounds as if in a storm. These noises lasted as long as the shocks. Very little damage was done. Pendulums were stopped by the motion.	Annual Register, vol. xv. p. 89; Gazette de France, 4 et 8 Mai; Journ. Encycl. 1 et 15 Mai; Journ. Hist. Juin, p. 473.
——— 8. Between midnight and 1 [illegible] (of the 8th or 9th).	Ditto	A less violent shock, but lasting a long time. From S. to N. as before.	....	....	Gazette de France, &c. *loc. cit.*

7 A.M.		but not so quick; also from S. to N. From the 6th to the 22nd shocks were felt daily in Algarve.			
—— —— 18. $2\frac{1}{4}$, $4\frac{3}{4}$, and some minutes past 5 P.M.	Algiers	Three heavy shocks at the hours mentioned.			Gazette de France, 1 Juin.
—— —— 19. $9\frac{1}{2}$ A.M.	Josselin in Bretagne	A shock from N.E. to S.W., lasting 3 secs.		Most violent in the mountains, *at salient angles.*	Ditto, 25 Mai,
—— —— ... Night between 26 and 27.	Genoa	A shock of but short duration.			Ditto, 18 Mai.
—— —— 30. 11 A.M.	Constantinople	Two shocks; the first slight, the second more violent.			Journ. Encycl. 15 Juin.
—— June 8. Between noon and 1 P.M.	Claussayes (department Drôme) in Dauphiny.	A slight trembling, followed, at 5 P.M., by three very distinct shocks.			Faujas de Saint-Fond, Hist. Nat. du Dauphiné, t. i. p. 320; Rozier, Obs. sur la Phys.
—— —— 9.	Ditto. Felt also in the neighbourhood.	Several shocks			Ditto.
—— —— 11. 5 A.M.	Ditto	Fresh and violent shocks. Slight ones were felt at intervals throughout June, the direction of which was then W. to E.		During the whole month of June subterranean noises, like a distant cannonade, were heard at intervals. In July, August, September and October nothing was felt or heard.	Ditto.
—— —— 16. $9^h\ 45^m$ (Italian time).	Padua	A shock			Toaldo, *loc. cit.*
—— —— 24. $9^h\ 39^m$ A.M.	Puy (France) and the country round.	A rather violent shock, lasting 2 secs., followed by others of violence at 11 A.M., lasting 1 second.		The first shock was accompanied by a noise like that of a carriage. The second set were felt in the "subdélégation de Saint-Bonnet-le-château, généralité de Lyon."	Gazette de France, 6 et 24 Juillet; Journ. Encycl. 1 Juillet.

1.	2.	3.	4.	5.	6.
1772. July 31. $2^h 41^m$ P.M.	La Rochelle in France...	A slight shock from S. to N. It was believed that another shock had been felt at 11½ A.M.	....	Accompanied by a noise resembling that of a carriage rolling rapidly.	Gazette de France, 24 Août; Merc. de Fr. Sept.
—— Sept. 13.	In the Tyrol	An earthquake	....	The earthquake brought down immense masses of ice from the mountains, which so choked up the rivers as to produce the most terrible inundations, many towns and villages being nearly submerged, and a mountain in one place being completely undercut by the water.	Journ. Hist. Déc. p. 467.
—— Oct. 31. 23rd hour (or 1st Nov. at 11 A.M.	Padua	One shock	....	....	Toaldo, *loc. cit.*
—— ——	In the mountains of Béarn (Pyrenees).	An earthquake.........	....	The village of Arudi was especially injured	Palassou, Mémoires, &c. p. 266.
—— Nov. 1 to 29.	Claussayes in Dauphiny	Slight tremblings from time to time during this period.	....	Accompanied by subterranean noise...............	Faujas de Saint-Fond, *loc. cit.* p. 321.
—— —— 29.	Ditto	A brief, sharp shock. Followed by slight ones at intervals up to the 6th Jan. 1773.	....	The attendant noise was heard almost daily up to the 6th January.	Ditto.
—— Dec. 23. $6^h 37^m$ P.M.	Havre and the neighbourhood.	A considerable shock	....	Accompanied by subterranean noise..............	Gazette de France, 1 Janv. 1773.
—— —— 25. 11½ P.M.	Prades (Roussillon) in France.	A shock of two secs. duration.	....	Accompanied by a low noise, apparently coming from the west.	Gazette de France, 18 Janv.; Merc. de Fr. Fév. 1773.
——	In the Beschtau mountains in the Caucasus.	An earthquake........	....	A portion of Mount Metschukh was severed from the rest, and fell into a chasm in the earth. On the 12th August of this year there was a great eruption of the volcano Tegal in Java and (in this year also) eruptions occurred from Hecla, and the volcano Awatschinskaja in Kamschatka.	Pallas, Reise in die südl. Statten halterschaften des Russ. Reiches. Th. 1. s. 347; Huot. Géol. t. i. p. 112.
1773. Beginning of the year.	At old Fez in Morocco..	A considerable earthquake.	....	Many houses were thrown down. This event is possibly only the same with that of the 12th April (see below), though it seems hardly usual to call April the beginning of the year.	Gazette de France, 3 Mai.

4 A.M. (According to the Annual Register, night of 12–13; hence this should be 4 A.M. of the 13th.)		in a direction between N. and E.	great height, inundating the town, and drowning many of the inhabitants.	France observes that no year had passed since 1763 without a shock being felt in this district.	Gazette de France, 8 Fév.
—— —— 16. 4½ P.M.	Claussayes in Dauphiny	Two violent shakes. The earth was often agitated during the following night.	......	......	Faujas de Saint-Fond, *loc. cit.* p. 321; Gazette de France, 12 et 22 Fév.; Journ. Encycl. 1 Avril; Merc. de Fr. Mars.
—— —— 18. About 7 A.M.	Ditto	A violent shock, followed, in an hour and a half, by four others of great violence. Other slight ones were felt during the day, and a very great one at 8¼ P.M.	......	The second set of shocks detached many stones from the walls. They were accompanied by a fresh, brisk breeze, *which only lasted as long as the noise and shocks.* These and all the other disturbances were attended with subterranean noise.	Ditto.
—— —— 19, 20, 21 and 22.	Ditto	Many feeble shocks...	......	Accompanied by noise	Ditto.
—— —— 23. 4 P.M.	Ditto. Also at Suze, Valréas, La Garde, Pierrelatte, Montelimar, &c., and even beyond the Rhone, in the direction of St. Andéol and Viviers.	The three most violent shocks hitherto felt.	......	Great damage was done. At Tulette (3 leagues from Claussayes) some saucers suspended by very long threads oscillated in a remarkable manner, as if attracted and repelled by each other, the motion ceasing suddenly and at once like that of the earth, but after the latter in point of time.	Ditto.
—— —— 24, 25, 26, 27, 28 and 29.	Claussayes	Many slight tremblings.	......	Accompanied by noise	Ditto.
—— —— ... Night between 27 and 28.	Semlin and Belgrade ...	Three shocks in the space of one minute.	......	The walls were cracked in a terrible manner ...	Gazette de France, 8 Mars; Journ. Encycl. Avril.
—— —— 28.	St. Savin (Poitou) in France.	Several shocks	......	Followed by a storm of such violence that houses were thrown down and trees torn up by the roots over a space of more than three leagues.	Gazette de France, 19 Fév.

1.	2.	3.	4.	5.	6.
1773. Jan. ... Night between 30 and 31.	Claussayes again.	Several shocks; one of them terrible.	....	The noise, ON THIS OCCASION, occurred at the same time with the agitation of the earth.	Faujas de Saint-Fond, &c. *loc. cit.*
——— 31. 11 A.M.	Ditto	Another shock, less considerable	....	....	Ditto.
—— Feb. 1, 2 and 3.	Ditto	Several moderate shocks.	....	Three of the shocks were much more perceptible in the farms lying N. to W.	Ditto.
——— 2. 4½ A.M.	Saint-Jean-Pied-de-Port in Navarre.	Two shocks, lasting more than two min.	....	....	Gazette de France, *loc. cit.*
——— 4. 2 P.M.	Claussayes	A violent agitation ...	....	Felt strongly at the farms spoken of above, though but slightly at the village.	Faujas de Saint-Fond, &c. *loc. cit.*
——— 7. 1¼ A.M.	Ditto	Another shock, nearly as violent as that of the 23rd Jan., but lasting at most only 4 secs. The direction of the shocks from their commencement to this day was uniformly E. to W. They were sharp, unequal, horizontal oscillations. Slight shocks continued up to the 15th.	....	The point from which these shocks seemed to come was a little hill, known as the "Sault de la pierre," about seventy toises in height, and situated not more than a thousand yards from the village. A trembling like that produced by carriages on pavement was felt, and at the occurrence of all the considerable shocks a "tourbillon" of wind was remarked, which stopped the progress of both men and animals, terrifying the latter.	Ditto.
——— 15. 11½ A.M.	Ditto	A very short, but violent shock, followed by slight ones up to the 22nd.	....	The motion became feebler at Claussayes, but increased to the S.W. The noise alone was often heard at the former place, while the agitation of the ground was quite sensible at Saint-Raphaël, a village at the distance of a league.	Ditto.
——— 22. Between 8 and 9 A.M.	Ditto	Three violent shocks..	....	Accompanied by a surprisingly loud noise	Ditto.
——— 24. Same hour.	Ditto	Ditto	....	Walls were thrown down	Ditto.
[illegible]	[illegible] Saint-Raphaël	Slight disturbance at [illegible]	....	....	Ditto.

		however, violent at Saint-Raphaël. From this until the 1st June the former was generally at rest, and only suffered slight shocks at intervals, while at the latter the disturbance became very violent, and extended to a part of the territory of Claussayes hitherto spared.			
1773. Mar. 24.	In the Söndmör, Norway.	Slight shocks	....	....	Keilhau, *loc. cit.*
—— April 1. 7 A.M.	Ragusa..................	A considerable shock, followed by a second, of less violence, at 10 P.M.	....	Accompanied by a subterranean noise	Gazette de France, 18 Juin; Journ. Hist. Août, p. 147.
—— —— 12. $5^h\ 15^m\ 40^s$ A.M.	Cadiz, Rota, S[ta] Maria, Port Royal, at the Ciclane, Lisbon, &c. Also at Madrid, Malaga and Gibraltar, and at Salee and Tangiers on the coast of Africa.	At Cadiz the shocks were violent from E. to W. for two minutes. At Lisbon several shocks were felt, lasting five or six seconds, the last ones being the most violent, and the direction *E. to N.W.* At Malaga they lasted one minute. At Salee but one shock was remarked. It was from E.S.E. to W.N.W., lasting 46 seconds. At Tangiers the direction was E. to W.	The sea at Cadiz remained quite calm.	The pendulums of the observatory at Cadiz were stopped, which gave the exact time of the phænomenon. At Lisbon the air was calm, and no subterranean noise was heard. Tangiers was almost completely ruined. Numbers of houses were thrown down and people injured. The Annual Register mentions two shocks at Madrid and Cadiz on the 13th at 5 A.M., but it seems pretty certain that it must refer to the morning of the 12th.	Gazette de France, 7 Mai, 2 et 16 Juillet; Journ. Hist. Juin, p. 474–5; Journ. Encycl. Juin et Août; Annual Register, vol. xvi. p. 100–101.

1.	2.	3.	4.	5.	6
1773. Apr. 15. Between noon and 1 P.M.	St. Malo. Also in Guernsey and Jersey. Also felt on the coast of Dorsetshire.	At St. Malo a shock of a minute's duration from N.W. to S.E. In Guernsey one was felt at 1¼ P.M., one in Guernsey and Jersey at 2¼ P.M., and another in Guernsey at 4 A.M. the following morning.	....	Accompanied by a noise like a cart rolling over a stone pavement. At Poole in Dorsetshire things were thrown off the shelves by the shock. Pendulums were stopped at St. Malo.	Annual Register, vol. xvi. p. 95; Gazette de France, 30 Avril, 7, 10, 17, 21 et 31 Mai.
—— —— — 2 P.M.	Pléneuf in the diocese of St. Brieuc. Also felt at Dol.	One shock, in the direction N.W. to S.E.	....	Accompanied by a noise like prolonged thunder.	Gazette de France, *loc. cit.*
—— —— ... and 18.	On the south-west coast of Spain.	Several shocks	....	....	Annual Register, vol. xvi. p. 101.
—— —— 23. 11¼ P.M.	Pléneuf again. Also all the country of Cotentin, at Dol, and in the island of Jersey.	Another shock in the same direction.	....	Ditto. Both shocks were felt most severely in the low lands.	Gazette de France, *loc. cit.*
—— —— 30. 8h 30m A.M.	Comorn in Hungary ...	A shock of more violence than that of the 28th June 1763. It was in the direction S. to N.E., and lasting ten seconds.	....	No damage done, notwithstanding the severity of the shock. A noise like thunder was heard at the time. The weather was calm and serene, but some days before heavy wind and rain had been experienced.	Ditto, 24 Mai; Journ. Encycl. Juin.
—— —— ...	Frascati in Italy	Several shocks of considerable violence.	....	....	Gazette de France, 17 Mai.
—— May 6. 10 A.M.	Algiers, Tangiers, and the north coast of Africa.	About twenty shocks. The tremulous motion between the shocks lasted from six to seven seconds to half a minute.	At Algiers the sea rose 5 feet 10 inches in every fourteen minutes, and then fell so low as to leave the boats aground. This decreased from noon until four the next morning. At Tangiers the sea rose 30 feet perpendi-	The earthquake consisted of a succession of tremblings and violent shocks. At Tangiers the fountains stopped, and at last there gushed out a black water having a bituminous taste.	Annual Register, vol. xvi. p. 105.

12. 6 A.M.	Ragusa	A violent shock	30 feet perpendi[illegible]		Gazette de France, 16 Juillet; Journ. Hist. Août, p. 147.
—— —— (Nearly at the same time with the last).	Corfu	An earthquake		The third part of the island was ruined	Gazette de France, 2 Juillet, quoting "la Rubrique d'Italie" of the 25th May; Merc. de Fr. Juillet.
—— June 1. 2½ P.M.	Claussayes again	A terrible shock, nothing more being felt during this month.		Unaccompanied by noise, though from 4 A.M. to midday a subterranean noise was heard, and again on the following day, when no shock was felt.	Faujas de Saint-Fond, *loc. cit.* p. 327.
—— —— 3.	Guatemala	The earthquake lasted five days.	The lake inundated its shores.	Two neighbouring volcanoes gave signs of action. From the one torrents of hot water, and from the other lava flowed. The earth opened, and the disturbance was accompanied by thunder, lightning, and rain. On the 7th the earth opened in huge chasms, and swallowed up the city of St. Jago with 5000 (or 8000) families.	Berghaus, Allgemeine Lander und Volker-Kunde, Th. 6. S. 448; Borowski, Abriss einer Naturgeschichte des Elementarreichs, pl. 82; Gazette de France, 27 Juin, 1774; Journ. Encycl. Fév. 1774; Annual Register, vol. xvi. p. 149; Vivenzio, *loc. cit.* p. 22.
—— July 7. In the morning.	In the western part of the territory of Claussayes.	Three more very severe shocks. From this day until the 13th October very little disturbance was felt at Claussayes, but very heavy shocks occurred from time to time at Saint Raphaël.		Scarcely felt in the village	Faujas de Saint-Fond. *loc. cit.*
—— ——29, or 31. 4 P.M.	Guatemala again	Violent shocks recurred.		Still later (the exact date not given) another earthquake completed the damage done before, and the city was afterwards rebuilt (for the third time) four leagues to the west of its former site. From Huot (Géologie, t. i. p. 112) giving the 29th June as the date of 45,000 people perishing by an earthquake in America, without specifying the place, it is possible that this event occurred at Guatemala at the end of June, not July.	Berghaus, &c., as above, *loc. cit.*
—— Aug. 8. 4½ P.M.	Luxemburg; extending as far as Vienna, though but slight at the latter place.	A severe shock			Gazette de France, 27 Août.

1.	2.	3.	4.	5.	6.
1773. Sep. Beginning of the month. (Day not given.) About 10 P.M.	In the valley of Ossau in the Pyrenees.	One shock		Felt very slightly at the Castle of Espalangue which stands upon chalk rocks, while at the houses of the warm baths, built upon granite, the shock was very severe.	Palassou (who was actually at the Castle of Espalangue at the time), *loc. cit.*
—— —— 13.	Bergen, Winger, and throughout a great part of Norway.	A trembling movement.		At Winger two terrible storms and the earthquake were experienced on the same day. The whole was accompanied by subterranean and whistling noises, and the fall of a torrent of rain.	Gazette de France, 26 Nov.; Vivenzio (1783), p. 46.
—— —— 24. $8^h\,30^m$ P.M.	Lisbon	A violent shock			Gazette de France, 5 Nov.
—— Oct. 13. 4 P.M.	Claussayes again	Three violent shocks. The motion was vertical, and followed the direction S. to N.		One of the shocks was followed by a considerable noise.	Faujas de Saint-Fond, *loc. cit.* p. 328.
—— —— 15. 4 P.M.	Ditto	Three slight shocks			Ditto.
—— —— 17. $10\frac{3}{4}$ A.M.	Pau, Gant, and Arudi, in the Pyrenees.	Two shocks from S. to N.E.			Gazette de France, 5 Nov.; Journ. Encycl. Janv. 1774.
—— —— 18. $5\frac{1}{4}$ A.M.	Ditto	Another shock			Ditto.
—— —— 19. 5 A.M.	Ditto	Ditto			Ditto.
—— —— 22. 6 A.M.	Ditto	Ditto			Ditto.
—— Nov. 25.	Claussayes again	Some slight shocks, followed by others, gradually decreasing until the end of December, when they had altogether ceased. At St. Raphaël, however, the shocks continued violently all this month, after which … also		Accompanied by noise. These villages were almost completely ruined by the long series of shocks to which they were exposed, especially Claussayes, it heing situated on the top of a mountain, the base of which consisted of a loose mixture of sand and clay.	Faujas de Saint-Fond, *loc. cit.*

—	Copiapo in Chili	An earthquake	....	According to Keferstein this earthquake occurred on the 29th July, the day of the second set of shocks at Guatemala.	Basil Hall, Journal written on the coast of Chili, vol. ii. p. 25; Keferstein.
1774. Jan. 15. $1\frac{1}{2}$ P.M.	Vienna, Neustadt, Presburg, and many places in Hungary.	Three (according to the Annual Register, two) shocks, lasting thirty-five to forty seconds. Direction = *N.W. to S.W.*	....	The weather was quite calm	Gazette de France, 4 et 21 Fév.; Merc. de Fr. Mars; Annual Register, vol. xvii. p. 92.
—— Night between 26 and 27.	Ratibor in Silesia	An earthquake	....	The tower of a church was thrown down	Gazette de France, 11 Mars.
— Feb. 7. 6^h 30^m P.M.	Martinique	One shock	....	....	Ditto, 10 Juin.
—— Night between 22 and 23.	Parma	A slight trembling ...	....	....	Ditto, 25 Mars; Vivenzio (1783), p. 47.
— Mar. 4. 19th hour.	Ditto	More shocks of considerable violence, in the direction S. to N., and lasting one minute. Several more were felt during the night.	....	Preceded by a loud subterranean noise. Chimneys and walls were thrown down.	Gazette de France, *loc. cit.*
—— 31. 23rd hour.	Padua	A single shock	....	....	Toaldo, *loc. cit.*
— April 12. 2^h 5^m (Italian time).	Ditto	Another shock.........	....	....	Ditto.
—— 17. Midnight.	Berne	Rather a violent shock.	....	....	Annual Register, vol. xvii. p. 122.
— *Before* the 6th Aug.	Cayenne	Violent shocks	....	....	Gazette de France, 26 Août, quoting a letter from London, dated Aug. 6.
— Sept. 10. 4 P.M.	Altdorf and Stirenzen in Switzerland.	At Altdorf and Stirenzen there were shocks at 3, 9, and 11 A.M., 4 P.M., and	....	The steeple of the church at Altdorf was split through, and many houses were thrown down. Great masses of rock were shaken from the surrounding hills. The earth continued in	Annual Register, vol. xvii. p. 166; Gazette de France, 18 Nov.; De Saussure, Voyages dans les Alpes, t. iv. p. 112.

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1.	2.	3.	4.	5.	6.
		the next day at midnight and 3 A.M.; altogether six violent shocks, and other slighter ones.		agitation for some time.	
1774. Sept. 10. $4\frac{1}{2}$ P.M. About 5 P.M.	Strasburg, Belfort, Besançon, Beaume (or Beaume-les-Dames?), and Bâle. Also slightly at Ratisbon and Anspach.	Several shocks from W. to E. At Belfort three occurred in the space of 4 mins. At Beaume a violent shock lasting about half a minute.	....	At some of these places the shocks produced much alarm, but no damage seems to have taken place.	Gazette de France, 23 (or 27) Sept., 7 Oct.; d'Annone's Meteorological Register.
—— —— 15. 10th hour (Italian time).	Padua	Another shock	On the 24th of this month the sea ebbed and flowed three times in an hour to the extent of 2 feet in perpendicular height, both at Malaga and Leghorn. No earthquake shock mentioned.	....	Toaldo, *loc. cit.*; Annual Register, vol. xvii. p. 160.
—— Oct. 22.	Comorn in Hungary ...	One shock	....	....	Gazette de France, 16 Déc.
—— —— 27. 10th hour (Italian time).	Padua	Another shock.........	....	....	Toaldo, *loc. cit.*
—— —— 29. 3 P.M.	In the prefecture of Hardanger, and at Bergen in Norway.	Several shocks	....	Many houses were shaken by the motion	Gazette de France, 20 Fév. 1775.
—— Nov. 29. 2 P.M.	Kongsberg and Egersund in Norway.	A shock of $1\frac{1}{2}$ minute duration.	....	Buildings were shaken	Ditto, 30 Déc.
1775. Jan. 4. 7 P.M.	Parma	Several shocks	....	....	Gazette de France, 27 Janv.; Journ. Encycl. Fév.
8^h 10^m P.M.	Padua	Ditto	....	....	Toaldo, *loc. cit.*
—— —— 5. Some minutes past 11 A.M.	Genoa	One shock, followed by another at 7^h 9^m. P.M.	....	....	Gazette de France, and Journ. Encycl. *loc. cit.*; Cotte, Tableau Chronologique, &c. in Journal de Physique, t. lxv.

1775. Jan. 6.	Modena	Two shocks, from S. to N.			Gazette de France, and Journ. Encycl. *loc. cit.*
—— —— 24.	Breslau	A slight trembling			Œconomische Nachrichten der Gesellschaft in Schlesien, B. 3. S. 25.
—— ——, or Feb. (day not given) 6½ P.M.	Skara in West Gothland, Sweden.	One shock			Journ. Encycl. Mars.
—— Feb. 4.	Rethel in Champagne	A trembling		During a tempest	Cotte, Tabl. Chron. *loc. cit.*
—— —— Night between 6 and 7.	St. Savin and several villages near Bourgoing (department Isère), France.	A violent shock		Preceded by a subterranean noise like thunder	Gazette de France, 10 Mars.
—— —— 14. 4 A.M.	Turin	A rather smart shock.		On the 11th Vulcano was in eruption. Shocks were felt in the surrounding islands.	Ditto, 24 Fév.; Cotte, *loc. cit.*
—— April. Night between 18 and 19.	Island of Amboyna	A violent shock from S.W. to N.E. The motion lasted altogether five minutes.	A ship in the bay was driven violently forwards, and then back.	Accompanied by a rumbling noise. The air was clear, and the weather perfectly calm. A wall of the rice warehouse which ran N.W. and S.E. was rent in a horizontal direction, just under where the rafters were inserted, for more than 40 feet.	"An Account of Celebes, Amboyna," &c. in Pinkerton's Voyages and Travels.
—— —— 30. 9½ P.M.	Villar in the généralité of Auch, and at Nortes in the Pyrenees.	Two shocks, followed at the second place by a third at 10¼ P.M. All in the direction E. to W.		The first two shocks were accompanied by subterranean noise; the third shock was not.	Gazette de France, 22 Mai.
—— May 23.	Sala in Sweden, and the country round.	A slight trembling	The waters of the lakes were violently agitated. Fish rose suddenly to the surface.	Accompanied by a noise like thunder. The shock was most remarkable in the interior of the mines.	Berendtson in Abh. d'Acad. zu Stockholm (German translation), Th. 37, S. 178.
—— June. Night of 20, 21	Monte Pulciano in Tuscany.	A violent shock			Gazette de France, 31 Juillet; Cotte, *loc. cit.*
—— ——	Fayal in the Azores	Several shocks			Cook's Voyage to the Southern Hemisphere.
—— July 1 and 2.	Guatemala	Another violent earthquake.		Accompanied by an eruption of the volcano Pacaya. The city was again ruined. v. Hoff (quoting Humboldt in Hertha, B. 6. S. 138), who gives the date 11th July for the eruption of Pacaya, does not mention the earthquake at all, and records (in this year, but without more exact date) an eruption of the volcano	Gazette de France, 5 Janv. 1776.

1.	2.	3.	4.	5.	6.
				Granada or Massaya near the lake of Nicaragua. Possibly this account of the earthquake is merely that of two years before.	
1775. Sept. 5 (or Oct. 8).	Island of Ternate	An earthquake			Vivenzio (1783), p. 47.
—— —— 8. About 9h 45m P.M.	Downing in Shropshire, Bristol, Bath, and Swansea.	Tremblings, in the direction E. to W.		Accompanied by noise	Phil. Trans. vol. lx. p. 368, and vol. lxxi. p. 193.
—— Oct. 6. 7h 35m P.M.	Vico in Corsica	A shock of considerable violence.			Gazette de France, 20 Nov.; Cotte, *loc. cit.*
—— —— 16.	Malaga	A shock of 3 or 4 secs. duration.		Accompanied by a violent gust of wind from the N.W.	Gazette de France, 24 Nov.; Cotte, *loc. cit.*
—— —— 22. 2h 12m A.M.	Vico in Corsica again	Four more shocks from *S.E. to S.W.*		A noise like the explosion of a mine was heard. One house was thrown down.	Gazette de France, 20 Nov.; Cotte, *loc. cit.*
—— —— 30.	Tournon in the Vivarais.	A trembling		Accompanied by a heavy gust of wind	Cotte, *loc. cit.*
—— Dec. 26, 6th hour (Italian time).	Padua	One shock			Toaldo, *loc. cit.*
—— —— 30. About $10\frac{3}{4}$ A.M. 10h 42m. 10h 34m. 10h 43m. 10h 32m.	At Toulouse, and many other places in France, Corbeil, Mortagne, Segré, Alençon, Havre, Caen, St. Lo, Falaise.	At Toulouse a slight shock from E. to W. At Corbeil a gentle undulatory motion from N.W. to S.E. At Alençon, two shocks, the first the most severe, and lasting half a minute. At Mortagne 3 shocks in a vertical direction, each more violent than the preceding. At Havre a slight shock from W. to E. lasting five seconds. At Caen three severe shocks, lasting five or six seconds, and coming from S.W.	At St. Lo and Falaise vessels at sea felt the shocks, but the waters of the Orne were not agitated.	At Alençon the first shock was accompanied by a noise like the rolling of a carriage. A well of 45 feet deep had its waters made turbid and blackish. At Segré (Maine-et-Loire) the streams which ran from S.W. to N.E. appeared to boil, while those running in the opposite direction were not affected. The villages in valleys not overlooked by mountains to the S.E. experienced hardly anything. At Caen the noise preceded the shocks, seemed to come from the S.W., and lasted two or three seconds. Another noise was heard *after* the shocks. Chimneys and some houses were thrown down. The shock of the 1st January threw down a house at Hérouville.	Gazette de France, 5, 8, 12, 19 et 29 Janv., 9 Fév. et 27 Mars, 1776; Cotte, *loc. cit.*

		...to N.E. A slight trembling succeeded them. At St. Lo and Falaise they were still more violent. A fourth shock was felt at 11 A.M., and a fifth on the 1st January.			
1775.	In Iceland	An earthquake			v. Hoff.
1776. Jan. 30.	At Brest, and Landernau in Bretagne.	An undulatory shock.			Cotte, *loc. cit.*
——— —	In the Spanish part of St. Domingo.	An earthquake			Ditto.
— Feb. 2.	Rhode Island, N. America.	Ditto		Accompanied by igneous meteors	Jameson's Journal, vol. xxxi. p. 302.
—— 7.	Irkutsk in Siberia	Ditto			Cotte, *loc. cit.*
—— 10.	The little Danish island of Thoröe near Fünen.	A trembling		An earthquake is mentioned by the Gazette de France, at the island of Thorn near Assens, on the 20th. It refers in all probability to this event.	Ditto.
—— 27. 0h 15m A.M.	Malta	A shock which lasted at least a minute. The motion was horizontal, from S. to N.		The dome of the cathedral was split by the shock, as in 1742.	Gazette de France, 12 Avril; Cotte, *loc. cit.*
— April 14.	In Poitou, at la Rochelle, and in the island of Oleron.	Several shocks			Cotte, *loc. cit.*
—— 21.	Acapulco	An earthquake		The greater part of the city was ruined	Dupetit-Thouars, *loc. cit.* t. ii. p. 213.
—— 22. 5h 36m A.M.	Fiume and Trieste. Also at Bukkari.	A violent shock; most severe at Bukkari.		At Bukkari the walls of a salt warehouse were split through. On the 28th March Vesuvius, and on the 27th April Etna was in eruption.	Ditto; Gazette de France, 14 Juin.
—— 24. 1 A.M.	Perpignan	Two shocks			Gazette de France, 10 Mai; Cotte, *loc. cit.*; Palassou, *loc. cit.*
—— 30.	In Poitou, at la Rochelle, and in the island of Oleron. On the same day at la Barthe de Neste in the Pyrenees.	More shocks		Cotte mentions an earthquake in this region of the Pyrenees on the 30th April 1775. One account or the other is probably erroneous.	Cotte, *loc. cit.*; Palassou, *loc. cit.*
— June 1.	Island of Ternate	An earthquake			Cotte, *loc. cit.*

1.	2.	3.	4.	5.	6.
1776. June 6. 5 A.M.	Gibraltar	One shock, lasting about fifty seconds.	Felt on board the ships in the harbour as well as on shore.	....	Cotte, *loc. cit.*; Annual Register.
—— July 10. 5ʰ 40ᵐ or 45ᵐ P.M.	Trieste. Also felt at Loubiano (Laybach?), Udine and Venice; and in the Frioul.	At Trieste three shocks from W. to E. The first lasted half a minute and was rather considerable, the second slight, and the third a little stronger.	....	In the Frioul many houses were thrown down. v. Hoff (quoting Cotte) gives the date 10th June.	Gazette de France, 19 Août; Cotte, *loc. cit.*
—— —— 11. 9ʰ 15ᵐ A.M.	Padua	One shock	....	....	Toaldo, *loc. cit.*
—— Aug. 4.	Carcassone (département de l'Aude), France.	A severe shock	....	Caused great damage	Cotte, *loc. cit.*
—— —— 20.	Cap Français, St. Domingo.	Several shocks........	....	....	Ditto.
—— Sept. 6.	Guadaloupe	An earthquake	....	Accompanied by a violent hurricane........	Ditto.
—— Oct. 28. 10ʰ 45ᵐ A.M.	Northampton. Less violent at Harborough, Loughborough, &c. in Leicestershire.	A sudden shock, lasting about two secs.	....	Accompanied by a noise like the jolting of a cart. The windows shook during the shock, and a ball or balls of fire were observed in the heavens. v. Hoff, quoting Cotte, gives the date Oct. 20.	Annual Register, vol. xix. p. 187; Cotte, *loc. cit.*
—— Nov. 27. 8ʰ 15ᵐ P.M.	Canterbury, Sandwich, Ashford, Dover, and all the coast of Kent. Also at Calais.	From S. to N., lasting about eight seconds. At Calais the direction was N. to S.	....	Attended with a rumbling noise. The day was gloomy and perfectly calm, wind south, barometer at 29·8 in. and thermometer in the shade 37°·3. Some china on a chest of drawers was moved an inch or two. Furniture was also moved, at Dover bells were made to sound, and at Calais loaves were thrown off the shelves in the bakers' shops. v. Hoff, quoting Cotte, gives the date Nov. 24, 8½ A.M.	Annual Register, vol. xix. p. 193; Gazette de France, 9 Déc; Cotte, *loc. cit.*
—— —— 28. 3ʰ 15ᵐ A.M.	Mannheim	Two violent shocks, of which one lasted a minute and some seconds, and the other a minute. Direction N.W. to S.E.	....	The houses were cracked and bells sounded of themselves. At the observatory the shock was supposed to be vertical, as a plumb-line of 10 feet in length was not moved, and a compass needle of 1 foot long deviated but 3′. The air was calm. A shock is mentioned at 8ʰ 10ᵐ A.M. of this day at Calais, Dunkirk, and Dover; but it obviously refers to the event of the day before.	Gazette de France, 9 Déc. et 27 Janv. suiv.; v. Hoff; Cotte, *loc. cit.*

[illegible]	[illegible] S. Carolina, North America.	An earthquake	....	....	Jameson's Journal, vol. xxxi. p. 302.
—— Dec. 19.	Spires	A trembling........	....	....	Cotte, *loc. cit.*
—— —— 24.	Hernösand in Finnland. (Norway?)	Ditto	....	....	Ditto.
—— —— End of the month.	Mannheim, Worms, Spires, and the neighbourhood of Mayence.	Direction = N.W. to S.E., lasting fifteen seconds.	....	This account probably arises merely from confounding those of the 28th Nov. and 19th Dec.; but from the details given it seems worth insertion.	Annual Register, vol. xix. p. 203.
——	Inverness........	An earthquake felt here during this year.	....	....	Thomson's Annals of Philosophy, vol. viii. p. 366.
——	From the neighbourhood of Lake Baïkal as far as the Altai, Kolyvan.	An earthquake	....	....	Humboldt, Asie Centrale, t. ii. p. 112.
1777. Jan. 19.	Leghorn and Tivoli........	Ditto	....	....	v. Hoff.
—— Feb 7. 2 A.M.	Lucerne, in the canton of Unterwalden, and in the environs. Perceived at Aarberg, Anet (Berne), Neuveville and Neufchatel.	A rather violent shock; the earth appearing to be raised without any oscillations.	....	At Sarnen some chimneys were thrown down...	Journal Helvétique, Avril 1777.
—— Mar. 5.	Spezin and along the Genoese coast.	A violent shock	....	....	Gazette de France, 31 Mars; Cotte, *loc. cit.*
—— April. Beginning of the month, or even before.	Cremble-Point near Turryburn, Scotland.	An earthquake	....	Accompanying the sudden sinking of several acres of land beneath which were mines. A noise like thunder was heard at the time. Probably the shock was due solely to the landslip.	Gazette de France, 14 Avril.
—— May 18 to 25.	In Hungary........	Trembling movements during this time.	....	....	Cotte, *loc. cit.*
—— June 6. 4 P.M.	Naples, and, more slightly, at Rome. Also felt in Sicily, La Puglia and Calabria.	Some other shocks had been felt up to the day before.	....	Many houses were thrown down in La Puglia, Calabria, and Sicily.	Gazette de France, 14 et 25 Juillet, 11 Août; Cotte, *loc. cit.*
—— —— 7. $7^h\ 55^m$ A.M.	Pau (in the Pyrenees) and the surrounding district, as far as the boundaries of Comminges and the Pays de Foix.	A violent shock	....	The date given is 1772, but v. Hoff says it is obviously intended to be 1777 or even 1778.	Palassou, *loc. cit.* p. 266.

1.	2.	3.	4.	5.	6
1777. June 7. 8h 15m A.M.	Padua	One shock			Toaldo, *loc. cit.*
—— —— 8. 3 A.M.	Nay in the Pyrenees	Two shocks			Palassou, *loc. cit.*
—— July 4. 5h 35m P.M.	Malaga	2 consecutive shocks, lasting 8 to 10 secs., in the direction N. to S.			Gazette de France, 8 Août; Cotte, *loc. cit.*
—— —— 6.	Messina	A single shock			Cotte, *loc. cit.*
—— —— 28.	Comorn in Hungary	An earthquake		Preceded by loud subterranean explosions	v. Hoff.
—— Aug. 5.	In some parts of Tuscany.	Tremblings			Cotte, *loc. cit.*
—— —— 13. About 10 P.M.	Village of Béon in the valley of Ossau in the Pyrenees.	A very violent shock in the direction E.S.E. to W.N.W.		The air was calm and the sky cloudless	Palassou, *loc. cit.*
—— —— 19.	Sola, Isola, and Veroli in the States of the Church. Also at Florence.	Very smart shocks		Houses were injured	Gazette de France, 19 Sept.; Cotte, *loc. cit.*; v. Hoff.
—— Sept. 2. 1h 30m P.M.	Island of St. Thomas in the West Indies.	Two violent shocks, each lasting a minute. The following day, towards evening, three more shocks were felt.		Accompanied by a frightful noise. The last shock, on the following evening, was succeeded by an abundant fall of rain, which lasted four-and-twenty hours.	Gazette de France, 2 Fév. 1778; Cotte.
—— —— 14. 10h 55m A.M.	Manchester. Also, though with less violence, at Lancaster, Liverpool, Birmingham, Derby, Chester, York, Gainsborough, over a space of 130 or 140 miles in diameter.	Three violent shocks in the space of half a minute. Direction = S.W. to N.E.	A boat on a canal near was stopped as if it had struck on a cable.	Preceded and accompanied by a loud noise. The wind was easterly before, but suddenly veered round to the opposite quarter at the time of the shock. The barometer was going up all day, and was not affected by the disturbance. The bell of one of the churches rang of itself. Various electrical phænomena manifested themselves. Cattle were very uneasy.	Phil. Trans. vol. lxviii. p. 221; Annual Register, vol. xx. p. 78.
—— —— 30. Half an hour after the rising of the sun.	Macaluba near Girgenti, Sicily.	Several shocks		Attendant on an eruption of a mud volcano. Loud noises, like the roaring of the sea, were heard to the distance of three miles. Ferrara reports this event on the 29th.	Dolomieu, Voyage, &c. p. 160; Ferrara, Campi Flegrei, p. 43.
—— Oct. 1. 6 A.M.	Lisbon, more violent at the castle of Cintra.	Smart shocks		Accompanied by subterranean noise	Gazette de France, 17 Nov.; Cotte.

Hour not given.					Cotte, *loc. cit.*
—— —— 5. Towards evening.	In the territory of Sienna.	Violent shocks		Houses were thrown down at Radicofani. Clefts opened in the ground.	Gazette de France, 24 Nov.; Cotte.
—— —— 16.	Florence. Also at Lucca.	An earthquake		Occurred in the midst of a violent storm	Cotte, *loc. cit.*; Annual Register.
—— —— 21. 1 A.M.	La Guayra and Cumana.	Ditto		In consequence of this earthquake an annual nocturnal procession was instituted. v. Hoff gives the date 1778.	Humboldt, Voyage, &c. t. v. p. 5.
—— Nov. 14. $5\frac{1}{2}$ P.M.	Sundval in Sweden, and the environs.	A violent shock, lasting $1\frac{1}{2}$ minute.	Succeeded by a sudden reflux of the sea, which caused the river flowing through the town to inundate its banks.	Accompanied by a low noise, in the direction N.E. to S.W. Several claps of thunder were heard after the shock.	Gazette de France, 5 Janv. 1778; Cotte.
—— Dec.	Carthagena in Spain	Several shocks		The weather was unusually cold for the climate.	Gazette de France, 9 Fév. 1778.
1778. Jan. 18.	Hermannstadt in Transylvania, and on the borders of Moldavia and Wallachia.	Shocks for half an hour.		A church at Cronstadt, on the frontiers of Moldavia and Wallachia, was thrown down. Many persons who were in it perished.	Gazette de France, 6 Mars; Cotte.
—— —— 19. About $8^h\ 45^m$ and 9 P.M.	Leghorn and Tivoli	Two slight shocks			Ditto.
—— —— In the course of the month.	Rome	A slight shock			Gazette de France, *loc. cit.*
—— Feb. 18.	Uglian-Caldo in Tuscany	Some shocks, followed for half an hour by a less perceptible oscillatory motion.			Ditto, 30 Mars; Cotte.
—— April 2.	Mannheim	A trembling motion			Cotte, *loc. cit.*; Bertholon, Électricité des Météores, t. i. p. 291.
—— —— 20. $5^h\ 45^m$ P.M.	Parma	Rather a slight shock			Gazette de France, 5 Juin; Cotte.
—— —— 30. $4^h\ 15^m$ (A.M. or P.M.?).	Guastalla	Rather a smart shock			Gazette de France, 8 Juin.
—— May 5. $5^h\ 10^m$ A.M.	Aleppo	An earthquake.		Accompanied by unusual cold	Ditto, 10 Août et 11 Sept.; Cotte.

1.	2.	3.	4.	5.	6.
1778. May 10.	Tief-Hartmannsdorf, in the government district of Liegnitz, circle of Schönau, Silesia.	A trembling..........	....	....	Œconom. Nachrichten der Gesellschaft in Schlesien, B. 6. s. 180.
—— —— 22. $3^h\ 30^m$ A.M.	Augsburg..........	A heavy shock..........	....	....	Gazette de France, 12 Juin; Cotte.
—— —— 25.	Ulm..........	Another shock	....	....	Ditto.
—— June 7. Between noon and 1 P.M.	Grenada in Spain. Also on this day at Pau and other places in the Pyrenees, and as far as Bordeaux.	At Grenada a very severe shock, lasting some seconds.	....	....	Gazette de France, 7 Août; Cotte.
—— —— 11. 8th hour (Italian time).	At Padua. Also, on the same day, at Forli in the Romagna.	....	On the 25th of this month an extraordinary motion of the sea was observed at Malta. No shock is mentioned.	....	Toaldo, *loc. cit.*; Cotte.
—— —— 16.	Smyrna	A very violent earthquake. Slight shocks occurred daily up to the 3rd July.	....	Many buildings were thrown down	Annual Register, vol. xxi. p. 193; Gazette de France, 14 Sept.; Cotte.
—— —— 18. 11 A.M.	Béon, in the valley of Ossau in the Pyrenees, and at other places in this region.	Another shock..........	....	....	Palassou, *loc. cit.* p. 267.
—— July 3. 7 to 10 A.M. Cotte and the Gazette de France give the date 2nd July.	Smyrna	A very violent earthquake. Two shocks of great violence were followed by twenty-four feebler, and slight motion until midnight of the following day.	....	Most of the city was either ruined by the shocks or destroyed by fires which broke out during the time. Each concussion was preceded by a subterranean noise like the firing of cannon.	Annual Register, &c. *loc. cit.*
—— —— 5. From $1\frac{1}{2}$ to 8 A.M., and	Ditto	Five or six slight shocks having been felt on the 4th, nine [illegible]	....	....	Ditto.

		occurred on this day.			
1778, July 19. 6 P.M.	Ditto	More shocks			Gazette de France, *loc. cit.*; Cotte.
—— —— 21, 10 A.M.	Ditto	Ditto			Ditto.
—— —— 22. 8 A.M.	Ditto	Ditto			Ditto.
—— —— 23. Between 11 P.M. and midnight.	Ditto	Ditto		These shocks were followed by the plague	Ditto.
—— —— 31.	S. Sepolcro in Italy	An earthquake			Cotte, *loc. cit.*
—— Aug. 1 to 4.	Ditto	Very severe shocks, especially two during the night.		Whether the earthquake given by Cotte on the 31st July refers to shocks which actually occurred on that day, or that it is merely a mistaken date, it is difficult to decide.	Gazette de France, 4 Sept.
—— —— 15.	Constantinople	An earthquake			Cotte, *loc. cit.*
—— Sept. 21. 1 A.M.	Peyrenère, in the valley of Aspe, in the Pyrenees.	A very violent shock, preceded by two severe ones at 9 P.M. the evening before, and by a slighter on the 18th.		On the 22nd lava flowed again from Vesuvius	Palassou, *loc. cit.*
—— Oct. 1. 1 P.M.	Smyrna	Two violent shocks, followed by eight others, not so severe, up to 9 P.M.		More ruins were produced	Merc. de France, Déc. 1778, p. 194; 25 Janv. 1779, p. 242; 25 Mars, p. 313; Cotte.
—— —— 3, 24 and 30.	Ditto	More shocks		Produced fresh disasters	Ditto.
—— Nov. 1, 3, 4, 5, 7 and 16.	Ditto	Ditto. Those of the 5th and 16th were particularly violent.		The winter was excessively cold, with ice and snow, which is rarely the case in this place.	Ditto.
—— —— 7. $7\frac{1}{2}$ P.M. ($8\frac{1}{2}$ according to the Gaz. de Fr.)	Cadiz	A rather smart shock			Gazette de France, 15 Déc.; Cotte.
—— —— 12, 13 and 14.	Grenada in Spain	Twenty-four shocks were felt during the three days.		Several houses were slightly shaken	Gazette de France, 22 Déc.; Cotte.

1.	2.	3.	4.	5.	6.
1778. Nov. 18. 11 A.M.	Trieste	A slight (or according to the Merc. de Fr. a very severe) shock.		Accompanied by a violent storm with thunder. v. Hoff gives the date 1779.	Gazette de France, *loc. cit.*; Merc. de Fr. 15 Janv. 1779, p. 209.
—— —— — 18th hour (Italian time).	Padua	A shock			Toaldo, *loc. cit.*
—— Dec. 19 to 26.	In Hungary, at Hamouna, Wranow, Taverna, &c.	Twelve shocks during this period.		Bertholon places this event in 1779	Cotte, *loc. cit.*; Bertholon, Elec. des Mét.
—— —— 31.	La Conception, near Domfront (department Orne) in Normandy.	An earthquake			Ditto; Mém. de l'Institut, t. iv. p. 533; v. Buch, Canar. Ins. s. 375.
——	At the abbey of San Salvadore (in Italy, but in what state?).	Some absolutely local shocks, not felt below the mountain.			Sarti, Saggio di Congetture su i Terremoti, cap. 2.
1779. Jan. 25. 5h 40m P.M.	Caraccas in the province of Cumana, S. America.	A violent earthquake, recurring as severely in three hours afterwards.		Houses thrown out of the perpendicular	Gazette de France, 8 Juin; Cotte.
—— Feb. 5.	Orizaba in Mexico	An earthquake			Cotte, *loc. cit.*
—— —— Night between 9 and 10.	Canea, in the island of Candia.	Three shocks from E. to W., lasting 11 seconds. Felt also "en rade."	On the 4th March an extraordinary rise of the waters of the Baltic was observed. No shock mentioned		Gazette de France, 15 Oct.; Cotte.
—— April 6.	Hamouna in Hungary	An earthquake			Cotte, *loc. cit.*
—— —— 16. 4½ A.M.	Constantinople	Ditto, consisting of two shocks.		The second shock awoke every one in Constantinople.	Mercure de France, 15 Juin, p. 195; v. Hoff.
—— June 1. About midnight.	Bologna	A violent shock, lasting 3 seconds. Two others were felt during the next two hours, and the earth trembled slightly all the night.			Gazette de France, 9 Juillet et 10 Sept.; Le Comte de Chabot in the Journ. de Phys. t. xiv. p. 198.
—— —— — 5th hour (Italian time).	Padua	Another shock			Toaldo, *loc. cit.*
[illegible]	[illegible]	[illegible]			Gazette de France, &c. *loc. cit.*

		to that of the day before.			
1779. June 4. 7½ A.M.	Ditto	Another, longer and more intense, followed until the 10th by others, slighter in the city, but stronger in the country round.		Walls were cracked. On the 7th meteors were observed like a rain of fire at the mountain St. Michael in Bosco.	Ditto.
— — — 11th hour (Italian time).	Padua	Another shock.			Toaldo, *loc. cit.*
— — 8. 12h 55m (Italian time).	Ditto	Ditto			Ditto.
— — 10. 9h 5m A.M.	Bologna	A violent shock, from E. to W., followed by a second.		The weather was calm, but cloudy. During the second shock a loud noise was heard in the air. The water in wells became warmer, and the magnetic needle deviated 3°. A letter from Rome, dated 18th August, says that the shocks still continued at Bologna.	Gazette de France, &c. *loc. cit.*
— — — 14th hour (Italian time).	Padua	Another shock.			Toaldo, *loc. cit.*
— — 26. 1h 30m P.M.	Sienna	A violent shock			Soldani, quoted by Pilla.
— July 1.	Smyrna	Another shock.			Gazette de France, 24 Septembre; Cotte.
— — 14.	Rouen in France, and on the same day at Larsböe-Sagewerek in Helsingland, Sweden.	Shocks felt at each of these places.			Gazette de France, 14 Sept.; v. Hoff.
— — 22.	In Sweden; probably at the same place.	Another earthquake shock.			Ditto.
— Aug. 8. 9 P.M.	Around Vesuvius, especially at Portici.	A violent commotion		Windows were broken and walls cracked at Portici. Accompanied by a rolling noise in the interior of the volcano, which had been in violent eruption since the 29th July, and continued so until the 26th August.	Hamilton in Phil. Trans. vol. lxx. pp. 42–84; Ditto in Suppl. to Campi Flegrei, p. 292; Vivenzio, &c.

1.	2.	3.	4.	5.	6.
1779. Sept. 21. Between 4 and 5 A.M.	Bergen in Norway	A trembling shock			Gazette de France, 19 Nov.; Cotte.
—— Oct. 1. 1 A.M.	Naples	Violent horizontal shocks from E. to W.			Gazette de France, 5 Nov.
—— —— 20. 9 A.M.	Saint Girons in the Pyrenees.	A slight shock, followed in three-quarters of an hour by a stronger vibration from N.W. to S.E., lasting 1 second.		Accompanied by a dull subterranean noise, that with the second shock being the louder. Some stones were thrown from the town walls.	Palassou, *loc. cit.*
—— Nov. 2.	Vivonne in Poitou	One shock			Cotte, *loc. cit.*
—— —— 9.	Bologna	Two more shocks, one of them rather severe.			Ditto; Gazette de France, 21 Déc.
—— —— 23. 2nd hour (Italian time).	Padua	More shocks		During an eclipse	Toaldo, *loc. cit.*
—— Dec. 1.	Vienna	An earthquake shock			Cotte, *loc. cit.*
—— —— 5.	Bergen, between Hanau and Frankfort.	Ditto			Ditto.
—— —— 12. At night.	Portici and Resina, near Naples.	Rather a violent horizontal shock.			Ditto; Gaz. de Fr. 21 Janv. 1780.
—— —— 22. About 6 P.M.	Valley of Ossau in the Pyrenees.	One shock			Palassou, *loc. cit.*
—— —— 24. About 6 P.M.	Pistoia in Tuscany	A violent shock		Commotions of this kind were frequent here, especially in the mountain country at San-Marcello and Categliano.	Gazette de France, 22 Fév. 1780; Cotte.
—— —— 28.	Valley of Ossau in the Pyrenees, and particularly at Nay.	A vibratory shock from S.W. to N.E., more violent than that of the 22nd.			Palassou, *loc. cit.*
—— —— 31. About 6 P.M.	Pistoia again	Another shock			Gazette de France, &c. *loc. cit.*
1780. Jan. 15. 6th hour (Italian time).	Padua	Another shock			Toaldo, *loc. cit.*
—— —— 20. after midnight [illegible]	Mont Dauphin and Em-[illegible]	A shock from S. to N., lasting 2 seconds.		Accompanied by subterranean noise at Mont Dauphin.	Gazette de France, 18 Fév.; Cotte.

or 21st?)					
1780. Jan. 27. 6 P.M.	Malta	Three violent shocks.		The fortifications were injured	Gazette de France, 4 Avril; Cotte.
—— —— — (according to others, on the 22nd.)	Java	An earthquake			Hist. Gén. des Voyages, t. ii. p. 401; Raffles' History of Java, vol. ii. p. 234, and Append. p. 7; Verhandel. van het Batavian Genootsch. D. 2. Bl. 51.
—— —— 28.	Mount Etna	A trembling		The volcano had remained at rest for 14 years	Ferrara, Descrizione del Ætna, p. 125.
—— —— — Towards the end of the month.	Various places in Sicily	Severe shocks		This fact is obviously connected with, if not merely the same as the preceding.	Gazette de France, 6 Juin et 4 Août.
—— Feb. 2.	Auvergne in Nibousan, France (?).	An earthquake			Cotte, *loc. cit.*
—— —— 5. 11th hour (Italian time).	Padua	Another shock			Toaldo, *loc. cit.*
—— —— 9. 9th hour (Italian time).	Ditto	Ditto			Ditto.
—— —— 18. About 1 A.M.	Selb in the Voigtland of Baireuth.	Continuous shocks			Ziehen, Nachricht von einer bevorstehenden grossen Revolution der Erde, 1783, 11–23 and following pages.
—— —— 23. About same hour.	Ditto	Ditto, more violent, followed by others at 3 (A.M. or P.M.?) the same day.			Ditto.
—— —— 24. $2^h\ 45^m$ P.M.	Ditto	Ditto, very sensible		The glasses on the tables were made to ring	Ditto.
—— —— 25. Between 6 and 7 P.M.	Throughout the whole of the country round Wetzlar and Königsberg. Also, though feeble, at Breitenbach.	A severe shock of 2 seconds' duration.		Heavy snow and wind the day before	Ditto.
$8^h\ 18^m$ P.M.	Selb again	A final shock. All those felt at this place appeared to come from the S.W.			Ditto.

1.	2.	3.	4.	5.	6.
1780. Feb. 26. Between midnight (of the 25th) and 1 A.M.	Coblenz	A severe shock			Ziehen, Nachricht von einer bevorstehenden grossen Revolution der Erde, 1783, 11–23 and following pages.
In the morning.	Wetzlar	Two shocks felt this morning, and one on the following day.			Ditto.
A little before 5h 30m P.M.	Coblenz	A much heavier shock than that at midnight.			Ditto.
6 P.M.	Dachsenhausen (Hesse-Darmstadt).	A shock lasting not less than a minute.		Accompanied by loud noise, both under ground and in the air.	Ditto.
6h 35m P.M.	Boppart on the Rhine	A severe shock from S. to N., followed by another (feebler) the following morning between 4 and 5 A.M.		It was remarked that several clocks had stopped on the evening of the 25th. At 7h 45m P.M. a violent gust of wind from the west was perceived at Wiesbaden, Frankfort on the Maine, &c., but decreasing in violence the further it extended from the Rhine.	Ditto.
—— —— 27. 4h 45m A.M.	Coblenz	A feeble shock, but lasting a long time.			Ditto.
10h 30m A.M.	Ditto	Another, still slighter.		The heavens looked unusually stormy. At St. Gothard slight motion had been observed, particularly on the 22nd at 7 P.M. And in the course of the month the lake of Wallenstadt and the river Reuss exhibited agitation, during which the earth shook, particularly at Lucerne. Many of these shocks on the Rhine probably occurred in reality at the same hour.	Ditto.
—— ——	Tabriz in Persia	A violent earthquake.		Did great damage	Cotte, *loc. cit.*
End of the month, and on March 3.					
—— Mar. 13.	Etna and throughout almost the whole of Sicily.	Trembling shocks			Ferrara, Descrizione, &c. *loc. cit.*; Gazette de France, 6 Juin.
—— [illegible]	Sicily and Calabria	Ditto			Cotte, *loc. cit.*; Gazette de France, *loc. cit.*

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	Sicily again, especially violent at Messina and the surrounding villages.	and from N. to S.		ings were injured. Etna was in eruption. Perrey gives the date 8th April.	4 Août.
—— —— 29.	La Rochelle and Rochefort in France.	A trembling..........	....	....	Cotte, *loc. cit.*
—— May 2.	The Limousin, Poitou, St. Aunis, and in Brittany.	Several shocks	....	....	Ditto.
—— —— 9. At night.	Bologna	A rather violent shock, accompanied by a very distinct oscillation. Two days after, a slighter shock.	....	Accompanied by noise. An extraordinary mass of vapour was observed in Sicily. v. Hoff, quoting Cotte, gives the date 8th May.	Gazette de France, 20 Juin.
—— —— 18.	Etna, and many other places in Sicily, extending into Calabria. Also in the Lipari Isles.	Many shocks every day up to the 25th. Others had been felt repeatedly since the end of April, and Messina was shaken almost the whole summer. At Ali and Fiume di Niso the shocks were sometimes so sudden and violent that every one believed that a new volcano was about to burst forth there.	....	Etna was in violent eruption until the 16th June. Vulcano also was in continual agitation, accompnied, as at Etna, by frightful noise.	Gazette de France, *loc. cit.* et 27 Juin; Ferrara, Descrizione, &c. p. 126; Dolomieu, Voy. aux îles Lipari, pp. 28 et 79; Mém. sur les trembl. de terre de la Calabre en 1783, p. 69.
—— —— 25.	Rimini, Ravenna, and Caserta (Casero ?).	Tremblings	....	....	Cotte, *loc. cit.*
21st^{h} 45^{m} (Ital. time).	Padua	Another shock	....	....	Toaldo, *loc. cit.*
—— July 30. 10 P.M.	Genoa	A very slight shock, lasting some seconds.	....	....	Gazette de France, 8 Sept.; Cotte.
—— Aug. 1 to 4. At night.	Tortona in Italy	Several rather smart shocks.	....	....	Gazette de France, 19 Sept.; Cotte.

1.	2.	3.	4.	5.	6.
1780. Aug. 29. $8\frac{3}{4}$ A.M.	Hafodunos, Downing, Isle of Anglesea, Carnarvon, Isle of Clwyd, Denbigh, Holywell, Flint, Conway, Beaumaris, Llanwrst and Holyhead.	At Hafodunos (at 8^h $37^m 30^s$) two shocks from S.E. to N.W. At Downing two severe shocks from N.W. to S.E.	....	The barometer was not affected at Hafodunos. At Downing a noise like that of waggons was heard before the shocks.	Phil. Trans. vol. lxxi. pp. 193 and 331.
—— —— Night between 29 and 30.	Lisbon	A slight shock	....	....	Gazette de France, 3 Oct.; Cotte.
—— Sept. 14.	Porti in Sicily	An earthquake	....	Perrey says, "Ne faut-il pas lire Patti?"	Cotte, *loc. cit.*
—— —— 21. $2^h 15^m$ P.M.	Ragusa	Three violent shocks. The first two succeeded each other almost without any interval, and lasted sixty seconds. Direction = E. to W.	....	Houses were injured	Gazette de France, 1 Déc.; Cotte.
—— —— 27.	Christiania in Norway...	An earthquake	....	....	Cotte, *loc. cit.*
—— Oct. Probably about the beginning of this month.	Island of Candia	A very violent earthquake, preceded by others for some time.	....	The castle of Eropeter with its garrison of 300 Turks was swallowed up. Thirteen small villages and their inhabitants disappeared in like manner.	Merc. de France of 11 Nov. p. 56, quoting "la rubrique" of Leghorn of the 15th Oct., which quotes letters from Trieste.
—— —— 5. 5th hour (Ital. time).	Padua	Another shock	....	....	Toaldo, *loc. cit.*
—— —— 13.	Tornea in Lapland	One shock	....	Keilhau reports this event on the 15th	Cotte, *loc. cit.*; Keilhau, *loc. cit.*
—— —— 31. $3\frac{1}{2}$ A.M.	Dijon, Bourbonne-les-Bains (Haute-Marne), Vaivre and Vesoul, in France.	At Dijon several rather violent shocks. At Bourbonne-les-Bains they were violent, and in the direction S. to N. At Vaivre and Vesoul one oscillatory shock from W. to E., of four seconds' duration; followed in [illegible] hour by a second.	....	At Dijon accompanied by a noise like that of a carriage rolling rapidly over pavement. At Vaivre and Vesoul an undulating sound was heard, and in the middle of it a sudden low explosion. The second shock threw down furniture.	Gazette de France, 10 et 14 Nov., 1 Déc.; Cotte.

Saturday before the 12th. Between 4 and 5 P.M.	in North Wales.	shocks, the second of which was violent. Direction = N.E. to S.W.		not perceptible in the mines.	331.
—— —— 11.	Hagenau in Alsace	One shock			Cotte, *loc. cit.*
—— —— 18. $4\frac{1}{2}$ P.M.	Newcastle, York, Leeds, Whitehaven, &c.	Lasted about 2 secs.		Attended with an extraordinary noise. The windows were shaken, and the furniture, &c. thrown about.	Annual Register, vol. xxiii. p. 77.
——	Island of Amboyna	An earthquake			Annalen der Physik, 30. S. 192.
1781. Jan. 2. At night.	In the most elevated portion of the province of Sienna.	Various shocks during the month, especially on this night.		Houses were injured	Gazette de France, 15 Fév.; Cotte.
—— —— 27.	Erzeroum in Armenia	A violent earthquake		Ditto	Cotte, *loc. cit.*; Huot, *loc. cit.*
—— Feb. 13.	Messina in Sicily	Several shocks		During a furious storm	Gazette de France, 13 Avril; Cotte.
—— —— 25.	Arricia in Italy (La Riccia?)	An earthquake			Cotte, *loc. cit.*
—— April 4. 10 P.M.	Padua	One shock			Toaldo, *loc. cit.*
Hour not given.	In the Romagna, especially at Modigliana; at Castrocaro, Forli, and slightly at Florence, Faenza, and Venice. Also at Bologna.	Severe shocks		The houses in the Romagna were cracked, and the pavement of the streets broken up. At Castrocaro a mountain separated into two parts. At Forli chimneys were thrown down.	Gazette de France, 15 et 18 Mai; Ephémérides de Mannheim (Société Palatine), 1781, p. 276; Cotte; v. Hoff.
—— —— 10. 3 P.M.	In the Romagna again, at Faenza, Imola, Cesena, and Bologna.	Ditto. At Bologna a long and very heavy shock.			Ditto.
—— —— 16.	St. Maurice le Girard in Poitou.	One shock			Cotte, *loc. cit.*
—— —— 24. 3rd hour (Italian time).	Padua	Another shock		On the same day an eruption of Etna began, and lasted the whole of May.	Toaldo, *loc. cit.*; Ferrara, Descrizione, &c. *loc. cit.*
—— —— 26.	Arles in Provence	Several shocks			Cotte, *loc. cit.*
—— May 4. $21^h 15^m$ (Italian time).	In the environs of Etna	A slight shock from N. to S., felt more strongly further away. Many other violent shocks were felt during the month.		The volcano continued in a state of eruption	Phil. Trans. vol. lxxii. p. 6; Ferrara, *loc. cit.*

1.	2.	3.	4.	5.	6.
1781. June 3. 11h 45m (Italian time).	Padua	Another shock	....	....	Toaldo, *loc. cit.*
Hour not given	Cagli in the duchy of Urbino, and in the Romagna. Also at Borgo-San-Sepolcro, apparently coming from Mounts Nero and Jego, and extending to Anghiari, Arezzo, and other places in Tuscany and the Romagna.	At Borgo-San-Sepolcro a severe shock from S.E. to N.W. The earth continued to tremble almost the whole day.	....	At Borgo-San-Sepolcro walls were cracked. The spring had been dry, but the summer was stormy.	Cotte, *loc. cit.*; Pilla quotes Sarti, *loc. cit.*
—— —— 20.	"Baillage" of Orgelet in Franche Comté.	An earthquake	Accompanied by an inundation.	....	Cotte, *loc. cit.*
—— July 1.	The duchy of Urbino. The shocks extended all along the Adriatic, and were felt at Ancona, Sinigaglia, Rimini, and other places in the States of the Church.	Severe shocks continued to be felt.	....	The town of Cagli was abandoned. Monte Nero opened.	Gazette de France, 7 Août; Hamilton.
—— —— — Night between 11 and 12.	Florence and Faenza ...	Some shocks were felt	....	....	Gazette de France, 17 Août et 4 Sept.
—— —— 15. 2 o'clock at night (2 A.M. on the 16th?).	Lisbon	A rather severe earthquake, lasting some seconds.	....	....	Ditto, 24 Août; Cotte.
—— —— — 18h 45m (Italian time).	Padua	Another shock	....	....	Toaldo, *loc. cit.*; Ephém. de Mannheim, 1781, pp. 281, 282.
—— —— 17. 10 A.M.	Florence, Faenza, and Marseilles.	A very violent and sudden shock, followed by a rapid oscillation *from E.*	....	The earth rose circularly from S. to N. more than once.	Gazette de France, 17 Août et 4 Sept.; Cotte.

		to N. and N. to W. The motion was almost continual up to the 22nd.			
13h 55m (Italian time).	Padua	Another shock			Toaldo and Ephém. de Mannheim, *loc. cit.*
1781. Aug. 14.	Foligno in the duchy of Spoleto.	One shock on this day, five others were felt during the month.			Gazette de France, 5 Oct.; Cotte.
—— Sept. 10. 5 A.M.	Padua	Another shock			Ephém. de Mannheim, 1781, p. 285.
17th hour (Italian time).	Milan, Mantua, Lodi and Crema.	At Milan a rather severe shock. At Mantua an undulatory motion, lasting five seconds, and felt more strongly at Lodi. At Crema, the motion (undulatory) was from E. to W., and lasted 1 minute.			Gazette de France, 12, 19 et 30 Oct.; Cotte.
—— —— 22.	At the lake of Bracciano, between Rome and Viterbo.	An earthquake	Accompanied by an extraordinary motion of the waters of the lake.		Cotte, *loc. cit.*
—— —— 23.	Harderwyck on the Zuydersee.	A trembling shock			Ditto.
—— Oct. 2.	Jamaica	Several severe shocks	The sea rose to the height of 10 feet at half a mile from its ordinary beach, and swept away numbers of houses.	Accompanied by a tremendous hurricane. v. Hoff, on the authority of Cotte, gives the date 2nd October, 1780.	Annual Register, vol. xxiv. p. 3; Cotte.
—— —— 6 and 7.	Presburg in Hungary	Vibratory shocks			Cotte, *loc. cit.*
—— —— 10. 3rd to 5th hour (Italian time).	Faenza and Berzighella.	At Faenza 3 shocks, and at Berzighella eleven were counted			Gazette de France, 16 Nov.; Cotte.
—— Nov. 17. 10 A.M.	Padua	A slight shock			Ephém. de Mannheim, 1781, p. 288.

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1781. Nov. 22. 9 P.M.	Padua	A slight shock........	....	The magnetic needle was agitated	Ephém. de Mannheim, pp. 289 et 292.
1782. Jan. ...	Beneventum, Naples, &c.	More shocks	....	Such numerous earthquakes had occurred in Italy the year before that the pope ordered public prayers to be offered up for their cessation.	Bertholon, Électricité des Météores, t. i. p. 292.
—— Feb. 25. One hour before the evening Angelus.	Ortona (in the Abruzzo Citerior).	Very violent	....	The walls were shaken to their foundations, and the next morning, at 3 A.M., a neighbouring hill covered with trees left no trace but a frightful chasm. The whole of its summit had fallen into the sea, and there formed a peninsula of 300 feet long by 1200 wide.	Gazette de France, 17 Mai.
—— March 3.	Beneventum in the kingdom of Naples.	An earthquake	....	....	Cotte, *loc. cit.*
—— April 5.	La Rochelle in France...	Ditto	....	....	Ditto.
—— May 15.	In the county of Trentschin in Hungary.	No shock is mentioned. Possibly only a landslip.	....	A chasm opened during a storm, and fifty-three houses were swallowed up.	Perrey, Suppl. to memoir on Earthquakes in the basin of the Danube, p. 76.
—— —— 23.	Near the lake of Brusjö in Westnorrland, Sweden.	*Probably* an earthquake, though the event does not seem well authenticated.	A loud noise was heard, like thunder, and the waters of the lake rose in an extraordinary manner, producing a terrible inundation. On the 22nd the sea rose with great violence on the coast of Formosa and the adjacent part of China, and remained eight hours above its ordinary level; having swept away all the villages along the coast, and drowned immense numbers of people. No shock is mentioned.	....	Neue Abh. der Akad. zu Stockholm (German translation), B. 3. S. 312; Annual Register, vol. xxvi. p. 35.

1782. July 17.	Guadaloupe	A vibratory shock			Cotte, *loc. cit.*
—— Aug. 15. $4\frac{1}{4}$ P.M.	Grenoble in France	Violent oscillations from E. to W.		Lustres and bells were set in motion in the upper stories of the houses. Walls were cracked. The barometer was agitated. v. Hoff gives the date 25th August.	Gazette de France, 30 Août; Cotte.
—— Sept. 15.	Oléron on the southern slope of the Pyrenees.	A violent oscillation, following the direction of the chain of the Pyrenees from the Atlantic Ocean to the Mediterranean.			Palassou, *loc. cit.* p. 268.
—— Oct. Some days before the 7th.	Rome	A rather smart shock			Gazette de France, 12 Nov.
—— —— 5. 8h 39m P.M.	Mold in Flintshire, Almwok in Denbighshire, Bangor in Caernarvon, at St. Asaph, and in the Isle of Anglesea.	A rather violent shock, lasting 15 seconds. At Bangor two shocks were felt at the hour specified. At Bodorgan in Anglesea the shock was very violent, from N.E. to S.W.		Accompanied by a noise like carriages rolling over pavement.	Phil. Trans. vol. lxxiii. p. 104.
—— —— —	Guadaloupe	Another shock			Cotte, *loc. cit.*
—— —— Night between 13 and 14.	Bergen in Norway	A slight earthquake		v. Hoff, quoting Cotte, gives the date 15th October.	Gazette de France, 26 Nov.; Cotte.
—— Dec. 9.	Vienne in Dauphiny. Also in Béarn.	Ditto			Cotte, *loc. cit.*; v. Hoff.
—— —— 26 and 27.	Oléron on the southern slope of the Pyrenees.	More oscillations			Cotte, *loc. cit.*; Palassou, *loc. cit.*
—— End of the year.	Comorn in Hungary			The town had been almost entirely destroyed by an earthquake, according to a letter from Vienna of the 4th January 1783.	Gazette de France, 28 Janv. 1783.
1783. Jan. 6.	In the Altai mountains in Siberia, especially on the Irtisch.	Several shocks			Keferstein.
—— —— 10. 4h 30m A.M.	Marseilles	A vibratory shock			Cotte, *loc. cit.*

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1783. Jan. 27.	Sienna and on the coast of Tuscany.	An earthquake which does not seem to have recurred during the disturbances in Calabria.	....	....	Pilla quotes Soldani.
—— Feb. 5. Half an hour after noon.	Throughout Calabria and Sicily. The centre of disturbance was, according to Hamilton, under the town of Oppido; others place it beneath Monte Aspero or Aspramonte in the Apennines; while Dolomieu considers that there were three distinct centres, Oppido being the principal one. Hamilton says that if two circles be drawn with the latter town for their common centre, and with radii of twenty-two and seventy-two Italian miles in length, the smaller one will include all the places where the earthquake was felt with destructive violence, while the larger will circumscribe the whole district shaken. Some of the shocks extended to the Romagna, and even Rome itself, and to the Lipari Isles. In the south of Cala-	One of the most disastrous earthquakes ever felt in Europe. After some slight oscillations the tremendous shock which did so much mischief took place, lasting about two minutes. The motion seems to have been very complex, and was divided by the Italians into three kinds, "orizontale, oscillatorio, e vorticoso." At Oppido the shocks seemed to come up vertically from beneath. Many other violent shocks were felt, especially during the night of the 6th, on the 7th at 1½ P.M., and almost continuously with more or less violence up to the 28th March. Those of the 23rd, 27th, and 28th of February, and the 1st and 28th of March were the	The sea in the straits of Messina was violently agitated, retreating suddenly, leaving the shore dry to a great distance, and then as suddenly coming back with such rapidity and violence as to carry off numbers of people who had fled from their houses to the shore on account of the earthquake.	All the towns and villages of Calabria were shaken with tremendous violence. Those built on loose detrital foundations were levelled with the ground, while those situated on solid rock, though greatly shaken, for the most part remained standing. On the 28th of March, however, the contrary seemed to be the case. Those on the east of the Apennines suffered less than those on the west. The devastation throughout the "Plain" of Calabria and Sicily was awful. In both regions a subterranean murmuring noise was heard before the shock; in Calabria it seemed to come from the S.W. At Scylla (Straits of Messina) a portion of a mountain fell into the sea (on the night of the 5th), when great damage was done in Sicily by the great sea wave resulting from its fall. Tremendous effects were produced over the surface of Calabria, hills were overthrown and levelled with the plain, chasms opened in the ground and swallowed up people in the moment of their flight, springs dried up, the course of rivers was stopped for a moment, to be renewed immediately after with such violence as to tear away every obstruction. Stromboli, which under ordinary circumstances constantly emits smoke, ceased almost, if not altogether, to do so on this day. Etna and Vesuvius were also perfectly still. The weather was unnaturally still and gloomy, like that which often precedes great thunderstorms, and immediately before the shock a heavy, whistling blast of wind was observed. Fire was reported to have issued from clefts in	Hamilton in Phil. Trans. vol. lxxiii. p. 169; Vivenzio, Istoria e Teoria de' tremuoti, &c., Napoli, 1783; Vivenzio, Istoria de' tremuoti avvenuti nella provincia della Calabria, &c., Napoli, 1788; Grimaldi, Descrizione de' tremuoti accaduti nell Calabria nel 1783, Napoli, 1784; Istoria de' Fenomeni del tremuoto avvenuto nelle Calabrie, &c., Napoli, 1784; Lyell's Principles of Geology; v. Hoff; Dolomieu, Mémoire sur les tremblemens de terre ressentis en Calabre en 1783.

	bria, in and around Reggio, the earthquake did not produce such terrible effects as in the region mentioned above.	most remarkable. On the last-named day, at 1h 16m (Italian time), a shock (one of the so-called vorticosi), lasting two minutes, completed the destruction of the 5th February. On the 25th and 26th April, the 5th May, the 8th, 11th and 12th June, the 29th July (at 1 and 6 A.M.), and the 30th August, severe shocks were felt, and in Calabria the motion had not ceased on the 20th September.		the earth near Messina. In many places small lakes were produced by the choking up of ravines through which streams formerly flowed. At Messina the quay sank so that the top was a foot under water, and Grimaldi asserts that the sea bottom itself sank considerably at the same place. At Terranova a church tower was split in two by a cleft running from top to bottom, and the one-half with the foundation raised considerably (producing what in rocks would be called a "fault"). At the monastery of S. Bruno some stones lying upon others were moved horizontally upon the lower ones, without the place of the latter being altered. In some places the earth appeared cleft by star-shaped fissures, like a cracked pane of glass. This year was remarkable for the extraordinary dry fog, which beginning in Calabria in February, overspread until autumn the greater part of Europe, and extended even to the Azores. This fog, though not consisting apparently of moisture, was so dense that the sky was quite obscured, appearing a light grey colour instead of blue, and the sun presented a blood-red disc. In Calabria the darkness was so great that lights were obliged to be used in the houses, and vessels at sea repeatedly came in collision. The odour was most disagreeable. For further details of this most remarkable earthquake see the various memoirs referred to.	
1783. Feb. 13.	Neustadt in Hungary ...	Some slight vibratory shocks.	....	....	Gazette de France, 14 Mars; Cotte; v. Hoff.
—— —— In the middle of the month.	Island of Amboyna......	An earthquake felt throughout the whole island.	....	....	v. Hoff quotes Labillardière.
—— —— 18. Between midnight (of the 17th?) and 1 A.M.	Selb in Upper Saxony...	Several shocks from the S.W.	....	....	Gazette de France, 8 Avril; Ziehen, *loc. cit.* p. 46; Cotte; v. Hoff.

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1783. Feb. 25. Between 7 and 8 P.M.	Selb in Upper Saxony...	Several shocks from the S.W.	....	....	Gazette de France, 8 Avril; Ziehen, *loc. cit.* p. 46; Cotte; v. Hoff.
—— —— 28.	Palermo in Sicily	Several slight shocks felt during the month, that on this day being rather more severe.	....	Perrey considers this and the other Italian earthquakes given by him further on as distinct from those of Calabria. It is difficult to believe however that they were not at least closely connected therewith.	Gazette de France, 2 Mai.
—— March 5.	Paris	Several shocks	....	The Gentleman's Magazine is the only authority I have been able to find for this event, which is not mentioned by either Perrey or v. Hoff. It appears therefore somewhat doubtful.	Gentleman's Magazine, vol. liii. p. 268.
—— —— 6. 11 P.M.	In the Angoumois (now department Charente), France.	A shock lasting two seconds.	....	On the 9th a mountain *fell* at Ardes in Auvergne. No mention made of any shock.	Gazette de France, 1 Avril; Cotte.
—— —— — Hour not given.	At Irkutsk, and along the Altai chain, from Lake Bäikal to the Altaï Kolywan.	Several shocks	....	....	Gazette de France, 25 Juillet; Cotte; v. Hoff; Humboldt, Asie Centrale, t. ii. p. 112.
—— —— 18. $5^h\ 45^m$ A.M.	Padua	An earthquake from S. to N.	....	....	Éphém. de Mannheim, 1783, p. 567.
—— —— 25. 3 A.M.	Malemort in Provence...	Two shocks. According to v. Hoff shocks were felt here also on the 26th.	....	Preceded by a loud noise. At Sallon-de-Crau, three leagues from Malemort, the weather was clear and fine, yet the electrical machine gave but very feeble sparks (a very uncertain subject of observation). A strong wind, without a fixed direction, succeeded the shocks, and lasted for an hour.	Gazette de France, 18 Avril; v. Hoff.
—— —— Night of 25-26.	Selb in Upper Saxony...	More shocks	....	....	Ziehen, *loc. cit.*
—— —— 26.	Venice, Padua, Sta Maura, Zante, and Cephalonia.	Shocks felt at all these places, according to v. Hoff.	....	....	v. Hoff.
—— —— 28.	In Calabria	A very violent shock. (See 5th Feb.)	....	....	Ditto.
—— April 5.	Mannheim	Several shocks.........	....	....	Ditto.
—— —— 8.	Vienna; Comorn, and other towns of Hungary.	An earthquake	....	It is hardly likely that this is a distinct event from those about to be mentioned. The date is very probably erroneous.	Gentleman's Magazine, vol. liii. p. 439.

1783. Apr. 11.	Comorn in Hungary ...	....	....	The fortress was destroyed	Férussac, Bull. des Sc. Nat. t. xviii. p. 195.
—— —— 12.	Selb in Upper Saxony...	Another shock, so violent that the inhabitants believed their houses about to fall.	....	....	Ziehen, *loc. cit.*
—— —— 13.	Lisbon. Also at St. Jago in Galicia.	Three severe shocks at Lisbon. One only, but that a violent one, at St. Jago.	....	....	Gazette de France, 12 Juin; Cotte.
—— —— 22. 4 A.M.	Comorn, along the Danube, at Raab, Presburg, Pesth, Buda, Odimburg, and Estherhaz in Hungary. Also at Vienna. The centre appeared to be at Comorn.	Very violent. At 10 A.M. twelve severe shocks had been reckoned at Comorn. The first at that place was from S. to N. At Offen-Pesth slight shocks had been felt from 2 A.M.	....	At Presburg followed by a violent storm. The mineral waters of Buda became warmer than usual. Comorn was almost completely destroyed, and it was resolved to rebuild it further from the Danube.	Gazette de France, 20 et 27 Mai, 3 et 13 Juin; Éphém. de Mannheim, 1783, p. 141; Cotte; Ziehen, *loc. cit.*
—— —— 23. 1¼ P.M.	Colebrook Dale in England.	An earthquake.........	....	....	Gentleman's Magazine, vol. liii. p. 442.
—— May 5.	Grenoble in France......	Ditto	....	....	Cotte, *loc. cit.*
—— —— 12 to 31.	Comorn in Hungary ...	Nineteen shocks during this period.	....	The last of these shocks, more violent than that of April 22, threw down the newly-built walls.	Gazette de France, 1 Juillet.
—— June 1.	Constantinople	A single shock.........	....	....	Ditto, 15 Juillet; Cotte.
—— —— 1 to 10.	In the province of Skaptarfiall, Iceland.	Numerous and violent shocks.	....	Accompanying violent eruptions of Skaptar-Jökal and other volcanoes of Iceland, which began about the end of May, and continued until the following year. The river Skapta disappeared completely, and a new island rose from the sea near the coast. For details see v. Hoff.	Stephensen's account of this eruption, Altona, 1786; Henderson; Pennant, Le Nord du Globe, t. i. p. 308; Eyriès, Abrégé des Voy. Mod. t. vii. p. 186; Marmier, Hist. d'Islande, p. 355; Gaz. de Fr. 22, 25 Juillet, 8 Août, 2 Déc. &c.
—— —— 8 to 13.	Calabria	More severe shocks. (See Feb. 5.)	....	....	Cotte, *loc. cit.*
—— —— 15. Between 4 and 5 A.M.	Godgard in Ost Gothland, Sweden.	Some shocks from E. to W.	....	*An hour before* a noise like that of a carriage rolling over pavement was heard. v. Hoff (without quoting any authority) records another earthquake in Ost Gothland on the 15th July. It is very improbable that there were really two.	Gazette de France, 1 Août; Cotte.

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1783. June 20 and 22.	Florence	Vibratory shocks......	Unusual motion of the sea was observed near Naples. From the way in which the date is given, it seems probable that the earthquake at Florence occurred on the 20th, and the agitation of the sea at Naples on the 22nd.	....	Cotte, *loc. cit.*
—— July 6. 9^h 56 or 57^m A.M.	Dijon, Verdun, Seurre, St. Jean-de-Leone, &c., over a space circumscribed by a line passing through Langrès, Châtillon, Aignay-le-Duc & Montbard; extending to the Rhone and felt at Besançon.	At Dijon two perceptible oscillations followed by a slight trembling. Apparent direction = N.N.E to S.S.W. At the three places named next, the clock had struck at the time. Some people believed the motion to be vertical. At Besançon a slight oscillatory but vertical shock was felt at 10^h 3 or 4^m; and at 10^h 15^m two shocks were observed at Lausanne, and three at Bourg and Salins.	....	At Besançon it appeared as if the air were compressed against the doors and windows. The noise was not subterranean, nor aërial, but like that produced on throwing a handful of grain against a flat surface. The weather was hot and fine, and was not altered. The celebrated mist which obscured almost the whole of Europe and part of Asia this year, was observed here.	Mém. de l'Acad. de Dijon, 1783, p. 26; Mém. de la Soc. de Lausanne, 1783, p. 120; Gaz. de Fr. 22 Juillet; Journ. de Paris, 22 Oct. 1784.
—— —— 18 and 19.	Calabria	Severe shocks were still felt.	....	....	Vivenzio, 1788, p. 28.
—— —— 20.	Tripolis in Syria, and a part of the mountains of Lebanon.	Two shocks, rapidly succeeding one another, and lasting altogether 8 or 10 seconds.	....	Preceded by a hollow noise like the roaring of distant waves. The weather before had been very tempestuous, with fogs and violent rain. Masses of rock were shaken down from the mountains in Lebanon.	Annual Register, vol. xxvi. p. 32; Cotte; Gaz. de Fr. 3 Oct.

	and Zinzoa, province of Sinano, island of Niphon, Japan. The earthquake was felt over a space of twenty or thirty leagues.	which lasted four or five days.	....	Accompanying a great eruption of the volcano Asama-Gadaki. Great clefts opened in the earth, rivers became dry, and many villages with their inhabitants were destroyed. For details see v. Hoff.	Titsing, Illustrations of Japan (translated from the Dutch by F. Shoberl), London, 1822; Humboldt, Fragmens Asiatiques, p. 230.
—— —— 29. 1 and 6 A.M.	Calabria and Messina...	A violent shock at each of these hours. (See 5th February.)	....	Four villages were completely ruined	Annual Register, vol. xxvi. p. 36.
—— Aug. 9.	Launceston in Cornwall.	An earthquake	....	....	Gentleman's Magazine, vol. liii. p. 708.
—— —— 30.	Messina	Another shock. (See 5th February.)	....	A slight eruption of Vesuvius took place on the 18th.	Cotte; v. Hoff.
—— Sept. 7.	La Rochelle and the environs, France.	A slight shock........	....	Accompanied by subterranean noise........	Gazette de France, 30 Sept.; Cotte.
—— Oct. 26.	Kapnik in Transylvania.	Some shocks	....	....	Cotte.
—— Nov. 17.	Bolsena in the States of the Church.	Ditto	....	....	Ditto.
—— —— 29. 10½ P.M.	New York, United States	A rather violent shock.	....	....	Gazette de Leyde, 1784, Janv. 23.
—— —— 30. 2½ A.M.	Ditto	Another of less violence.			
—— —— End of the month.	Thessalonica	A violent earthquake.	....	The shocks here were considered to be more destructive than those at Messina. On the 25th and 29th November falls of portions of mountains in Spain took place. (See Perrey's memoir on Earthquakes in the Iberic peninsula, p. 22.) There is no proof of these events being consequent on earthquake shocks.	Annual Register, vol. xxvi. p. 60.
—— Dec. 8.	Pistoia in Italy	An earthquake shock.	....	On the 9th a noise like thunder was heard at Cambray (depart. Nord) in France. It was *supposed* to proceed from a slight earthquake, though no shock seems to have been felt. (Gazette de France, 19 Déc.)	Cotte, *loc. cit.*
—— —— 14.	Aleppo........	A slight vibratory shock.	....	....	Volney, Voyages, &c. t. vi. p. 359.
—— —— Night between 17 and 18.	The Danish island of Christian near Bornholm.	Three shocks, of which the second was the most severe.	....	....	Merc. de France, 7 Fév. 1784; v. Hoff.

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1783. Dec. In the course of the month.	Messina, and in Calabria.	Two or three more shocks.	....	Although no shocks are specified in October and November, it is probable that these regions were not during that time altogether still.	Merc. de France, 31 Janv. 1784.
—— End of this year, and beginning of 1784.	Guatemala	Terrible shocks	....	Houses were thrown down. Humboldt (in his Nouvelle Espagne, t. i. p. 304) mentions terrible subterranean noises, as heard here from the 9th of January to the 12th February, 1784, and which extended as far as Guanaxuato; but he adds that *no other* phænomenon followed them. Perrey thinks however that this passage refers to phænomena connected with those here recorded.	Journ. Encycl. 1 Mai, 1784.
1784. Jan. 17. 6 and 9 P.M.	La Rochelle in France...	Two shocks at the hours mentioned (v. Hoff, quoting the Journal de Paris, gives but one, namely at 9 P.M.).	....	Accompanied by a violent storm at 9 P.M., with thunder, lightning, and hail. Some persons denied the fact of there being an earthquake altogether.	Merc. de Fr. 14 Fév., 20 Mars; Journ. de Paris, 4 Fév.
—— —— 20. In the afternoon.	Siebenlehn near Nossen in Saxony, on the northern slope of the Erzgebirge.	A vibratory shock ...	....	....	Hamburger Correspondent, 1784. Nr. 19.
—— —— 23.	In Hungary	Several ditto	....	....	Cotte.
—— Feb. Night between 10 and 11.	In the suburb Leopold at Vienna.	Some people *believed* they felt a trembling.	....	....	Hamburger Correspondent, Nr. 28.
—— —— and in March.	In Calabria	Pretty numerous shocks, of which one (at Terranova) was very severe.	....	The preceding winter had been unusually severe and long continued both in Europe and America. A thaw of alarming suddenness took place in the middle of March, but afterwards severe cold set in again.	Dolomieu, *loc. cit.* pp. 50 and 69; Hamburger Correspondent, Nr. 57.
—— Mar. 6.	In some Danish islands.	Several shocks........	....	....	Cotte, *loc. cit.*
—— —— 19. 4 P.M.	Udina in Italy..........	One shock	....	....	Toaldo, *loc. cit.*
—— —— 20.	Prague, the circle of Leutmeritz, and the circle of Saaz as far as Eger.	A very violent shock.	....	Accompanied by a loud subterranean noise. At Ossek a mountain opened, and a little stream came forth which ran for several hours. Several buildings, amongst others a belfry at Dux, were injured. On the 18th a mountain fell in Transylvania. No shock said to be felt.	Schriften der Berlinischen Gesellschaft naturforschen der Freunde. B. 5. S. 490; Cotte.

At noon, and in the evening.	di Tortona in Italy; the village and a circle of three leagues radius round it being shaken.	[illegible] shocks		The same day a mountain fell near Lucca. No shock mentioned.	Merc. de Fr. 15 Mai; Cotte.
—— April 1.	In Calabria. Both here and at Messina fresh shocks seem to have occurred during the month.	Another severe shock.	....	Preceded by a terrible storm, with lightning and hail.	Merc. de Fr. Mai et Août.
—— —— 7. Five minutes past midnight to $2\frac{1}{2}$ A.M.	Albino, Frescati, and other places near Rome.	Seven violent shocks.	....	....	Ditto; Gentleman's Magazine, vol. liv. p. 376.
—— —— 20.	Briançon in France	A vibratory shock ..	....	....	v. Hoff.
—— May 11.	Zailgrotz in Hungary ...	Several shocks........	....	A thick vapour arose from a spring at this place.	Cotte.
—— —— 13.	Arequipa. Also the districts of Cumana and Maquiqua, South America.	A terrible shock at Arequipa.	....	The districts of Cumana and Maquiqua were devastated. Masses of soil were transported to great distances.	Merc. de Fr. 8 Janv. 1785; Journ. Encycl. 1 Fév. 1785.
—— June 5. Between 12 noon and 1 P.M.	Caub on the Rhine. Still more violent at the castle of Guttenfels, and the Pfalz.	One shock, followed by another at 6 P.M.	....	A mist preceded the first shock, and a storm followed it on the Rhine.	Hamburger Corresp. Nr. 99.
—— —— —— On to the end of the month.	Reggio in Calabria	Repeated trembling motion during this period.	....	....	Cotte.
—— —— 6. About 8 P.M.	Carrara	A severe shock	....	....	Hamburger Corresp. Nr. 103.
—— —— 15.	Comorn in Hungary ...	Several shocks........	....	....	Cotte.
—— July 8.	Messina	A violent shock	....	Preceded by a noise like thunder	Hamburger Corresp. Nr. 129.
—— —— 10.	Bagnères de Luchon in the Pyrenees.	Several shocks........	....	....	Palassou, *loc. cit.*
—— —— 23.	In the Paschalik of Erzerum. Felt at Erzerum itself.	A most destructive earthquake.	....	The city of Arsingham (Ezinghian), 15 leagues from Erzerum, was ruined, and Soliman Pasha, the new governor, all his suite but eleven, and 5000 other individuals perished beneath the ruins. Perrey, on the authority of the Mercure de France and Journal Encyclopédique, gives the date 19th July.	Hamburger Corresp. Nr. 143, 148, 149, 155; Gazette de Leyde, 14 et 21 Sept.; Merc. de Fr. 25 Sept.; Journ. Encycl. 15 Nov.

1.	2.	3.	4.	5.	6.
1784. July 29. Between 9 and 10 P.M.	Port-au-Prince and Cap (Français?) in St. Domingo, and Leogano in Jamaica.	In Jamaica two shocks	......	A hurricane occurred at the same time, both here and in Florida. Twelve houses were thrown down at the Cape (Français?), and much damage was done at the other places.	Hamburger Corresp. Nr. 171; Gaz. de Leyde, 22 Oct.; Suppl. et 5 Nov.; Suppl. Merc. de Fr. 9 et 30 Oct.; Mém. de l'Acad. de Dijon, 1784, p. 78.
—— —— 30.	In Norway	A trembling shock ...	......	......	v. Hoff.
—— —— 31. 2 A.M.	Kingston in Jamaica ...	Two shocks	......	Accompanied by a noise like thunder. A furious hurricane raged during the whole night.	Mercure de France, *loc. cit.*; Mém. de l'Acad. de Dijon, *loc. cit.*
—— Aug. 7.	Comorn in Hungary ...	Two slight shocks ...	......	......	Mercure de France, 18 Sept.; Cotte.
—— —— 10. 11h 10m A.M.	In the Pyrenees, at Sta Marie in the Pays de Soule, and especially at Camon and Ogen.	One shock, apparently in the direction of the chain of the Pyrenees.	......	But little damage was done. On the side of Betharram and Lourde nothing was felt.	Palassou, *loc. cit.*
—— —— 14.	Langöre and Olavsvik in Iceland.	A vibratory shock lasting some minutes, and followed by 7 others of less violence the night after.	......	......	Mercure de France, 16 Oct., 27 Nov., 3 et 8 Janv. 1785; Voyage en Islande, *loc. cit.*; Hamb. Corresp. Nr. 152; Cotte.
—— —— 15. 4 P.M. (9 P.M. according to v. Hoff).	Ditto	Another shock, succeeded by more during the night.	......	......	Ditto.
—— —— 16. 2 P.M.	Ditto	Another shock of great violence.	......	Thirty large farms were ruined by these shocks. Bells rang of themselves.	Ditto.
—— —— 19.	In Calabria Ulteriore ...	A violent earthquake (the most so in this year). The earth remained in agitation a whole hour.	......	Clefts opened in the earth	Hamb. Corresp. Nr. 165.
—— —— 23.	At Betpouey near Barèges in the Pyrenees, and also, though slighter, at Barèges itself.	A slight vibration ...	......	......	Palassou, *loc. cit.*
—— —— 25.	Neumark. ("Does this refer to the Neumark near Zwickau, to that in Weimar, or to one of the two *Neumarkts* in Bavaria?")	Ditto	......	......	Cotte, *loc. cit.*

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

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MATHEMATICS AND PHYSICS.

Mathematics.

On the Expressions for the Quotients which appear in the application of Sturm's Method to the discovery of the Real Roots of an Equation. By J. J. Sylvester, *M.A., F.R.S., F.R.A.S.*

Many years ago I published expressions for the residues which appear in the application of the process of common measure to fx and $f'x$, and which constitute Sturm's auxiliary functions. These expressions are complete functions of the factors of fx and of differences of the roots of fx, and are therefore in effect functions of the factors exclusively, since the difference between any two roots may be expressed as the difference between two corresponding factors. Having found that in the practical applications of Sturm's theorem the quotients may be employed with advantage to replace the use of the residues, I have been led to consider their constitution; and having succeeded in expressing these quotients (which are of course linear functions of x) under a similar form to that of the residues, *i. e.* as complete functions of the factors and differences of the roots of fx, I have pleasure in submitting the result to the notice of the Mathematical Section of the British Association.

Let $h_1\, h_2\, h_3 \ldots\ldots h_n$ be the n roots of fx.

Let $\zeta(a\, b\, c \ldots l)$ in general denote the squared product of the differences of $a, b, c \ldots\ldots l$.

Let Z_i denote in general $\Sigma\zeta(h_{\theta_1}\, h_{\theta_2} \ldots\ldots h_{\theta_i})$, where $\theta_1, \theta_2, \ldots \theta_i$ indicate any combination of i out of the n quantities $a, b, c, \ldots l$, with the convention that $Z_0=1$, $Z_1=n$; and let (i) denote $\frac{1}{2}\{1+(-1)^i\}$, being zero when i is odd, and unity when i is even; then I find that the ith quotient Q_1 may be written under the form

$$Q_i={}_i\mathrm{P}_1^2\cdot(x-h_1)+{}_i\mathrm{P}_2^2(x-h_2)+\&c.\ldots\ldots+{}_i\mathrm{P}_n^2(x-h_n),$$

where in general

$${}_i\mathrm{P}_e=\frac{Z_{i-1}}{Z_i}\cdot\frac{Z_{i-3}^2}{Z_{i-2}^2}\cdot\frac{Z_{i-5}^2}{Z_{i-4}^2}\cdots\cdots\frac{Z_{(i)}^2}{Z_{(i)+1}^2}$$

$$\times\Sigma\{\zeta(h_{\theta_1}\, h_{\theta_2}\ldots\ldots h_{\theta_{i-1}})\times(h_e-h_{\theta_1})(h_e-h_{\theta_2})\ldots\ldots(h_e-h_{\theta_{i-1}})\}.$$

If we suppose $\frac{f'x}{fx}$, by means of the common measure process, to be expanded under the form of an improper continued fraction, the successive quotients will be the values of $Q_1\,Q_2 \dots\dots Q_n$ above found,

$$i.\,e.\ \frac{f'x}{fx}=\frac{1}{Q_1-}\,\frac{1}{Q_2-}\,\frac{1}{Q_3-}\dots\dots\frac{1}{Q_n}.$$

The successive convergents of this fraction will be

$$\frac{1}{Q_1};\quad \frac{Q_2}{Q_1Q_2-1};\quad \frac{Q_2Q_3-1}{Q_1Q_2Q_3-Q_1-Q_3};\quad \dots\dots;\quad \frac{f'x}{fx}.$$

The numerators and denominators of these convergents will consequently also be functions of the factors exclusively. They are the quantities the sum of the products of which multiplied respectively by fx and $f'x$ produce (to constant factors *près*) the residues. The denominators are expressible very simply in terms of the factors and the differences of the roots; and their values under such forms were published by me about the same time as the values of the residues in the Philosophical Magazine; the expression for the numerators is much more complicated, but is given in my paper, "The Syzygetic relations," &c., in the Philosophical Transactions.

By comparing the expression for any quotient with the expressions for the two residues from which it may be derived, we obtain the following remarkable identity:—

$$Z_{i-1}\times Z_i,\ i.\,e.\ \Sigma\zeta(h_1h_2\dots\dots h_{i-1})\times\Sigma\zeta(h_1h_2\dots\dots h_i)$$
$$={}_iP_1^2+{}_iP_2^2+{}_iP_3^2+\dots\dots+{}_iP_n.$$

When the roots are all real, we have thus the product of one sum of squares by the product of another sum of squares (the number in each sum depending upon the arbitrary quantity i), brought under the form of a sum of a constant number (n) of squares, which in itself is an interesting theorem.

The expression above given for Q_i leads to a remarkable relation between the quotients and convergents to $\frac{f'x}{fx}$.

Let it be supposed, as before, that

$$\frac{f'x}{fx}=\frac{1}{Q_1x-}\,\frac{1}{Q_2x-}\,\frac{1}{Q_3x-}\dots\dots\frac{1}{Q_n(x)},$$

and let the successive convergents to this continued fraction be

$$\frac{N_1(x)}{D_1(x)};\quad \frac{N_2(x)}{D_2(x)};\quad \frac{N_3(x)}{D_3(x)};\quad \dots\dots\frac{N_n(x)}{D_n(x)},$$

where the numerators and denominators are not supposed to undergo any reductions, but are retained in their crude forms as deduced from the law

$$N_i=Q_i\ N_{i-1}-N_{i-2},$$
$$D_i=Q_i\,.\,D_{i-1}-D_{i-2}.$$

$N_1(x)$ being 1, and $D_1(x)$ being $Q_1(x)$, then it may be deduced from the published results above adverted to that

$$D_i(x)=\frac{Z_{i-1}^2\ \ Z_{i-3}^2\dots\dots Z_{(i)}^2}{Z_i^2\ \cdot Z_{i-2}^2\dots\dots Z_{(i)+1}^2}\{\zeta(h_{\theta_1}h_{\theta_2}\dots h_{\theta_i})\,(x-h_{\theta_1})\,(x-h_{\theta_2})\dots(x-h_{\theta_i})\}.$$

Hence

$$\Sigma\{\zeta(h_{\theta_1}h_{\theta_2}\dots h_{\theta_{i-1}})\times(h_e-h_{\theta_1})\,(h_e-h_{\theta_2})\dots\dots(h_e-h_{\theta_{i-1}})\}$$
$$=\frac{Z_{i-1}^2\cdot Z_{i-3}^2\dots\dots Z_{(i-1)+1}^2}{Z_{i-2}^2\cdot Z_{i-4}^2\dots\dots Z_{(i-1)}^2}\,D_{i-1}(h_e);$$

and we have therefore

$${}_i P_e = \frac{Z^3_{i-1}}{Z_i} \cdot \frac{Z^4_{i-3}}{Z^4_{i-4}} \cdot \frac{Z^4_{i-5}}{Z^4_{i-6}} \cdots\cdots \frac{Z^4_{(i)}}{Z^4_{(i)+1}} D_{i-1}(h_e),$$

and consequently

$$Q_i = \frac{Z^6_{i-1}}{Z^2_i} \cdot \frac{Z^8_{i-3}}{Z^8_{i-4}} \cdots\cdots \frac{Z^8_{(i)}}{Z^8_{(i)+1}} \Sigma\{\left(D_{i-1}(h_e)\right)^2 \cdot (x-h_e)\},$$

which is the general equation connecting the form of each quotient with that of the denominator to the immediately preceding unreduced convergent in the expansion of $\frac{f'x}{fx}$ under the form of an improper continued fraction.

If instead of the denominator of the unreduced convergents, the denominators of the convergents reduced to their simplest forms be employed, the powers of Z in the constant factor will undergo a diminution. The essential part of this theorem admits of being stated in general terms as follows:—

"If the quotient of an algebraical function of x by its first differential coefficient be expressed under the form of a continued fraction whose successive partial quotients are linear functions of x, any one of these quotients may be found (to a constant factor *près*) by taking the sum of the products formed by multiplying each factor $(x-h)$ of the given function by the square of what the denominator of the immediately antecedent convergent fraction becomes after substituting in it for x the root corresponding to such factor."

P.S. Since the above was read before the British Association, the theory has been extended by the author to comprise the general case of the expansion of any two algebraical functions under the form of a continued fraction, and has been incorporated into the paper in the Philosophical Transactions above referred to.

LIGHT, HEAT, ELECTRICITY, MAGNETISM.

On the Production of Crystalline Structure in Crystallized Powders by Compression and Traction. By Sir DAVID BREWSTER, *K.H., D.C.L., F.R.S., & V.P.R.S. Edinb.*

The author had found that by pressing certain crystalline powders against slips of glass, sometimes smooth, sometimes roughened by grinding, with the clean broad blade of a knife or spatula, and drawing it along, he could give to the mass of powder thus treated the same polarizing action on light possessed by large crystals of the same kind; and which could be given to annealed glass and other non-crystalline substances by mechanical compression, but which they lost when relieved from the compressing force. The author then gave an enumeration of the crystalline powders in which he had succeeded by this compression and traction in producing this polarizing structure,—distinguishing those in which the glass over which they were so distributed required to be rough, from those in which it might be used smooth. He also enumerated the powders which he had tried, but in which he had not succeeded in producing the same effect.

On the Optical Phænomena and Crystallization of Tourmaline, Titanium, and Quartz within Mica, Amethyst, and Topaz. By Sir D. BREWSTER, *K.H., D.C.L., F.R.S., & V.P.R.S. Edinb.*

The author, after stating that crystals of titanium within quartz had been long known and attended to, drew attention to the fact that regular crystals of tourmaline, titanium and quartz had been discovered by him within mica, amethyst and topaz; that in some instances these crystals had been found grouped in very regular figures, and that the groups of crystals were sometimes distributed over what were obviously surfaces of inner crystalline forms of exactly the same shape as the entire crystal, from which the author drew inferences as to the original growing of the crystal. He also entered into an examination of some of the optical peculiarities of these crystals.

On the Angle to be given to Binocular Photographic Pictures for the Stereoscope. By A. Claudet, *F.R.S.*

Mr. Claudet's paper, which was illustrated by several stereoscopic Daguerreotype pictures, went to establish some rules for the angle at which the photographic pictures must be taken in order to produce, without exaggeration, the best effect of relief and distance. The angle depended on the size we wished to give to the model and the distance at which we were looking at it, so that pictures taken at the same angle might produce different effects of relief and distance if they were examined more or less amplified, and the converse might produce a contrary effect. To exemplify the relation between the stereoscopic effect and the dimensions of the image, Mr. Claudet observed, that when we look at objects with a double opera-glass, which magnifies say four times, we have four times less relief and less distance than when we look at them with the naked eye; and that when we turn the opera-glass, looking through the larger end, we diminish considerably the dimensions of objects and increase considerably the relief and distances. Mr. Claudet entered into some considerations of the principles of binocular vision, in order to explain the causes of perfect vision, with relief and solidity, which we obtain with two eyes. The photographic image being the representation of two different perspectives, we must, when we look at them in the stereoscope as we do in looking at the natural objects themselves, converge more or less the axis of the eye according to the plane on which the objects are represented or really situated. Therefore we make the same effort, and we have the same sensation, when we look at photographic pictures, as when we look at the objects represented. When we look at a single picture with two eyes, we have less relief and less distance than when we look at the same picture with one eye, because with one eye we have the natural effect we are accustomed to feel when we look at the natural objects with one eye, while, if we look at the single picture with two eyes, we have on the two retinæ the same image with the same perspective, which is not natural, and the eyes have not to make the usual effort for altering their convergence according to the plane on which the object observed is situated. This inaction in the convergence of the eyes destroys in some measure the illusion of the picture, because the same convergence for all the objects represented gives an idea that they are placed on the same plane. The angle of the two binocular photographic pictures may be larger than the natural angle of vision, if we suppose that the reduced model is examined at a small distance. If we have before us, at 2 or 3 feet, a model of our friends of the size they appear to be at 20 or 30 feet, we have a greater effect of relief than if we were looking at them at 20 or 30 feet, and this effect, instead of being a defect, is more artistic and satisfactory. We may reduce the model as much as we like, and look at it at the smallest distance possible; but in order to preserve the proper proportion between the stereoscopic effect of the nearest and furthest planes, we must take the photographic pictures with object-glasses having the longest focus possible. It is only when we employ, too, lenses of short focus that the stereoscopic effect is unnatural, being exaggerated for the more distant planes and reduced for the nearest.

On the Practice of the Daguerreotype. By A. Claudet, *F.R.S.*

This morning was devoted to Photography; the Section having requested Prof. R. Hunt and Mr. Claudet to arrange the means of exemplifying all the processes at present employed. By the aid of the local photographic artists, this was accomplished in as satisfactory a manner as the suddenness of the occasion would admit of. Mr. Hunt explained all the processes on paper and on glass, while Mr. Claudet exhibited the manipulatory details of the Daguerreotype. A great number of very beautiful specimens of the art were exhibited. Two views in particular, executed by Messrs. Ross and Thomson of Edinburgh, of an unusually large size, were most remarkable for the perfection of every part. There was not anything new given in the discoveries or elicited in the discussion which ensued, but from the crowded state of the Section, it appeared to excite much interest to the end.

On the Mixture of Homogeneous Colours. *By* Professor Helmholtz, *Königsberg.*

The author published a year ago experiments on the mixture of homogeneous coloured light, which seemed to prove that there are only two colours in the solar spectrum capable of being combined into white, namely, yellow and indigo. He has repeated these experiments, following another method, similar to that lately described by M. Foucault, for obtaining larger fields equally dyed with the mixture of two homogeneous colours, and has found that there are more pairs of complementary colours in the spectrum. These colours are situated at both ends of the spectrum,—on one side from red up to a yellow shade, a little greenish,—on the other side from violet up to a blue shade, also a little greenish. The shades, however, in the middle of the spectrum, in which the green preponderates, cannot give white with any other homogeneous colour. Their complement is purple, and must be compounded by violet and red. The complementary colour of red is greenish-blue,—of orange, sky-blue,—of yellow, indigo,—of greenish-yellow, violet.

The author found, moreover, that the complementary colours are arranged in the spectrum in a most irregular manner. As the breadth of the differently-coloured bands in prismatic spectra depends not only on the wave-length, but on the substance of the prism, he refers the following results to interferential spectra, where the distance of two colours is proportional to the difference of their respective wave-lengths. If you pass with an equal velocity through the different colours of such a spectrum, the shade is altered very slowly at both its extremities on the red and violet; but in those parts where the complements of red and violet are placed in the greenish-yellow and greenish-blue, the shade alters very rapidly, so that the distance of extreme red and golden-yellow is about ten times greater than the distance of their complementary colours, greenish-blue and sky-blue.

The author observed two circumstances in these experiments which had prevented him in his former experiments from finding other complementary colours than yellow and indigo. At first, according to the peculiar distribution of complementary shades in the spectrum, the said colours were able to give a larger white spot than the others. Secondly, it appeared to be very difficult to the human eye, which is not quite achromatical, to find and to keep the right focal length for objects illuminated by two kinds of homogeneous rays of very different refrangibility. Indigo and yellow are of less different refrangibility than any other pair of homogeneous complementary colours, and are therefore easily combined. Others, as red and greenish-blue, on the contrary, are united in the same field of the retina with great difficulty.

Finally, the author gave some remarks on the best method for bringing the whole variety of colours into a system. He stated that Newton's coloured disc appeared to be the most simple and complete manner. Some points, however, are to be changed. First, not only the seven principal colours of Newton must be arranged on the margin of the disc, but the whole infinite number of them existing in the spectrum, so that complementary colours are placed on the opposite ends of the same diameter. Secondly, the two ends of the spectrum cannot meet together, but must be separated by an interval, where the complementary colour of the green shades, namely purple, is to be intercalated. The commonly received theory of three principal colours includes a restriction of Newton's method, contradictory to the author's former experiments.

On the Distribution of Electrical Currents in the Rotating Disc of M. Arago. *By* Professor Matteucci, *Pisa.*

After the discovery of the induction between the electro-magnet and the closed conducting circuit, Faraday conceived the idea of applying the extremities of a galvanometer upon a disc of copper revolving in the neighbourhood of a magnet. In this way he found the electric currents, which were developed by the induction of the magnet, upon the disc, of which the points change successively according to the distance from the magnet; and, by having recourse to the law of electro-magnetism, he arrived at an explanation of the magnetism of rotation of M. Arago. The author, after giving some further historical details, proceeded to point out how perplexing were the phænomena arising from the abrupt and numerous changes of direction. He then proceeds to state his own conception of the subject, and to detail the experimental researches which he had founded upon them; draws general conclusions from the experiments; and has drawn up a simple and perspicuous diagram, indicating the poles of the magnet, the revolving disc, and the curves which show the neutral points upon the disc, and those indicating the directions of the tangential forces, or those giving to the disc the tendency to revolve, and all of which he finds to have a fixed relation to the position of the poles of the magnet and the velocity of the rotation. The memoir is to be published entire.

On the Magnetism of Rotation in Masses of Crystallized Bismuth. By Professor MATTEUCCI, *Pisa.*

The apparatus used by the author consisted of an electro-magnet caused to revolve by clockwork; and the body to be submitted to the action of the electro-magnet was suspended between its poles. Sometimes he suspended it by a fine silver wire, and determined the force of torsion, when equilibrium took place, the body being usually suspended in water to check its tendency to vibrate. Sometimes he used a single thread of cocoon silk, and the forces developed were measured by counting the number of uniform rotations which took place in a given time. The author first describes certain preliminary experiments which he made with this apparatus. He suspended solid spheres of copper, and hollow spheric shells, of exactly the same diameter, formed by the electro-plate process, between the revolving poles, and measured the force by torsion. With a full sphere weighing 59·80 gr., and a hollow one weighing 10·85 gr., he found the torsions in the proportion of 1 : 0·71. With spheres of a less size the differences were less than these. The author concludes from this that the internal shells of metal, on which the induced forces are less, serve to discharge the currents developed in the exterior shell; and that an analogous effect shows itself in many other cases of magnetism of rotation. The author also submitted to the same apparatus a cube, formed of very thin square laminæ of copper, insulated from each other by layers of varnish; when this cube was suspended a few centimetres above the electro-magnet, so as to have its constituent laminæ horizontal, it experienced no action from the magnet; but when its laminæ were vertical it received a very rapid motion of rotation; in this latter case the currents induced having the power to develope themselves freely, and circulate on each lamina, which cannot take place in the former case. In his experiments with crystallized bismuth compared with amorphous masses of the same substance, he found,—1. That the forces developed by the revolving electro-magnet are greater for the amorphous masses of bismuth than for the crystallized metal; 2. that the forces developed in the masses of crystallized bismuth are greater when the cleavages are disposed vertically and perpendicularly to the planes of the currents of the electro-magnet, than when these cleavages are placed horizontally.

On the Magnetism of Rotation developed in very small Insulated Metallic Particles. By Professor MATTEUCCI, *Pisa.*

On Magnetic Phænomena in Yorkshire. By JOHN PHILLIPS, *M.A., F.R.S., F.G.S.*

The author proposed, in this communication, to place on record some measures of the direction of magnetism in Yorkshire, and some inferences touching the relation of magnetism to the physical geography of the district. The magnetic *declination* from the true meridian is at this time about 24° to the W. of North at York, and is slowly diminishing. The magnetic inclination from the vertical, measured in the plane of the magnetic meridian, is now at York 70° 10′, and is diminishing about 2′·54 in a year. This result is obtained by comparing many careful observations between 1837 and 1853.

In tracing the lines of equal dip over the large area of Yorkshire, the author employed the results obtained at forty stations distributed over the whole, and he arranged these for a final conclusion in groups and lines related to the great natural features of the county. By the method of least squares it was found that the *Isoclinal* lines made with the meridian, on the average of the whole county, angles of 70° 31′ to the east of north; that the rate of maximum augmentation of dip was, on a line at right angles to this, ·553 parts of a minute of dip for one geographical mile. But on examining by the same method, or by a simple graphical process, the direction of these lines in different parts of the county, it was found that they were bent into large curves, so as to retire southward across the great vale of York, and to advance northward on the hilly regions to the west and east of this vale, but especially turning up northward in the country between Flamborough Head and the mouth of the Tees.

Besides other ways of viewing these phænomena, the author called attention to the probable effect of the *inclination of the strata*, which by varying the direction of maximum pressure, as in the case of anticlinals and synclinals, would necessarily affect by a similar variation the direction of the suspended needle; and he proposed as a new and curious question, the possibility of seeing, by help of the magnetic needle, through the parts of the crust of the earth near the surface, so as to trace the deep-seated axes and centres of movement, which by no other way could be made sensible to the geologist*.

On Magnetism. By Professor Plücker, *Bonn.*

By repeating Dr. Faraday's experiments on diamagnetism six years ago, I first observed that a piece of charcoal suspended between the two poles of a magnet was either repelled or attracted, according to the distance from the poles. The same day I observed the same phænomenon, when I substituted a prism of tourmaline for the piece of charcoal; but these phænomena, similar as they are in appearance, were produced by quite a different kind of magnetic action. I made a communication to the British Association, when I attended the Swansea meeting, on the particular action of a magnet on crystals, but I did not speak then on the other class of phænomena, the transition from magnetic attraction into diamagnetic repulsion, which takes place on mixed bodies when the power of the magnet increases. I had deduced from a long series of facts, that by increasing this power the action on diamagnetic bodies augments more rapidly than the action on magnetic ones. I believe it is a mathematical law, and being such a one, whatever may be its physical interpretation, is out of the reach of attack; but I had not the satisfaction to see it generally adopted, therefore I undertook last summer a new series of experiments, which will give, I think, to that law a more universal character and a more distinct description.

The experimental results I immediately obtained may be represented best by curves, giving for the different bodies I examined the law according to which the attraction produced by the electro-magnet varies with the intensity of the current made use of. If the induced magnetism were always in the same ratio as the inducing power, if there were no *resistance* against further magnetization either in the electro-magnet or in the body examined, that curve must be a parabola; on the contrary, if the body were *saturated* with magnetism, it would be a straight line. Now by examining different substances, I got curves passing through all intermediate steps from one limit to the other one. Nickel is nearly saturated when I make use of one single element of Grove; the hydrate of oxide of cobalt presents, under the same conditions, scarcely any resistance against magnetization. The resistance is also very small in oxygen; it is very small too in bismuth and phosphorus, the two diamagnetic bodies I examined, wherein the repulsion by the magnet is to be substituted for the attraction exerted on magnetic substances. Then comes oxide of nickel, oxide of iron, iron, cobalt, and at last nickel.

From the curves I have spoken of, we may deduce others giving the intensity

* In the discussion which followed, Prof. Plücker confirmed the truth of the supposition of Prof. Phillips, that such magnetic effects would follow from the varying direction of maximum pressure, but whether the effects would be sensible must be settled by experiment.

of the induced magnetism in the different substances for any inducing power of the electro-magnet. All these curves will be very nearly represented by the equation

$$\frac{M}{c} = \tan \frac{I}{k},$$

M being the power of the magnet, I the intensity of the induced magnetism, and k and c two constants varying from one substance to another. The curve will be transformed into a straight line parallel to the axis when the substance is saturated with magnetism; it will be an inclined straight line when there is no resistance against magnetization. Between these two straight lines are placed all our new curves.

The Professor deduced the following conclusions:—

1. For every substance, either magnetic or diamagnetic, there is a particular law, according to which the intensity of induced magnetism is determined by the inducing power.

2. There is for every substance a limit of magnetization, to which it approaches more or less rapidly by increasing the power of the electro-magnet.

3. The curves for diamagnetic bodies ascend very rapidly, much more rapidly than the curve for iron does. By means of these curves we may find in what proportion bismuth, for instance, is to be mixed with iron, so that the mixture may, by a given power of the magnet, be neither attracted nor repelled.

4. An eminent German philosopher explained all diamagnetic phænomena by admitting that there is in diamagnetic substances no resistance to magnetization; but his theory cannot hold, the curves for bismuth and phosphorus ascending more rapidly than the curves for most of the magnetic substances, but not so rapidly as the curves for oxygen and hydrate of oxide of cobalt. The Professor was much inclined to believe that all bodies retaining magnetism, as steel does, and, according to his experiments, also oxygen, oppose a very small resistance against magnetization. So may be explained in a more satisfactory way what has been improperly called "coercive force."

5. There is, generally speaking, no specific magnetism, as there is a specific weight, a specific heat. The specific magnetism varies with the power inducing it. Cobalt is more magnetic than iron when we make use of one of Grove's elements; but by giving to the current an intensity four times greater, the magnetism of cobalt becomes only $\frac{8}{10}$ths of that of iron. Let the magnetism of iron be one million; then by employing the stronger current and also the weaker one, the diamagnetism of the bismuth will be in the first case 39, in the second 23·6; while Professor Weber, making use of a much smaller inducing power, found only 10. So we may also, partly at least, explain why Edm. Becquerel gives for the magnetism of oxygen a number ten times less than Prof. Plücker found, while his number agrees pretty well with the approximate estimation of Dr. Faraday, who employed nearly the same inducing power as he did.

6. The Professor does not know what magnetism and diamagnetism are; but the curves for diamagnetic bodies being included on both sides by curves for magnetic substances, he thinks there is no difference at all between the magnetic and diamagnetic states of bodies, except that the conditions inducing these two states are opposite ones.

7. After having obtained his results, he was highly surprised by learning that a French philosopher, Lallemand, had deduced from experiment the law according to which the intensity of an induced current is dependent on the intensity of the inducing one. He found for this case exactly the same law that Prof. Plücker got for magnetic induction. Though we do not know what an electric current really is, by supposing that Lallemand's law and Plücker's are true laws of nature, not merely laws of approximation, we may conclude that magnetism and galvanism are one and the same agency of nature.

SPECIFIC MAGNETISM.

	Intensity of the current = 1.	Intensity of the current = 4.
Iron	1000000	1000000
Cobalt	1008900	912200
Nickel	465700	350900
Oxide of iron	758	954
Oxide of nickel	286	405
Hydrate of oxide of cobalt	2178	5015
Bismuth	23·6	39·03
Phosphorus	16·45	27·31

On a New Photometer. *By* ASTLEY PASTON PRICE, *Ph.D., F.C.S.*

The object sought in this modification of the Photometer is the combination of the two images usually obtained when estimating the difference of intensity between two sources of illumination, and by so doing facilitating the valuation of the difference betweeen the light to be determined and a recognized standard.

The Photometer is so constructed that the rays of light, after passing through orifices at either side of the instrument, impinge on two mirrors placed at an angle of 45°; by such an arrangement, when an observation is made the two images are united, which facilitates the comparison and permits the more easy approximation to neutrality.

The orifices may be of any desired form; those which have been adopted are either oblong apertures covered with tissue paper, placed, on the one side horizontally, and on the other perpendicularly, or two semicircular discs may be substituted; in the former case the two are united and crossed at right angles, and in the latter a circular disc is obtained. It is obvious that any design may be adopted, the object being that the resulting combination shall afford facility of comparison.

General View of an Oscillatory Theory of Light. *By* W. J. MACQUORN RANKINE, *C.E., F.R.S.S. Lond. and Edin.*

The author endeavours, while retaining the whole of the mathematical forms of the undulatory theory of light, to render the physical hypothesis which serves as its basis more consistent with itself and with the known properties of matter. Light, according to the undulatory theory in its most general sense, consists in the propagation of some species of motion amongst the particles of the luminiferous medium, the nature and magnitude of which motion are functions of the direction and length of certain lines transverse to the direction of propagation. According to the existing hypothesis of *vibrations*, this motion is a vibration of the atoms of the luminiferous medium in a plane transverse to the direction of propagation. In order to transmit motions of this kind, the parts of the luminiferous medium must resist compression and distortion, like those of an elastic solid body; its transverse elasticity being great enough to transmit one of the most powerful kinds of physical energy with a speed in comparison with which that of the swiftest planets of our system is appreciable, but no more, and its longitudinal elasticity immensely greater; both these elasticities being at the same time so weak as to offer no perceptible resistance to the motion of the planets and other visible bodies. The author considers that it is impossible to admit this hypothesis as a physical reality. He also points out the difficulties arising from certain inconsistencies in the present theory as to the relation of the direction of vibration in polarized light to the plane of polarization.

The author then proposes what he calls the *hypothesis of oscillations*, which consists mainly in conceiving that the luminiferous medium is composed of detached atoms or nuclei, distributed throughout all space, more or less loaded with atmopheres of ordinary matter, and endowed with a species of *polarity*, in virtue of which three orthogonal axes in each atom tend to place themselves parallel respectively to the three corresponding axes in every other atom; and that plane-polarized light consists in a small oscillatory movement of each atom round an axis transverse to the direction of propagation, and perpendicular to the plane of polarization. The square of the velocity of propagation of such a movement would be proportional directly to a coefficient depending on the rotative force, or polarity of the particles in a given space, and inversely to a coefficient denoting the sum of the moments of inertia of the luminiferous atoms in a given space, together with their loads of atmosphere, round the axes of oscillation. The author shows that it is necessary to suppose that the coefficient of polarity, for transverse axes of oscillation, is the same in all substances and for all directions; and that the variations in the velocity of light depend wholly on the variations of the moments of inertia of the luminiferous atoms, with their loads, in different substances and round different axes. The coefficient of polarity for longitudinal axes of oscillation must be supposed to be very great compared with that for transverse axes. How powerful soever the polarity may be which is here ascribed to the luminiferous atoms, it is a species of force which must necessarily be wholly destitute of effect in producing resistance to compression or distortion; so that it is no longer necessary to suppose the luminiferous medium to have the properties of an elastic solid.

The author deduces from this hypothesis the known mathematical laws of the wave-surface, of the intensity and phase of reflected and refracted light, and its plane, circular, and elliptic polarization, and of all other phænomena to which the existing theory has been applied, the equations being identical in form.

On the Composition and Figuring of the Specula of Reflecting Telescopes. By J. D. Sollitt, *Hull.*

The author of this paper was of opinion that all makers of reflecting telescopes cast their metals too low in tin. He thinks they ought to be made in proportion to the true atomic weights of the two metals, which would give 32 parts of copper to 17·4 of tin; and if this composition be found too difficult to work, it is easily reduced without injuring the colour of the metal by the addition of one or two parts of nickel. Such a composition he uses, and finds that the light reflected from it is perfectly white; and when the telescope is made, a *front view one,* very nearly equal in quantity to an achromatic of the same aperture. He further observed that the pores may be taken out of a composition containing them by the addition of *metallic arsenic,* he also repudiated the practice of fluxing the metal with the salts of potash or soda as being highly injurious. In polishing he uses extremely hard pitch, so hard that no impression can be made upon it with the edge of a knife; and the polishing powder (either putty or colcothar) he grinds very fine on a slab, and uses only a very small quantity, but works it down on the pitch for a very long time, and in order to obtain a very fine polish only puts the powder on the tool once. He prefers dividing the surface of the pitch by ten concentric circles, with six, eight, or ten radii, the radii being made gradually wider towards the edges of the tool; and for the size of the tool, to produce a true parabolic figure, adopts the following formulæ: Let $D =$ the diameter of the metal, $d =$ the diameter of the tool, and $F =$ the focal length of the metal; then, if worked with the metal below, $d = D - \frac{D}{F+D}$, or if the metal be above, $d = D + \frac{D}{F}$; in either case the metal will come off a true parabola, provided the pitch be of sufficient hardness and the powder worked down a sufficiently long time to produce a high polish.

Description of a Graphic Telescope. By Cornelius Varley.

The author drew attention to the imperfections and difficulties experienced in using the Camera Lucida, and then exhibited and described his instrument. The stand of it united great portability with complete steadiness; and the instrument itself, which had something of the appearance of a telescope, could be adjusted so as to focus the image exactly at the spot where the pencil was to delineate it, and the direct view of the point of the pencil easily caused to trace the picture to be drawn. The object-end also of the instrument could be turned round so as to place on the paper any portion of the landscape before the artist which he wished to delineate; or, if his object were to take the inside of a building, he could take the ceiling, or roof, floor, or any portion of the sides, at pleasure. The Graphic telescope can give images of every size useful to an artist, up to the largest panoroma; by this Mr. Horner traced the great panorama of London from the top of St. Paul's. The existence of this instrument caused the Colosseum to be built. Through this instrument original sketches may be printed from. By taking the flat speculum from the object-end the images will be given the reverse way, and thus suited to trace direct on stone.

Observations on the Density of Saturated Vapours and their Liquids at the Point of Transition. By J. J. Waterston.

The chief object of the author in these experimental researches was, to ascertain if the low density in saturated vapours holds good up to that point when, according to M. Cagniard de la Tour's interesting researches, the liquid condition seems to terminate suddenly. The observations were made on the same principle as those which were the means of detecting the general law of density, the details of which have been communicated to the Royal Society. The tubes used by the author were from 2 to 3 inches in length, filled with the same liquid in different proportions and sealed at the blowpipe. The author then described the method used in graduating them, and the simple graphic principle employed in calculating the density of the vapour and of the liquid; the same strictness not being required in these researches as in those detailed in the paper above referred to in which the strict method of computation is given. The author then described his mode of heating the tubes, which is by suspending them by a brass wire frame in a glass funnel about 3 feet long, 1 inch diameter, and $\frac{1}{12}$th of an inch thick, fixed vertically over an Argand cocoa-nut oil lamp. The brass wire frame being slipped with the tube into the top of the funnel, kept it in the middle of the current of heated air about 4 or 5 inches below the top of the funnel. The liquid volume in No. 1 tube being noted, the tube was taken out and the thermometer put exactly into its place. The mercury quickly rising, the temperature is noted after it had become steady. The thermometer being then removed, a second tube, No. 2, was slipped into the same place and its transition volume noted; then removed, and the thermometer substituted and noted as before. This was the general course of observations; when the temperature had to be carried above 600°, a funnel only 18 inches long was used. The state of the liquid in the tube was closely examined by means of a watchmaker's lens, and could at all times be seen distinctly by transmitted light. One set of tubes were of hard Bohemian glass, one-eighth of an inch bore and one-fiftieth of an inch thick. These sometimes burst when the pressure was calculated to be about 400 atmospheres, if the laws of density and pressure hold good at these extreme points. The force of the explosion was quite what might be anticipated: it was as if the liquid, which never exceeded three grains in weight, had been fulminating powder. The thick glass funnel was shattered into small fragments immediately opposite the tube. Other sets of tubes were of soft glass, one-twentieth of an inch thick and one-fifth or one-sixth of an inch bore. None of these burst; at a very high pressure one merely gave way, breaking across into three pieces as if cut by a file. The author then gave the details of his experiments in a tabulated form, each noting the low temperature and volume, the maximum volume and temperature, and the transition volume and temperature, with notes of the successive appearances noted in the liquid at its surface and in the vapour. The surface of the liquid at one stage always assumed a flat form, showing cessation of capillarity; often assumed a conoidal form, wasting at the apex; sometimes two surfaces showed themselves; the conversion currents seen clearly in the early stages often changing into zigzag motions of spherules of vapour at the transition point. In this way the author examined sulphuric æther, alcohol, sulphuret of carbon, distilled water, chloroform, dichloride of sulphur, anhydrous oil of turpentine, acetic acid, and sulphuric acid.

On a Law of Mutual Dependence between Temperature and Mechanical Force. By J. J. Waterston.

The author began by stating that the experiments performed by MM. Gay-Lussac and Wetter, and again by MM. Clément and Desormes, to discover the ratio of temperature evolved by a small compression of a volume of air to the diminution of temperature required to produce the same condensation under a constant pressure, although originally intended to supply the data required by La Place in his peculiar views on the transmission of sound, have also been employed with good effect in advancing the physics of gases with relation to temperature and mechanical force. The ratio is in fact approximately an initial or differential ratio, which affords the means of obtaining integrals that express simple laws of great importance. The experiments of MM. Clément and Desormes have shown that the value of the ratio is constant throughout a considerable range of temperature and density; and Mr. Ivory proved that it is constant under every change of density and temperature as long as the laws of Marriotte and of Dalton and Gay-Lussac are maintained, or the air-thermometer is an exact measure of heat (Phil. Mag., 1827). The mathematical reasoning is much simplified by reckoning all temperatures from the zero of gaseous tension. This zero by M. Rudberg's experiments, confirmed by Magnus and Regnault, is situated at minus 461° upon Fahrenheit's scale, or minus 273°·89 Cent. To save circumlocution, the author calls this the G temperature. This G temperature of a gas is a definite and essential quality belonging to it, to be classed with its density, volume and pressure. The author then proceeds to lay down the differential equations, simplify their expressions by the results of experiments, and state the final equations deduced by integration, from which he draws the following conclusions:—1. When air is compressed or dilated, the G temperature varies as the cube root of the density, and the tension as the fourth power of the G temperature or cube root of the fourth power of the density. 2. The mechanical force exerted by a given quantity of air while freely expanding from one density to another is proportional to the difference of the cube roots of these densities, or to the difference of their G temperatures, and the fall of temperature is proportional to the force expended. 3. The mechanical force exerted upon a given quantity of air while compressing it from one density to another is proportional to the difference of the cube roots of these densities, or to the difference of their G temperatures, and the rise of temperature is proportional to the force exerted. 4. The total force exerted by a volume of air while expanding to infinity is equal to its tension acting through three times its volume and the limit of its G temperature while thus expanding in zero, and the same reasoning applies to compression. 5. The total mechanical force exerted by a volume of air while expanding to infinity is proportional to its G temperature. 6. A given quantity of air while expanding under a constant pressure from one temperature to another exerts a mechanical force equivalent to one-third the difference of temperature, and the quantity of heat required to change the temperature of air under a constant pressure is four-thirds that required to effect the same change of temperature with a constant volume. Hence the author shows that 1 lb. raised through 600 feet is the mechanical equivalent of 1° of heat applied to 1 lb. of water; but if 0·267 be the specific heat of air under a constant pressure, 800 feet will be the number equivalent to 1° of heat, which is the number experimentally deduced by Mr. Joule. The author notes this as perhaps the simplest example of that correlation of natural forces brought to light by the elegant researches of Mr. Grove.

Astronomy, Sea Currents, Depth of Sea.

On the Currents of the Indian Seas. *By* George Buist, *D.C.L., F.R.S.*

Water in motion is found to exercise two classes of agencies on the surface of our globe:—first, a destroying one, levelling and throwing down continents and mountains, transferring them to the depths of the ocean, either to be raised gradually by those mysterious elevations now in operation or upheaved by violent cataclysms, such as seem so frequently to have burst asunder the crust of the earth; and second, a destroying and reconstructing agency as in the case of the Gulf-stream, redressing the equilibrium which it had just before disturbed—transferring the heat of the torrid zone to mitigate the rigour of the northern temperate and polar regions, and eating away the roots by which the icebergs would have remained for ever anchored, and so enabling them to transport themselves to cool the tepid waters of the tropical seas. With the first of these, which has been so fully treated of in the Geological Section, we at present have no concern; and it is to the second that attention is proposed to be directed. One cubic inch of water, when invested with a sufficiency of heat, will form one cubic foot of steam—the water before its evaporation, and the vapour which it forms, being exactly of the same temperature, though in reality, in the process of conversion, 1700 degrees of heat have been absorbed or carried away from the vicinage, and rendered latent or imperceptible; this heat is returned in a sensible and perceptible form the moment the vapour is converted once more into water. The general fact is the same in the case of vapour carried off by dry air at any temperature that may be imagined, for down far below the freezing-point evaporation proceeds uninterruptedly, or is raised into steam by artificial means. The air, heated and dried as it sweeps over the arid surface of the soil, drinks up by day myriads of tons of moisture from the sea, as much indeed as would, were no moisture restored to it, depress its whole surface at the rate of 4 feet annually over the surface of the globe. The quantity of heat thus converted from a sensible or perceptible to an insensible or latent state is almost incredible. The action equally goes on, and with the like results, over the surface of the earth as over that of the sea, where there is moisture to be withdrawn. But night and the seasons of the year come round and the surplus temperature thus withdrawn and stored away at the time it might have proved superfluous or inconvenient, is reserved, and rendered back as soon as it is required; and the cold of night and rigour of winter are modified by the heat given out at the point of condensation, by dew, rain, hail, and snow. There are, however, cases in which, were the process of evaporation to go on without interruption and without limit, that order and regularity might be disturbed, which it is the intention of the Creator, apparently for an indefinite time, to maintain, and in the arrangements for equalizing temperature the equilibrium of saltness be disturbed in certain portions of the sea, and that of moisture underground in the warmer regions of the earth.

Thirty-six years ago Sir John Leslie pointed out that the waters discharged by the rivers of southern Europe were not sufficient to supply the Mediterranean with store enough for vapour for the countries on its shores, and that the immense amount drawn off by the arid borders of Northern Africa, which from Alexandria westward supplied not a single rivulet, required to be provided for by an inward current from the outer ocean through the Straits of Gibraltar. Founding apparently on this, Sir Charles Lyell, in his geological work published in 1832, assumed the filling up of the Mediterranean with salt; and a doctrine about to be shown in conflict with a first law of hydrostatics which nothing can upset, is still retained amongst the dogmata of orthodox geology without anything whatever to support it. The error seems to have been fallen into from the assumption that the water at the surface of the sea would remain in its place exposed to the action of the sun until evaporated up to the point of saturation, and only begin to descend on being transformed into solid salt, in which condition it would remain of course accumulating in the recesses of the sea. In point of fact, however, the instant the upper stratum of a fluid becomes one atom lighter than that beneath, it inevitably begins to descend, all other portions following it according as additional gravity is acquired by them. So soon as this mass of brine grows high enough to run over the barrier of the inland sea, it must, as a matter of necessity, flow outwards to the external ocean, where no such brine existed, and mingled with the average of the sea. It is matter of easy demonstration, that without some such arrangement as this, the Red Sea must long ere now have been converted into one mass of salt; and its upper waters at all events, being, on the other hand, known in reality to differ at present but little in saltness from those of the southern ocean. Here we have salt water flowing in perpetually through the Straits of Babelmandeb to furnish supplies for a mass of vapour calculated, were the strait shut up, to lower the whole surface of the sea 8 feet annually, and even with the open strait, to add to its contents a proportionate quantity of salt. But an under-current of brine, which, from its gravity, seeks the bottom, flows out again to mingle with the waters of the great Arabian Sea, where, swept along by currents, and raised to the surface by tides and shoals, it is mingled by the waves through the other waters which yearly receive the enormous monsoon torrents the Concan and the Ghauts supply, becomes diluted to the proper strength of sea water, and rendered uniform in constitution, by the agitation of the storms which then prevail. Flowing back again from the coasts of India, where they are now in excess, to those of Africa, where they suffer from perpetual drainage, the same round of operations goes on continually; and the sea, with all its estuaries and its inlets, retains the same limit, and nearly the same constitution, for unnumbered ages. Capt. Haines, in his survey of the Arabian seas, describes the perplexing currents betwixt the Straits of Babelmandeb and Cape Aden; strong bands of inshore currents sixty miles in breadth or so running in one direction, while similar bands of an outward current run in the opposite direction; and currents similarly turbulent and irregular are found at the mouth of the Persian Gulf. Dr. Buist has no doubt that both may be explained on the principle so well laid down by Dr. Scoresby in reference to the Gulf-stream, where the tropical current running northward meets and intermingles with the polar one running southward. Speculating on these matters some years since, Mr. Maury, of the United States Observatory, had, from a totally different series of considerations, come to exactly the same conclusions as these Dr. Buist had arrived at. So eager was this distinguished observer to follow up the subject, that he afterwards offered a sum equivalent to 300*l*. annually for the collection of information at Bombay to enable him to construct for the Indian seas wind and current charts, similar to those he had constructed for the Northern Atlantic, and these, it is understood, are now in a state of great advancement. The money was respectfully declined; some Bombay merchants having undertaken to provide for his use, at their own charge, the information desired, conceiving that it was enough that British traders should receive from America a survey of the currents of the English seas in the East without at the same time accepting funds from a foreign state which the British Government had failed to provide. Such were looked on as the advantages likely to accrue from the labours of Mr. Maury, that an estimate was published, showing that, assuming the statement of the Royal Society to be correct, maps and sailing directions for the Eastern seas, such as had been provided for the Northern Atlantic, would save to the ports of Calcutta, Madras, and Bombay from a quarter to half a million annually in freights.

On Drawings of the Moon. *By* JAMES NASMYTH, *F.R.A.S.*

These magnificent drawings of the moon, three in number, were exhibited and described, in the absence of the author, by Prof. Phillips. The first was a drawing of the moon's visible surface 6 feet in diameter. The two others were drawings, on a larger scale, of two particular portions of the lunar mountains. They were executed in a very peculiar style, white on grey ground, with shadows, which conveyed a very clear conception of the relief and depressions of the several parts of the surface. Mr. Phillips described several of the ring mountains, mountain ranges, and other peculiarities of the surface as depicted upon them. In particular he drew attention to long narrow bright lines, like the meridional lines on a globe, which in some places were seen to stretch across a large portion of the disc. He stated the ingenious explanations of these features given at a former meeting by Mr. Nasmyth, and the experiment which he had devised to illustrate the cause and nature of them. Mr. Nasmyth held them to be fissures filled up by some very dense or highly reflective mineral substance which had been forced up from underneath the solid crust of the moon by the same agency which had produced the cracks or fissures as they were seen to traverse hill and valley, mountain and crater, in nearly unbroken lines, regardless of surface inequalities, which facts appeared to Mr. Nasmyth to justify and confirm his conclusions as to the nature and cause of these bright radiating lines. Professor Phillips stated that these lines were only seen when the light of the sun fell in particular angles upon them. If he were to offer a conjecture as to their origin, he would say that they originated in some peculiarity of the reflecting surface of the moon, by which the peculiarities of what lay below the surface were manifested.

On Photographs of the Moon. *By* JOHN PHILLIPS, *M.A., F.R.S., F.G.S.*

The fascinating processes of Photography can perhaps be hardly ever more usefully applied than in fixing on metal, paper, or glass pictures of objects which are known or supposed to be variable,—the law or rate of such variation being put as a problem to be determined. The moon, our friendly satellite, is exactly in the condition to require this kind of investigation; and if photography can ever succeed in portraying as much of the moon as the eye can see and discriminate, we shall be able to leave to future times monuments by which the secular changes of the moon's physical aspect may be determined. And if this be impracticable, if the utmost success of the photographer should only produce a picture of the larger features of the moon, this will be a gift of the highest value, since it will be a basis, an accurate and practical foundation for the minuter details, which, with such aid, the artist may confidently sketch.

When, therefore, at the Ipswich Meeting of the Association, the 2–3-inch Daguerreotype of the full moon, which had been taken by Professor Bond from the great Achromatic of Cambridge, U.S., was shown to astronomers, their gratification was extreme. Humboldt possesses one of these curious light-pictures of the moon, of 2 inches diameter, prepared by Mr. Whipple, of Boston, U.S., in which the so-called seas and annular mountains are clearly distinguished*.

The Committee, to whom the Association, at its Belfast Meeting, committed a Survey of the Physical Aspect of the Moon, were not negligent of this powerful aid to an accurate drawing. The great telescopes of Birr, which in regard to light, definition, and steadiness, offered the greatest temptations to this trial, were at the disposal of the Committee; and to them, and the genius of their noble owner, we must probably look for photographs of the moon on the largest scale, and with the deepest contrast of light and shade. But they are not yet mounted equatorially, and in the mean time I thought it useful to try the power of my own 6¼-inch achromatic, the work of our excellent artist Cooke, which is driven equatorially by very equable clock movement in the open air.

Before my attempt was made, some trials were made by Mr. De la Rue and others, but I am not able to say what is the value of their results.

Though prepared in some degree for this experiment in the commencement of this year (1853), it was not till the middle of July that I was able to submit an excited collodion surface to the concentrated rays of the moon. On the 15th and 18th of July, with my friend Mr. Bates, I obtained the pictures now presented for consideration. They prove beyond a doubt that the research is of a useful and practicable kind, and, if I mistake not, will be followed by far better things.

In the expectation that this will become a favourite object of inquiry among photographers, I solicit a few minutes' attention to some of the conditions of the problem, for, without a right notion of the thing to be done, much disappointment will attend the trials.

First, it must be remembered that, as moon-light is fully 100,000 times weaker than sun-light, and only appears to us bright in consequence of the general darkness around, photographs can only be taken *quickly* by very sensitive surfaces. The moon's image in the telescope has not, indeed, really more actinic effect on the silver surface than some of the duller terrestrial objects which are slowly depicted in the camera. On a highly sensitive collodion, the feeblest radiants operating for the shortest time produce SOME *effect*; but firm impressions can only be had by the integration of these differential quantities. In the telescope which I employ, with a sidereal focus of 11 feet, the moon's diameter, as traced on the collodion, is about 1¼ inch†; and the aperture being 6¼ inches, the light of the moon's image is augmented about 26 times as compared with the brightness of the object seen directly by the eye. The time required for this image to be firmly impressed does not exceed 5 minutes, when the moon has a maximum south declination, and an elevation of only 12°. I think it probable that when her declination is at a maximum to the north, and I employ the most sensitive collodion, she will draw her own likeness in my camera in 1 minute, with sufficient firmness for printing. ‡

* Kosmos, iii. part 2. 362.

† The moon's mean diameter being $\frac{1}{110}$th of her mean distance from the earth, the mean diameter of her image on my collodion plate would be 1·2 inch, but the actinic focus is on the outside of the focus for white light 0·75 inch.

§ Since this was written many trials have been made; the result being that a picture, 2 inches in diameter, may be taken by using the Huyghenian eye-piece in 30 seconds.

In the great mirror of Lord Rosse (6 feet in diameter), having a sidereal focus of 52 feet, I saw a moon-image, of extraordinary beauty, or rather magnificence, nearly 6 inches across. The light received on this image (supposing the loss by reflexion equal to that by refraction)* was $\frac{144}{24}$ of that on mine, so that the picture might probably be impressed on a collodion surface in one-fourth or even one-sixth of the time required on mine; or in the same time as on mine, it would give a twice magnified image ($\sqrt{4}$), viz. a moon 12 inches across. I confidently believe that the master of this mighty engine will make it do its work.

I now turn to a different view of the subject, which is, however, of fully equal importance; viz. the nature of the movement by which the telescope must be made to follow the moon. The clock now usually employed, with centrifugal balls, I find quite equal to follow star, sun, or moon, by an easy variation of its rate. The moon's motion in her orbit is variable, but not so much variable as to require in a few minutes any differential rating of the clock set by trial to her mean rate for the hour. It must, however, be accurately set to this rate, for, otherwise, in direct proportion to the magnifying power, will be the brush or indistinctness of every meridional outline, and the equatorial extension of every part of the picture by an angular quantity (m) expressing the clock error. The moon has never, at two succeeding moments of time, the *same declination*; and except about the epochs of greatest north and greatest south declination, her change of declination is sensible in a few minutes. Except at these times the change of her declination is sensible in the picture obtained by an exposure of even 5 minutes; as may be seen by the photograph of 15th July, where the north and south edges are brushed, and the craters appear elongated in a meridional direction, the western edge remaining quite sharp. This difficulty might be practically overcome by a piece of mechanism connected with the clock, giving to the telescope a slow motion in declination (+ or —) proportioned, in a given short time, nearly to the number of hours from the nearest epoch of greatest north or greatest south declination.

The image obtained by the photographer should not only be *perfect*, but must be taken on a surface quite fine and true, so as to bear magnifying by eye-glasses. In this particular, at present, only the silver-plate and the collodion film on glass have claims to approbation. I am not able to report at present the possession of such perfect images, as to bear any but very low magnifiers; but this imperfection of the images will probably diminish or vanish by further trials, or by the aid of more fortunate experimentalists.

Supposing our photographic power to be raised so much as to copy on silver, glass, or paper, all that the lens can show, what will be the picture presented under a magnifying eye-glass? Let us assume in the case of Lord Rosse's telescope, a first image of 12 inches in diameter, and that it will bear magnifying eight times. This will be equivalent to 96 inches diameter for the moon, and about $\frac{1}{22}$ of an inch for a mile. The physical maps of Yorkshire which I now exhibit in comparison are on nearly the same scale ($\frac{1}{24}$th of an inch to a mile), and if inspected at a distance of 10 inches will give a fair notion of the apparent magnitudes of objects on the moon on this condition, which nearly expresses a magnifying power of 1000. It is obvious therefore that by such means we may have a record of the moon's physical aspect under every phase of illumination, under every condition of libration, nearly as we should see her at a distance of 240 miles, undimmed by more than a few miles of the strata of the earth's atmosphere. We should see and measure on the glass or the metal, her mountains and valleys; her coasts and cliffs; her glens and precipices; her glacial moraines, escars and sand-banks; her craters of eruption, of upheaval, or explosion; her lava streams, and the scattered heaps projected from the interior. We should spy out the various actinic powers of the different parts of the surface, compare these with their obvious reflective powers, and thus come to

* The loss of *illuminating power* is greatest by reflexion; but there is no course of experiments known to me from which it can be determined what is the proportionate loss of *photographic power* in reflectors and refractors. It seems probable that reflectors should be more efficacious than achromatics, which are suited, as mine is, to astronomical observation.

some reasonable conjectures on the mysterious light streaks which radiate from some of her mountains.

To what degree of minuteness shall we see the objects? This question has not been much considered with reference to photography, or the kind of objects which the moon exhibits. If we assume that one minute of angle is a good general measure for the *visibility* of areas presented to the eye, and therefore that areas are *visible* at a distance about 3000 or 4000 times as great as their diameters, an area on the moon, 70 miles across, can be *seen* by the naked eye; magnifying this 1000 times, we may *see* an area on the moon $\frac{70}{1000}$ of a mile across, or 370 feet. But though a spot of such dimensions can be *seen*, it cannot be defined under such a power as square, circular, elliptical, or triangular.

To be thus clearly defined, so as to be positively drawn or described, its diameter must be such as to subtend nearly 3′ of angle; so that to be clearly defined to the naked eye, black spots on a white ground must have a diameter of about $\frac{1}{1200}$ of radius$=$200 miles, and under the magnifying power of 1000, $\frac{200}{1000}=\frac{1}{5}$ of a mile $=$1056 feet.

But this calculation applies to black spots not greatly varying in their diameters. We have on the moon many cases of entirely different figures, arched, or triangular shadows, long streams of light, and long stripes of darkness. I was much impressed while at Parsonstown with the minuteness of some of the 'rillen,' as the Germans call the narrow deep often winding clefts, such as those about Aristarchus, and the much finer ones on the north-east of the Mare Humorum, of which I have made drawings. On returning home, I made some trials of the visibility of narrow spaces, as compared with square areas of the same breadth. The results, which are of a kind to encourage greatly our surveys of the moon, appear in the subjoined table, and indicate that black narrow spaces not exceeding 12 feet in width, are within the *magnifying power* of the great Rossian reflector. To what extent the *photographic power* of the instrument is competent to *define* such shadows, or the mechanism which must be employed to *follow them* exactly, are points for experiment to settle. As far as the eye is concerned, Lord Rosse's mirror has light enough for such a power, but the eye is more sensitive than collodion.

Description of black area on white ground.	At how many diameters' distance it was visible to the eye.	At how many diameters it was defined by the eye.
1. Square, one inch	3000	1200
2. Square, half inch	3840	1200
3. Square, quarter inch	4560	1200
4. Long space, one inch across	....	Above 3000
5. Long space, three quarters of inch across	....	Above 4000, seen as long narrow spaces.
6. Long space, half of inch	....	Above 6000, beyond the limit of my measured ground.
7. Long space, quarter of inch across	....	12,000
8. Long space, eighth of inch	....	15,320
9. Long space, thirtieth of inch	....	35,000

Hence it appears that *linear spaces* may be noted as such to three, five, ten, and even thirty times the minuteness with which *spots* can be well defined. The distinctness of very narrow 'rillen' is thus accounted for, but at the same time it appears that the breadth they seem to bear is merely the 'optical,' not the 'physical' breadth. If we apply the last measure to the moon, we find that very narrow and very dark spaces ('lines' in ordinary language), less than seven miles across, on the moon, would be visible to the eye, through a really 'clear' atmosphere. By applying to a small portion of the moon, Mr. Dawe's process of scrutiny by small apertures, and a power of 1000, black bands 12 yards across might be seen, and if a power of 3000 could under such conditions be effective, 12 feet bands might be visible. How much of this the really 'unclear' condition of our atmosphere will allow to be realized, remains to be determined by experiment.

On the Surface Temperature and Great Currents of the North Atlantic and Northern Oceans. *By* the Rev. WILLIAM SCORESBY, *D.D., F.R.S. L. & E., Cor. Mem. of Institute of France, &c.*

The currents of the ocean, exerting as they do so great an influence on the condition of the air, the earth, and of the sea itself, constitute a subject of very important consideration in physical geography, and, indeed, in general science; and they are specially interesting as a compensating instrumentality against the extremes of condition to which the fervid action of the sun in the tropics, and its oblique and inferior action in the polar regions, tend,—an instrumentality serving not only to moderate the extremes of temperature, but to render the general surface of the earth more favourable for the comfort and benefit of its inhabitants.

Our knowledge of the great currents of the ocean has hitherto been mainly derived from the observations of navigators on the differences found betwixt the ship's actual position during the voyage, as determined by celestial observations, and that of the daily reckoning from the course steered and distance run. The results of observations of this nature, extensively collected and collated, are found in the labours of Major Rennell, Lieutenant Maury of the United States Navy, Mr. Findlay, &c.

Dr. Scoresby then noticed the errors to which this mode of investigation is ordinarily subject from defects in the log, compass action, and steerage of the ship—all of which are liable to render the determinations uncertain unless where numerous observations are found accordant, or those in different voyages made mutually corrective.

The process he had used, affording data for the present paper, consisted mainly in the observing, during the progress of the ship, of the differences occurring in the surface temperature of the ocean, which in many cases were such as to give unquestionable indications of currents coming from different regions, though not generally serving to determine the exact direction or velocity.

His observations would refer, in the first instance, to *the currents of the North Atlantic*, as indicated by thermometric changes and peculiarities within a belt of ocean about 220 miles in average width, extending in a W. by S. direction from the entrance of the English Channel to Long Island, proximate to New York.

Four transatlantic passages made by himself, with numerous voyages by Captain Jos. Delano, a scientific American and excellent observer, who had furnished him with the results of many of his researches, had supplied the materials for the present determinations. These materials, extending to about 1400 observations (usually taken six times a day) on the temperature of the sea, being placed on a chart along with the projection of the ship's track on each voyage, were then tabulated, and the leading indications finally represented in a diagram (Plate I.) before the Section.

Of thirteen passages tabulated, seven were made in the spring of the year, two in summer, one in autumn, and three in winter. Taking the middle day of each passage, the *mean day* at sea was found to be May 18–19, a day fortunately coincident, with singular nearness, with the probable time of the mean oceanic temperature.

The results indeed thus derived could not be considered as complete, nor the normals of surface temperature in the different sections of the route conclusive; yet they exhibited, in certain particulars, facts of considerable interest and importance.

The mean surface temperature of the whole range of observations was 56°, the mean temperature of the air in the same passages (the result of 1000 to 1500 observations) being 54°·2, indicating the prevalently received fact of the general superiority of the temperature of the sea over that of the atmosphere.

Though the observations were not sufficient for conclusive determinations of the effects of *latitude* and *season* on the surface temperature, yet they obviously yielded something sufficiently proximate to be not unworthy of notice, especially for the early part of the passage westward, from longitude 12° to 36° W., and latitude 50° to 46°. And within this limited range, the observations under discussion seemed, in respect of *latitude*, to indicate an *increase* of the surface temperature, steering W. by S. from the English Channel, of about three-quarters of a degree for each degree of latitude southward in *winter*, and a change of about a degree of surface temperature for each degree of latitude in *summer*.

In regard to the effects of *season* (taking the average) within the same portion of the transatlantic passage, there appears to be a *range* of 9° or 10°; the highest being about 61° in July and August, and the lowest 51° to 52° in January and February. The analyses of the observations on the various passages yielded, as to changes in the surface temperature, betwixt 12° and 30° W., something like the following series:—

Jan.	52°	Feb.	52°	March	52°·8
April	53·8	May	56	June	59
July	61	August	61	Sept.	60
Oct.	59	Nov.	55	Dec.	53

The atmospheric changes for the same range of ocean may thus, perhaps, be proximately represented:—

Jan.	43°	Feb.	45°·5	March	47°·5
April	51	May	56	June	59·5
July	63	August	61	Sept.	58
Oct.	54	Nov.	50	Dec.	45·5

In specifying the general results of all the observations on the oceanic temperature, we find the first and leading fact to be, a division of the transatlantic belt into two characteristic portions of nearly equal extent, differing, in a striking and singular manner, both in their ordinary temperatures, their extremes, and their changes.

Thus for nearly half the passage across from England, that is, as far as longitude 38° W., in a W. by S. direction, the surface temperature was not found to descend below 50° even in the winter passages, nor to rise in any part of the year (as far as the observations go) higher than 66°. But on reaching 42° W. a temperature of 44° was met with, and at 48° to 50° W. longitude a minimum of 32° was not uncommon, with a maximum sometimes reaching to 69°. Further west, in 58° to 60° longitude (the mean latitude being about 42° N.), along with a minimum temperature ranging from 32° to 42°, a maximum was found as high as 74°. From this meridian to 72° W. similar differences of temperature, except near the American coast, were found to be prevalent.

In regard to mean differences of the extremes of temperature, taking the averages of all the observations within meridians of 2° in width, the results are still more striking; for in the first half of the passage, going westward, we find a *mean range* of surface temperature, for each 2° of longitude, of only 11°·3; whilst in the western half the mean range extends to 29°·7. Within the first half, too, where the *extremes* of temperature of the whole section were found to differ only 19°, the difference betwixt the highest and lowest temperature observed in the second or westerly half, reached to 42°.

This diversity of temperature clearly pointed out the two great and well-known oceanic currents—one from the tropics, the other from the Polar regions—meeting, coalescing, and interlacing within the range of the belt of waters referred to; the former current yielding an occasional warmth of 20° to 22° above the mean atmospheric temperature, and the latter a frequent cold as much below it.

But the phænomena may be rendered more intelligible and instructive if we note the appearance and trace the progress of the more marked alternations in sailing from the English Channel westward; say from longitude 12° W., in the mean latitude of 50° N., to that of 72° W., in the 41st parallel. This belt, extending to 60° of longitude, may be conveniently taken in six decimate sections, as represented in Plate I., several of which, it will be seen, afford peculiar and characteristic differences.

The first *three* of these decimate sections exhibit, for the most part, a striking uniformity of character; for as far, at least, as longitude 38° W. no particular in the differences of surface temperature strikes us, except a gradual rising of the means, within two degrees' space, from 52°·9 to 58°·7, during a descent in the mean latitude from 50° to 46° N. But in longitude 38° to 42° W. the range of oceanic temperature obtains the first marked increase, indicative of a slight action of a current from the southward.

In the *fourth* decimate section, 42° to 52° W., however, the indications respectively of the two great currents of the North Atlantic become striking and characteristic. Beyond the meridian of 42°, where the cold current from the north becomes first decided, an increase of its prevalency, gradually becoming more and more conspicuous, is observed. Thus in the two degrees' space, from 42° to 44° W., the somewhat low temperature of 44° was only observed in *one* out of *thirteen* passages; but in the next two degrees a like moderate fall of temperature (about 7° below the mean) occurred in *three* or *four* of the passages; in the next meridional stripe, cold water was met with in *eight* of the passages (four or five falling from 10° to 16° below the mean); in the next, the cold water occurred in *nine* or *ten* passages (six falling 10° to 24° below the mean); in the next stripe, longitude 50° to 52° W., the cold water was met with in *eight* passages (five falling 12° to 22° below the mean).

Within the same section, 42° to 52° W., very perceptible marks of an ascending *tropical current* occurred, yielding, in alternations with the cold water from the north, an occasional warmth of 66° to 68°. The prevalency, however, of the occurrence of warm water in this position of the Atlantic appears from the observations tabulated to be in reverse order (when sailing westward from longitude 42°) to that of the cold current; the first two-degree stripe presenting a rise of from 63° to 68° in six passages; the next, a rise of similar extent in five; the next, a smaller rise in four; the next, less marked in three; and the last, 50° to 52° W., in four, but still less marked. Hence from these observations it appeared, that the *greatest prevalence* of the *polar* currents (betwixt 42° and 52° W.) is within the meridians of 46° and 52°, and of the *warmer* current in 42° to 46° W.

It is within this meridional section mainly, corresponding in its central part with the eastern edge of the great bank of Newfoundland, in which the icebergs and drift ice from the north are usually met with; so that the prevalence of a descending polar current obtains actual demonstration.

The *fifth* decimate section, reaching from 52° to 62° W., is found to be equally characterized by peculiar phænomena as the one preceding it. The general prevalence of the *descending polar current* is shown by the *minimum* temperature of each meridional space of 2°, ranging betwixt 32° and 42°, with a mean of the five minima of 37°·2. The prevalence of an *ascending current* from south-westward is, in like manner, shown by the occurrence of a *maximum* surface temperature ranging betwixt 63° and 74°, with a mean of the five maxima of 68°·9.

But the characteristic features of this fifth decimate section were found to consist *in the suddenness of the changes of the surface temperature and the various alternations, indicative of singular interlacings of warm and cold water.*

In a passage in the "Patrick Henry" in May 1844, made by Dr. Scoresby, these sudden and alternating changes were remarkably prevalent. Thus when in longitude 57° 0′ W. (lat. 41° 31′ N.) the surface temperature, at 8 A.M. of May 17th, was found to be 60°·5; but after sailing W.N.W. (true) 10 miles, it was found to be 50°, and at noon 16 miles further on the same course 46°. At 2 P.M. of the same day, longitude 57° 55′ W., the sea was still at 46°; but at 4 P.M., after 15 miles' sailing W.N.W., it had risen to 57°, and in 15 miles further in the same direction it was found to have fallen to 42°! The next day, May 18th, presented further remarkable changes. At 8 A.M., longitude 59° 52′ (latitude 42° 8′ N.), the surface temperature was 46°; but at 10 A.M., 15 miles W. ½ S., it had risen to 61°, a change of 15° in two hours! At midnight, again, of the 19th–20th the sea was at 50°; four hours afterwards, 26 miles to the S.W. by W., it was 63°.

Within this decimate section the cold or polar current was found to be chiefly prevalent in the first and last of the two-degree spaces, but the most so in the last, that is, in longitude 60° to 62° W.; and the most prevalent examples of the Gulf-stream appeared within the meridians of 58° and 62° W.

The sixth and last section of the belt of waters traversed in the transatlantic passages under discussion, is found to be characterized, especially within the three westernmost spaces, 66° to 72° W., by *a singular depression of the surface temperature generally*, the mean temperature of all the observations registered on the chart being 49°·4, and of the last three stripes 46°·7. As some of the voyages, however, here failed, the mean of the registered observations may be a little too low; but the obvious deduction nevertheless remains untouched, of the descent of a polar current *within* the tract of the Gulf-stream by the coasts of New England.

The relations of the Polar current and Gulf-stream, as thus indicated by the analyses of thirteen transatlantic passages generally, change, it should be observed, materially with the *seasons* of the year. Thus the descending Polar current, which appears so prevalent within the western half of the belt of waters referred to in the discussion of the *whole* of the voyages, is found to be of comparative small importance in the summer and autumn passages, whilst the Gulf-stream is then the most predominant. Hence the shifting of the upper margin of the Gulf-stream northward at these seasons, as popularly understood, obtains very decided confirmation.

In the results thus derived from the discussion of original observations on surface temperature of the North Atlantic, there will be found a *general* agreement with the conclusions of many other observers; but these now communicated, it is presumed, will be found of some importance as to the specific information yielded in respect of the belt of waters referred to. The indications, too, of a variety of effects from the meeting of contrary currents, are perhaps as conclusive as they are in some respects remarkable; for from the results now obtained, taken in connexion with a few auxiliary facts, we may safely infer the following varieties of operation derived from the meeting of the polar and tropical currents within the track discussed:—

1. *Strata Currents,* consisting of a continuance of the respective currents after meeting in or near their original direction, by the overlaying of the denser waters from the North by the warm water of the Florida stream. Of this characteristic we have the most striking evidence in the observations of the Coast Survey of the United States, by intersections of the Gulf-stream. Thus in tracks across the stream having a general surface temperature of 80° to 82°, a depression of 10° to 15° was usually found at depths not exceeding 120 fathoms; of 20° to 25° at depths short of 500 fathoms; and in cases of 700 fathoms and upwards, a reduction sometimes of about 40° below the surface temperature! So that the existence of *strata currents* in this region of research—the Gulf-stream flowing above and the polar current below—seems to be unquestionable.

2. *Interlacing Currents*—where the polar and tropical currents on meeting seem to run past each other in repeated alternations of comparatively small breadth, in the manner of the fingers with the clasped hands—were strikingly shown in the rapid and great changes of the surface temperature within the fifth decimate section; and there is reason to believe that in these interlacings the edges of the respective waters flowed past each other with little intermingling, as if guided by walls in separate channels.

3. *Deflected Currents*—where currents on meeting from different but not exactly opposite quarters, as, for instance, from the S.W. and N.—are partially or mutually deflected into an easterly direction, so as to give rise to certain branches falling, as to one, on the southern coasts of Europe, and, as to the other, on the Norway and Spitzbergen shores. This species of mutual action in dense streams of water may find familiar illustration in places where the ebb-stream from a river falls into the tide-stream of the coast—the former pushing away the other, and each for a time pursuing a separate deflected course, with but little apparent intermingling.

4. *Passing Currents*—where they run in parallel but opposite courses, and over separate ground—as in the distinctive Gulf-stream, in its general body, and the *inshore* polar current running within it over the St. George's and other American banks. Of the distinctiveness of the inshore polar current, Dr. Scoresby adduced this very striking evidence,—1st, that in observations on the temperature at the surface and bottom on the St. George's Bank made on one of his voyages, the surface temperature was, with trifling difference, maintained below: thus in latitude 40° 43′, longitude 68° 35′, the surface and the bottom, in 35 fathoms water, were both (May 22) at the temperature of 46°; and nearer the shore, in 69° 39′ W., when the surface was at 47°, the bottom in 39 fathoms was at 45°; and 2ndly, that the New England and New York pilots remark, in regard to an inshore current guided by the direction of the wind, that the current running south-westerly under a north-easterly gale is much stronger than the contrary current urged by a south-westerly gale.

In regard to the surface temperature and great currents of the *Northern Ocean,* Dr. Scoresby could on this occasion only briefly touch. The discovery, in personal researches near the western coast of Spitzbergen, of comparatively warm water, increasing in warmth with the depth, he had long ago set forth, in the 'Account of the Arctic Regions,' as an indication of the extension of a branch of the *Gulf-stream* into the Icy Seas of Greenland; whilst the descent of a *polar current*, as indicated by the general set to the south-westward of the Greenland ices, had in the same work been amply proved and illustrated. This south-westerly drift from the east side of Greenland, associated with the southerly set out of Baffin's Bay, sufficiently explained both the cold surface temperature met with in the researches of the present paper, and the occurrence so prevalently of icebergs and drift ice in and near the meridians embraced by the banks of Newfoundland. And it might be reasonably inferred, perhaps, that both the position of these banks and the characteristic differences of the currents within the fifth and sixth decimate sections, so fully discussed, would have their true explanation in the consideration of the polar currents descending in two branches—the main one by the east coast of Newfoundland, the westerly and smaller one by the Strait of Belleisle.

Connected with this subject, it is very interesting to trace *the œconomy and beneficial effects*, as in many respects most obviously elicited, of the currents of the ocean. For here we find, as in all the Creator's works, the striking marks of benevolent design in the ordering and controling of the most subtle, or apparently vaguely acting agencies, to the benefit of the earth and its inhabitants. Of such indications may be noticed:—

1. The grand œconomy of oceanic currents in their equalizing tendency on the extreme temperatures of the different regions of the globe, from which the climate of the British Islands, for example, notwithstanding some minor disadvantages, derives such marked benefit in the diminishing of the range of temperature.

2. The maintaining, by the reciprocating currents, of the equable saltness of the ocean, and so preventing the differences in evaporation from the surface in the tropical and polar regions from destroying the characteristic quality of the *salt sea*.

3. The production by current eddies of sand-banks, favourable for the habitation of fishes, of which the banks of Newfoundland may be pointed to as characteristic examples.

4. The mingling of the waters of all regions of the globe, and the manuring, as it were, with fresh soil, of the great pastures of the creatures inhabiting the ocean.

5. The carrying away of large portions of the ice-formations of the higher latitudes for dissolution in a warmer climate, thus preventing the entire polar regions being filled with ice, and that ice being gradually pushed forward and maintained by its direct action on climate, which so might have rendered large portions of the now *temperate* zones uninhabitable or unsuitable for man.

6. And, in order to the due operation of counter and reciprocating currents betwixt the equatorial and polar regions, we must not overlook the œconomic design obvious in the distribution and configuration of the *continents* of the eastern and western hemispheres, betwixt which we find two great meridional channels permitting a free circulation of waters betwixt the two continents on opposite sides of the globe, and running, not improbably, from pole to pole!

On Deep-Sea Soundings and Errors therein from Strata-Currents, with Suggestions for their investigation. By the Rev. W. Scoresby, *D.D., F.R.S., Corresp. Institute of France, &c.*

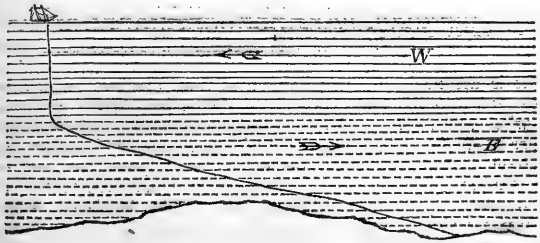
No long time has elapsed since the notion was very prevalent among seamen, that it was impossible to sound the ocean beyond the depth of a very few hundreds of fathoms. It was imagined that in water exerting a superincumbent pressure on the plummet greater than the weight of metal, no sounding-lead would sink; a curious notion, which could not have been otherwise than a delusion, unless the water of the sea had been indefinitely compressible, so as to have become of equal density, at least, with that of the metal of the plummet.

There is a difficulty, however, though of a very different nature from that just noticed, in respect to the obtaining of correct information in very deep soundings, which seems, from the confidence given to recent experiments, to have been altogether overlooked. To this difficulty, and the errors likely to be produced thereby on the determination of depths, it was one of the objects of the author of this communication to elucidate and establish.

He did not refer, however, to cases where the depths were not very profound, or where the time occupied by the descent of the plummet was inconsiderable; for he, Dr. Scoresby, had frequently reached depths of near a mile, or even more than a mile, in the Greenland Seas—at a period when such soundings were novel or unprecedented—with results, owing to peculiar and favouring circumstances, he believed, perfectly satisfactory. But far otherwise than satisfactory, as he expected to be able to show, must be some of those extraordinary soundings of recent years, in which depths of five, six, or nearly eight miles were supposed to be established.

If the sea were a stationary body, or if its currents were uniform movements of the entire mass of waters from the surface to the bottom, then the plummet might be fairly expected to take a direct and perpendicular course downward, so that the length of line run out would be the accurate measure of the depth sounded. But if in the place or region of sounding, strata-currents, so prevalent in the Main Ocean, should be running in different directions; or, what would have the same effect, if one stratum of water, say a superficial stratum, should be at motion and the main body below at rest, no correct results could be derived from the experiments referred to, where the time occupied in the running out of the line extended, in some of the more interesting cases, to many hours.

Under such circumstances, during the passage of the plummet through strata-



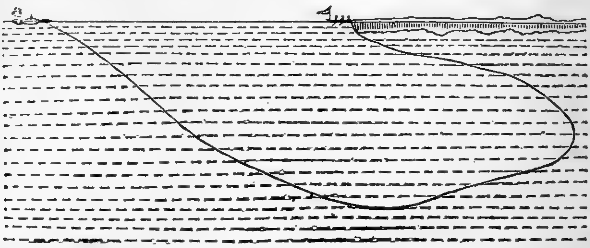
currents, the line, it must be obvious, would be carried away in its different portions by the movements of the water, for which the tendency to assume a perpendicular position below the point of surface-suspension could afford no adequate corrective.

Thus suppose the surface-stratum, W, to be running westerly, and the lower stratum, E, easterly (or at rest) with a difference of velocity of two miles an hour. The descent through the first portion, where the vessel would participate in the action of the current, might be quite perpendicular; but on the entering of the plummet into the lower stratum, the lead and line would be carried, or, in relation to the surface position, appear to be carried eastward, at the rate of two miles in the hour. Hence in the case of the experiments of Captain Denham, where the descent in the last four miles required above an hour and a half of time per mile, the plummet might be carried some miles away from the perpendicular, so as to occasion a very large error in the depth apparently determined. In respect to Captain Denham's deep-sea soundings, indeed, the error assumed is but conjectural, depending on the circumstance of the actual existence in the place of experiment—latitude 36° 49′ S., longitude 37° 6′ W.—of strata-currents. But in some of the deep soundings attempted in the Gulf-stream, where, in the difference of the temperature above and below (some 46°), we have conclusive evidence of strata-currents, the determinations must, it is to be believed, have been more or less inaccurate, probably greatly erroneous.

In regard to the proportion of error—being without data both as to the flow of the different currents, and the measure of resistance, under the circumstances, afforded by the water to the attainment of a perpendicular position by the plummet—no satisfactory estimate can be offered; but that a considerable resistance would be presented against the corrective tendency of the plummet, so that the line, however thin, would be greatly carried away, evidence from analogous facts may be satisfactorily adduced.

Thus, the manner in which the deep-sea lead is carried away, and the determinations rendered uncertain, when soundings are attempted in depths only of 50 to 100 fathoms, from a ship having but very little headway, might alone justify the asserted grounds of probable error on the deep-sea soundings referred to.

But further evidence of resistance in water, against the assuming of a straight position of a rope or line, under tension, where it may have been previously thrown into a curve, may be derived from some striking facts in the author's personal experience whilst engaged in the Northern Whale Fishery. Let the annexed diagram be supposed to represent one of these characteristic cases, where a boat is seen with its bow in contact with a large field of ice.



A whale, it is assumed, has been harpooned from this boat, which, as in such circumstances generally happens, retreats for shelter beneath the ice-field, drawing out the line with great force after it. Having pursued its original course beneath for a distance probably of a mile, the necessity for respiration induces its return. Its probable course may be shown by the line in the diagram, one end of it being attached to the boat, and the other, by means of a harpoon, to the whale here represented as having risen to the surface *astern* of the fast-boat. A few minutes previous, perhaps, to the reappearance of the whale, the line attached to the boat, which might have been for some time in a state of quiet or unaltered tension, is, by a second effort of the entangled animal, powerfully withdrawn, so that the boat may be pressed against the ice, as at first, with a force, possibly, equivalent to that of a ton weight! Yet, in this case, whilst the direction of the action on the boat is *ahead*, say, northward, the actual place of the whale exerting this singular energy, may be *astern*, or southward, the resistance of the water on the line preventing its taking a straight direction, and causing it to sweep round a body of water in a circuit, something after the manner of resistance of a more solid material.

Observing this curious fact whilst he, the author of the communication, in very early life occupied the station of harpooner in the Greenland Fishery, he successfully availed himself of it for facilitating the capture of whales which might have been "struck" by any of his associates. In the case of a whale being harpooned in "clear water," where the "fast-boat," unencumbered by ice, was free to follow the course of the entangled animal, the practice of the other pursuers, as they might successively come up to assist in the capture, was ordinarily to distribute themselves in different angles in considerable *advance* of the fast-boat. But he, noting carefully the cessation of the *advance* of the original boat, which often happened, or its gradual deviation from the course at first pursued, was accustomed to take up a position either astern of the fast-boat, or wide upon its *beam* on the side towards which the deviation tended, calculating that the resistance of the line by the water would cause the direction of the boat's deviation to lag far behind that of the whale. The result was so satisfactory, that in a large majority of cases, where the rule applied, his boat was found so near the wounded animal on its reappearance at the surface, that he was most frequently successful in striking the second harpoon.

Hence, under such variety of illustration applicable to the case of deep-sea soundings in the regions of strata-currents, it appeared to be an inevitable result, that the sounding-line in these attempts must be so carried away with the moving strata of waters as to render the length of line run out a very imperfect indication of the depth reached by the plummet.

Dr. Scoresby next proceeded to communicate his *plan for the determination of surface-currents, and relatively of strata-currents.*

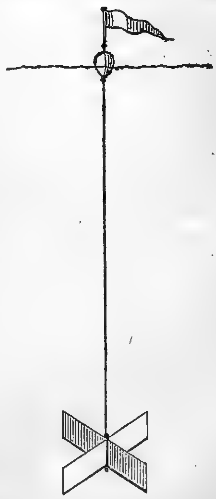
The ordinary mode of determining the set and velocity of currents—by the differences betwixt a ship's position on each day's run as determined by celestial observations and the "dead-reckoning"—is necessarily and obviously very uncertain, often entirely delusive. None of the elements of the log and reckoning are or can be correct; the distance run, the compass course, the steerage of the ship, are all more or less inaccurate. The author's own experience had afforded numerous cases in practical navigation of great and remarkable differences betwixt the day's-reckoning and celestial observations, such as might have been taken as indications of currents of considerable influence, where, it was almost certain, the main differences were really due to bad steering (when scudding or sailing with the wind on the beam or quarter); to errors in the distances indicated by the log, or to peculiarities or changes in the ship's local attraction.

No doubt broad determinations as to great and decided currents, and proximate results by means of multiplied observations on currents of moderate velocities, are derivable from the ordinary process; but for really satisfactory results, far more accurate and conclusive processes need to be instituted. And it would be well deserving of an enlightened government of a maritime country like ours to employ some of their smaller war-vessels, and so to afford useful and instructive practice to junior officers, in investigations concerning currents, and particularly strata-currents. And for such investigations certain modes, Dr. Scoresby believed, might be made easily available, calculated to yield much valuable and interesting information on this important subject.

Two leading processes were then described as appearing to be applicable to these determinations:—

1. The planting in particular positions in the ocean, from an attendant vessel, buoys with flags, kept in their places by a resisting apparatus below the surface, which may be denominated a *current-measurer*, and determining, after a night's interval, for instance, the changes of their position from celestial observations.

A convenient construction of the current-measurer, with a view to portability of stowage, might be a double oblong frame of iron, attached by a transverse pin as a hinge, by the middle of each, so as to allow of their being spread out as vanes in a vertical plane, or placed flat on each other when not in use. These frames, which might be 6 or 8 feet in length by 2 or 3 in breadth, being covered with linen, would, when sunk in the water, as indicated by the annexed figure, afford sufficient resistance, probably, for all the purposes contemplated.



2. Placing, during a calm, a small boat in the water, constructed for the purpose, light, and slightly resisting of motion, with the current apparatus for the determination of the relative set of strata-currents.—The current-measurer, attached and suspended by a small wire run off a reel fixed in the bow of the boat, might be let down to various depths in succession, with a register-thermometer attached at each new depth, when the motion of the boat and its direction, as shown by the position of a surface-float or buoy, would, after but short intervals of time, indicate, proximately, the relative motions of the surface-water and the water at the several depths of the resisting apparatus below; whilst the register-thermometers might give useful information on the extremes of temperature of the various sections of water passed through.

By these arrangements information would be obtained as to the following particulars:—

By the surface-buoy (1) we should ascertain, if the weather were sufficiently calm, the motion of the surface-water; by the movements of the boat, (2) the relative motions of the surface-water, and that at the depth of the current-measurer, at the first trial; an indication of the changes at other depths; and, on reeling in the wire, the highest and lowest temperature would be shown at each of the depths examined (that is, when the changes were in one way, as from warm to cold), and thus the several results might be compared with the *surface*-temperature taken at the commencement, and at each change of depth.

The cases in which such experiments would be the most interesting, would probably be found in places of the ocean where great differences of temperature are met with at comparatively moderate differences of depth. In some of the positions examined, for instance, by the officers of the United States Coast Survey, the temperature was found to sink, from about 80° at the surface, sometimes to 70°, or even 65°, in depths not exceeding 120 fathoms, and down to 64° or 63° (near 20° lower than at the surface), in depths of 120 ranging to 480 fathoms; whilst a temperature as low as 44°, or less, was met with at the depth of about 700 fathoms. Now, in such cases—cases prevailing extensively within and about the edges of the Gulf-stream, or within the changes of surface-temperature in the transatlantic passage—we should probably obtain by the processes described results of no ordinary interest and importance.

The results, it must be admitted, could only be proximate; for the boat, moved by the deeply-sunk current-measurer, it is obvious could not follow vertically above it; but under the action of an obliquely ranging wire, when both boat and wire must present a force of resistance, the boat must take a position behind. Yet, if the current differences were considerable in velocity and direction, perhaps experiments continued for a few hours at a time, and repeated under a due variety of circumstances, might afford data for mathematical determinations of resistance and corrections. And, in certain cases, in regions where the great oceanic currents overlay one another, like those from the Polar Seas and the Tropics, conclusions abundantly satisfactory might, no doubt, be realized.

Meteorology.

On a proposed Barometric Pendulum, for the Registration of the Mean Atmospheric Pressure during long Periods of Time. By W. J. Macquorn Rankine, *C.E., F.R.S.S. Lond. and Edinb.*

The author proposes to use the variations of the rate of a clock to determine the mean barometric pressure during long periods.

For this purpose the clock should be regulated by a centrifugal or revolving pendulum, part of which should consist of a siphon barometer. The rising and falling of the mercury would affect the rate of the clock; so that from the number of revolutions of the pendulum in a given time might be deduced approximately the mean height of the mercurial column during that period.

The author investigates the formulæ to be used for this purpose, and points out the nature and mode of determination of the corrections required for temperature, obliquity of the barometer, and centrifugal force, and also for the difference between the square root of the mean of the squares of the barometric heights, which is the quantity ascertained in the first instance, and the mean of the heights, which is the quantity sought.

On a Concentric Iris, as seen from the ridge of Snowdon, near the summit, on the morning of the 13*th of June* 1853, *about an hour after sunrise, projected upon the clouds floating along the sides of the Mountain. By* William Gray, Jun

The iris continued in sight about an hour, becoming gradually depressed into the shadow thrown by the mountain on the clouds.

When first seen the colours were exceedingly brilliant, and exhibited four concentric ranges of the prismatic colours nearly perfect, ranging from violet in the centre to a fourth circle of violet forming the outermost distinct circumference; faint indications of a fourth circle of red were occasionally visible beyond it.

The Irish Sea seen in the distance.

On the Meteorology of Hull. *By* William Lawton.

After describing the instruments used and their situation with regard to the town and surrounding objects, the author referred to the observations themselves, which consist of three separate series. 1st. The observations on temperature of Dr. Fielding, late of Hull, extending from 1831 to 1836 (both inclusive), left in the form of a chart. These have been reduced to their numerical value and placed in a tabulated form. 2nd. Mr. Lawton's observations of a general character, commencing with January 1849, and still continued. 3rd. The Literary and Philosophical Society's observations, commencing with 1851, and also continued.

The following table headed Atmospheric Pressure, represents the mean barometrical observations for each month and for the year. The first three columns are the results of the author's observations taken daily at 9 A.M. and 6 P.M. The first column represents the average highest monthly maxima for the years 1849, 1850, 1851 and 1852; the second column the average lowest monthly minima; and the third column the mean monthly height for the same period.

The fourth and fifth columns give the highest and lowest readings for each month from the Philosophical Society's Register, and the sixth column of the same table the mean of each month for the year 1851, which closely coincide with Mr. Lawton's observations for the same period. The mean height of the barometer for December of that year was the greatest yet registered, being 30·34; the Philosophical Society's 30·264. By a reference to the third column containing the mean height on the average of four years from 1849 to 1852, it will be perceived the readings are the highest in February, March and September, and lowest in January, October and November.

The mean heights of each of the four years observed have not varied above ·05 of an inch.

To this table are added the results of four years' observations made at Wakefield by W. R. Milner, Esq., Surgeon, during the same period, and kindly furnished by that gentleman.

Table I.—*Atmospheric Pressure.*

	1849 to 1852.			1851.		
	Max.	Min.	Mean.	Max.	Min.	Mean.
January	30·51	29·37	29·98	30·356	29·162	29·740
February	30·62	29·34	30·12	30·478	29·436	30·018
March	30·61	29·48	30·14	30·446	28·846	29·713
April	30·38	29·47	29·99	30·248	29·426	29·904
May	30·39	29·64	30·07	30·612	29·702	30·064
June	30·31	29·76	30·06	30·386	29·632	30·074
July	30·31	29·61	30·04	30·240	29·322	29·900
August	30·35	29·65	30·02	30·466	29·622	30·090
September	30·58	29·37	30·14	30·696	29·368	30·242
October	30·50	29·22	29·96	30·498	29·128	29·624
November	30·48	29·16	29·94	30·424	29·308	29·919
December	30·58	29·42	30·07	30·608	29·600	30·264
	30·46	29·45	30·04	30·455	29·383	29·963

1849.	1850.	1851.	1852.	
30·04	30·06	30·06	30·01	Hull.
29·818	29·807	29·824	29·728	Wakefield.

Bearing in mind the daily fluctuations or tides of the barometer, which it is stated by Professor Phillips rise at York twice to maxima, about 9 or 10 A.M. and P.M., and sink twice to minima about 4 A.M. and 4 P.M., Mr. Lawton referred to the observations, to see how far such ebb and flow of the mercurial column was borne out. In his own observations taken at 9 A.M. and 6 P.M. there was no evidence of such fluctuation; but in the Philosophical Society's Register taken at the time of the greatest ebb and flow, the mean of the morning readings in each month of the year is in every case above the mean of the afternoon readings, as will be seen by the following Table.

TABLE II.

Mean height of Standard Barometer, 25 feet above high water.		
1851.	10 A.M.	4 P.M.
January..................	29·753	29·727
February	30·025	30·012
March	29·723	29·720
April.....................	29·909	29·899
May	30·064	30·063
June	30.108	30·038
July	29·902	29·898
August	30·099	30·082
September	30·255	30·229
October..................	29·854	29·846
November...............	29·921	29·916
December	30·271	30·257
Mean................	29 990 29·972	29·972
Difference.........	·018	

From observations on atmospheric pressure we pass to those on its temperature, in illustration of which the following Table (III.) has been constructed. The first four columns are the results of four years' observations, from 1849 to 1852. The second four columns are Dr. Fielding's observations, from 1831 to 1836; to these are added a third table, copied from Professor Phillips's recent work on the Mountains, Rivers, &c. of Yorkshire, giving the average highest daily and lowest nightly temperature for each month at York, from 1812 to 1818 inclusive.

TABLE III.—*Temperature. Average Daily Maxima and Minima.*

	Hull, 1849 to 1852.				Hull, 1831 to 1836.				York.		
	Daily Max.	Nightly Min.	Daily Var.	Mean	Daily Max.	Nightly Min.	Daily Var.	Mean	Ann. Max.	Ann. Min.	Diff.
January......	42·8	36·0	6·8	39·3	41·7	33·9	7·8	37·8	38·16	29·29	8·87
February	46·4	36·9	9·5	41·2	44·8	35·2	9·6	40·0	43·26	32·60	10·66
March	48·2	39·2	9·0	43·7	47 9	36·6	11·3	42·2	45·77	34·69	11·08
April.........	53·6	40·0	13·6	46·9	52·2	39·3	12·9	45·7	51·54	37·49	14·05
May	59·4	45·0	14·4	52·2	59·7	46·1	13·6	52·9	58·31	44·29	14·02
June	66·7	51·2	15·5	59·0	65 9	49·9	16·0	57·9	64·79	49·07	15·72
July	68·7	53·8	14·9	61·2	69·0	52·3	16·7	60·6	67·70	52·69	15·01
August	66·0	54·7	11·3	60·3	67·6	51·9	15·7	59·7	64·81	51·04	13·77
September...	60·9	49·9	11·0	55·4	62·8	48·6	14·2	55·7	61·99	48·73	13·26
October......	52·8	42·3	10·5	47·5	57·0	44·9	12·1	50·9	53·34	43·04	10·30
November...	47·0	38·4	8·6	42·7	47·1	37·9	9·2	42·5	46·03	36·24	9·79
December...	43·9	38·5	5·4	41·2	44·8	36·2	8·6	40·5	39·53	31·11	8·42
Mean...	54·8	43·8	11·0	49·2	55·0	42·7	12·3	48·9	52·93	40·85	12·08

A comparison of these three tables shows during the summer months considerable uniformity; but during the colder months of the year the effects of the German Ocean and of the Humber in raising the sea temperature are manifest. This comparison of temperature between Hull and York would have been more satisfactory had the observations been made during contemporary years.

To the combined influence of the Sea and the Humber in mitigating the heat of the summer day and softening the cold of the winter's night at Hull, a third may be added, namely, the large surface area of water, which in the form of spacious docks and harbour occupy a space of from 60 to 70 acres. The effect of this area of water passing through the centre of the town must be in summer to absorb heat, which houses, streets, or dry ground would reflect into the atmosphere, and in winter to communicate during the night a portion of the heat absorbed during the day.

It is to be much regretted that no data whatever exist as to the temperature of the docks, the Humber, and the sea washing the Yorkshire coast, a blank in meteorological science which the author hopes to fill up.

It may next be interesting to show the extreme monthly maxima and minima registered at Hull. For this purpose Table IV. is constructed, showing the highest and lowest monthly maxima and minima from the observations of Dr. Fielding and Mr. Lawton, to which is added a similar table again copied from Professor Phillips's work before mentioned.

Table IV.—*Extreme Monthly Temperature.*

	Hull, Ten Years.			York, Seven Years.		
	Highest Monthly Max.	Lowest Monthly Min.	Diff.	Highest Monthly Max.	Lowest Monthly Min.	Diff.
January	47·0	31·8	15·2	42·6	21·0	21·6
February ...	47·5	29·5	18·0	47·1	27·1	20 0
March.........	50·8	31·4	19·4	51·0	31·3	19·7
April	55·2	37·0	18·2	56·1	35·2	20·9
May	65·1	42·8	22·3	59·9	39·9	20·0
June	70·6	47·6	23·0	71·8	46·4	25·4
July	73·4	48·9	24·5	72·9	51·2	21·7
August	71·6	48·8	22·8	66·2	49·4	16·8
September ...	66·7	45·9	20·8	63·5	46·0	17·5
October	60·6	40·7	19·9	58·2	37·9	20·3
November ...	50·4	32·7	17·7	51·8	31·1	20·7
December ...	46·7	34·0	12·7	42·3	29·7	12·6

From this table the influence of adjacent waters in raising the temperature of January and December, at Hull, compared with the same months at York, is more apparent.

Following this table is another, Table V., also of extremes, which is formed from Dr. Fielding's observations alone, by taking the highest and lowest point registered on any day in each month of the six years.

Table V.—*Dr. Fielding's Extreme Temperatures.*

1831 to 1836.	Highest Point registered.	Lowest Point registered.	Diff.
January	56·5	21·5	35
February ...	54·5	24	30·5
March.........	64·5	27·5	37
April	67	28·5	38·5
May	77	29	48
June	82·5	34·5	48
July...... ...	81·5	38·5	43
August	85·5	38	47·5
September ...	75	34·5	40·5
October	71	30	41
November ...	60·5	21·5	39
December ...	56·5	23	33·5

The temperature of 85·5, in Table V., was registered on the 10th of August, 1835

The highest point reached, in my own observations, was on the 7th of July, 1849, 83°; the lowest on the 19th of February, 1853, 18°.

The greatest daily variation I have registered occurred on the 16th of May, 1852, 33°.

Table VI. is also copied from Professor Phillips's work before named, so far as regards Halifax, York, and Keyingham. For the purpose of comparing our local climate, at particular seasons, with that of Halifax, situated in the Yorkshire hills, York in the valley, and Keyingham in the Holderness level, Mr. Lawton has added Hull. It will be seen that in the cold month of January Hull has the warmer climate, April and July rather colder, October rather warmer.

Table VI.—*Mean Temperature.*

	Halifax, 2 Years.	York, 25 Years.	Keyingham, 2 Years.	Hull, 4 Years.	Hull, 6 Years.	Hull, 10 Years.
January	36·9	34·8	38·6	39·3	37·8	38·4
April	45·4	47·6	44·6	46·9	45·9	46·2
July	60·5	62·0	62·0	61·2	60·6	60·8
October	50·5	48·2	49·4	47·8	51·9	50·2

The author concludes his observations on temperature by giving the mean annual temperature of each ten years observed, likewise the general annual mean deduced therefrom, with the greatest and least annual means observed, these again being compared with York, Wakefield, Malton, Keyingham, and London.

Table VII.—*Mean Annual Temperature.*

1831.	1832.	1833.	1834.	1835.	1836.	1849.	1850.	1851.	1852.
48·4	48·6	48·3	51·1	49·4	47·9	50·2	49·8	48	47·8

Mean annual temperature 49°; greatest 51°·1; least 47°·8.

Mean annual temperature at	Hull,	on the average of	10	years,	49
,,	,,	York,	,,	25	,,	48·2
,,	,,	Wakefield,	,,	5	,,	48·6
,,	,,	Malton,	,,	0	,,	47·6
,,	,,	Keyingham,	,,	2	,,	48·8
,,	,,	London,	,,	0	,,	51·8

Mean temperature of Hull from	January to June,	46°·6
,, ,,	July to December,	51°·5
	Difference	4°·9 on the average of 10 yrs.

We now proceed to consider the humidity of the climate of Hull, which in this respect will bear a favourable comparison with most places in the British Isles; the east coast, from about the mouth of the Thames to near the Tyne, being in general considerably drier than the midland, western, or southern portions of England. The results of observations made at Hull on the fall of rain, evaporation, and hygrometrical condition of the atmosphere, are shown in the annexed table.

The fall of rain is given on the average of four years, the evaporation on the average of two years. The hygrometrical observations are taken from the Philosophical Society's Register for 1851.

TABLE VIII.—*Humidity.*

	Rain.		Evaporation.	Hygrometer.	
	Depth in inches.	Days of Rain.		Mean Temp. Dew-point.	Mean amount of Humidity.
January	1·32	13·0	·15	39	0·914
February......	·49	7·66	·13	38·8	0·928
March	·82	11·66	·19	38·7	0·872
April	·63	8	·56	39·6	0·816
May	·61	13	·71	47	0·832
June	2·17	8·33	·75	53·2	0·796
July	2·90	11·33	1·04	53·3	0·801
August	1·95	11	·96	55	0·789
September ...	2·53	8·75	·52	50·8	0·812
October	1·77	16	.25	48	0·847
November ...	1·71	12·75	·02	34·4	0·852
December ...	1·41	12·25	·10	34·2	0·911
	18·31	133·73	5·38	44·5	0·847

The rain here indicated in the four months from February to May will not, it is presumed, represent the average fall if a longer period was taken. It is probable, however, that in Hull, as in most other places, the average fall of rain is the greatest during the latter half of the year.

The fall of rain during the twelve months from July 1852 to June 1853, in inches, was 25·84.

The last table, being a synopsis of the meteorology of Hull, is sufficiently explanatory to need no further elucidation.

The author, however, calls the attention of observers to the last column, 'Clear Nights,' which is a register of those nights that were either apparently, or from actual trial, found to be suitable for telescopic observation, and is therefore an approximate indication of the astronomical climate of Hull.

TABLE IX.—*Results of Meteorological Observations taken at Hull.*

	Barometer.	Thermometer.		Rain.	Weather.					
	Annual Mean.	Annual Mean.	Mean Daily Range.	Depth in inches.	Cloudless.	Fair.	Cloudy.	Rain.	Snow.	Days registered.
1849	30·04	50·2	9	11·93*	92	67	55	138	13	365
1850	30·06	49·8	10·8	14·57	97	59	60	122	9	347
1851	30·06	48	13·3	15·15	85	38	86	124	10	343
1852	30·01	47·8	10·8	20·36	75	59	78	118	4	334

Winds.

	N.	N.N.W.	N.W.	W.N.W.	W.	W.S.W.	S.W.	S.S.W.	S.	S.S.E.	S.E.	E.S.E.	E.	E.N.E.	N.E.	N.N.E.	Var.	Calm.	Force of Wind.	Days registered.	Clear Nights.
1849	13	3	25	9	61	3	43	3	8	5	30	4	29	4	33	4	74	10	...	361	101†
1850	16	1	30	...	73	9	46	8	16	3	34	2	24	1	35	2	38	8	...	346	147
1851	20	8	28	10	48	6	48	13	22	6	19	3	10	3	26	20	37	8	851	335	138
1852	29	1	14	3	68	4	39	...	19	3	40	1	25	1	26	3	35	10	767	321	140

368 Northerly. 604 Westerly. 437 Southerly. 396 Easterly.

* From August to December inclusive. † From January not registered.

In conclusion, Mr. Lawton presents a few facts referring to the chief meteorological features of the present year. The mean temperature of February was 32°·2, being 9° below the average of the past four years. The lowest of the month was 18°, the highest 38°. Snow fell on eighteen days.

The mean temperature of March was 35°·4, being 8° below the average of the same period. Snow fell on twelve days.

During a considerable portion of March, April, May, and June, easterly and north-easterly winds prevailed. The fall of moisture was also in excess, being, during the first six months of the year, in inches, 5·47 above the average of the previous four years.

The atmosphere, during the months of June, July, and August, was unusually cloudy.

No thunder-storm worthy of note has occurred in this neighbourhood during the present year.

But in the summer of 1851 thunder-storms of extreme severity occurred on the 21st June, 29th July, 13th and 17th of August. The one on Saturday the 21st of June continued from 3·30 to 5·30 P.M., during which there fell in inches 1·68 of rain, the heaviest fall of many years. The storm of the 29th of July continued from 5·30 to 7 P.M., and was remarkable for the long continuance of vivid fork and sheet lightning prior to rain descending; the quantity of rain in inches was 76 hundredths, which fell in about one hour. That of the 13th of August was accompanied by a terrific and most destructive hail-storm.

Meteorological Summary for 1852 *of Observations at Huggate, Yorkshire. By the* Rev. T. Rankin.

Continuation, across the Country, of the Thunder and Rain Storm, which commenced in Herefordshire on September 4th, and terminated on the Yorkshire Wolds on September 5th, 1852. *By the* Rev. T. Rankin.

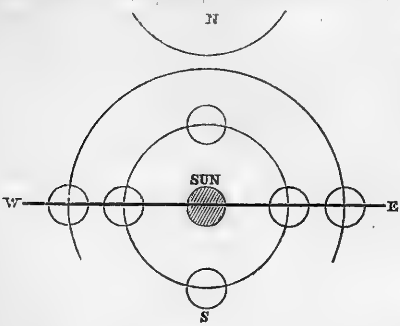
Notice of a terrific Thunder-Cloud on the Wolds, September 26th, 1852. *By the* Rev. T. Rankin.

On the Action of the Winds which veer from the South-West to West, and North-West to North. By R. Russell.

In almost all the violent storms which occur in the British islands, the currents above seldom coincide with those at the surface of the ground, which statement also often applies to ordinary weather, when there is little atmospheric disturbance. On previous occasions, Mr. Russell had endeavoured to show that many of the phænomena of our storms would ultimately be explained by the mutual action of the under and upper currents. He had never seen an instance of a British storm that admitted of being explained on the rotatory theory, and he thought this theory altogether erroneous as applied to our high latitudes. A south-east current in the upper regions of the atmosphere seldom occurred in Britain, but south-east surface winds were common in moist and rainy tracts of weather. In these circumstances, however, an upper current of S.W. overlies the S.E., and supplies it with rain. Direct E. winds, prevailing not only at the surface, but at those atmospheric heights where the cirrus clouds are formed, are much more common than from the S.E., and undivided currents from the N.E. are still more frequent. A west wind seldom or never blows below when an east wind prevails above; but on the contrary, it is very common for a S.W. current to prevail above, when a N.E., E., or S.E. wind may blow furiously below. The solution of many of the primary phænomena of those storms which commence in Britain with easterly winds and terminate with westerly or northerly winds, is to be found in the mutual action of the upper and lower currents moving in different directions, and not in the principle of rotation. A current from the N.W. at the surface of the earth never blows for any length of time with an upper current from the S.W.; but in certain tracts of weather, it is very common for a S.W. under-current to prevail, while a N.W. or N. wind is blowing above. It has been noticed that gales begin to blow from the S.W. or S., and afterwards veer round by W. with great violence to N.W. or N. The advocates of the rotatory hypothesis find a solution of this by supposing that at those places where the wind veers from S.W. by W. to N.W., a vast body of air is in a state of gyration from right to left, and in a state of translation from S.W. to N.E. The centre of rotation is supposed to lie far to the north of the stations where the wind goes through these points. This is a very plausible explanation of the veerings, and is always adduced in support of the rotatory hypothesis, in favour of which much may be said in one class of storms, but in these there can be no rotation, as the S.W. wind flows in one broad stream over the island, and no observations can be found to indicate a recurring of the S.W. wind. In the class of storms where the wind goes through the course of S.W., W. to N.W., an upper current from the N.W. prevails. The veering, Mr. Russell is of opinion, may be accounted for in the same way as variations in the summer months, which arise, he thinks, from an intermixture and interchange which is effected along the course of the wind, the hot air rising up and the cold air descending. A similar phænomenon is to be seen in the commingling of water. This, too, he believed, affords a proximate explanation of many of our easterly gales; and so the reversal of the lower current by the heat of the sun during certain states of our atmosphere in summer is maintained by the constant ascent and descent of the air of the two opposite currents, so far as the south wind extends. Every gust of the breeze must be considered as the effect of vertical gyrations caused by air of different specific gravities. As soon as the sun lessens his heat, the disturbing influences are diminished, and at last night brings a calm at the earth's surface, while the north current above still flows on. The length of time which the wind will blow from the S.W. is very uncertain. It commonly varies from eight to forty-eight hours, and in some cases it continues for days. The wind at once turns round to the N.W., when the barometer again begins to rise. The cause of this change of wind to the N.W., he believed, is merely the upper current resuming its sway at the surface of the earth by putting the thin stratum of air which has been flowing from the S.W. into the same course as the current above. The temporary eruption of the S.W. wind, which has been heated over the warm ocean and replenished by moisture, appeared to him to be a parallel phænomenon to the southerly breezes which play over our island during the day in summer when the N. wind is prevailing above. These dry breezes are daily called into action by the solar rays disturbing the equilibrium of the air in the lower depths of the atmosphere where rarefaction takes place. In this manner, then, may the moist S.W. winds from the Atlantic be hurried over the continent of Europe, and when once set in motion they possess a self-sustaining force in mingling with the dry cold current which overstratifies them. Although it may be against general theory and belief, he thought that the returning polar current in our latitude is much more frequently from the N.W. than from the N.E. Both Mr. Green and Mr. Mason were of opinion, from their aëronautic experience, that in whatever direction the wind might blow at the surface of the earth, at 10,000 feet the current was invariably from some point between N. and W. This opinion was no doubt carried too far, but it clearly showed the frequency of the N.W. wind above the lower currents. Many of the storms which begin to blow from the S.W. and veer round to N.W., are apparently caused by the mutual action of two currents from these quarters stratified over one another. In these storms, too, the barometer does not usually give much warning of their approach; indeed the mercury will sometimes be actually on the rise when cirrostratus cloud, the precursor of the S.W. wind, is already formed along the western horizon. On the contrary, the storms which come on with easterly winds give notice of their approach by a fall in the mercury. In conclusion, Mr. Russell observed that the extraordinary change of the wind from S.W. to N.W. had been noticed by Shakspeare, and he had some very beautiful lines on the subject, which Mr. Russell quoted.

On Parhelia observed at St. Ives. *By* J. K. Watts, *F.R.G.S.*

These beautiful phænomena were seen on Tuesday, the 15th of February, 1853, from about 12^h 20^m P.M. to 2^h 30^m P.M. The wind at the time was north-west, very slight; barometer, 29·65; thermometer, 31°. The morning was clear, with a slight frost, and about noon a thin haze came over and covered the sun, which still shone with considerable power; and there were a few scattered light clouds. At the time stated above, four mock suns, or parhelia, were very visible, situated at equal distances in a circle round the true sun, two being in the same vertical with him, and two in the same horizontal range. These displayed splendid prismatic colours. Shortly afterwards two other mock suns appeared, of a pale white light, in the same horizontal range with the true sun and two of the bright mock suns. Each of the mock suns appeared as large as the true sun, and through him and the four horizontal mock suns a stream of pale white light passed to a considerable distance be-



yond the outside ones. The author gave a diagram, as below. The circle in which the two outer parhelia were placed was only about three-fourths formed; the diagram showed it exactly twice the size of the inner circle; immediately above, to the north, was an inverted arch. The inner circle and outer partly-formed circle were of a light brown colour on the outer edges, and of a violet-red on the inner. The inverted arch was of white light, having the outer edge tinged with red. The long streak was of white light, which passed through the true sun and the two parhelia on each side of it, and to a considerable distance beyond the two outside ones. The wind being scarcely perceptible, the haze hung over the sun for a long time. The phænomenon was in full splendour for upwards of two hours; and it was a considerable time afterwards before all traces had disappeared.

On the Graduation of Standard Thermometers at the Kew Observatory. *By* John Welsh.

In the year 1851 the Committee of the Kew Observatory, impressed with the importance, in meteorological investigations, of possessing thermometers of a better class than those hitherto procurable from opticians, took steps with the view of producing such instruments, under their own superintendence, for distribution to institutions and individuals who might require accurate standards of reference. The Committee were furnished with the information necessary to carry out their intentions by M. Regnault of Paris, who had been accustomed to construct his own thermometers by a method proposed by himself, and with an accuracy previously unknown: they were also supplied, under his directions, with the requisite apparatus. It has been assumed by physicists that at all temperatures, as high at least as that of boiling water, the apparent expansion of mercury in a glass envelope is uniform for equal increments of heat. A mercurial thermometer may therefore be called a standard instrument when the divisions of its scale correspond everywhere to equal volumes of the contained fluid, and when the readings are known for the temperatures of melting ice and of water boiling under a certain barometric pressure. If the tube were perfectly uniform in its bore, it would only be necessary to make a scale of equal parts between the freezing and boiling-points, and to extend the division above and below these points; but as perfect tubes are in practice not procurable, it becomes necessary, in dividing the scale, to make allowance for the variations in the tube's capacity. These variations are obtained by carefully measuring a short column of mercury (1 inch or less in length) as it is made to pass along the tube by successive steps, each of which is as nearly as possible its own length. In the thermometers constructed according to M. Regnault's process, the divisions do not represent degrees of the ordinary scales of temperature, but are of an *arbitrary* value, differing for each instrument, and requiring separate tables for each thermometer to convert the scale readings into degrees; the divisions at all parts of the scale being equivalent to equal *volumes*, although their *lengths* may vary very considerably. Mr. Welsh described a modification which he had made in M. Regnault's process, by which he has been enabled to divide the scales of the thermometers graduated at Kew at once into *degrees*, the readings being afterwards subject only to the small errors of manipulation, and such errors as arise from the unavoidable changes which take place in the zero-points of all thermometers. The freezing-points are determined in the ordinary way by immersion in well-pounded ice, from which the water is drained off as it melts. The boiling-points are determined by the apparatus devised by M. Regnault, in *steam*, whose elastic force is exactly equal to that of the atmosphere at the time, a correction being made for the difference of the barometric pressure from the adopted standard pressure. The boiling-points, besides being determined for the usual position of a thermometer, with the stem vertical, are also observed in a similar apparatus with the stem horizontal; so that, if the instrument should ever be used in any other than the vertical position, the proper correction may be applied. The difference between the boiling-point of a thermometer, in the two positions, is found to be from 0°·2 to 0°·5 Fahr., according to the thickness of the glass and the form of the bulb. After the graduation of a thermometer has been completed, its accuracy is examined by a subsequent calibration with a longer column of mercury. If the length of the column, with reference to the scale divisions, is everywhere the same, the graduation is considered good; but if any difference is found to exist, a more complete examination is made by using columns of different lengths, each of which is nearly an aliquot part of the range of the scale, the remaining errors being deduced from these measurements by the method adopted by Mr. Sheepshanks for the thermometers used in connection with the national standard yard. It is, however, seldom that any appreciable correction is found needful. It has long been known that the freezing-point of a thermometer is not constant, but rises by a considerable amount during the first year after its construction. There is, however, another peculiarity in thermometers which is less known. If a thermometer, after having been for some weeks exposed to the ordinary temperature of the air, is placed in melting ice, its freezing-point will be, for example, 32°·2; if the bulb is then put for two or three minutes into boiling water, and soon afterwards again placed in ice, the reading will no longer be 32°·2, but will have fallen to nearly 32°·0: if in a day or two it is again placed in ice, the freezing-point will have risen a little —about 0°·1; and if again tried, after two or three weeks, the freezing-point will be found to have acquired exactly the original position of 32°·2. This has been found to be the case with every thermometer examined at Kew, whatever was its age; the difference in the freezing-point, before and after boiling, being about 0°·17 Fahr., and varying inappreciably in different instruments. This peculiar displacement of the freezing-point seems to be owing to a temporary alteration in the dimensions of the bulb caused by a considerable change of temperature; the glass, after having been expanded by heat, requiring a week or two to contract to its original size. It appears, therefore, that the alteration in the freezing-point of a thermometer depends upon two separate causes, the one being a slow contraction of the bulb, continuing for many months but ultimately ceasing, and the other a temporary alteration in the dimensions of the bulb, produced by a sudden and considerable elevation of temperature, which disappears in two or three weeks. The rise in the freezing-point of ordinary thermometers is probably due to a combination of both these causes; for if a thermometer has its freezing-point set off soon after being blown and filled, there will be, first of all, the comparatively rapid contraction of the bulb due to the great heat to which it has lately been exposed, and afterwards the more gradual contraction which continues for several months. The author recommended opticians, instead of "pointing off" their thermometers immediately after being filled, to allow them to rest for a month or six weeks, so as to avoid at least the first great change which occurs; but of course the longer they are kept the better. Mr. Welsh mentioned another fact which he had observed in thermometers. He took about fifteen thermometers, and, after carefully ascertaining their freezing-points, kept them exposed to the temperature of boiling water for about 60 hours, allowing them afterwards to cool very slowly. It was then found that the freezing-point had been *permanently raised* in all of them by about 0°·3 to 0°·4 Fahr. The effect of a subsequent *sudden* elevation of temperature was exactly as before, to *lower* the freezing-point by nearly

0°·2; the reading which was found *after* the long-continued boiling being again restored in about a fortnight. He was not yet prepared to say whether any effect is produced by the boiling in the way of bringing the freezing-point of a newly-made thermometer to a permanent position, irrespective of the temporary alteration caused by a sudden elevation of temperature.

Strength of Materials.

On the Elasticity of Stone and Crystalline Bodies. By Professor Eaton Hodgkinson, *F.R.S.*

It is generally assumed by writers on the strength of materials, that the elasticity of bodies is perfect so long as the material is not strained beyond a certain degree. But from the experiments I made several years ago, at the instance of the British Association, on the strength of hot and cold blast-iron (vol. vi.), I was led to conclude that the assumption was very incorrect, as applied to cast iron at least; and further experiments rendered it probable that it was only an approximation in any. Among the bodies of most value in the arts, cast iron holds an important place; and I found that bars of that metal, when bent with forces, however small, never regained their first form, after the force was removed; and this defect of its elasticity took place whether the cast iron was strained by tension, compression, or transverse flexure. I subsequently found that in the first two strains (by tension and compression), the straining force might be well represented by a function composed of the first and second powers of the change of length produced,—thus,

$$w=ae-be^2$$
$$w=a'c-b'c^2,$$

where w is the weight applied, e the extension, c the compression, and a, a', b, b' constant quantities. If the elasticity were perfect, the part depending on the second power must be neglected. The necessity of a change in the fundamental assumptions for calculating the strength of materials may be inferred from the fact, that in computing the breaking weight by *tension*, from experiments on *transverse* flexure and fracture, we obtain the strength of cast iron three times as great as from numerous experiments I have found it to be. The formulæ of Tredgold give this erroneous result, and those of Navier are in accordance with them.

Stone.—To obtain the elasticity of stone, I had masses of soft stone, obtained from various places, sawn up into broad thin slabs, 7 feet long, and about 1 inch thick. They were rubbed smooth, and rendered perfectly dry in a stove, and were bent transversely in their least direction by forces acting horizontally. The slabs, during the experiments, were placed with their broad side vertical, and had their ends supported, 6 feet 6 inches asunder, by friction rollers, acting horizontally and vertically. It resulted from the experiments (as shown in a former volume of this Association), that the defects of elasticity were nearly as the square of the weight laid on; or consequently, as the square of the deflexion nearly, as in cast iron. The ribs never regained their first form after the weight was removed, however small that weight had been. From other ribs of stone, obtained from various localities, and broken transversely by weights, acting vertically, and increased to the time of fracture, the ratio of the deflection to the weight applied was found in various experiments to be nearly as below:—

·02	·01	·02	·018	·02	·027
·035	·012	·022	·023	·022	·032
·05	·0125	·033	·024	·024	·035
·07	·014	·036	·027	·025	·038
·09	·015			·026	
·11	·016				

The ratios represented by the numbers in each vertical column, are those from each separate rib of stone; and they would have been equal if the elasticity had continued perfect, but they were increasing where the weights were increased in every instance. The change shown by these experiments to be necessary would increase considerably the mathematical difficulties of the subject; and the difficulties would be greater still, if the change of bulk and lateral dimensions in the bodies strained were included, according to the conclusions of Poisson, or the experiments of Wertheim, which are at variance with each other. But these last changes are so small in the bodies I am contemplating, that they may be neglected for all practical purposes. Thus, from my experiments, the utmost extension of a bar of cast iron, 50 feet long, is about 1 inch, or $\frac{1}{600}$dth of the length, and therefore the change of lateral dimensions of the bar being only a fraction of this $\frac{1}{600}$dth, according either to Poisson or Wertheim, it is too small to need including. The experiments from which I deduced the utmost extension of cast iron, are given in the 'Report of the Commissioners on the Strength of Iron for Railway Purposes.' If the body strained were wrought iron, brass, or others of a very ductile nature, the change of lateral dimensions might, in extreme cases, be included. I beg to mention, with great deference, that the profound work of Lamé, lately published, 'On the Mathematical Theory of Elasticity,' in which the elasticity is considered as perfect only, does not appear to apply to such bodies as I have here treated of.

Trigonometrical Survey.

Communication from Lieutenant-General Sir John Burgoyne, *G.C.B., Inspector-General of Fortifications, regarding the progress made in the Publication of the Trigonometrical Survey.*

O. M. O., Southampton, September 5, 1853.

The labours of the Ordnance Survey Department have been directed during the past year to the determination, according to the theory of minimum squares, of the most probable corrections to be applied to the angles of the principal triangles.

This process, which is a most laborious one, involving the solution of about 1300 equations of condition, is now well advanced, and every exertion is being made to hasten its completion. Until it has been finally completed the computations of distances cannot be properly undertaken, for it must be borne in mind that the trigonometrical operations of the Ordnance Survey embrace a connected triangulation, extending through the length and breadth of the United Kingdom, which must be considered as a whole, in deducing the results.

Besides preparing for the publication of the principal triangulation, the Ordnance Survey Department are about to publish a volume of Levels in Ireland, and another of the Meteorological Observations made at the Ordnance Survey Office near Dublin, the printing of both works being at the present time in progress.

L. A. Hall, Lieut.-Colonel Royal Engineers.

CHEMISTRY.

On a Simple Instrument for graduating Glass Tubes. *By* Thomas Andrews, *M.D., F.R.S., M.R.I.A.*

This instrument is intended to supply the chemist with a means of accurately graduating his glass measures of capacity. The divisions admit of being varied in length to the $\frac{1}{17,000}$dth of an inch, so as to allow the graduation to be adapted to the changes in calibre of the vessel. They are obtained by the action of a micrometer-screw, 1 inch long, on a wooden block on which a standard scale is firmly fixed; but the details of the construction could not be rendered intelligible without a figure. Scales exceeding 3 feet in length may be divided by means of this instrument, which the author has very successfully employed in the construction of thermometers for delicate investigations. The dividing instrument itself, and a thermometer graduated by its aid, were exhibited to the Section.

Exhibition of British Lichens, containing Dyeing Lichens. *By* Professor Balfour, *M.D., F.R.S.E.*

They were collected and prepared by Dr. Lindsay, and consisted of specimens of *Roccella tinctoria, R. fuciformis, Lecanora tartarea, Scyphophorus pyxidatus*, and *Cla-*

donia rangiferina. Along with the Lichens, the various dyes which they furnished by the action of different reagents were exhibited. Prof. Balfour also exhibited specimens of *Polypodium alpestre*, which he stated was common in the Scotch highlands, although only recently pointed out as a British plant by H. C. Watson, Esq.

On the Effect of Sulphate of Lime upon Vegetable Substances. By Chevalier Claussen.

About six weeks since I was engaged in making various experiments on the effect of sulphate of lime upon vegetable substances. A portion of the substances then used by me was thrown carelessly aside, and upon returning to my experiments about a fortnight afterwards, I was surprised to find that decomposition had not taken place in those parts of the vegetables which had been subjected to the action of the sulphate, while those which had not been so treated were completely decayed. Among the articles experimented upon were a number of potatoes, each of which was affected by the prevalent disease; some of these remain sound to the present day, the others have some time since completely rotted away. Subsequently, I procured some more potatoes, and also some beet-roots, the former being, as far as I could judge, all diseased. I divided the potatoes into three portions. One lot I placed in a vessel with a weak solution of sulphuric acid, and from thence I placed them in a solution of weak lime-water. In the second lot the process was reversed, that is to say, the potatoes were first placed in the lime-water, and then in the acid. The third lot was left untouched. Ten days afterwards I examined the potatoes, and found, as I expected, that the potatoes which had not been treated with the sulphate were rapidly decaying; those which had been first placed in the solution of lime and then in the acid were more nearly decomposed; while those which had been treated in the mode first described remained as sound as when first taken in hand. Upon being cut open the diseased part of the potatoes was not found to have spread internally, and the flavour of the root was in no degree affected by the application of the process, nor do I think that its germinating power was injured by the effect of the sulphate. The effect upon the beet-roots was similar to that produced upon the potatoes, and which would seem to be somewhat analogous to that of galvanizing metals, viz. protecting the substances from the effect of atmospheric agencies. I may add, that muriatic and other acids have been employed by me on other occasions with equal success, the only agents required appearing to be those which will most readily produce a sulphate in contact with the substances required to be preserved. As at present it does not appear that any means can be successfully adopted to prevent the potato from becoming diseased while in the ground and arriving at maturity, it would certainly be of immense advantage if anything could be discovered by the use of which the roots when taken up could be prevented from that absolute decay and irreparable loss to which potatoes affected by the disease are liable. The results which I have described seem to me to point to the possibility of arresting this loss. How far the plan suggested may be practicable or applicable upon a large scale, my present very pressing and numerous engagements have hitherto prevented me from ascertaining. I do not think that any insuperable difficulty exists with respect to the application of the process. The acid employed by me was very weak, about 1 part to 200 of water; the lime-water was about the consistency of milk. The materials are not therefore expensive; and when the value of the crop to be saved is taken into consideration, it would be a matter well worthy of being tested by some of those extensive growers of potatoes in the county in which the British Association is now holding its sittings. For my own part, I should be most happy, if by any suggestion of mine I had merely been the instrument of directing the attention of scientific men to the subject of the possibility of preserving from total destruction a vegetable so valuable and so indispensable as the potato.

On the Cause of the Transmission of Electricity along Conductors generally, and particularly as applied to the Electric Telegraph Wires. By the Rev. Thomas Exley, *A.M.*

From phænomena, I infer the existence of an element in great abundance, which I call electrogen; the proof will be given in a work which I hope speedily to publish, in which I have clearly proved that each tenacious atom attaches to its sphere of repulsion a number of ætherial atoms, such that the sum of their forces is exactly equal to that of the atom to which they are attached. These are uniformly disposed, and therefore, as Newton has shown, have the same effect as if placed in its centre: this may be called the *attached atmosphere*.

Circles being described on each of these as centres, with the radius of an ætherial atom, and a sphere concentric to the tenacious atom, touch them internally, and another externally; then between the attached atmosphere and the inner sphere will be a spherical shell equal in thickness to the radius of the ætherial atom, less the diameter of the tenacious atom; the ætherial atoms in this shell are all repulsive and equal together to the attraction of the tenacious atom, and hence it may be called the neutral shell. After this succeeds another shell, whose thickness is equal to the diameter of the central atom; in this the ætherial atoms begin to attract more and more from the concave to the convex side, to the surface of which the united actions bring an atmosphere of electrogen; the electrogen is abundant, so that by the pressure of the atmosphere the centres are within the spheres of each other's repulsion. The difference of conducting power will be found in the difference of these shells.

Suppose two tenacious atoms the force of one ten times greater than the force of the other, but its sphere of repulsion ten times less; calculation gives the repulsive force between the centres of its attached atmosphere, which force is one million times greater, and shows its diametrical shell contains ten times more atoms crowded in a space many times less, the difference being chiefly on the convex side. Hence electrogen cannot by any moderate force enter its diametrical shell; it will be a conductor, because the electrogen easily floats on its surface. A moderate force will bring electrogen into the shell of the other, which will prove more or less an obstruction to the passage of electrogen; it will therefore be a non-conductor and an electric.

Suppose, now, the balls of a long conductor brought near the sides of a charged electric. The electrogen, tending outward from the positive side of the electric, affects the contiguous air to the conductor, and along it to the negative side, where the effect is increased by the tendency of electrogen to supply the defect on that side; when brought to the striking distance, a spark passes from the positive side and another to the negative side, and the equilibrium is quickly restored from both sides towards the middle of the conductor, although it pass but to a short distance. The passage of the spark is quite different from the conducting of the fluid; in the spark a body of electrogen forces its passage in a prepared direction, but a current is propagated along a conductor from atom to atom. Thus, in the wire of the electric telegraph, by the action of the galvanic apparatus, the lines of electrogen along the sides of the wire are affected through the whole length, and as there is a continual supply from the apparatus, the whole line is at once and continually put in motion, each atom of electrogen taking place of the next through the whole line, so that the apparatus causes the passage of the atoms nearly at the same time to proceed at the other end, distant 30, 50, 100, or 1000 miles; a greater distance requiring of course a greater intensity of galvanic action. It ought not to excite surprise that these effects are so readily produced, when we consider that the wire of itself, in certain positions, without any galvanic apparatus, would convey electricity to the earth, to which in high latitudes it always has a tendency to move along any conductors in the air; hence the air itself assists the transmission, which would be instantaneous, and of equal amount in every part of the wire, were it not for want of perfect conductibility; as soon as electrogen begins to enter at one end, an equal portion tends to go off at the other end, the current being at once produced in the atoms which occupy its whole length.

On the Decomposition of Water under Pressure, by the Galvanic Battery. By JOHN P. GASSIOT, *V.P.R.S.*

It is a well-known law, long since discovered by Dr. Faraday, that whatever may be the liquid electrolysed by the galvanic battery, and whatever may be the size of the electrodes used, the same amount of chemical decomposition takes place in each cell of the battery; if water is placed in any number of separate vessels, connected by platinum electrodes with each other, and thus introduced within the circuit of a galvanic battery, the same amount of the mixed gases will be evolved from each vessel.

If, instead of allowing the gases to escape from each, such vessels are closed, a very considerable amount of pressure is obtained. The late Professor Daniel many years since experimented with a closed glass vessel, as did Dr. Leeson, but in each instance, before any great pressure was obtained, the vessels broke with very considerable violence.

Will Faraday's law hold good under extreme pressure? Is there any point at which the pressure will recompose the hydrogen and oxygen evolved by the electrolysis of water? Is there any point at which water under such pressure will cease to be electrolysed? and will it, under such circumstances, continue a conductor?

All these questions appear to me to be well worthy of examination; and although the experiments I have hitherto made are far from being conclusive, they prove that, as far as I have been able to obtain apparatus of sufficient strength to withstand the pressure, water does continue to be electrolysed according to the law of Faraday, and that the gases under such a condition do not recombine.

My first experiments were made in glass tubes; in each end I inserted a platinum wire, and filling the tube with diluted water slightly acidulated with pure sulphuric acid, the ends of the tubes were closed by mechanical pressure. A voltameter constructed on the principle of Mr. Martyn Roberts, and a galvanometer were introduced in the circuit of a battery consisting of 10 small cells of Grove's. Many experiments were made with such and similar apparatus, but all the tubes *broke* long before any great amount of pressure had been obtained.

Finding it was useless to expect any results from using glass, I then attempted the experiment with metal.

Into a copper tube, a hole of $\frac{1}{4}$ inch diameter, and about $\frac{3}{4}$ inch long, was bored. This was insulated by being placed on a piece of dry leather, a platinum wire attached to a platinum plate being introduced into the copper vessel, which had been previously filled with diluted water slightly acidulated.

The air from the water had been carefully extracted by boiling under a good air-pump; as before, I used 10 cells of a small Grove's battery, a galvanometer and a Roberts's voltameter being introduced in the circuit, and the circuit completed by making the copper vessel negative and the platinum wire positive; when 10·5 of the mixed gases had been evolved in the voltameter, the tube burst with considerable violence; taking the capacity of the tube at $\frac{2}{10}$ths of a cubic inch, the pressure thus obtained was about $52\frac{1}{2}$ atmospheres.

Since that period I have had an apparatus constructed by which I can collect the amount of gas from the vessel in which it is confined, for unless some mode could be devised by which this could be effected, no satisfactory result could be expected.

In all my previous experiments I calculated on being able to collect the gases by opening the vessels under water, but finding it indispensable that the apparatus should be much stronger, and consequently larger, I was compelled to use other means.

The apparatus in which my experiments have since been conducted, were constructed entirely of platinum encased in solid pieces of gun-metal about 6 inches in diameter.

The first had a capacity of $\frac{6}{10}$ths of a cubic inch. In one experiment, after 103 cubic inches of the gases had been evolved, a loud explosion took place; the concussion was so great as to extinguish the two gas lamps in my laboratory; my assistant, who was observing the apparatus, saw a sudden appearance of light as of a flame round the upper part of the apparatus as the gas escaped, the leather washer driven out in perfect shreds, and from the upper valves being perfectly dry, no gas had escaped previous to the explosion.

On testing the platinum vessel by nitric acid, I found it had burst, the acid acting in the copper through the platinum; this fracture must have taken place at the time of the explosion, as the wire attached to the upper part, which was the negative electrode, would otherwise have had a coating of copper, whereas it was perfectly clean.

The above experiment will give a pressure of 171 atmospheres.

Another apparatus was then constructed, having a capacity of $\frac{4}{10}$ths of a cubic inch.

I will not occupy the time with any detailed account of experiments which have now occupied me some years, as after an accident I have often been detained for months before I could obtain another apparatus, but I will briefly describe two which may be interesting to this Section of the Association.

In the first, after 110 inches had been evolved in the voltameter, I opened the valve of the apparatus, and collected the *same quantity* which had been under pressure; the capacity of this vessel being $\frac{4}{10}$ths of a cubic inch, gives a pressure equal to 275 atmospheres.

In the second experiment an explosion took place when 179 cubic inches had been evolved by the voltameter; the concussion was so loud that a friend who was in the laboratory likened it to the report of a company of soldiers firing with blank cartridge. The leather (placed between two portions of the apparatus to ensure insulation) was forced out with such strength as to pass through the hat of my assistant, who was about 4 feet from the apparatus.

In this instance, presuming that the whole quantity of gases as evolved in voltameter had also been evolved in apparatus, we obtain the enormous pressure of $447\frac{1}{2}$ atmospheres.

In one experiment we have an undoubted pressure of 275, and in the other a calculated pressure of 447 atmospheres, at which water is electrolysed and conducts without apparently offering any extra resistance to the current, for during the whole of these experiments the needle of the galvanometer remained steadily deflected.

On the Corrosion of Iron-built Ships by Sugar Cargoes. *By* John Hall Gladstone, *Ph.D., F.R.S.*

The author stated that his attention had been drawn by his brother, Mr. George Gladstone, to the fact that the owners of iron-built vessels object to sugar cargoes, on account of the rusting of the metal by the saccharine juices that exude from the casks; and this had led to a chemical examination of the reaction then instituted. It was found that when pieces of iron were placed in bottles containing a solution of cane-sugar, the metal at the edge of the liquid soon became deeply corroded, but that which was permanently immersed in the fluid remained bright for a considerable time. The solution soon gave indications of the presence of protoxide of iron, which absorbing oxygen from the atmosphere was speedily thrown down as the red sesquioxide, leaving the sugar free to dissolve a fresh quantity of iron, the precipitated oxide in the mean time forming a deposit. After eighteen months, the liquid was of a deep red-brown colour; it became pale blue with ferrocyanide of potassium, black with sulphuret of ammonium; alkalies produced no precipitate; nitric acid peroxidized it. A portion dried and analysed gave 20·78 parts of metallic oxide to 100 of combined sugar, which is almost exactly in the proportion expressed by the formula $C_{12}\,H_{11}\,O_{11}$, FeO. The author, however, considered that this might differ from the true composition by an equivalent of water. No such iron compound could be formed by direct combination. In vain was it attempted to dissolve any freshly-precipitated and well-washed oxide of iron in a solution of sugar; and almost equally unsuccessful was the attempt to do so when the oxide was liberated by means of potash in the presence of sugar itself. It was found that under all circumstances of dilution or quality of the sugar solution, iron was attacked; the presence of zinc in contact with the iron did not prevent its being acted upon; nor was there any marked difference when the salts of sea-water, or the nitrates, sulphates, or chlorides of the alkalies were added to the solution. No other ordinary metal was found to be so easily acted upon as iron. Copper was very little affected by the sugar. Lead was slowly attacked, indications of the presence of its oxide in solution being obtained after three days' exposure. Tin appeared to give the binoxide. Zinc was little affected when alone; it seemed to be dissolved more quickly when in contact with iron. It is doubtful whether mercury was touched by the sugar solution; silver certainly was not. The author regretted that his experiments did not suggest any method by which the corrosion of iron ships by sugar cargoes might be prevented. They showed rather the strong disposition to combine that there is between the two substances; and how a small quantity of sugar may eat continuously into a large sheet of iron. The attention of chemists was especially drawn to the fact that the iron enters into combination with the organic matter, not when it has already been oxidized, but only when in a metallic condition, rendering the action, as would be imagined, more complicated.

On the Spontaneous Decomposition of Xyloidine. *By* J. H. Gladstone, *Ph.D., F.R.S.*

This was a description of the changes that had taken place in a specimen of xyloidine, made by treating arrow-root with nitric acid of specific gravity 1·5. After remaining about six years unaltered, this specimen suddenly began to give off gases, and in a few weeks' time nothing remained of the original xyloidine, but in its place a light brown viscid liquid.

After describing the various chemical substances of which this decomposed mass consisted, the author proceeds, "We may suppose that the decomposition of this sample of starch xyloidine has taken place in somewhat of the following manner:—some of the peroxide of nitrogen has split up into nitric oxide and nitric acid, whilst a small portion of the nitrogen has combined, as might be expected, with some of the hydrogen of the compound to form ammonia, and a larger quantity has combined with carbon and hydrogen to form prussic acid. During this process oxygen must have escaped as such, or combining with carbon have passed off as carbonic acid, or it may have been consumed in the formation of the slightly acid principle which has been described as found in considerable quantity among the resulting solids.

"Whether the ammonia and the nitrous fumes have reacted upon one another with the formation of nitrogen gas and water, I know not.

"The separation of so much carbon in the form of cyanogen must be looked upon as the principal cause of so much water being produced, for the viscid mass is essentially a strong aqueous solution of the organized bodies. A very large portion of the starch, freed from its combined nitric acid, has remained in a gummy condition, perhaps as dextrine, though it was certainly not of the variety colourable by iodine; whilst the change had advanced further with another portion, and it was converted into sugar. These substances, with traces of a bitter principle, and of a singular odoriferous substance, were the only products of decomposition, at least as far as I could detect."

On the Conduction of Electricity by Flame and Gases. *By* W. R. Grove, *M.A., Ph.D., F.R.S.*

A somewhat extended series of researches has been recently carried out by M. Edmond Becquerel with a view to determine the conducting power of flame and of hot air. These investigations have led M. E. Becquerel to conceive that he has proved the conducting power of both for electricity. The apparatus employed was a platinum tube, with the conducting wire passing through it. Mr. Grove has adopted a somewhat different arrangement. This consisted of a glass tube, with two copper wires inserted through corks at either end; from these within the tube proceeded a piece of platinum wire, which, by connexion with the battery, could be brought to a state of intense ignition. In this state these were adjusted at the distance of $\frac{1}{50}$th of an inch apart, and then connected with the powerful voltaic combination of Mr. Gassiot. Notwithstanding the proximity of the wires, no trace of electricity could be detected as passing through the interposed stratum of heated air. Mr. Grove inclined to the opinion, that the effect described by M. Becquerel was more analogous to the disruptive discharge than to conduction, as it was stated not to take place until the solid bodies arrived at red heat, and then to be increased by attenuating the gases, though at temperatures below that point; no degree of rarefaction allowed any electricity to be transmitted.

On the Origin and Composition of the Mineral called Rottenstone. *By* Professor Johnston, *M.A., F.R.S. L. & E.*

Note on the Formation of Magnesian Limestone. *By* Professor Johnston, *M.A., F.R.S. L. & E.*

The author produced specimens of magnesian limestone formed by deposition from a spring near the village of Neesham upon the northern banks of the Tees. This limestone possessed the colour, general appearance and porous structure of the limestones of the county of Durham, and contained as much magnesia as some of the purer beds of magnesian limestone in that county. From the production of this limestone he reasoned as to the deposition of dolomitic limestones in general, and the relative probability of the two theories which ascribe their magnesia to the impregnation of previously existing limestones, either by sublimation from beneath, or by percolation from above. He considered both agencies inadmissible as general causes, and was favourable to the view that as a general rule magnesian limestones were deposited from aqueous solution, though occasional impregnation of previously existing rocks by percolation was by no means unlikely.

On the Properties and Composition of the Cocoa Leaves. By Professor JOHNSTON, *M.A., F.R.S. L & E.*

After describing the remarkable physiological properties of the leaves of this plant, the author explained that they yield to æther a peculiar volatile resinous substance possessed of a powerful odour, in which the peculiar virtues of the leaf are supposed to reside. The plant is as yet to be obtained in too small quantity in this country to admit of a complete chemical examination of the substances which the leaves contain.

On the Causes, Physical and Chemical, of Diversities of Soils. By Professor JOHNSTON, *M.A., F.R.S. L. & E.*

In this paper, the author, assuming as a general rule that the materials of which soils are composed are derived from the rocks on which they rest, and that therefore the agricultural is very materially dependent upon the geological character of a country, showed how physical and chemical influences subsequently interfered almost everywhere materially to modify the agricultural indications of geology.

I. Among physical influences, he showed—

1. How the flatness of a country and the absence of outfalls causes the rain-water to stagnate, covers it with bogs, and obliterates the agricultural influence of the rocks beneath.

2. How high and sloping lands yield their finer particles to the rains which fall upon them, to be borne down to lower levels. Thus the granites yield their felspar and the red sand their fine marls, and thus from the debris of the same rock, often extending over large areas, regions of very different soils are established.

3. How along the line of ancient or existing water-courses, a ribbon of varying breadth is found in every country, upon which the soils consist of these fine matters separated and sorted by the action of water, and possessing agricultural characters more or less different from those which naturally belong to the geological formations on which they rest. And these differences become the more marked along the courses of great rivers, or of such as descend from great distances, and flow through various geological formations, of which they wash out, bear away, and intermingle the debris.

4. How along the shores of the sea, successive elevations of the sea establish upon the same geological formation belts of sand, very unlike in agricultural value.

These remarks were illustrated by an agricultural map of New Brunswick; and the conclusion the author endeavoured to establish was, that the physical geography, the hydrography, and periods of elevation of a country were scarcely less important than its geological structure in determining the agricultural value of its surface.

II. Among important chemical influences, the author mentioned as of much weight—

1. The production of acid matters in the soil wherever vegetation existed. Such acid matters are constantly produced wherever vegetable substances undergo decay in the surface soil, and sometimes in such quantity as to render the soil sour to test paper. These acids are washed downwards by the rains which sink into the soil. As they descend, they dissolve out of the soil such earthy substances—lime, alumina, oxide of iron, &c.—as they are capable of taking up, and these they bear away with them in a fluid form wherever they flow. Thus they gradually establish differences, both chemical and physical, between the upper and under portions of the drift or rocky debris from which the soils are formed, and at last render the uppermost layers in which the plants grow, totally different in its agricultural character from that which belongs to the original unaltered materials themselves. Hence the thin non-calcareous soils which cover the chalk and other limestone formations—the constantly recurring necessity for the re-addition of lime to cultivated land—the benefits from bringing up new soil from beneath, and of many other agricultural practices.

2. The firing of the forests in new countries, where hot summers scorch vegetation and raging fires spread their devastations sometimes over thousands of square miles. Such fires are almost invariably attended by strong winds, which bear away the ashes of the burning wood to immense distances. Thus in a single day all that the trees have been extracting from the soil during a whole half-century is swept away; even the surface soil itself is sometimes scorched and swept bare. After a time a new

vegetation springs up to suffer the same fate; it may be in another half-century, and thus a constant chemical robbing and exhaustion of the soil takes place. Thus barrenness at last overspreads regions which are naturally fertile, and which rest upon rocks, the debris of which naturally yield the materials of a rich agricultural surface. Such results of burning are often observed in North America, and the author advanced the fact as one of personal observation which he had been led thus chemically to explain.

The general conclusion to which the author arrived was this,—that while the geology of a country has certain broad and undoubted direct relations to its agricultural value, yet when we follow the subject into detail, these relations become more and more indirect; other influences, chemical and physical, come into play and assume the character of leading agencies, and as we investigate them more and more closely, we almost seem to lose sight of geology altogether.

Description of some new kinds of Galvanic Batteries, invented by M. KUKLA *of Vienna.*

The combination used in one of these is antimony, or some of its alloys, for a negative plate, with nitric acid of specific gravity 1·4 in contact with it, and unamalgamated zinc for a positive plate, with a saturated solution of common salt in contact with it. A small quantity of finely powdered peroxide of manganese is put into the nitric acid, which is said to increase the constancy of the battery.

The alloys of antimony which M. Kukla has experimented with successfully are the following:—

Phosphorus and antimony.
Chromium and antimony.
Arsenic and antimony.
Boron and antimony.

These are in the order of their negative character, phosphorus and antimony being the most negative. Antimony itself is less negative than any of these alloys. The alloys are made in the proportions of the atomic weights of the substances.

All these arrangements are said by M. Kukla to be more powerful than when platinum or carbon is substituted for antimony or its alloys.

In this battery a gutta percha bell cover is used over the antimony, and resting on a flat ring floating on the top of the zinc solution, this effectually prevents any smell, and keeps the peroxide of nitrogen in contact with the nitric acid solution.

When a battery of twenty-four cells was used, M. Kukla found that in the third and twenty-first cells, pure ammonia in solution was the ultimate result of the action of the battery, but only water in all the others.

This experiment was tried repeatedly, and always with the same result.

A battery was put into action for twenty-four hours; at the end of that time the nitric acid had lost $\frac{13}{20}$ths of an ounce of oxygen and $\frac{1}{4}$th of an ounce of zinc was consumed. Now as one quarter of an ounce of zinc requires only 0·06 of an ounce of oxygen to form oxide of zinc, M. Kukla draws the conclusion that the rest of the oxygen is converted directly into electricity, and this view he says is confirmed by the large amount of electricity given out by the battery in proportion to the zinc consumed in a given time; in the above battery each zinc plate had a surface of 40 square inches.

The addition of peroxide of manganese does not increase the effect of the battery, but it makes it more lasting; the peroxide of nitrogen formed in the bell cover taking one atom of oxygen from the peroxide of manganese. This is evident from only the oxide of manganese being found in the battery after a time. In the salt solution no other alteration takes place than what is caused by the oxide of zinc remaining in a partly dissolved state in the solution.

For this battery M. Kukla much prefers porous cells, or diaphragms of biscuit ware, as less liable to break, and being more homogeneous in their material than any other kind.

This battery is very cheap, antimony being only 5*d.* per lb. wholesale, and the zinc not requiring amalgamation.

The second arrangement tried by M. Kukla was antimony, and amalgamated zinc with only one exciting solution, viz. concentrated sulphuric acid. This battery has great heating power, and the former great magnetizing power; it however rapidly decreases in power, and is not so practically useful as the double fluid battery, which will last about the same power for fourteen days, when the poles are only occasionally connected as in electric telegraphs; certain peculiarities respecting the ratio of intensity to quantity when a series of cells is used, have been observed, which differ from those remarked in other batteries.

M. Kukla, on directing his attention to the best means of making a small portable battery for physiological purposes, has found very small and flat Cruikshank batteries, excited by weak phosphoric acid (1 of glacial phosphoric acid to 20 of water), to be the best; phosphoric acid being very deliquescent, and forming with the zinc, during the galvanic action, an acid phosphate of zinc. A battery of this description does not decrease in power very materially until it has been three hours in action.

Note on the Advantages arising from the Purification of Coal-Gas, by the Application of Water in an Instrument called "The Scrubber." By G. Lowe.

On Changes observed in Wood from the Submerged Forest at Wawne in Holderness. By T. J. Pearsall, *F.C.S.*

While the agricultural drainage was cutting, the remains of a forest was found, principally consisting of gigantic pines. Sections of the timber having been obtained for the Hull Philosophical Society, they were carefully piled away; some days afterwards they were found giving a peculiarly penetrating and ætherial odour, showing that some great changes were taking place; after they were separated from each other, it was found that some of these timbers had crystals of a waxy appearance and inflammable character attached to the wood.

On Crystals from the Sea-coast of Africa. By T. J. Pearsall, *F.C.S.*

The crystals here shown were obtained by Capt. Mitchell of the Merchant Ship 'Frankfield,' while searching the coast of Africa between Saldanah Bay and the island of Ichaboe for guano deposits.

The crystals are of carbonate of lime, enclosing sand; 15 to 20 per cent. sand are obtained from some specimens.

The crystals are very hard and have sharp cutting edges, so as to make it a painful task to walk upon them. The beach was covered with crystals to the extent of miles; about three miles was walked over, but it seemed as far as the eye could reach, and was half to one mile in breadth. Some of the specimens are from 4 to 5 inches in length, showing a thickness of half an inch, and from 2 to 3 inches across the plane; the report given was that some of the crystals protruded up from the sand so far as to wound the ankles and legs without great care in walking over.

Some crystals seem to be opake, with the sand enclosed, except at the edges; 15 to 20 per cent. of sand is obtained from portions of crystals; carbonates of lime and magnesia with small quantities of saline matter. Common salt principally can be obtained by breaking them up in distilled water. They are extremely soluble in diluted nitric acid.

Mineralogists and chemists are perfectly well aware of the stony substance called 'Fontainbleu Sandstone,' where the sandstone is found having forms of crystals of carbonate of lime; these crystals now exhibited show the fact of sand of the beach enclosed without altering the general form, and also that the crystal has at its base adapted itself to the sand and other crystals.

These specimens show the great facility on that coast of producing mineralized crystals, and also suggests the opportunities constantly offered to intelligent merchant seamen, of bringing home specimens of great interest which are uncommon in most parts of the world, except in some places, where they may visit, and where there may be abundance.

On Lime Flowers, or peculiarly formed Substances from the brickwork of one of the Reservoirs of the Hull Water-works before final completion for use. By T. J. Pearsall, *F.C.S.*

These strange productions were found on one side of a reservoir, neither at the end nor on the other sides; the brickwork with the mortar and cement had not properly set, and when the first quantity of water let into the reservoir was withdrawn, these substances were found upright on the brick slope; they consisted of irregular tubes terminated by a sort of expansion or bulb. They stood erect in many cases, from the joints of the brickwork having strange shapes; but some closely resembled tulips, the tube having a sort of bulb about the size of a small egg; some of the tubes were found prostrate, that showed they had attained the altitude of 14 to 18 inches. They were all of a gray-white colour, of a rough exterior; inside the tubes and bulbs they were much whiter, and the substance appeared in concentric layers; they were formed, it was supposed, from the soft mortar, by the pressure of the water and filtration of fluids and air through the side, as on that part of the reservoir the whole excavated earth had been thrown up more than 20 feet above the surface of the water in the reservoir.

These substances at their base showed the tubular portions attached to the brickwork, the mortar, and the cement; they dissolved readily with effervescence in diluted nitric acid.

These substances were not observed until the water had been withdrawn, they were then found in parallel lines to an extent of 150 to 200 feet, and so numerous that a small cart might have been filled with these brittle exudations. However much the pressure of water and the passage of air and gases might have in some way contributed to these forms, one learned naturalist had considered it probable that some species of Flustra might have lent its assistance to some of the shapes. Mr. Pearsall stated he had not heard of similar formations.

On the Employment of Pentasulphate of Calcium as a Means of preventing and destroying the Oïdium Tuckeri, *or Grape Disease. By* Astley Paston Price, *Ph.D., F.C.S.*

Of those substances which have been employed to arrest the devastating effects of this disease, none appear to have been so pre-eminently successful as sulphur, whether employed as powdered or flowers of sulphur, or by sublimation in houses so affected. But notwithstanding the several methods described for its application to the vines, I am not aware that any has, or had, appeared prior to 1851, when these experiments were instituted, by which sulphur might be uniformly distributed over, and become to a certain extent firmly attached to the vines.

Three houses, situated at Margate in Kent, in the vicinity of the one in which the disease first made its appearance in England, having been for five consecutive years infected with the disease, and notwithstanding the employment of sulphur as flowers of sulphur, no abatement in its ravages could be detected, I was induced to employ a solution of pentasulphide of calcium, a diluted solution of which, having been found to act in no way injuriously to the young and delicate shoots of several plants, was applied to the vines; the object in view being that the pentasulphide should be decomposed by carbonic acid, and that 4 atoms of sulphur, together with the carbonate of lime formed, should be deposited in a uniform and durable covering on the stems and branches of the vines affected. Although but few applications were made, the stems became coated with a protective deposit of sulphur, and the disease gradually but effectively disappeared, insomuch that the houses have been, and now are, entirely free from any disease or symptoms of infection.

The young shoots are in no way affected by its application, and the older wood covered with the deposited sulphur continues exceedingly healthy.

The specimens exhibited to illustrate the durability and protective influence of the deposited sulphur were from vines which in the autumn of 1851 were covered with the disease, but which since the autumn of 1852 have received no further treatment.

The vines in the immediate neighbourhood, and adjoining one of the houses, are covered with the disease, but, notwithstanding their close proximity, no indication of the disease has at present been detected in either of the three houses.

A solution of pentasulphide of calcium is prepared by boiling 30 parts by weight of caustic lime with 80 parts by weight of flowers of sulphur, suspended in a sufficient quantity of water; heat is applied until the solution has acquired a dark red colour, and the excess of sulphur ceases to dissolve. The clear solution is drawn off, and after dilution with water may be applied to the vines by means of either a sponge, brush or syringe. A saturated solution of pentasulphide of calcium may be diluted with from 12 to 20 times its volume of water previous to being employed.

On a New Method for determining the Commercial Value of Oxide of Manganese. By ASTLEY PASTON PRICE, *Ph.D., F.C.S.*

It is well known that several methods have been described for determining the commercial value of oxide of manganese, that is to say, for estimating the amount of available chlorine capable of being obtained from a given sample of manganese.

There are, however, certain practical inconveniences attendant on the employment of many of these processes, most of them demanding an amount of time and manipulation which it is most desirable to obviate.

The method I have for some time employed, and which I have found to give accurate results, is based on the conversion of arsenious into arsenic acid by means of chlorine, and the transformation of arsenious into arsenic acid by the employment of a solution of hypermanganate of potash.

The specimen of manganese under examination is dissolved in a normal hydrochloric acid solution of arsenious acid; and the arsenious acid remaining unchanged into arsenic acid is determined by a standard solution of hypermanganate of potash. In employing a solvent containing a reducing agent, it will be found that the solution of the oxides of manganese is materially facilitated, and may be effected at a low temperature in a very short space of time.

In adopting this method, some difficulties presented themselves:—

On dissolving arsenious acid in hydrochloric acid, terchloride of arsenic is given off, and it becomes difficult to obtain a correct normal solution. This difficulty is avoided by dissolving the arsenious acid in a solution of caustic potash, and then adding the alkaline solution to an excess of hydrochloric acid.

Another difficulty occurred in effecting the solution of the oxide of manganese in the arsenical solution, as in proportion to the elevation of temperature does the loss of terchloride of arsenic increase. This source of error is prevented by employing a dilute acid solution of arsenious acid, and adapting one of Will's nitrogen bulbs, containing a solution of potash, to the flask in which the oxide of manganese is dissolved. Any terchloride of arsenic which may pass over is there effectually retained, provided solution be effected at a low temperature. The normal solution of arsenious acid is made by dissolving 113·53 grs. of arsenious acid, corresponding to 100 grs. of peroxide of manganese, in a solution of potash, and then adding hydrochloric acid until the solution occupies 100 measures.

A standard solution of hypermanganate of potash is obtained by diluting, for example, 5 measures of the normal solution of arsenious acid, corresponding to 5 grs. of peroxide of manganese, and then determining the number of measures of the solution of hypermanganate of potash that are required to transform the arsenious acid therein contained into arsenic acid.

These two solutions being obtained, an estimation of the value of a specimen of oxide of manganese may be expeditiously and accurately made.

Ten, or any number of grains of the specimen under examination, are placed in a small flask, to which 10 or more measures of the normal arsenical solution are added, and to the flask is adapted one of Will's nitrogen apparatus, containing a solution of potash. The flask is then placed in a water-bath, or a gentle heat is applied until solution is effected. The contents of the flask, after having been allowed to cool, are, together with the solution of potash, transferred to a larger flask, and diluted with water. The amount of arsenious acid remaining unchanged is then determined by the addition of the standard solution of hypermanganate of potash, and the quantity thus indicated being deducted from the number of grains of arsenious acid employed in the first instance, will give the value of the specimen submitted to analysis.

In order to obtain correct results by this method, it is of course necessary that the hydrochloric acid and the potash employed should be free from sulphurous or nitric acid, or any other reducing or oxidizing impurities.

On a New Method for determining the Amount of available Chlorine contained in Hypochlorites of Lime, Soda or Potash. By ASTLEY PASTON PRICE, *Ph.D., F.C.S.*

Numerous as have been the methods proposed for determining the available amount of chlorine in bleaching powder and other hypochlorites, there is not one that I am acquainted with by which correct and expeditious determinations can be made. The following method is based on the known reactions of hypochlorites of lime, potash or soda, and hypermanganate of potash, on arsenious acid, the former of which reactions has, as is well known, been frequently proposed as the principle of many ingenious chlorimetric processes. The application of hypermanganate of potash to the estimation of iron and other substances having been attended with such good practical results, I am led to anticipate that the extension of its application to the estimation of chlorine, in the manner hereafter described, may tend to simplify the manipulations, and curtail the time now requisite for determiniug the commercial value of the hypochlorites in the several conditions in which they are met with and employed in the arts. The first point to be attained, in the correct estimation of bleaching powder, is to effect complete solution without endangering a loss of available chlorine. This may be effected by weighing a given quantity of the specimen under examination into a large flask, and adding a normal solution of arsenite of potash or soda in such quantity that an excess be always present, and after dilution with water, gradually pouring in during agitation an excess of hydrochloric acid. A normal solution of arsenious acid is obtained by dissolving 139·63 grs. of arsenious acid, corresponding to 100 grs. of chlorine, in a solution of potash or soda, and diluting the solution with water to 1000 measures. If 50 measures of this normal solution be measured into a flask, and after dilution with water be acidified with hydrochloric acid, and to it be carefully added from a graduated burette a solution of hypermanganate of potash until the solution acquires a decided pink colour, the value of the solution of hypermanganate of potash will be obtained, as the number of measures employed will correspond to 5 grs. of chlorine. Having obtained a normal solution of arsenious acid and a standard solution of hypermanganate of potash, the commercial value of the hypochlorites of lime, potash or soda may be most easily determined. 100 grs. of the bleaching powder under examination are placed in a flask graduated to 1000 measures; 500 measures of the normal solution of arsenious acid are then added, and after dilution with water hydrochloric acid is gradually poured in until a slight excess has been employed. The solution is then made up to 1000 measures. If 100 measures of this solution be now transferred into a large flask, and after dilution with water, a standard solution of hypermanganate of potash be gradually added from a burette until the solution assumes a distinct coloration, the number of measures employed will indicate the amount of arsenious acid remaining unchanged into arsenic acid, which quantity being deducted from the amount of arsenious acid originally employed will give the proportion of available chlorine contained in the sample of bleaching powder. Thus supposing that 10 grs. of bleaching powder had been employed, and that 50 measures of the normal solution of arsenious acid, corresponding to 5 grs. of chlorine, had been added, and that 30 measures of the standard solution of hypermanganate of potash, corresponding to 3 grs. of chlorine, had been necessary to transform the excess of arsenious into arsenic acid, then the 10 grs. of bleaching powder would have contained 2 grs. of chlorine, or the value of the specimen would be 20 per cent.

Instead of employing 100 grs. of bleaching powder, and proceeding as before mentioned, any number of grains may be taken,—30 grs. I have found to be a very convenient quantity,—which being placed in a flask, a known quantity of the normal solution of arsenious acid is added, and after dilution with water, a clear solution is obtained by the addition of hydrochloric acid. To this a standard solution of hypermanganate of potash is added, and from the number of measures employed the value of the sample under examination is determined. With a small amount of practice, the estimations may be made in a very expeditious manner, and the results obtained I have hitherto found to be most satisfactory.

In the estimation of the commercial value of the hypochlorites of potash or soda, the amount of available chlorine will be indicated in the same manner, and with the same degree of accuracy, as the determination of the value of bleaching powder.

On the Chemical Constitution of the Humber Deposits.
By J. D. Sollitt, *Hull.*

By far the largest constituent part of the Humber mud is an exceedingly fine sand, the particles of which are so minute as almost to float in water, and being of such a quality as to render the whole perfectly unstable and liable to be moved about by the slightest motion of the water; many of the particles of this sand, when examined by a powerful microscope, appear to have their corners worn down by the attrition of one particle against another so as to be reduced to nearly a globular form, and great numbers of those particles are so small as not to be more in diameter than a fourth part of that of a globule of human blood, or about $\frac{1}{12,000}$dth part of an inch: hence the sand which forms about 75 per cent. of the Humber deposit is, so far as relates to its particles, almost in the condition of a fluid easily displaced and driven about by every tide, both when it rises and when it falls. The author stated that in a gallon of water taken from the Humber when the water was agitated by the tide either running up or down, there were from 315 to 320 grs. of this above-named fine deposit, and that it was so exceedingly fine, as not all to have settled at the end of ten hours from the taking of the water from the river.

The first sample of the deposit, of which is given the analysis, was taken about eight miles above Hull, namely, at

Brough,

and consisted of sand moderately fine	77
Alumina	6
Carbonate of lime	6
Carbonate of magnesia	1
Soluble salts	2
Oxide of iron	2
Organic matter	6
	100

The second, taken at four miles above Hull, viz. at

Hessle,

and consisted of very fine sand	75
Alumina	7
Carbonate of lime	6
Carbonate of magnesia	2
Soluble salts	3
Oxide of iron	2
Organic matter	5
	100

The third at

Hull,

and consisted of very fine sand	71
Alumina	7
Carbonate of lime	6
Carbonate of magnesia	2
Soluble salts	5
Oxide of iron	2
Organic matter	7
	100

The fourth sample was taken on the opposite side of the river, at

New Holland,

and consisted of fine sand	69
Alumina	13
Carbonate of lime	5
Carbonate of magnesia	1
Soluble salts	4
Oxide of iron	2
Organic matter	6
	100

The fifth sample was taken four miles below Hull, at

PAULL,

and consisted of sand	82
Alumina	4
Carbonate of lime	3
Carbonate of magnesia, a trace	0
Soluble salts	5
Oxide of iron	1
Organic matter	5
	100

The sixth sample was taken at

GRIMSBY,

and consisted of fine sand	76
Alumina	10
Carbonate of lime	2
Soluble salts	5
Oxide of iron	3
Organic matter	4
	100

This sample contained no carbonate of magnesia. Mud taken three or four miles below Grimsby, is nearly all sand, and of a much coarser kind. In some places it is a mixture of the coarse sand with a little of the finer deposit of the Humber, which is found at all the places higher up the river.

GEOLOGY.

On the Comparative Richness of Auriferous Quartz extracted at different Depths from the same Lode. By Dr. J. BLAKE.

THE writer stated that no shaft had yet been made in California deep enough to test the correctness of the opinion that auriferous lodes diminish in value as they descend, but he described a circumstance which seemed to confirm that view. A horizontal mass of auriferous quartz was discovered in Grass Valley, which measured 60 yards by 45, and was from 6 to 18 inches thick; in the centre it was depressed 10 yards below the surface, its edges cropping out all round. Every part of this mass had been removed, and was found to contain 1 oz. or 1¼ oz. of gold to the ton; some part was extremely rich, affording 60 oz. to the ton. No continuation of this quartz vein could be found in the valley or surrounding hills, but at some distance above a similar vein occurred in which the proportion of gold was much smaller. In another locality a more than average amount of gold had been obtained from a lode which appeared to have been the upper part of a vein. The writer had never heard of 'nuggets' being found in mining operations.

On the Cornbrash of Gloucestershire and part of Wilts. By Professor BUCKMAN, *F.G.S.*

This stratum was described as not more than 8 feet in thickness, but covering a considerable horizontal area. The relative productiveness of soils on the 'cornbrash' to those on the 'stonebrash' was represented to be as follows:—

	Inf. Oolite.	Great Oolite.	Cornbrash.
Wheat	15	20	25
Barley	25	30	40
Oats	25	36	45

Analyses of the rocks themselves, made by Dr. Voelcker, show that the cornbrash is richer in two important elements, viz. sulphate of lime and phosphoric acid:—

	Inf. Oolite.	Great Oolite.	Cornbrash.
Carbonate of lime...	89·20	95·346	89·195
Magnesia	·34	·739	·771
Sulphate of lime	·09	·204	·241
Oxide of iron			
Alumina	4·14	1·422	2·978
Phosphoric acid	·06	·124	·177
Soluble silica	2·75	1·016	1·231
Insoluble sand	3·27	·533	4·827
Alkaline salts		not determined.	
	99·85	99·384	99·420

The cornbrash frequently abounds in fossils; out of sixty-five species collected more than half were bivalve shells. The author expressed his opinion that certain oolitic Terebratulæ (viz. *T. digona, obovata, lagenalis, ornithocephala*) should be considered as forming only one species, at the same time admitting that these forms characterized particular strata and localities. He also pointed out that nearly half the bivalves, and six out of eight sea-urchins, were identical with species found also in the inferior oolite, but not in the intervening great oolite.

Notice of the curious Spiral Body in certain Fossil Sponges, and of several other remarkable Fossils from the Yorkshire Strata. By E. CHARLESWORTH, *F.G.S.*

Mr. Charlesworth exhibited a diagram of a specimen of *Choanites Königi*, described by Mr. Cunnington at a former meeting of the British Association, and stated that he had formerly doubted the correctness of Mr. Cunnington's account, but now agreed with him that the spiral body was an essential part of the sponge. The remarkable fossils were an Inoceramus from the chalk, and a coprolitic-looking substance from the lias.

On the Remains of the Hippopotamus found in the Aire Valley Deposit near Leeds. By HENRY DENNY, *A.L.S.* (*Communicated by* T. P. TEALE, *F.L.S.*)

During the last year, in a brick-field near Leeds, have been discovered the remains of the Hippopotamus. From the specimens already placed in the Museum of the Leeds Philosophical Society, it appears that the bones have belonged to not less than three individuals. Of these, two were adults, but of different size, their molars being considerably worn. The youthful condition of the third is shown by the canine teeth being perfectly smooth and pointed, and by the apophyses having separated from the metacarpals and vertebræ.

These remains were found at a depth of 9 feet in a bed of clay, and 20 feet above the present bed of the river. This bed of clay, along with sand and gravel, which at distances of even a few yards pass and repass into each other, constitute an extensive flat deposit in the lower valley of the Aire, commencing a little above Leeds, and extending along the valley of the Aire, varying in breadth from one to three miles, until it becomes continuous with a similar deposit in the valley of the Calder. Pursuing the course of the Aire further towards the sea, we find the plain which the river traverses becoming wider, and at length continuous with the flat district of the lower part of the Ouse, and of the Trent, and of the other tributaries of the Humber.

At Leeds this flat valley formation rests upon the outbreak of the coal measures. It consists of clay, sand, and gravel, irregularly deposited under the varied influence of currents and eddies, and forming in the neighbourhood of Leeds a deposit averaging from 10 to 20 feet in thickness. The gravel is chiefly formed of millstone-grit and other sandstones, with occasional portions of mountain limestone, from the strata traversed by the river in the upper part of its course.

Along with the remains of Hippopotamus have been found in this valley deposit, the bones of the Elephant, of two bovine animals, apparently the *Bos latifrons* and

Bos primigenius, of the *Cervus Elaphus*, *Equus Caballus*, *Capra Hircus?*, and *Sus Scrofa*. Associated with them are laid horizontally the trunks of trees, as the oak, fir, and others, and hazel-nuts.

On a Chemical Cause of Change in the Composition of Rocks. *By* Professor Johnston, *M.A.*, *F.R.S. L. & E.*

The first example of a chemically altered rock adduced by the Professor, was the rottenstone of Derbyshire, a light and porous substance used chiefly for polishing metals, and stated in Phillips's 'Mineralogy' to be composed of silica, alumina, and carbon. It is obtained from a ridge known as the Great Fin, on the right-hand side of the road from Bakewell to Buxton. This ridge is covered with "drift" 10 or 20 feet thick, consisting of brown clay, with fragments of black marble, chert, and rottenstone. The rottenstone is so soft whilst in the soil that the spade goes through it readily, but it hardens on exposure; the holes from which it is dug are sometimes only 2 feet deep, at others from 6 to 8 feet. On examining a series of specimens, Professor Johnston found that whilst some were homogeneous, others had a nucleus of black marble; he then treated specimens of the black marble with weak acid, and found that on the removal of the carbonate of lime, there remained from 30 to 35 per cent. of a siliceous substance perfectly like the natural rottenstone. He concluded that there existed in the soil some acid which penetrated it and dissolved out the calcareous matter of the rocks below. The agent in this case might be said to be the carbonic acid of the air brought down by rain; but there were instances not capable of explanation by this agency alone, and attributable to other acids, which are constantly being produced under certain conditions and exercise a much wider influence. The acids he alluded to were those which are produced naturally and everywhere by the decay of vegetable matter. The bottoms of peat bogs present very strong evidence of the action of acids; the stone and clay are bleached and corroded, only siliceous and colourless materials being left. The source of the acid is here the same as in the former instance; the vegetable matter growing on the surface produces in its decay acid substances which exert a chemical action on the subsoil, and escape by subterranean outlets, carrying away the materials dissolved in their progress. Another instance was afforded by the mineral Pigotite, formed in the caves of Cornwall by water dripping from the roof; this water contains a peculiar organic acid, derived from the soil of the moors, which dissolves the alumina of the granite and combines with it. The organic acids are very numerous and differ in composition, but agree in producing chemical action upon rocks. They are produced over the entire surface of the earth, especially over uncultivated tracts, and are among the means provided by nature to dissolve the mineral food of plants; they are also amongst the chief causes of the exhaustion of soils. The author then alluded to Professor Way's examination of some of the greensand strata of Surrey, known as *firestone*,—a light and porous rock, containing silica in a soluble state. It was well known that common sandstone, quartz, or rock crystal were not acted upon by potash or soda at ordinary temperatures; but of the firestone 30 per cent., and sometimes 50 or 70 per cent., may be dissolved. In all such cases the silica must have been originally in a state of chemical combination with lime, alumina, or something else, which has been subsequently removed. The silica in the *rottenstone* was soluble, but he had never met with instances of black marble in a bedded state converted into rottenstone. He believed, however, that a similar cause, operating over a wide area, and during a long period, had produced the altered condition of the firestone. Professor Johnston then alluded to the nodules of phosphate of lime in the greensand and crag, and suggested that the phosphorus had been derived from animal remains in higher strata, dissolved out by acids, and redeposited at a lower level. The last example was the *fireclay* of the coal-measures, a stratum almost universally found beneath beds of coal. It differs from the other clays both in colour and composition, being whiter, and containing less of those substances which acid bodies could dissolve, viz. the earthy bases, which would render the clay fusible in fire; the condition of the fireclay might be accounted for by the action of acids developed during the production of the vegetable matter now forming coal.

On the Waste of the Holderness Coast. By George G. Kemp.

The writer computed the actual waste on this coast at from 1½ to 4 yards per annum, the amount varying with the conditions of the shore and the direction of the currents. The average loss of land amounted to 33 acres annually; whilst the destruction of public and private roads, houses, and churehes, was not less injurious. The causes of the waste are, the action of frost and rain producing falls of the cliff, and the agency of the sea in removing the beach and making hollows at the base of the cliffs. To these was added another, viz. the removal of the shingle for ballast, mending roads, paving streets, building walls, and a variety of other purposes. At Hornsea, 500 tons of beach had been removed in a week, and near Spurn Point 1000 tons had been taken in a day. The floor of the beach was thus lowered, and the natural defence of the coast removed. Mr. Kemp urgently recommended that a grant should be obtained from Government to repair the breaches which the sea had made, and that the removal of the shingle should be absolutely prohibited.

[Mr. Kemp has, since the Meeting, added to his paper the following series of Measurements taken along the line of the Holderness coast, from Spurn Point, and continued to Flamborough Head, of objects from the nearest point of the cliff. Magnetic variation 24° 19′ West.]

Place.	Object.	Direction.	Distance. yds.	ft.	in.
Kilnsea	Blue Bell Inn, N.W. corner to the cliff.	East	525	2	5
Easington	Church, S.E. corner	East	905	0	0
Holmpton	Church, N.E. corner	East	1118	2	1
Withernsea	Church, N.E. corner	East	381	2	0
Tunstall	Church, N.E. corner	East	737	1	0
Ringbrough (Farmstead).	Waggon Shed, N.E. corner.	East	230	0	0
Hilston	Church, centre, East end.	East	1117	1	10
Aldborough	Church, S.E. corner	East	1943	2	1
Aldborough	Church, N.E. corner	East-north-east	1966	0	0
Mappleton	Church, N.E. corner	East	456	2	9
Hornsea	Church, N.E. corner	East	957	2	0
Hornsea	Church, N.E. corner	East*	988	0	0
Atwick	Cross, S.E. corner	East	828	0	0
Skipsea	Cliff House, North-east corner.	East	176	1	0
Ulrome	Church, S.E. corner	East	1817	0	3
Barmston	Church, S.E. corner	East	1826	0	0
Wilsthorp House	Barn, S.E. corner	East	155	1	0
Hilderthorpe House	House, E.S.E. corner	East	310	2	0
Mainprize's Farm-House, near South Pier, Bridlington Quay.	House, S.E. corner	South-east	61	1	9
Ocean View, eastward of Bridlington Quay.	House, S.E. corner	South-east	115	2	0
Railway Bridge, Sewerby	West corner, under the arch.	South-south-east	264	0	0
Sewerby	Church, S.W. corner	South-south-west	455	1	0
Flamborough	Old Tower, centre	South-east	953	2	3

* To a datum line drawn from the east end of the road near the Marine Hotel on the north, to the margin of the cliff opposite the end of the road at Hornsea Burton on the south.

On the most Remarkable Cases of Unconformity among the Strata of Yorkshire. By Professor PHILLIPS, *F.R.S.*

On the Dispersion of Erratic Rocks at higher Levels than their Parent Rock in Yorkshire. By Professor PHILLIPS, *F.R.S.*

The Professor stated that in a comparatively modern geological period, every part of Yorkshire, below the level of 1500 feet, was covered by the waters of a glacial sea. Icebergs appear to have floated over the whole of this district, depositing where they melted, or were overturned, the materials brought from the higher hills, which at that time were partly covered by glaciers. Amongst these were blocks of stone from Cumberland and the North Riding, now found perched on the limestone hills. Some of them must have come over the Pass of Stainmoor, a height of 1440 feet, and been thence radiated over all the eastern parts of Yorkshire. A remarkable case of local distribution occurred in the country of Ribblesdale, where in several places, as on Feizer and Giggleswick Scar, the blocks of 'Horton Flag' (Cambro-Silurian) were found perched on broad surfaces of limestone resting *on* these flags. On the east side of Ribble, above Langcliffe and Settle, there were large blocks near the summit, 150 or 200 feet above the level of the rock from which they were derived. At Long Scar, blocks of limestone lay on the hills immediately *over* their source. These erratic blocks were not much water-worn, and must have been transported by ice; no violent rush of water would have accomplished it. He believed the glacial movement to have been one of Continental elevation and depression, occupying a long period of time, and that the assigned depression of 1500 feet affected the land far up towards the north, and to the east and west, but ceased, or grew much less, towards the south.

On a new Plesiosaurus in the York Museum. By Professor PHILLIPS, *F.R.S.*

It was a curious circumstance, that each of the three great Plesiosauri lately discovered in Yorkshire belonged to distinct and undescribed species. One of these, described by Mr. Charlesworth at a former meeting, was now in the possession of Sir P. Crampton, in Ireland; the other two were in the York Museum. One of them was 18 feet long, and had a very small head; the other was nearly equal in size to the large Plesiosaurus of the Kimmeridge clay. Its head is 42 inches long, and much narrower in proportion than in the other species; the neck is much shorter, being only half as long in proportion as in the *P. dolichodeirus.* The paddles are 5 feet in length, and offer analogies to Pliosaurus. The vertebræ are like those of the other species; the teeth slightly different. It was found in Lord Zetland's works, at Lofthouse, on the Yorkshire coast.

On the Formation of Boulders. By the Rev. T. RANKIN.

The writer's observations were made in some of the valleys on the Scotch borders, with the view of exciting Mr. Hopkins to re-examine the theory which he had embraced with some hesitation, and whether it be tenable. Mr. Rankin endeavoured to explain the phænomena of the boulder formation by a general deluge, and subsequent river-action.

On the Classification and Nomenclature of the older Palæozoic Rocks of Britain. By the Rev. Professor SEDGWICK, *M.A., F.R.S.,* &c.

The term Palæozoic includes all the known fossiliferous rocks from the Permian to the lowest Cambrian. It is separated into three natural divisions:—1st. *Lower division,* including all deposits which have been called Cambrian and Silurian. 2nd. *Middle division,* including the Old Red Sandstone; and the whole Devonian series, of which the lowest group appears to be wanting in the English sections. 3rd. *Upper division,* including the Carboniferous and Permian series. If the old terms, Primary, Secondary and Tertiary, be retained, the three above-named divisions make up the Primary System of Britain; and to these divisions, collectively, the author applies the term *Palæozoic System.* They do not interchange species with the fossils of the *Secondary System*, including under that term all deposits from the Triassic to the Cretaceous. They are characterized by Graptolites and many peculiar genera of Corals, by a vast abundance of Brachiopods, by Trilobites, and by peculiar forms of Cephalopods. On the other hand, a few *species* are continued through a great ascending series of groups, from the Cambrian to the Carboniferous; and between the successive primary or palæozoic groups, it is very difficult, and sometimes (in the actual state of our information) impossible to draw a well-defined line of separation. Hence (although all the types of organic life, from the oldest palæozoic to the modern, belong properly to one *Systema Naturæ*) it is convenient for description to regard the palæozoic fauna as a sufficiently distinct *Systema Naturæ* to have a separate name as a *system*.

In vindication of the previous statements the author quotes the following examples of fossils which have a wide palæozoic range:—

Favosites alveolaris,	from the	Bala group	to the	Devonian	inclusive.
——— gothlandica	,,	,,	,,	Carboniferous	,,
Hexopora fibrosa	,,	,,	,,	Devonian	,,
Spirigerina reticularis	,,	,,	,,	Devonian	,,
Leptagonia depressa	,,	,,	,,	Carboniferous	,,

and he doubts not that several other species might be added to the list.

After these preliminary remarks the author gave the following *Tabular Views*.

1st. *Tabular View of the British Palæozoic System.*

Upper division.	V. Permian series. Divisible into three subordinate groups.		
	IV. Carboniferous series. Divisible into three or four subordinate groups.		
Middle division.	III. Devonian series.	8. Petherwin group.	
		7. Caithness group?	
		6. Plymouth group, without any ascertained base, and therefore, [perhaps, capable of further subdivision.	
Lower division.	II. Silurian series.	5. Ludlow group.	*d.* Tilestone.
			c. Upper Ludlow.
			b. Aymestry limestone.
			a. Lower Ludlow.
		4. Wenlock group.	*d.* Wenlock limestone.
			c. Wenlock shale.
			b. Woolhope limestone.
			a. May Hill sandstone and Pentamerus [limestone.
	I. Cambrian series.	3. Bala group or Upper Cambrian.	*b.* Upper Bala—Caradoc sandstone and shale; Hirnant and Bala limestones; flagstone and conglomerate, &c. &c.
			a. Lower Bala—dark slates, flags, grits, &c.
		2. Festiniog group.	*c.* Arenig slate and porphyry.
			b. Tremadoc slate.
			a. Lingula flags.
		1. Bangor group.	*c.* Harlech grits.
			b. Llanberris slates*.
			a. Longmynd slates.

This tabular view (chiefly derived from the Welsh sections) agrees very nearly with one published by the author in the 2nd Fasciculus of the Palæozoic fossils in the Cambridge Museum, two changes only having been introduced: 1st, the Longmynd slates are arranged provisionally with the lowest or Bangor group; for they form the oldest group (not metamorphic) in the Cambrian and Silurian country, and by the gentlemen of the Government Survey they are regarded as the base of what is here called the Bangor group. 2ndly. The May Hill sandstone and Pentamerus limestone are now cut off from the Caradoc sandstone, and placed at the base of the Wenlock group. Some of the reasons for this latter change were given in a paper read before the Geological Society of London, Nov. 3, 1852, and are now published in No. 35 of the Journal of the Geological Society of London (Aug. 1853).

The previous tabular view is derived from the sections of Siluria and Cambria.

* This sub-group (Llanberris slates) is of great thickness, and includes several bands of slates and hard grits which are below the great quarries of Nant Francon and Llanberris. These quarries are *immediately* under the so-called Harlech grits.

The following is in like manner derived from the sections of Cumberland, Westmoreland, N. Lancashire, and a part of Yorkshire:—

2nd. *Tabular View of the British Palæozoic System.*

Upper division.	V. Permian series.		*b.* Magnesian limestone and conglomerate. *a.* Coarse red sandstone and conglomerate*.
	IV. Carboniferous series.		*d.* Upper carboniferous. *c.* Millstone grit. *b.* Lower carboniferous ("Yordale series"). *a.* Great scar limestone.
Middle division.	III. Devonian series.		Coarse red conglomerate and red sandstone, here and there of great thickness, and always unconformable to the older groups; but discontinuous, and often thinning out or disappearing altogether.
Lower division.	II. Silurian series.	6. Group from Benson Knot, south of Kendal, through Kirkby Moor to the Lune, called Kirkby Moor group.	*c.* Tilestone and red calcareous flagstone. *b.* Grits and coarse flagstone, without transverse cleavage. *a.* Coarse slates, &c., with occasional transverse cleavage; north of Kendal Fell, forming a passage into the lower group.
		5. Ireleth slate group.	*d.* Coarse striped slates alternating with beds of gritstone, much contorted and of great thickness. *c.* Great or Upper Ireleth slate; no traces of Aymestry limestone. *b.* Ireleth limestone in a discontinuous and concretionary form. *a.* Lower Ireleth slate.
		4. Coniston grit.	Coarse hard gritstone, conglomerate, and thin bands of slate. Collectively of great thickness.
	I. Cambrian series.	3. Coniston limestone group.	*b.* Coniston flagstone and calcareous slate. *a.* Coniston limestone and calcareous slate.
		2. Green slate and porphyry.	Great beds of roofing-slate, &c., alternating indefinitely with porphyry, trappean conglomerate, trap-shale (*shaalstein*), &c. Collectively of enormous thickness.
		1. Skiddaw slate.	*d.* Some rare examples (probably in the upper part of this great group) of black slate with fucoids and graptolites. *c.* Masses of gritstone, rarely of coarse texture. *b.* Mountain masses of black slate, with veins of quartz; not effervescing with acids. *a.* Beds of porphyritic chiastolite slate, passing (when near the granite) into chiastolite rock, and beds which are entirely metamorphic.

In this tabular view (derived from actual sections in the north of England) the Skiddaw slate may be put on the same parallel with the old slates of the Longmynd. The older roofing-slate of the second group (*e. g.* the slates of Borrowdale) may be (provisionally) compared with the Llanberris and Nant Francon slates of the Welsh section. In the mountains of Cumberland we have found no trace of the Lingula flags, or of the Tremadoc slates with their subordinate beds of granular magnetic iron ore. But the green slate and porphyry (of group second) are the exact counterpart of the

* A still higher group (*c*) of the Permian series, not here noticed, is found in Nottinghamshire and the southern part of Yorkshire. It is composed of gypseous red marls and thin-bedded limestone.

slates and porphyries of Arenig and Cader Idris. In Cumberland, the porphyritic impress is so far continued in the ascending section, that the Coniston limestone (group three), at the south end of the county, becomes interlaced with the highest beds of the second group. Hence the second group of this second tabular section appears to represent, with a different mineral type, both the Festiniog and Lower Bala groups. The Coniston limestone is identical, in structure and fossils, with the Bala limestone; and the Coniston limestone and flagstone represent (as to thickness, in a degenerate form) the whole series of upper Bala rocks (3*b* of the 1st tabular view).

Continuing this comparison through the upper or Silurian series, we may safely identify the great zone of the Coniston grits with the more sterile portions of the May Hill sandstone (Wenlock group, 4*a*). A part of the Ireleth slate group (5*a*, 5*b*, 5*c*), however different in structure, is in the exact place of the upper parts of the Wenlock group (*i. e.* 4*b*, 4*c*, 4*d*). The upper stage of the Ireleth group (5*d*), together with a portion of a higher stage (6*a*), is in the place of the Ludlow stage (5*a*). And, lastly (excepting a few beds at its base), the sixth group (of Benson Knot, Kirkby Moor, &c.) unequivocally represents the upper stages of the Ludlow group (5*c* and 5*d*).

If we assume the approximate truth of these identifications, it must be obvious that the Cambrian sections are palæontologically more perfect than the Cumbrian, and are therefore more fit to supply us with the means of a correct classification and nomenclature.

Returning then to the Cambrian series as defined in the first tabular view, the author remarks upon its enormous thickness, its unambiguous development, its physical characters, and its organic remains; whereby it is very widely separated from the overlying and *generally unconformable* Silurian series. If the May Hill sandstone be struck off from the inferior groups with which it has been classed in the 'Silurian System,' it becomes (as in the tabular view) the palæontological, as well as the physical base, of the 'Silurian System.' For in the May Hill sandstone the great palæontological, as well as the great physical, change takes place, whereby the Silurian and Cambrian groups do admit of a clear separation. The Cambrian series is palæontologically quite as distinct from the Silurian as is the Devonian from the Carboniferous.

While the May Hill sandstone, with a perfect Wenlock group of fossils, was classed under one name with the Caradoc sandstone, which has a perfectly Cambrian group of fossils, no wonder that Cambrian and Silurian rocks should have been regarded as of one palæontological type. Now that this erroneous nomenclature and classification has been corrected, the author does not believe that the two *series* (Cambrian and Silurian) will prove to have in their fossil lists more than six or seven per cent. of common species. M. Barrande's investigations in Bohemia give not more than about five per cent. of species common to rocks which answer to those which are here called Cambrian and Silurian. Mr. Hall's investigations in New York give, for that great region, a still smaller per-centage of such common species. An examination of all the fossils derived from the lower division of the palæozoic rocks in the north of England, after they have been separated into two great groups—one representing all fossils found below the Coniston grits, and the other representing all the fossils found from the Coniston grits inclusive, up to the base of the old red sandstone,—gives (out of a total of 165 species) not more than three and a half per cent. of species common to the two groups*.

After these facts, the author contends that there is now no rational ground of dispute either as to the classification or nomenclature of the great groups of strata which form the lowest division of the British Palæozoic series.

The nomenclature here presented has the priority in time. The physical sequence was made out (as to all essential points) by the unassisted labours of the author, who first adopted the name Cambrian for the vast groups which form the so-called Cambrian series. The nomenclature is not only palæontologically right, but is geographically true and congruous; for every rock of which the true place had been determined by the author of the 'Silurian System' is still called Silurian; while

* Several sections from Wales and Cumberland were exhibited in illustration of the classification here vindicated; but they are necessarily omitted in this abstract.

the vast (and generally unconformable) inferior groups, which collectively are found in Cambria, and are assuredly not found collectively in any Silurian section, are still called Cambrian.

The preceding classification places the Silurian series on its true physical and true palæontological base; but it does exclude from that series the shelly sandstones of Caer Caradoc, and the calcareous flagstones of Llandeilo.

To confirm the preceding conclusion, the author then went on to a discussion of certain sections examined (by Professor M'Coy and himself) immediately before the meeting of the British Association at Hull. They were prevented from extending their examination to the sections of Builth and Llandeilo by a very vexatious accident; and their joint remarks, so far as they appear in this abstract, relate to sections at the south-west end of the Longmynd, and to sections through the typical Caradoc sandstone, where it forms a well-known terrace, ranging from the banks of the Onny to the banks of the Severn.

(1.) *Sections of the Pentamerus Limestone and May Hill Sandstone of Norbury and Linley.*—From these rocks (which rest unconformably on the old Longmynd slates) they obtained the following fossils, the species determined by Professor M'Coy:—

**Ptilodictya lanceolata*, as at Dudley.
**Palæopora interstincta*, common to Cambrian and Silurian.
**Favosites multiporatus*, ditto.
**Petraia bina*, as in Wenlock limestone and May Hill sandstone.
*—— ——, unnamed species, same as at May Hill.
**Encrinurus punctatus*, common to Cambrian and Silurian rocks.
Pentamerus lævis } in almost incredible abuudance.
—— *oblongus* }
**Leptæna transversalis*, as in Wenlock and limestone of Woolhope, Dudley, &c., and May Hill sandstone.
*—— *euglypha* as in Wenlock limestone, and Dudley.
**Orthis elegantula*, common to Cambrian and Silurian.
*—— *pecten*, ditto.
*—— *Davidsoni*, as at Wenlock limestone of Walsall, and sandstone of May Hill.
***Spirigerina reticularis*, common to Cambrian, Silurian, and Devonian.
**Littorina octavia*, as in Wenlock limestone.

Upon this list it is remarked, that out of fifteen species eight have not yet been found, except in the Wenlock group or its equivalents; and that of the remaining seven species, one ranges through both the Silurian and Devonian series, while the other six belong to species *already known* to be common both to Cambrian and Silurian rocks. On the other hand, all the types hitherto regarded as exclusively characteristic of Cambrian rocks are wanting. Hence the author (along with Professor M'Coy) arranges the Pentamerus limestone, &c. of Norbury at the base of the Wenlock group, and cuts it off from the Caradoc sandstone. He further remarks, that those fossil species which are admitted to be common to the Cambrian and Silurian rocks, appear chiefly to abound in the uppermost beds of the Cambrian series; as also in the May Hill sandstone, which is the true base of the Silurian series. In other words, the common species abound in the very beds where we should expect to find them.

(2.) *Section of the Onny in descending order.*—The lower parts of the river banks were under water during the author's visit to the country along with Professor M'Coy; but the following facts were partly supplied by excavations which had been kindly made, at the author's request, by Mr. Duppa of Cheyney Longville, in places out of the reach of inundation.

In the first excavation, 200 yards above Stretford Bridge, abundance of the following fossils:—

Graptolites Ludensis. *Calymene tuberculosa.*
Odontochile longicaudata. *Cardiola interrupta.*

Between this locality and the following is a change of surface, and no rock is distinctly seen for some hundred yards. This is the place where we might expect the May Hill sandstone and Pentamerus limestone.

About 300 yards above Longville Bridge the following fossils are abundant, without intermixture of the above-named species:—

Orthis calligramma,
—— *elegantula*, var. *a.*
—— *parva*,
Leptæna sericea,
—— *quinquecostata*,
} exclusively Cambrian.

Spirigerina reticularis, Cambrian to Devonian inclusive.

In a second excavation, 30 yards higher up the river, occurs a bed with innumerable specimens of *Trinucleus*. Still further up the river, the well-known Caradoc beds of Horderley.

In this section, therefore, the highest beds are undoubted Wenlock shale, the lowest are undoubted Cambrian (Caradoc sandstone of the Bala group), and the intermediate May Hill group is lost. These facts do not invalidate, but, so far as they go, confirm the conclusion drawn from the Norbury section; and tend to prove that the author was in error, when, in a previous communication, he placed the Pentamerus beds within the limits of the Caradoc group (paper read before the Geol. Soc., Nov. 3, 1852).

(3.) *Sections of Shineton, &c., where the terrace of Caradoc Sandstone approaches the right bank of the Severn* (Map of the 'Silurian' System).—As the author was prevented from examining these sections, he gives *verbatim* the notes upon them by Professor M'Coy:—

"(1.) Close to Shineton Church, olive shales on the roadside; dip about 35° E. of S. at about 30°, containing—

Agnostus pisiformis (as at Llandeilo, &c.), *in great abundance*.
Olenus? (same as at Hollybush) (Phillips' Malvern Section, see his Memoir, p. 55.)
Asaphus?, undetermined fragments.
Cytheropsis Aldensis (as at Aldens on the Stincher, N.B.).
Siphonotreta micula (as at Wellfield, Builth, and at Pentre, N. of Llangynyw).

"All the above are Cambrian types.

"(2.) Over the above, and also *over* some black shales with a few traces of *Fuci* and *Orthoceratites*, in Belswardine Brook, several thin beds of Pentamerus limestone and May Hill sandstone occur (dip about 50° E. of S. at 20°), full of—

Hemithyris hemisphærica.
Pentamerus lævis.
—— *oblongus*.
Petraia (unnamed species, same as at May Hill and Malvern).

"(3.) One mile W. of Harley, olive-coloured shales like those at Shineton, with nearly the same dip and direction, are *overlaid* (with a small unconformity) by very coarse unfossiliferous May Hill conglomerates (exactly like those forming the base of the May Hill sandstone near the top of May Hill), seen in numerous openings extending along the road to Church Preen.

"*Beneath the above conglomerates*, in the large quarries at W. edge of Round Nursery near Harnage Grange, the Caradoc sandstone and limestone are found, both dipping 10° E. of S. at about 20°, and full of the following fossils:—

Orthis expansa,
—— *vespertilio*,
—— *elegantula*, var. *a.*
—— *parva*,
—— *Actoniæ*,
—— *bilobata*,
} all exclusively Cambrian."

These sections (at Shineton, &c.) had been previously examined, in detail, by Mr. Salter, whose list of fossil localities was kindly communicated to Professor M'Coy and the author before their visit to the country.

The conclusion from the above facts seems to be inevitable. The great (and supposed) typical section of Caer Caradoc and Wenlock Edge is not, probably, a continuous, but a broken section; and the conglomerates, grits, Pentamerus limestone, &c. (which overlie the *Olenus shales*) must here (as at the Malverns) be cut off from the Caradoc terrace, and arranged with the Wenlock group, as in the above first tabular view.

From all the above facts, as well as from facts previously published, the author concludes, that in no part of Wales, or the adjacent counties, is there any one continuous unbroken section through which we can ascend from the Cambrian to the Silurian groups. There is a physical break between them; and in very near coordination with that break (often marked by a discordancy of position) there is a great change in fossil species. The author showed the bearing of these views on the sections from the Clea Hills to the Longmynd, and on similar sections from the vicinity of Llandeilo; and from both districts drew confirmations of his conclusion, *that all the older* groups of North and South Wales, and of a part of the Silurian district, up to the base of the May Hill sandstone, must retain the name 'Cambrian,' which has the claim of priority, is geographically true, and palæontologically right.

The author, after referring to the history of the investigations into the Silurian and Cambrian systems, remarks that he never had the expectation of establishing, by the evidence of fossils, a separation between Cambrian and 'Lower Silurian' rocks, which has been attributed to him. He had from the first a contrary opinion, founded both on sections and fossils,

That the fossils of the whole Bala group and the fossils of Snowdonia were identical with the fossils of the so-called Lower Silurian groups, was certain *long before* there was any matter of dispute about the Palæozoic nomenclature; but that was considered by the author as *no reason* for extending the Lower Silurian nomenclature over all the older groups of Wales. It was, however, a *very good reason* for keeping the Lower Silurian nomenclature in abeyance; and pretending to no strictly defined nomenclature of Lower Silurian or Upper Cambrian rocks, till it could be permanently fixed both by true sections and corresponding groups of fossils. That period it has at length reached through the determination of the May Hill group; which group was introduced, or immediately preceded, by great physical movements indicated here and there by great masses of conglomerate, by great groups of rock with a new physical type, and generally in a position discordant to the Cambrian series; and at the same time by a great change in the organic types; *i. e.* by the sudden disappearance of the undoubted Cambrian types, and by the sudden appearance of undoubted Silurian types. Such phænomena may well be considered as the prelude to a new system or a new series of physical groups demanding a separate name. The scheme of nomenclature and classification, given in this communication, does not deprive the 'Silurian System' of a single stratum or a single group of fossils which belong to it on a right and natural interpretation of the sections. At the same time, the original Silurian map is on this scheme not greatly changed. The groups of Caer Caradoc and Llandeilo become indeed absorbed in the upper Cambrian groups, among which they find their true geographical and true sectional place; but the greater part of the rocks hitherto called Caradoc sandstone still have their place in the map of Siluria under another name (May Hill sandstone). The remarkable groups of Tortworth and the Usk; all the groups of May Hill and Woolhope; all the Silurian groups on the west side of the Malvern Hills (with an almost evanescent exception at Holly Bush); the groups of Abberley, Presteign, Aymestry, and Ludlow; all these groups will remain almost untouched, or with one new Silurian colour for the May Hill beds. A distinct colour for the May Hill sandstone must appear at the base of Wenlock Edge. Further north the changes in the Silurian map will be more considerable; but it will be compensated, for the loss of certain Cambrian groups, by a large extension of the May Hill sandstone through the chain of the Berwyns, and thence, as in the Government map (in which it is laid down under the erroneous name of "Middle Silurian"), to the sea near Conway.

The author then compares with the results of his investigation the nomenclature and classification adopted in the publications of the Geological Survey of Great Britain, in which only those lower groups which are without fossils are ranked as 'Cambrian'. He objects to the extension of the meaning of 'Llandeilo rocks,' so as to make them comprehend the Upper and Lower groups of Bala; and to the use of such a term as 'Middle Silurian,' embracing the May Hill and Caradoc sandstones. The distinction of these two sandstones was first made out in the Cambridge Museum by Professor M'Coy, after a detailed examination of the Cambrian and Silurian fossils collected by the author; it has since been confirmed by an examination of sections in the field; and the author believes there is no alternation of Cambrian and Silurian rocks, no confusion of these separate groups, and no well-defined great 'middle' group, blending the characters of the two extremes. He claims the right to suggest to the Government Survey a return to the nomenclature which he was the first to propose, and of which he now vindicates the justice and propriety.

In this way (and this way only) can there be an end of controversy. The groups will have their first names, and their right geographical names. While the rocks of Cambria are called Cambrian, the rocks of Siluria will be called Silurian; and not so much as one single bed of rock will be seen out of the limits of the true Silurian colours of the Geological map, of which bed the right place had been fixed in the original sections and details of the 'Silurian System.'

Finally, the author contends that the most recent and mature works of great Continental and American palæontologists (such as Barrande, D'Orbigny, Hall, Rogers, &c.) do not invalidate, but confirm, the views here communicated to the British Association. These authors have not, indeed, ever entered on any formal discussion of British palæozoic nomenclature. They have taken the British groups and names as they found them published; and naturally left their final adjustment to British geologists. But they have presented the data in a form clearly showing the general equivalency of the so-called 'Lower Silurian' to the Cambrian rocks; and the results which they have obtained appear, not only to the author of this communication, but also (as he can affirm) to some of the great American geologists themselves, to confirm in all important points the physical and palæontological separation between the Cambrian and Silurian series.

The author ended by stating, as an excuse for the very great and unusual length of his paper, that he believed it, out of comparison, the most important communication he had ever made to the British Association. It contained historical and geographical details, and several illustrative sections (of which little or no notice is taken in this abstract), and exhibited conclusions derived from evidence, the unfolding of which had taken many years of hard field-labour. And as some of its conclusions were still controverted, they were, on that very account, specially fitted for a calm discussion in the Geological Section (of the British Association), in which he had, at this meeting, the honour to fill the Chair.

On Pseudomorphous Crystals in New Red Sandstone. *By* H. E. Strickland, *M.A., F.G.S.*

These pseudo-crystals were cubical projections from the under surfaces of laminæ of white sandstone, of the age of the red marls, and had been detected at various localities in Gloucestershire, Nottinghamshire, and Cheshire. They might have been formed in cavities left by the decomposition of iron pyrites, or by the removal of crystals of common salt. That the latter was really the case seemed evident from some of the specimens, in which the faces of the cubes were concave, and exhibited concentric lines. The author inferred that the crystals of salt were formed on, or in the mud of the shore, during a temporary exposure to the sun, and being again covered by the sea, the crystals had dissolved, and their form had been assumed by the material of the next succeeding deposit.

On some Ayrshire Fossils. *By* Wyville T. C. Thomson, *LL.D.*

Dr. Thomson exhibited a collection of fossils from the Lower Silurian (or Cambrian) rocks, on the South bank of Girvan Water, in Ayrshire: they were obtained by breaking up the rock, and still retained their natural surfaces in very great perfection; whereas, fossils of the old rocks in general only retain their real surfaces when developed by the weather.

On Refracted Lines of Cleavage seen in the Slate Rocks of Ballyrizora, in the County of Cork. *By* R. W. Townsend, *M.A., M.R.I.A.*

The author exhibited a diagram representing the surface of some Devonian rocks near Cork, in which the angle of the cleavage planes changed slightly on passing from the argillaceous layers to those of a more arenaceous character.—[The subject had been already examined by Prof. Phillips, and discussed at the Meeting of the British Association at Cork, in 1843.]

On a singular Fault in the Southern Termination of the Warwickshire Coal-field. By CHARLES TWAMLEY, *F.G.S.*

This narrow coal-field is described as extending from Polesworth, near Tamworth, to Sow, three miles east of Coventry. At the Victoria Colliery, near Bedworth, the coal-seams lie nearly together, with very thin partings, and measure from 8 to 10 yards. At Polesworth the seams are widely separated, forming, with the interposed strata, a thickness of more than 70 yards. The *fault* described is in the Victoria Colliery; the coal lies at the depth of 225 yards, dipping S.W., 12 inches in the yard. In driving a gate-road southerly a fault occurred, the coal-seams being cut off in succession; the top one disappearing first, and the bottom one last. The road was continued on a level, through fractured rocky shale containing coal fossils, for about 120 yards, when the coal-seams were again met with, in the same order in which they disappeared: the bottom one first occurring and the top one last; but the dip had increased from 12 to 20 inches in the yard. The interval in the top coal was 180 yards wide; in the bottom coal 120 yards, and in a band of ironstone below the coal 80 yards. The level at which the coal reappears is 22 yards higher than it would have been but for the fault. A headway was driven upwards 60 yards, and a shaft sunk downwards 40 yards in the shale, without finding a trace of coal. The fault has an irregular N.W. and S.E. course at right angles to the dip of the beds.

BOTANY AND ZOOLOGY.

BOTANY.

On the Structure of the Endochrome in Conferva Linum. *By* Professor ALLMAN, *M.D., M.R.I.A.*

THE cells of this plant are filled with a deep green endochrome, which when liberated from the cell and examined under a power of about 150 linear, is found to be composed of exceedingly delicate utricles, filled with homogeneous green matter which surrounds a central nucleus-like body. The form of this body is peculiar, being that of a more or less circular disc, with a thickened ring-like margin, and generally bent irregularly on itself. Iodine, by turning it blue, proves it to be a starch-granule. In one or two instances, the endochrome-utricles were found after the application of iodine, with their green contents contracted towards one side, and the starch-granule lying free in the otherwise empty portion of the utricle. In some cases two or three starch-granules were found in a single utricle.

It frequently happens that the utricles become ruptured, probably by the endosmose of water, or by the actual solution of their very delicate walls, and thus liberate their contents; the starch-granules were then seen to float away perfectly free upon the field of the microscope. In none of the utricles could any true nucleus be detected.

Besides the simple utricles with their green contents and starch-granules, others were not unfrequently met with of a larger size, and filled with a brood of smaller utricles, exactly similar to those just described; like them filled with homogeneous green contents, and containing a nucleus-like starch-granule.

It is thus proved,—1. That the green matter in *Conferva Linum* is immediately contained in distinct cells or utricles. 2. That it surrounds in each utricle a peculiarly formed starch-granule. 3. That these utricles are themselves the product of parent utricles, in whose cavity they are formed; the endochrome of *Conferva Linum* thus possessing an independent organization by which it is enabled to multiply itself within the filament.

On the Utricular Structure of the Endochrome, a Species of Conferva. *By* Professor ALLMAN, *M.D., M.R.I.A.*

The plant which constituted the subject of the communication, is closely allied to *Conferva linum*, and the author showed that the deep green endochrome, when liberated from the cell, is seen to possess a very definite utricular structure. Each utricle is filled with homogeneous green matter, which surrounds one or more peculiarly formed starch-granules. In many instances, utricles were met with of a large size, and filled with a brood of secondary utricles, each containing homogeneous green contents, surrounding a nucleus-like starch-granule.

On some New Plants. By Professor J. H. Balfour, *M.D.*

Notes on the Growth of Symphytum officinale *in the Botanical Gardens of the Royal Agricultural College. By* Professor James Buckman, *F.G.S.*

During some experiments on plants of *Symphytum officinale*, the common comfrey, and *S. asperrimum*, the comfrey cultivated in the Gardens, the author was struck with the resemblance of the two species; and gave an account of certain intermediate forms, which led him to the conclusion that these plants were one and the same species.

Additional Observations on a New System of Classifying Plants. By B. Clarke.

On a Method of Accelerating the Germination of Seeds. By Robert Hunt.

This communication was merely a recapitulation of the results obtained by the author, and fully communicated in Reports published in former volumes. Its object was to introduce a letter from Messrs. Lawson and Co. of Edinburgh, who stated that by adopting the plan of cutting off the luminous rays by the use of cobalt blue glass, as recommended by Mr. R. Hunt, they succeeded in obtaining healthful germination far more rapidly than under ordinary circumstances. They had constructed a house glazed with blue glass, and in this all their seeds were tested. This practical application of a scientific discovery was of the utmost value to them. Tropical seeds under the same circumstances were found to germinate in a few days, whereas in ordinary conditions many weeks were required for the completion of the process.

On the Pentasulphide of Calcium as a Remedy for Grape Disease. By Dr. Astley P. Price.

On the Diatomaceæ found in the neighbourhood of Hull. By J. D. Sollitt *and* R. Harrison.

It was the purport of this paper to show how exceedingly rich the vicinity of Hull is in those beautiful forms of living atoms called Infusorial shells, or Diatomaceæ, upwards of 145 species having been found and examined by the authors of the paper. The contents of the paper not only went to show the beauties of those formations, but also the great value of some particular species as test objects for microscopes, particularly the *Pleurosigma attenuatum*, *P. strigosum*, *P. elongatum*, *P. quadratum*, *P. fasciola*, &c., the delicate markings on each of which had been first discovered by the authors of this paper, and their superiority, above all others, as test objects pointed out. The paper then went on to show the errors into which the Rev. W. Smith had fallen with regard to the number of markings in the inch on each of those delicate coverings, and also the impossibility of the markings being the result of internal structure. It was likewise stated, that in making a large drain in Holderness for the purpose of taking the water from the low lands into the Humber, an immense bed of fossil Diatomaceæ had been discovered, which bed consisted of almost 100 different species, but generally of the smaller kinds; and that in examining the matter taken from a large submerged forest on the Holderness coast, an immense number of fossil *freshwater* Diatomaceæ had been found, although the sea washes over the same at every tide, clearly showing that the forest had been overthrown by some great run of fresh water long before the sea had reached the point which it now has. The paper concluded by the authors entirely disagreeing with those naturalists who wish to place these living forms in the vegetable kingdom, the motions of many of them being more rapid in proportion to their size than that of several larger animals.

On a New Alga. By W. Somers.

Zoology.

On the Structure of Hydra viridis. *By* Professor Allman, *M.D., M.R.I.A.*

The author had been recently led to examine *Hydra viridis,* with special reference to its alleged non-cellular structure, as maintained by Ecker, and has arrived at conclusions entirely opposed to those of the German physiologist.

Hydra viridis, like all the other Hydroid zoophytes, is composed throughout of two distinct layers; to the external of these the author gives the name of *ectoderm,* and to the internal that of *endoderm.* When examined under slight pressure and with a power of about 100 diameters, *Hydra viridis* may be seen to possess throughout the whole thickness of its substance a multitude of clear spaces, which at first look like cells, but by a careful examination may be satisfactorily proved to be mere *vacuolæ.* So far Ecker is right in asserting the existence of vacuolæ in the tissues of *Hydra,* but he is quite wrong in his opinion as to the relation of these vacuolæ to the intervening substance. The vacuolæ of the endoderm may be seen to be separated from one another by multitudes of green spherules, to which the characteristic colour of the species is due; and it is the appearance thus presented which has led to the erroneous belief that the spherules are imbedded in a continuous semifluid matter in which the vacuolæ are excavated.

By a little manipulation, however, the tissue of the endoderm may without difficulty be broken up into detached portions, each almost always containing one, or occasionally more of the clear vacuolæ, surrounded by green granules, and *isolated by a distinct though extremely delicate cell-membrane.* It is therefore evident that the substance which separates the vacuolæ of the endoderm is not continuous, but is contained as cell-contents in true cells, that the vacuolæ are excavated in this protoplasm, and that the green spherules are imbedded in it. The cells themselves appear to possess but a very weak union among one another; they are easily separated by a slight force, and on becoming free, immediately assume a spherical figure without any trace of their having been previously united into a tissue.

Those endodermal cells which present a free surface in the gastric cavity are deficient in green spherules, but contain a large vacuola, with one or more brown granular masses, which appear to be immediately included in a small secondary cell, in which they are probably elaborated by a true secretory action; they may perhaps be fairly assumed as representing the biliary secretion in the higher animals. Whether the cells, however, which thus constitute the gastric surface of the endoderm are entirely destitute of green spherules, the author could not positively assert: it is certain, that in the disintegration of the endoderm, several cells are liberated containing both green spherules and brown granular masses, the latter immediately included in minute secondary cells, but from what part of the endoderm they were derived he could not determine. The cells which thus constitute the immediate walls of the stomach, cannot be viewed as forming a third layer distinct from the endoderm.

The green spherules possess an exceedingly definite form, and the author was of opinion that they must be viewed as cells. They present in their interior a lighter coloured space, which appears sometimes circular, sometimes somewhat flask-shaped, and sometimes triradiate, a difference perhaps depending on the difference of aspect in which it presents itself to the eye.

The structure of the ectoderm differs in no essential point from that of the endoderm, except in the fact that its component cells are totally destitute of green spherules and brown granules, while one or more *thread-cells,* each immediately enclosed in a secondary cell, constitute their characteristic contents; besides the thread-cells they contain homogeneous colourless contents with vacuolæ.

Hydra is certainly destitute of cilia on any part of its external or internal surface, and yet weak currents may be distinctly seen in the fluid in contact with separate portions of the endoderm. It appeared to the author that the true cause of these currents is to be sought for in certain chemical changes, which, by virtue of their vital endowments, these cells, like secreting cells generally, effect in the fluid in contact with them.

In the tissues of *Hydra viridis* nothing beyond the elements now mentioned could be detected. There is no trace of nervous or muscular tissue, and the high degree of contractility presented by the animal, must be an endowment of its simple cellular structure, but whether residing in the membrane of the cells or in their contents, or in both, we have not yet sufficient facts to enable us to determine.

On the Structure of Bursaria.
By Professor Allman, *M.D., M.R.I.A.*

In this communication the author advocated the unicellular structure of the true Infusoria as maintained by Siebold. The phænomena presented by *Bursaria* incontestably prove it to be a solitary cell with an inversion of its wall at one spot, constituting a deep horn-shaped depression, which terminates behind in a blind extremity. The whole of the external surface of the animalcule is thickly set with vibratile cilia, and within the horn-shaped depression, along the entire of its convex side, there runs a broad band of vibratile organs, which appear to be very delicate plates rather than cilia.

The contents of the Bursaria-cell are remarkable. Under slight pressure and a magnifying power of about 100 linear, the whole of the interior appears at first to be composed of a cellular parenchyma. It is, however, easy to convince oneself that this appearance of cells is due to the presence of simple vacuolæ, thickly distributed through a semi-fluid granular substance. When by rupture of the external wall, a portion of these cell-contents escapes into the drop of fluid in which the animal is placed for observation, it may be seen to possess the property of immediately assuming a definite outline; it generally acquires a nearly spherical figure, and with a number of contained vacuolæ, it then so exactly resembles a parent cell with secondary cells in its interior, as to be very likely to give rise to erroneous views of the structure of the animalcule from which it had been liberated. It is not easy to decide whether the masses of escaped cell-contents possess a power of independent motion; there is reason, however, to believe that such power is really possessed by them, and that it manifests itself in slight changes of shape, which after considerable intervals may be witnessed in them, and which cannot be referred to any purely mechanical cause. In the unmutilated animal a movement of the contents may be frequently seen through the transparent cell-wall, during which the vacuolæ constantly change their relative position to one another.

In the midst of the cell-contents is a sinuously bent cylindrical body of a yellowish colour, and somewhat granular structure; it is solid, and appears to lie quite free in the surrounding substance. It is to the homologues of this body in so many Infusoria, that Ehrenberg has so variously attributed a digestive or reproductive function, or that he has assigned some undefined glandular office. Siebold, however, has certainly indicated its true signification when he supposed it to represent the *nucleus* of the unicellular solitary cell, forming the body of every true Infusorial.

In a well-fed *Bursaria,* masses of alimentary matter may be seen enclosed in little cavities scattered through the substance of the animalcule. These cavities seem to have no definite position, and there appears to be no doubt whatever that they are mere vacuolæ temporarily excavated in the substance of the cell-contents, for the reception of the alimentary matter. Their contents, when presenting any definite form, may be seen to consist chiefly of minute *Desmidieæ* or *Diatomaceæ* or *Infusoria,* but most usually the cavities contain nothing but granular brownish masses. The author had not succeeded in witnessing the actual reception of food, and could not state, from direct observation, how this gained admittance to the interior; there seems little doubt, however, that it is first carried into the horn-shaped depression, through whose walls it is then forced into the interior of the animalcule, and when once introduced into the semi-fluid cell-contents, each little alimentary mass forms around it a vacuole. In this vacuole digestion goes on, and during the continuance of the process each may be seen to contain, besides its solid contents, a transparent colourless fluid. The temporary digestive vacuolæ seem capable of formation in any part of the cell-contents; they are the so-called stomachs of the advocates of the polygastric structure of the *Infusoria.*

While engaged in the examination of specimens of *Bursaria,* it occasionally happened that a minute pyriform body, with a ciliated surface and vacuolated structure, became detached and swam rapidly away. The definite form of this little locomotive body renders it exceedingly unlikely that it was a fragment accidentally torn from the surface of the Bursaria. It is probably either a gemma or an embryo set free by the manipulation employed in the examination, but to what exact part of the parent animal it is indebted for its origin, the author could not satisfactorily discover.

On the Structure of the Freshwater Polyp, Hydra viridis. *By* Professor ALLMAN.

It had been stated by Ecker and Kölliker that these creatures possessed no cells, but were composed of a mass of granules between which occasional vacuolæ occurred. He had succeeded in observing that the whole of the structure of the *Hydra* was cellular, and no exception to the general law that regulated the existence of organic beings.

On the Morphology of the Pycnogonidæ, and Remarks on the Development of the Ova in some Species of Isopodous and Amphipodous Crustacea. By SPENCE BATE.

On the Physiological Action of Inorganic Substances introduced directly into the Blood. By Dr. J. BLAKE.

The paper detailed a continuation of the author's experiments on this subject. The salts employed in this series of experiments were those of alumina and iron, where the same result followed; the action of the medicine was regulated by the isomorphism of the substances administered.

Notices of some Living Aquatic Birds at Santry House, near Dublin. By W. C. DOMVILLE.

On the Nature of Ciliary Motion. By P. DUNCAN.

The author detailed what had been done by English observers on this subject, and came to the conclusion that the cause of the bending and returning of the cilium resided in the cell-wall of the cell which sustains the cilia, and that to a greater or less extent the whole of the cell-wall is contractile.

Of the Influence of the Circulation of the Blood on the Mental Functions. By R. FOWLER, *M.D.*

This is a practical question, for as the whole body of an animal is a secretion from the blood of its parents, is kept in repair and rendered sensitive and contractile by the blood, and in ratio of its purity, and as all we can know of the external world is by inference from the subjective sensations impressed on our organs of sense, it is obvious that our knowledge must be dependent on the fitness of the bodily organs for being adjusted by the mind, and receiving impressions from existing objects, analogous to a telescope which must be adjusted by the mind of the astronomer, and reflective or refractive of the impressions it receives.

Cretins, unfitted for the functions of life by impure air and insufficient food and filth, are restored by removal to pure air, wholesome food, cleanliness, and exercise. But the result is obviously referable to the agency of the blood; man, therefore, is a coil, secreted by his parents and actuated by vitality and animated by mind.

I have in former papers, read in this Section, adduced facts to prove that vitality and mind are forces, and in correlation with the physical forces. Alike to these, their manifestation is in ratio of the fitness of their coils. The circulation of the blood is in a real coil of tubes, it is the oxygen of the decarbonized blood which excites the propulsive motion of the heart and arteries. The stimulating effect of the oxygen may be fully estimated by the pain it excites on an abrased surface or cut, and the suffering of a person recovering from suspended circulation. The nitrous oxide gas is described by Sir H. Davy to have excited feelings of extended touch. It is still the opinion of some persons, that the impulse given to the blood by the heart is the only impulsive force actuating the circulation, but there are facts adduced by the late Sir Charles Bell, to prove that the muscular coat of the minute arteries assist in working the functions of secretions, and that in the instances of tears, saliva from conceptions of food, and many other instances well-known to physiologists, that minute arteries are excited by retransmissions from conceptions.

May not the flow of blood through the capillaries be accelerated by the electricity evolved from the chemical affinities of oxygen with the carbon?

In the year 1792, while making experiments on frogs and rabbits, and some experiments with zinc and silver suggested by Galvani's discovery, I divided the nerve of one of the legs and tied the crural arteries of the others; the muscles whose arteries were tied soon lost their contractility, while those whose nerves were divided, but whose arteries were not compressed, were excitable for months after the nerve had been divided. From these facts I inferred that the blood and not the nerves influenced communication by the brain, and was the source of both sensibility and contractility. The frogs were kept in a large pan of water renewed every day, and their skins as little injured as could be avoided; but when the skin was lightly brushed so as to excite the sensitive extremities of its nerves, a blush was seen on its surface, and the muscles were excitable by zinc and silver in contact with the trunk of the nerve and with each other.

This appeared to me then, as now, a proof that both sensibility and contractility were communicated analogous, as it now seems, to the sensitiveness communicated to Talbotype paper by chemical preparation. May it not be by the blood projected to the eyes of cats, owls, and all animals who seek their prey in the dark, that the retina is rendered sufficiently sensitive to the smallest degree of light?

The late Sir William Herschel says, in one of his astronomical papers, that he always sat in a moderate light, and without moving his eyes, so that the retina might recover its sensibility before he looked into his telescope. We grope our way from a bright sunshine to a diorama, but all is light when we return, and the sensibility of the retina has been revivified by the blood, and the absence of exhausting light. As it is with the eyes, so I infer that it may be with the brain, the organ employed by the mind to effect the thinking functions.

Blood, says Sir A. Cooper (Guy's Reports), was seen to flush the surface of the brain (perceivable from the loss of a part of the skull and dura mater) with every change of thought, even the most indifferent; and any one may have observed that the scalp is overheated and the brain sensitive of an accelerated circulation in it when the mind has been long and intently thinking, that with every thought there is a retransmission or projection of blood, not only to the brain, but also to the part whose functions are required for action.

We have proofs in such cases as those described by Dr. Yellowly in the Medical and Chirurgical Transactions, and others, so ably commented on by Sir Henry Holland.

The sensibility communicated by the blood in a like case appears to me the efficient cause of consciousness. I have thus far spoken with reference to the red arterial blood only. The venous black blood injected into the brain by Bichat, destroyed life; and Sir A. Cooper could also suspend all its phænomena by pressure on the carotid and vertebral arteries. Now since all the blood in patients in cholera is black, how is it that their consciousness is not suspended? Mr. Magendie, in his able pamphlet on cholera, says that the intellect of one patient continued clear for more than two hours after the pulse in the wrist had ceased to beat. I asked him how he reconciled this fact with those recorded by Bichat; he answered, "My friend Bichat, if living, would have to write that paper over again." May not the following aid our conception of two facts so seemingly incompatible? The skull cannot probably contain more blood at one time than at another, but the proportion of the venous blood may be abnormal, and by its congestion and pressure (as the finger on the denuded brain of the beggar) render a patient comatose. In cholera there is no pressure by venous blood, for all the fluid parts of the blood have been discharged from the bowels.

That conceptions are more vivid when we are in such a state of excitement as to accelerate the circulation of the blood in the organs in which conceptions are produced, as in emotions, passions and intensely pleasurable or painful sensations, cannot but have been noticed by all who can and do give their attention to the operations of their own minds. The painter seems to see on his canvas such a conception of the face; he by trying to paint the lover sees "his mistress where she has not been," and such conceptions are the object of most illusive appearances. Appearances luminous to the eye are evidently from an excited state of the minute abstract arteries of the retina and brain, and I much suspect that the vivid coruscations of light, said to have been seen issuing from the poles of magnets in the dark, are caused by a like excited state of the minute arteries of the retina and brain.

On a New Species of Cometes; *a Genus of Humming-Birds. By* John Gould, *F.R.S.*

The author gave an interesting account of the family of humming-birds, and of the species which were new in his collection. Of the genus *Cometes*, to which the new bird belonged, two species had already been described, the *C. Sparganurus* and *C. Phaon*, and he proposed for the third species the name of *C. Mossia*, after its discoverer.

On the Artificial Breeding of Salmon in the Swale. By John Hogg, *M.A., F.R.S., F.L.S.*

In the latter part of the autumn of 1851, two or three gentlemen of Richmond caught with a net three or four male and female salmon when they were observed to be about to deposit their roe and milt in the gravel-beds which they had made in the river Tees. They expressed into a vessel with fresh water some of the roe from the female salmon, and afterwards did the like with the milt from the males. They returned the fishes to the river. After shaking together the roe and milt, they in a day or two deposited them so mixed in beds in the gravel of a small stream, tributary to the Swale near Richmond, and carefully staked off the ground with thorns and whins to prevent the access of small trouts, minnows, and other fishes, which would have greedily devoured the roe. In the spring of the following year 1852, the gentlemen were happy to find that some fry of the salmon had emerged from the roe or ova so artificially fertilized and deposited; and the experiment, in fact, succeeded. Again, on Christmas Eve of last year, 1852, the same gentlemen obtained from the river Tees some more male and female salmon, and expressed from them respectively some roe and milt. These were conveyed to the Swale, or one of its tributaries near Richmond, and the result was, this spring (April 1853), still more satisfactory, inasmuch as many of the ova produced a fine stock of healthy fry. These active gentlemen and practical ichthyologists, to whom the author referred, consider that they have now the means of ensuring a supply of that noble and useful species, the salmon, in the waters of the Swale. That beautiful river, as it is satisfactorily recorded in the Annals of Richmond, had many years ago an annual supply of salmon; but owing to the erection of a mill-dam some years since between Richmond and the sea, the free access up and down the Swale was prevented, and consequently the salmon took to other rivers. The removal of the dam, at least for a portion of the season, will this year be effected. The author also communicated a similar important fact respecting the artificial breeding of the common trout; as he with pleasure learnt this spring that Major Wade, of Hauxwell Hall in this county, had during the last autumn and the April of this year, been equally successful with the ova and milt taken from female and male trouts. Mr. J. Hogg then made a few observations on the facility of this method of the artificial propagation of fishes; and trusted that it only required to be better known to secure a more universal adoption of it, which would stock many of our rivers, lakes and waters throughout the kingdom, and consequently prove a source of wealth to poor persons, and give an abundant supply of delicious and wholesome food to all classes. By the same method the roe and milt might be obtained and conveyed in proper boxes filled with water and some gravel even to distant places,—probably, in time, to many of our colonies in foreign climes, and so be a ready means of exporting as well as of importing different species.

On some discoveries relative to the Chick in Ovo, and its liberation from the shell. By F. R. Horner, *M.D. of Hull.*

The author observed, that the chick in ovo had ever been a deeply interesting subject of investigation to the physiologist as well as to the naturalist, both of this and of other countries, inasmuch as, from the facility of observation, it so admirably illustrated the order of development and growth of the various organs and parts of the body. After describing the usual phænomena observable in the egg during the last forty-eight hours of its incubation, as well as at the period of hatching, Dr. Horner stated that the special object of his communication was, to announce the discovery of the true nature of the sound which is heard within the egg during the last two days of incubation; and also to show what is the exact mode by which the chick breaks the shell.

The opinion so universally held, not only by amateurs and breeders of poultry, but also by naturalists and physiologists, that the tapping, or more correctly speaking, crackling sound, heard in the egg on the twentieth and twenty-first days of incubation, were caused by the efforts of the chick to break the shell, he proved to be erroneous, by the following experiments:—first, by breaking a hole in the large end of the egg, when the bill of the chick was seen to be quite stationary, and never coming in contact with the shell, though the sound referred to continued before; secondly, that the sound was heard in other instances before the bill had emerged from the folds of the membrane which envelopes the chick, and consequently, therefore, could not be then used to break the shell; and thirdly, by enlarging the aperture in the shell first made by the chick so as to isolate the bill, and prevent the possibility of its coming in contact with the shell, when still the same sound continued to be produced as before, thus proving that the sound heard within the egg was not, and could not be produced by the bill of the chick breaking the shell.

On examining a recently-hatched chick, by placing the ear and also the stethoscope on its breast and sides, a precisely similar sound was identified as had been heard within the egg. Thus, observed the author, *my inquiry was complete, viz. that the sound heard within the egg during the last two days of incubation is not caused by the tapping, or by any other mode of contact of the chick's bill with the shell, but that it is truly respiratory, and produced by the transmission of the air through the lungs; in other words, that it is nothing more than the natural respiratory sound of the chick.* Such explanation receives also collateral testimony from the discovery of physiologists that air first enters the lungs of the chick about the end of the nineteenth day, viz. at the very period at which this sound, truly respiratory, first begins to be heard;—and yet more, the author ascertained that the frequency of the respiratory act accorded with the repetition of the sound within the egg. The action of the heart in a newly-hatched chicken, he observed, was so rapid, that it could not be counted; whilst its impulse and sound were discerned with difficulty.

The opinion that the shell is broken by a cutting, or scraping motion of the bill, through the agency of the pointed horny scale at its end, was shown to be fallacious, as the membrane which lines the shell is in the first instance left entire, while the shell itself without has been chipped or broken off. The author then observed that the shell is really broken, bit by bit, and with apparent ease, by a healthy chick; and generally by a single smart blow only, though in some instances the blow is immediately repeated, or double; that each strike of the bill is made with considerable power impinging with force against the shell, as is not only seen, but also felt and heard, by placing the ear against the part when broken; that when the period of hatching approaches, the chick, which previously had occupied but two-thirds of the egg, now raises itself in the shell by a hustling struggling motion; and by thus unpacking, as it were, of itself, acquires more liberty for its efforts of liberation from the egg. He explained that the reason why the shell is always broken by the chick from left to right, is, because, the chick is so packed in the shell that its head always reclines under the left wing, and on the left side of its body, so that it can only work and turn with facility towards that side.

Notice of Jelly Fishes. By Dr. Lankester, *F.R.S.*

The observation was made on the coast of Suffolk, between the rivers Orwell and Deben, on the 5th, 6th, and 7th of August last. Their numbers were so great as seriously to interfere with fishing operations, and every receding tide left the shore in many places covered with them. The most common species was the *Aurelia aurita*, next to this *Cyanea capillata*. A few individuals of *Rhizostoma Pulmo* were also taken. *Noctiluca miliaris* was so abundant, that a hand-net was soon filled on carrying it over the surface of the water. At night the water was brilliantly phosphorescent.

On Photographic Plates and Illustrations of Microscopic Objects in Natural History. By Dr. Lankester.

The object of the author was to draw attention to Photography as a means of procuring accurate copies of objects of natural history, more especially of those only seen by the microscope. The disadvantage of drawings in natural history was, that they more often represented the views of the author than correct delineations of the object. This was so much the case with drawings of microscopic objects, that the representations of different observers of the same thing could hardly be recognized as similar.

Dr. Lankester exhibited a series of drawings of the British Freshwater Polyps, executed by Prof. Allman, which he stated were intended to illustrate a work on this subject to be published by the Ray Society. Among these were several new species, and he especially called attention to one of these, which seemed to be an exception to the general law that the polypidom of the polyp-bearing animals is fixed. In this case the polyp stalk possessed the power of moving, as well as each individual member of the mass.

Dr. Lankester read the 'Report of the Committee for the Registration of the Periodic Phænomena in Plants and Animals.' Registration papers filled up had been received from M. Moggridge, Swansea; Miss Llewellyn, Llangewellach, Glamorganshire; G. H. M. Sladen, Ninfield; W. C. Nourse, Clapham; W. C. Domville, Santry, Co. Dublin, Ireland. These papers would be published probably in the next volume of the Transactions of the Association. In connexion with the registration of the phænomena of life, as affected by changes in the weather, &c., Dr. Lankester called attention to an effort that was now making to register the occurrence of disease in conjunction with the state of the weather.

Note on the Habits of Fish in relation to certain Forms of Medusæ. By C. W. Peach.

The author had observed at Peterhead that the young of the whiting and pollack frequently sought safety from their pursuers in the umbrellas of the various species of Medusæ. He especially mentioned the *Cyanea aurita*, and also a species called *C. inscripta* by Templeton. He thought this clearly proved that the Medusæ did not destroy fish for food, as had been sometimes supposed.

Notes on a living Specimen of Priapulus caudatus, *dredged off the Coast of Scarborough. By* John Phillips, *M.A., F.R.S., F.G.S.*

The specimen, of which drawings were exhibited to the Section, was sent alive to the author by Mr. John Leckenby of Scarborough, in the month of February 1853. It was kept in life three weeks, by renewing of the sea water, with sea-weed and sand. The animal was never observed to make any special efforts to take food, though on the affusion of fresh sea-water, fæcal matter was ejected from the anal opening near the base of the plume. In the sunshine it became active, drawing in and exserting the anterior proboscis, quickly and even suddenly; opening and again contracting the large caudal plume; bending, extending, and shortening the body without any settled order of changes. The diameter was variable in every part, but near the base of the plume it was sometimes thrice as large as at other times. When in a state of greatest activity—a few days after it arrived in York,—agitation of the vessel occasioned some disturbed contraction of the plume; the penicilli of this appendage would contract separately on being touched; after repeated contacts, the whole would be shut up so as to resemble a narrow papillated rachis. The surface of the whole body is annulated; the rings (about forty) being prominent on the body, but only marked by lines (above sixty) on the proboscis. These rings and lines are ornamented by numerous small prominences, papillary and blunt on the body, mucronated, a little recurved and horny on the proboscis, where they are ranged in twenty-four beautifully exact lines, continued to the centre of the variable disc which terminates the proboscis. When the proboscis is drawn inward, the disc becomes folded, so as to represent, in some degree, the oral aspect of a Cypræa, and the skin between the mucronated lines is curiously folded and packed.

The skin is translucent enough to show, during the retraction and exsertion of the proboscis, internal movements manifested by shady parts pushed far forward and backward; but these movements are disguised by the partial opacity caused by many white narrow longitudinal bands, which being collected together to closer proximity in one particular band, make there a narrow continuous ridge, terminating near the anal opening.

The plume when expanded shows, on each of its penicilli, a roughly papillous surface; the papillæ, being examined, are found often to be long, conical, and sometimes covered with finer prominences or thread-like parasites. The expansion and contraction of this plume—doubtless the respiratory organ—is probably connected with an internal cavity filled with a watery fluid, but the author has deferred a strict dissection of the interior till other specimens should be placed at his disposal. He proposes the following specific character:—

Priapulus caudatus, Fleming.—P. corpore cylindrico, annulato, antice proboscidifero, posticè ramoso-penicillato; proboscide lineis (24) longitudinalibus dentiferis, signato; papillis corporis ovato-conicis; penicillorum papillis acutis conicis.

On the Connexion between Cartilage and Bone. *By* Peter Redfern, *M.D., Lond., &c.*

The author described in detail the nature of the structure of bone and cartilage at their junction, and pointed out that the relation between them is much more intimate than is generally supposed, and that it accounts satisfactorily for the characters of disease of the articular surfaces of bones. It shows likewise the actual passage of cartilage into bone.

On a curious Exemplification of Instinct in Birds. *By* the Rev. Francis F. Statham, *B.A., F.G.S., Walworth.*

The author stated that his communication partook more of the nature of an anecdote than of any elaborate disquisition. He made some references to the theory of the facial angle, as indicative of the amount of sagacity observable in the animal race, but expressed his conviction that this theory was utterly at fault in the case of birds; many of those having a very acute facial angle being considerably more intelligent than others having scarcely any facial angle at all. Size also seemed to present another anomaly between the two races of beasts and birds; for while the elephant and the horse were among the most distinguished of quadrupeds for sagacity and instinct, the larger birds seemed scarcely comparable to the smaller ones in the possession of these attributes. The writer instanced this by comparing the ostrich and the goose with the wren, the robin, the canary, the pigeon, and the crow. The author then proceeded to describe in detail the particular case of instinct which formed the subject of his paper. It referred to the poisoning of two young blackbirds by the parent birds when they found that they could neither liberate them nor permanently share their captivity. The two fledgelings had been taken from a blackbird's nest in the garden of S. Swonnell, Esq., of Surrey Square, London, and had been placed in a room overlooking the garden, in a wicker cage. For some time the old birds attended to their wants, visited them regularly, and fed them with appropriate food; but at last, getting wearied of the task, or despairing of effecting their liberation, they appeared to have poisoned them. They were both found suddenly dead one morning shortly after having been seen in good health; and on opening their bodies, a small leaf, supposed to be that of *Solanum nigrum*, was found in the stomach of each. The old birds immediately deserted the spot, as though aware of the nefarious deed befitting their name.

On the Partridges of the Great Water-shed of India. *By* H. E. Strickland, *M.A., F.R.S.*

The author drew attention to a new Part of Mr. Gould's Birds of Asia, in which the genus *Tetraogallus* was illustrated. These birds had been correctly named, as they truly partook of the characters of the genera *Tetrao* and *Gallus*. Specimens of these birds were now alive in the Gardens of the Zoological Society of London.

On the Mode of Growth of Halichondria suberea. *By* H. E. Strickland, *M.A., F.R.S.*

This species of sponge, which is frequently obtained by dredging, has long been known for the peculiarity of its habitat. It is found investing the surface of old dead univalve shells, which often present the appearance of being actually converted into, or replaced by, the substance of the sponge; for we find that the spiral cavity of the shell is continued through the sponge for a considerable number of volutions, and is always inhabited by some species of hermit crab. This has been explained by Dr. Johnstone, in his 'History of British Sponges,' who supposes that the sponge by some means dissolves, or absorbs, the larger volutions of the shell, and only leaves a small portion of the apical volutions undestroyed. On carefully examining some specimens which I lately dredged up, I found reason to believe that the sponge does not, as supposed, remove any portion of the original shell, but merely prolongs its spiral volutions beyond their original extent. It is true that the enveloped portion of shell is often corroded and imperfect; but this is owing to its having been in a dead and decayed condition before the sponge began to grow: for in other cases the shell is sound, full-sized, and with a perfect mouth; and yet the spiral cavity is continued beyond it for several volutions, through the substance of the sponge. In a specimen now produced is a perfect shell of the *Nassa macula*, a small species of univalve; and yet the sponge has grown to such an extent as to suggest the idea of having been modelled on the much larger species, *Nassa reticulata*. The continuation of the spiral cavity through the sponge is evidently due to the presence of the hermit crab, round whose spiral body the sponge continues to grow, beyond the margin of the original shell. On first noticing this peculiarity, it occurred to me that it might throw light on the very remarkable spiral tube, filled with flint, which perforates certain fossil sponges from the chalk, as described by Mr. Charlesworth in the Geological Section. It appears, however, that the tubes in the fossil sponges do not *taper*, like those which in the recent sponge are modelled on the continually enlarging body of the hermit crab, and consequently the nature of the former structure still remains to be explained.

On Preserving the Balance between Vegetable and Animal Organisms in Sea Water. By Robert Warington.

The public were first indebted to Mr. Warington for a statement of the conditions in which animals could be kept in fresh water without changing the water. It is not sufficient that there be plants alone; but where the higher animals such as fish are kept, it is necessary that some beings should exist which will feed on the decaying vegetable matter. This desideratum is supplied by the various forms of phytophagous Mollusca. The author's success with fresh water led him to try experiments with sea water, and the results of his investigations were given in this paper. The most important fact established was, that marine animals could be kept in sea water without changing in the same manner as in fresh. The conditions of the existence of sea-water creatures are, however, much more varied than those of fresh; hence the difficulty had been proportionally great in arriving at a successful issue. The nature of the plants in the first place is a matter of importance. The author found that the green sea-weeds answered better than the red or brown. In introducing animals they should be healthy and uninjured. Those should not be put together which devour each other. Crabs, especially the common crab, are very destructive; so are gobies, blennies, and rock-fish. The sea water should be kept of a proper gravity. It should be about 1·026 at a temperature of 60°. Rain or distilled water should be added from time to time to supply any loss. All dead animal or vegetable matter of any kind should be removed.

GEOGRAPHY AND ETHNOLOGY.

On the Influence of the Invasion of the Danes and Scandinavians, in Early Times, on certain Localities in England. *By* Sir C. ANDERSON.

HAVING lately visited Denmark and the northern parts of Europe, the author had been much struck with the similarity pervading the Danish and English languages, and he had thought it might not be deemed superfluous if he ventured to lay before the Meeting some of the results of his inquiries. The similarity he ascribed to the influence which the Danes possessed when they made a conquest of this island, and planted themselves as settlers in it. Sir Charles proceeded to give several examples in support of his assertion.

On the Dialects North and South of the Humber compared. *By* CHARLES BECKETT.

Mr. Beckett commenced by observing that the boundaries of English counties were various, and often arbitrary, the most natural being rivers. The river Humber, from its width and length, has always formed a most distinct boundary, not only between two different counties, but also between two classes of peasantry, differing much in many respects,—in origin, physiognomy, manners, conformation, and dialect. Abundant evidence exists of Danish origin in the names of towns and villages in both counties; no less than 212 places terminating in "by" in Lincolnshire, whilst in the north and east ridings of Yorkshire 135 of the same were found. This termination always points out a Danish origin. Several other Danish names of places, persons, and things, are also found. The distinction between the peasantry north and south of the Humber cannot escape the attentive observer. The Lincolnshire peasant is somewhat more phlegmatic, his physiognomy less marked and acute, and the face more oval in form than that of the Yorkshireman. His manner is more amiable and polite, but less decisive and acute. This harmonizes not only with his own appearance, but, singularly, also with the general mildness of the aspect of the landscape around him. These inquiries are the more interesting, because the progress of civilization, increased travelling facilities, and the lapse of time, all tend rapidly to efface ethnological distinctions. The successive irruptions of the Roman, Saxon, Danish, and Norman people into this country, were analogous to the warping of low land by successive tides; the existing language being a rich alluvium left by them all. Yorkshire has probably several dialects; Lincolnshire, two, according to Halliwell, the north and the south. Both agree in the broad pronunciation of many syllables—as, for instance, changing one into two: as, sea, sea-ah; seat, se-at; beast, bee-ast. Both use many archaic words, each county, however, having its own. The intonations and inflexions of the voice vary also in the two counties. But the chief difference lies in the relative value of the two vowels *i* and *o*. These are rendered *ei* in Yorkshire, and double or long *i* in Lincolnshire: as, wife, weife, wiife; life, leife, iiife, respectively. These apparently trivial differences are in fact sufficient to change the whole character of the vernacular speech. The *o* also has similar varieties; thus in Yorkshire we have now, noo, and thou, thoo. In Lincolnshire these would be thaou, naou. Some other characteristics were also mentioned. On the whole the Lincolnshire dialect is more soft and agreeable, contains fewer obsolete words and accents, and approaches more nearly to pure speech. The paper closed by inquiring how far climate and the social history and progress of the two counties might have operated, along with some differences of origin, in leading to these probably transient ethnological distinctions.

Substance of a Topographical Essay on the Navigation of the Rivers "Plata," "Parana," "Paraguay," "Vermejo," and "Pilcomayo." *By* HERMAN C. DWERHAGEN.

In 1828 M. Herman C. Dwerhagen published some observations on the immense importance of the free navigation of the river Plata and its various ramifications to the Republics of Buenos Ayres and Bolivia, which, he complains, met with no attention either from natives or foreigners, because they were unacquainted with the geography of both these Republics. This consideration has induced him to publish a map, which, although on a small scale, he considers sufficient for the object he had in view, although it only contains the names of the chief towns and such places as the navigation of the rivers lead to. The author states that the navigation of the river "Plata" would eternally unite the territories of Buenos Ayres and Bolivia, as it is navigable from its mouth in 35° S. latitude, to the junction of the Jauru with the Paraguay in 16° S. latitude, being an inland navigation of 19° in extent; the principal provinces in Bolivia, which would be directly benefited by the free navigation of the Paraguay (a branch of the River Plata), are Moxos, Chiquitos, and Santa Cruz de la Sierra.

These extensive territories, the most fertile in Bolivia, about 43,000 square leagues in extent, produce little or nothing at present, compared with what they might produce if they had an outlet for their products, which consist of sugar, rice, coffee, indigo, cocoa, cotton (that of Moxos being one of the best in the world), grain, many kinds of valuable drugs, and amongst them bark, dyewoods, tobacco, canes, numerous kinds of wood of the most beautiful description, hides, tallow, &c., articles which cannot on account of their bulk be sent over the Cordilleras to a port on the Pacific, as the expense of the carriage would exceed their value on their arrival there. The author considers these territories as the most choice in the Republic, and in proof states that they met the especial favour of the Jesuits, and have now the advantage of being peopled by industrious and intelligent Indians; and all that is wanted is the introduction of steam-navigation to bring forth the natural capabilities of the country, and to produce a most extensive commercial intercourse betwixt the States of Buenos Ayres and Bolivia, in lieu of the present slow mode of communication by vessels. These are sometimes made fast to a tree for a fortnight waiting for a fair wind, during which time the whole extent of the navigation might be accomplished by a steam-vessel; so that a large territory, now producing but little, might, by having proper stations on the Paraguay and the aid of steam navigation, become productive in the most extraordinary degree, and greatly increase its population. At present, the only port which Bolivia turns her attention to is Lamar, *alias* Cobija, on the Pacific, but by the plan now under consideration, the intercourse with Buenos Ayres and Europe would be made easy and constant, and the navigation round Cape Horn avoided. The passage from Buenos Ayres to latitude 16° 20′, that is, to the mouth of the river Jauru, might be made in about a fortnight as soon as the navigation of the river should be properly understood, allowing the same rate of time as is required for an equal distance on the river Mississippi, and the return would be effected in less than half the time. The mouth of the Jauru is on the same parallel of latitude as the town of Santa Anna, the capital of the province of Chiquitos, and distant from it about 70 leagues, and is a much less distance from various other towns of the same province. From the capital of Matagroso it is about 73 leagues, and about 100 leagues from the nearest towns in the province of Moxos.

This steam navigation being once established, the inhabitants of Bolivia might with ease bring all their own products down to Buenos Ayres and Monte Video, and take back in return such articles as they might require, all of which would be found at either place at reasonable prices. All these remarks apply with equal force to the noble river Pilcomayo, which is navigable nearly as far as Chuquisaca and Santa Cruz de la Sierra; thus by means of this celebrated river, which runs through a most fertile country, supplies of sugar, coffee, cotton, tobacco, &c., and in fine all the products of the East and West Indies and Brazil, everything which nature is capable of producing within the tropics, might be received. The navigation of the Pilcomayo is said to be obstructed by three falls, which might perhaps be remedied; but if not, such steam-boats would have to be constructed as would navigate betwixt them, and proper arrangements made to facilitate the transhipment of the goods from one steam-boat to another. All this would attract the attention of the Indians and bring about a trade with them, for they would soon begin to cultivate all kinds of tropical productions; in addition to this, on the banks of this river, honey, wax, skins, and many other articles are to be found, besides the finest wood in the world; and in fine, the navigation of the "Pilcomayo" would more rapidly promote the civilization of the Indians of the Chaco, and of that part through which it runs, than all the attempts of the last three hundred years. Thus the whole of the Argentine Republic would have an active commerce with that of Bolivia, which would be furnished with all the products of the world, and in return would give her own. To the inhabitants of the eastern side of Bolivia it would be more advantageous to make their purchases at Buenos Ayres rather than at any port on the Pacific, because they would be able to reach Buenos Ayres more conveniently, and quite at their ease, and be certain of finding there everything they wanted, and cheaper than in the ports of the Pacific, the number of vessels which arrive at Buenos Ayres being so much greater. The traffic in gold and silver can only be carried on beneficially from the ports on the Pacific, but all merchandise of any bulk is most advantageously transported by the rivers, and generally where the property goes there goes the owner also. The foreign trader will always prefer the river Plata, and be content with half the gain which he might make in such places as Arica and Lamar, as the returns would be so much quicker as to make him ample amends. It may be said that by means of the new canal by the river St. John and lake Nicaragua an active commerce may be established with Bolivia by means of Puerto Lamar, but a vessel from Europe or from the United States of America would reach the river Plata as soon as it could the mouth of the river St. John. This canal will enter the Pacific in about 11° 30′ N. latitude, from whence a new voyage is to be commenced for Port Lamar, during which time the cargo, which may be shipped to Buenos Ayres direct, will have been placed on board the steam-boat and arrive much quicker at Santa Anna or Chuquisaca. Some people imagine that Bolivia might have an active commercial intercourse by means of the river Bini or Rio Grande, branches of the great Maranham; but in the first place, the distance is much greater from the three provinces of La Plata, Santa Cruz de la Sierra, Chiquitos, and even Moxos; secondly, these rivers run through deserts and countries inhabited by savages, and filled with clouds of insects and other things which torment mankind, and the air breathed in such voyages is pestiferous; thirdly, the greater part of the year it rains, and immediately after a shower the sun bursts forth with such excessive power as to open the upper works of the vessels, and before they could reach the mouth of the Maranham great part of their cargoes would have perished.

Now, if all these difficulties are attendant on the descent of the river, how much would they be increased in the ascent, which would require double the time; and what human frame could stand such a trial? for the heat being excessive to begin with, would be increased as the voyage was prolonged, the navigation being continued under the equator, so that none but the most hardy Indians could support it; whereas the descent of the rivers to Buenos Ayres would have exactly the contrary effect, as a more genial climate would be approached with extraordinary rapidity. The river Vermejo is navigable nearly as far as Tarija, and which, by means of its branches, brings us in contact with Jujuy and Salta, which was ascertained by Don Francisco Gavino de Arias in 1789, Don Juan Adrian Cornejo in 1790, and Don Pablo Soria in 1827; they all three descended the river, and reached the Paraguay without difficulty, the first in February, the second in May and June, and found not less than three varas of water. The advantages which the free navigation of this river would be to the Argentine Republic are incalculable, for a steam-vessel would be able to reach Oran in twelve days, or even perhaps nearer to Tarija. What a stimulus would this be to cultivate the rich territory of the three provinces Tarija, Salta, and Tucuman! and these would have a direct interest in the free navigation of the Vermejo, as they all border on the said river, and they now produce rice, sugar, grain, indigo, coffee, wax, honey, tobacco, woods of all sorts, dyewoods, leather, hides, skins, &c.; but these articles are abandoned, although not for want of hands, because in those provinces very good Indians are to be had, who come from Chaco of their own free will to work for moderate wages. The province of Paraguay alone is capable of producing an enormous quantity of tropical products, besides many other important and useful articles; and as soon as ever person and property become respected and secure, there will be no want of individuals ready to engage in so lucrative a business as steam-navigation will afford; and rivers which are little known and almost abandoned will be enlivened by a brisk trade, and the territory through which they run will acquire a very increased value, owing to their quick and easy communication with the sea. It would also be to the interest of Brazil to allow the products of that country to be exported from one or two ports of Matagroso situate on the Paraguay.

A Sketch of the Progress of Discovery in the Western Half of New Guinea, from the Year 1828 *up to the Present Time. By* G. Windsor Earl.

This paper is a continuation of an essay on the same subject by Mr. Earl, which appeared in the Transactions of the Geographical Society in 1837. In 1849 the Dutch war-schooner Circe was sent by the Netherlands Government to explore the north coast of New Guinea, for the purpose of choosing a site for another settlement. Port Dory and the trading ports on the shores of the Great Bay were investigated; after which the Circe proceeded to the eastward along the coast, intending to examine Port Humboldt, but contrary winds prevented her from entering the bay, after having arrived within a few miles of the head. Nevertheless, the information collected was considered sufficient to authorize the establishment of a settlement, and a garrison, consisting of burghers, or native militia, was fixed there in the early part of 1852. Mr. Earl is of opinion that this settlement is likely to prove useful to shipping employed in the traffic between India and the west coast of America, as the neighbouring coast has hitherto afforded no place of refuge for distressed vessels, which is so much the more necessary from the savage character of the inhabitants. The only discovery of importance made during the voyage of the Circe was between Dobie and the Arimoa Islands, where the low land, through an extent of nearly 100 miles, was found to be the delta of a large river, called Ambermo by the natives, which, from the immense quantity of alluvium that has been deposited at its mouth, forming a shallow bank, extending many miles out to sea, may be a river of importance, affording access to the interior. Some mountains were seen far inland from the mouth of the river, which were conjectured to be the same lofty range seen from the south-west coast in 1828, and supposed, from their white appearance, to be covered with snow. A lithographed sketch of this range, by one of the artists attached to the Dutch Expedition of 1828, accompanied the paper.

On the Currents of the Atlantic and Pacific Oceans. By A. G. Findlay, *F.R.G.S.*

The progress of meteorological science having been pre-eminently fostered by the British Association, it was thought that one hitherto much neglected, but very important branch of it, would form a fitting subject for their consideration. When it is remembered that of the surface of our planet, the proportion of water to land is at least 391 to 100, or nearly four times greater in area, and that the phænomena of the atmosphere must be exhibited much nearer their normal condition at sea than on land, amid the infinite variety of terrestrial disturbances, the nature of oceanic circulation must be allowed to be of no small importance in the generalization of atmospheric phænomena, and the distribution of climate.

Yet this branch of natural science has had as yet but few votaries. The labours of Lieut. Maury at the National Observatory of the United States have of late drawn attention to it, and it is hoped that England may enter into an honourable rivalry in this domain of science. It was, however, with deference urged that the labours of our American brethren had not, as yet, added much to our knowledge of the North Atlantic currents, as it was left to us by the personal labours of Major Rennell, who gave us the first memoirs on the subject as it now stands in 1778 and 1793.

It is with the currents of the North Atlantic only that we are tolerably intimate, but even this knowledge is imperfect, for we know nothing of submarine or subsurface currents, though such knowledge is greatly attainable. Of the other parts of the wide world of waters we are in great ignorance, and it is in the Pacific, the Asiatic Archipelago, and the Indian Ocean that the real harvest of maritime meteorology is to be gained.

There are several difficulties in the formation of an entire system from the labours of Rennell; the waters constantly setting into the Sargasso Sea, the origin and continuance of the North African and Guinea currents and of the Arctic currents are not satisfactorily explained by him, but by analogy with the Pacific currents and further observations, these anomalies may perhaps be removed.

The Arctic current setting southward out of Baffin's Bay and between Iceland and Greenland, passes down Labrador and Newfoundland, and turns to the westward in soundings along the coast of the United States as far as Cape Hatteras, in opposition to the direction of the Gulf-stream; this was first explained by Mr. Redfield in

1838. The warm Gulf-stream closes in with the land in its northern progress at Cape Hatteras, and the line between this and the cold inner currents is a nearly perpendicular wall of warm and cold water in juxtaposition. At the banks of Newfoundland the Arctic current flows beneath the Gulf-stream and transports icebergs into its warm waters. Another feature of the Gulf-stream lately elicited by Bache and other officers of the U.S.N., its bifurcation off Cape Hatteras, may be attributed to the recurving of that portion of the equatorial current which flows to the northward of the Bahamas. Between Porto Rico and the Bermuda Islands, some singular phænomena were observed in May 1850 by Lieut. Walsh, U.S.N., the currents at the depth of 126 fathoms flowing in opposite directions on consecutive days, generally with greater velocity, and always different in direction to the surface current, indicating a sort of eddy. The Gulf-stream does not stop at the Azores, as was supposed by Rennell, but a portion is propelled toward the Bay of Biscay, and producing the temporary Rennell's or 'thwart-channel current, and probably impelled by the prevalent S.W. wind, it reaches the western shores of the British islands and the coast of Norway, causing the climates of these countries to be in marked contrast to those of Greenland and Labrador in the same latitudes. It also reaches the S. and W. shores of Iceland, as shown by Capt. Irminger of the Danish Navy. The portion which strikes the coast of Portugal passes southwards, forming the North African current, and south of Cape Verde and Cape Roxo it turns to the westward into the great equatorial current, and does not probably form the initial portion of the Guinea current flowing eastward into the African Bights. The equatorial current, with less regularity on its eastern side, but constantly on the western, flows from east to west within the tropics, and the northern portion forms the commencement of the Gulf-stream; that southward of Cape S. Roque on the Brazil coast, flows southward as the Brazil current, whence it is deflected to the eastward as the Southern Connecting Current across the Atlantic into the Indian Ocean south of the Agulhas Bank off the Cape of Good Hope. The Agulhas current flowing to the west around the Cape, and then along the west coast of Africa northwards to the Bight of Biafra, enters the southern portion of the equatorial current, which flows in opposition to and in juxtaposition with the Guinea current. The waters thus circulate around the parallels of lat. 30° in each hemisphere, the central portion of the North Atlantic on this line being known as the Sargasso (or weedy) Sea.

The Guinea Current, a *warm* stream setting to *eastward*, or in opposition to the equatorial currents, along the coast of Guinea as far as Fernando Po and Princes' Island, has been attributed to a prolongation of the North African current; but why this latter should turn to the east instead of to leeward or to west has not been explained. It was here affirmed to be an independent stream, originating in mid-ocean, in the zone of equatorial calms, between the N.E. and S.E. trade-winds, and the true character of which is cleared up by the existence of a similar current in the Pacific, which was first placed on the charts laid before the Meeting, and presently alluded to.

In describing the currents of the Pacific Ocean, we enter upon comparatively a new subject; but from a collection of observations arranged on the charts laid before the meeting some new features and extended knowledge may be established. It may be asserted, however, that the waters of the Pacific do not appear to move with so great velocity and apparent regularity as in the North Atlantic, and this especially so in its south-western portions. The southernmost movement is in the Antarctic current, moving with a velocity apparently of 10 to 35 miles a day from southwards towards the north and *east*, down to lat. 33° or 34° S. Of many particulars we are still ignorant, which is to be regretted, as it has an important bearing upon the track of our Australian homeward-bound ships. It is analogous to the Southern Connecting Current in the Atlantic, and, as has been demonstrated by Duperrey, it strikes the west coast of Patagonia about the parallel of Chiloe, one portion passing south and east around Cape Horn, and carrying the drift-wood to the Falkland Islands, and even 900 miles eastward of them. This current also flows past Tristan d'Acunha to the E.N.E., and also past the islands south of New Zealand. The northern branch of this cold antarctic current is a remarkable one, and was first demonstrated by Humboldt in 1802, and hence called the Peruvian or Humboldt's Current. It is a moving mass of cold water, of great depth, moving northwards along the American coast, as far as Cape Blanco, whence it is deflected to the W.N.W. towards the Galapagos Islands on the equator, where it produces some singular effects: there appears to be a constant struggle between these cold waters and those of the very warm counter current to the northward. Henceforward this current must be considered as forming the initial portion of the great South Equatorial current, which flows in a westerly direction between 4° N. and 26° S. But in its progress it has many variations, in its eastern portion, and especially among the archipelagos in the central portion of its course. Notwithstanding these exceptions, which cannot be further noticed in this abstract, it assumes the true character of a strong westerly stream about the islands north-east of Australia, and a portion passing to north-west by the New Hebrides and New Caledonia, has been termed Rossel's Drift; but this portion is not constant. It runs strongly past the north coast of New Guinea, but between the neighbourhood of the New Hebrides and Torres Strait there does not appear to be any well-marked current. A portion of the South Equatorial Current, south of New Caledonia, is turned to W.S.W. towards the Australian coast, and thence descends to the southward, a warm stream of 1 or 2 miles an hour, to the southern part of Australia, where it turns eastward, joined by the current through Bass's Strait and south of Van Diemen's Land. Thus, on a minor scale, it resembles the Atlantic Gulf-stream or the Brazil current, and appears to circulate around the space between New Zealand and Australia.

The Northern Equatorial Current flows from east to west in the Pacific, between lats. 10° N. and 24° N. There is a paucity of observations on the eastern portions of its course, and it has no well-marked commencement, as is the case with the Southern Equatorial Current; but it is strong and regular in many portions of its progress, and it may be traced with great exactness through the various ranges of islands which it traverses (the authorities for which were cited); and having brought the great mass of tropical waters across the breadth of the North Pacific, and, as is the case with the southern portion, with a gradual augmentation of heat, it has been usual to consider that it then passed onwards through the Asiatic archipelago. But in giving a connected view of the Pacific currents, it is confidently stated that some very important branches of the subject have been entirely overlooked, or only slightly hinted at. Two currents, at least, of immense magnitude have not yet appeared on our physical charts, and were placed for the first time in a Directory for the Pacific Ocean, in 1851, by the author. The authorities and details for these currents were laid before the meeting. One of these is a great belt of water lying under the zone of tropical calms, and flowing to the *eastward*; and a second was a Gulf-stream of the Pacific, hinted at by M. Tessan in 1837–44 as perhaps existing in the central portion, but which was here traced to Japan, and hence named the Japanese current.

The Japanese current is a continuation of the Northern Equatorial Drift, which being obstructed by the Philippine Islands, turns to the northward towards the Loochoo Islands and Japan, off the south coast of which it is a most violent north-easterly stream, as was demonstrated from the Japanese charts of Von Siebold and Krusenstern, the observations of Capts. King and Gore, Krusenstern, Broughton, and others. Its further course is manifest from the dense fogs entered by Capt. Beechey, and it reaches the shores of Kamtschatka, as shown by M. de Tessan. Japanese junks have been drifted and wrecked on Kamtschatka, on Kodiack, at Oregon, and at the Sandwich Islands—all evidences of the easterly set, and we have the observations of Admiral Du Petit Thouars, as recorded by M. de Tessan, for its central portion. On its reaching the shores of America, it turns to southward, like the Gulf-stream, and flowing southwards past the coast of California, a portion continues towards central America; but the chief portion re-enters the equatorial current past the Sandwich Islands—a fact proved by the pine timber of N.W. America drifting on to the eastern sides of that archipelago. This current, here imperfectly developed, it is true, must be an important assistance to vessels proceeding from China towards Oregon, California, or Panama, following as it does the great circle route between these places. It is thus shown that the waters of the Pacific circulate around the parallels of 30° N. and S. as axes.

Between these two systems of revolution there exists another important current, here named the Equatorial Counter Current, from its relation to the great tropical or westerly drifts on either side of it. It is an easterly stream setting across the entire breadth of the Pacific between the latitudes of 4° or 5° and 10° North. Only one small portion of its course had been previously noticed. Without quoting the observations here, it may be stated that, proceeding from west to east, the remarks and experience of Krusenstern, Duperrey, Lütke, Hunter, Wilson, the U.S. Exploring Expedition, Du Petit Thouars, the Prussian ships Mentor and Princess Louise, Lütke again, the Dutch frigate Koerier, Beechey, and Vancouver, besides other facts drawn from natural phænomena, will demonstrate its almost permanent existence; and these observations are almost all authentic, and above suspicion.

The current system which thus centres at Panama is most singular, and, as far as known, is unexampled: the only approximation to a similar position is in the Bight of Biafra. We have here the waters of the equatorial counter-current, frequently those of the Peruvian current from the southward, and of the Mexican currents almost always from the northward. The outlet as a *surface* current to these great masses of water does not seem to have been detected as yet.

In assigning a cause or combination of causes for these mighty operations, we are met with many and, at present, insuperable difficulties. Our knowledge of many most material facts is most incomplete. We know little or nothing of the maximum density of sea water. Dr. Marcet places it at a temperature of 22° Fahr., M. Erman at 25°, Col. Sabine at 42°, and Sir James Ross at 39°·5. The latter states that the zone of equal density arising from temperature is in a mean lat. of 56° 26′ S. Whatever may be its maximum density, it is certain that we can sink a sounding weight to an enormous depth (8¾ miles of line having been run out), but the author did not admit the experiment as satisfactory, and concludes that it has not informed us of the depth of the ocean. We know little of the ratio of absorption and radiation of heat—a most powerful cause. The effect of the rotation of the earth is difficult to be calculated without these additional elements, nor can the accumulated action of tides, if any, be estimated, though more exact and extended observations will doubtless enable us to integrate all these sources of motion, and assign to each its amount of action.

The action of the wind, it was maintained, was the chief and efficient source of *surface* current action, and a diagram of the trade and passage winds was offered to explain this. Thus the north-east and south-east trade-winds, blowing towards the equator, impel the surface waters in the same direction; but the winds meeting, neutralize each other as to horizontal motion, and rise up, depositing their great moisture in the deluges of the equatorial rains. From the fact of the unequal distribution of land and water in the two hemispheres,—in the south the proportion being 100 land to 628 water, and in the north 100 to 154,—this line of junction is to the north of the equator; thus the mathematical and atmospheric equators do not coincide. The countries in south latitudes are as remarkable for dryness as those in north are for wetness; and Panama, lying in this junction, is inundated with rain during the northern summer,—sufficient water falling to feed the high level of any canal that may be made with locks.

From the waters being impelled thus to the western side of each ocean, it might readily be argued that the Atlantic would be several feet higher than the Pacific, and such was formerly supposed to be the case; but engineering operations have shown that they are sensibly the same; and this equality of level must be owing to the compensative effect of the equatorial counter-current.

The great utility of a proper knowledge of ocean currents may be made evident by an example. A ship sailing from Shanghaë in China to Panama, may in ignorance follow the *apparently* direct course, a distance of 8982 miles; but her voyage would be extended by adverse winds and currents (the latter 600 or 800 miles) to the extent of not less than 1800 or 2000 miles. But if our acquaintance were more complete, and analogy be borne out by facts, by taking a proper course, of about 9500 miles, she would be assisted 900 miles in her course by current and fair winds,—thus making the unknown voyage 11,000 miles, and that on correct principles 8600, a difference worthy of being appreciated in this commercial age. Again, as to the influence of ocean currents upon commercial products. The famous Sea Island cotton of the United States owes its superiority to the warm waters of the Gulf-stream flowing past these sea islands. The trade-wind, passing over the Gulf-stream, and absorbing its saline vapours, deposits them on the sea coasts in question, and causes the peculiar growth of the long-stapled sea-island cotton. The north-east portion of Australia is now looked at with great interest as a site for colonization. It may be predicted that a similar climate will be found there; the ocean, being abnormally warmer than the land, will favour the growth of cotton, as it does on the east coast of the United States.

Manners and Customs of the Yacoutes. By Prince ERN. GALITZIN, *Corresponding Member of the Royal Geographical Society of London. Translated and communicated by* DR. NORTON SHAW.

The Yacoutes among themselves are known by the name of *Sokha*. It is believed that they are of Tartar origin, which fact is confirmed by the similarity of the tongues, as well as by a great number of usages common both to the Yacoutes and to the Tartars. They live partly in that region of Siberia, the centre of which is the town of Yacoutsk; and partly also in the different districts of the Yeniseïsk's government. Their stature is middling, their complexion swarthy, and their hair black.

As wealth among the Yacoutes consists in numerous flocks, from this circumstance it follows that they take care to live dispersed in small groups of two or three *yourtes*, so as to have at hand sufficient pasturages. A certain number of these little villages form a *notchlegh*, administered by a *knïazetz* or small prince. Several *notchleghi* compose an *oulouse*, which is governed by a *golova*: these different functions are elective. The inhabitants of a *notchlegh* call themselves *tjonobout*, or of the same kind. When they make an election, each elector deposits his vote in a box divided in as many compartments as there are candidates; then the votes are counted, and the candidate who has obtained the largest number is proclaimed. Besides, it is always in the power of the governed to depose the chief with whom they are dissatisfied, in order to proceed to a new election. The district of Yakoutsk contains six *oulouses*, with a population of about 40,000; there are besides, about 30,000 *yacoutes* settled in the government of Yeniseïsk and in other parts of Siberia.

Their little boats made with the birch-tree's bark, called *vétotchki*, are constructed with much skill; the seams, after having been laid on with tar, become waterproof. Besides this, they make use of a kind of canoe, made with the trunk of a tree. In the building of it they begin by making on one side of the trunk a longitudinal cleft, which does not quite extend itself to the extremities; this cleft is next widened gradually by means of wedges larger and larger, so as to make a sloping opening, which, when wide enough, forms the interior of the small craft. In order to render it more spacious, sometimes they add side-planks at the upper part.

The winter's *yourtes* of the Yacoutes have the form of truncated pyramids. They are square. To construct them, they make use of poles fixed in the ground in an inclined position, and they spread on them a mixture of dung and soil. The roof is flat and made with planks of birch-tree's bark, which possesses the property of being almost inaccessible to rottenness. Seldom any floor is to be found. The hearth or *tchouval* occupies the centre; above there is a chimney made with planking laid on with clay. This dwelling, however light be its construction, is sufficiently warm to be able to live in it in the winter season; besides, it offers the advantage of being constantly ventilated by means of the hearth, which being always lighted, purifies the air. During the summer months, the Yacoutes construct for their use temporary yourtes without hearth in the localities to which they remove in the hay-harvest season. There is a Yacoute among the wealthy of the country who possesses as many as 1000 horses. However, being impossible to gather a sufficient quantity of hay for feeding all of them, the owner feeds only a certain number of them; the others wander about and get grass and moss by removing the snow with their forehoofs.

The tail forms an indispensable part of the costume of the Yacoutes; both men and women wear it so long, that in order to support it they tie it behind round the waist. The summer costume of the men consists of a kaftan (a Turkish vest) descending to the knees, made with China tissue or with cloth, lined all round with some stuff of a showy colour. For their feet they have boots with a soft sole. The *Sarama* is a kind of buskin made with horse-hide which is waterproof. Trowsers of reindeer-skin, a cap and gloves which have only the thumb, complete their garment. This costume is common to both sexes. In winter, for the simple kaftan, they substitute a furred dress. They wear also *torbases* or furred boots having the hair outside. During this severe weather the traveller puts on a large riding-coat, called *sanaïak*, made with reindeer-skin, having equally the hair outside; he applies upon his forehead, cheeks, and ears, pieces of fur made on purpose, and surrounds his knees with *soutouvi* or bands. The furred robe which the women wear in winter, is called *parka*. It is made with reindeer-skin, and has the form of a long shirt. The sleeves and the collar are trimmed with furs of the finest quality. The dress of the wealthy Yacoutes is often very expensive.

The Yacoutes are kind and officious; hospitality towards strangers is one of their virtues. At the same time they are suspicious, mistrustful, and timid. When occasion requires it, they are extremely sober, and a little *sora* or sour butter suffices for their nourishment; but as soon as necessity has ceased to compel them, they become such gluttons as to render it difficult to give an idea how far their gluttony goes. A Yacoute is capable of devouring an extraordinary quantity of meat; but cares little about its quality or its freshness. The entrails of the animals and the ox's hide are aliments which do not cause him any disgust. To eat a fresh ox-hide, they are satisfied with putting it for a little while under hot ashes in order to make the hair fall off. Fat in a liquid state is one of their most exquisite dainties; they feed upon it without measure. Among them the faculty of being able to eat much is considered as a kind of merit fit to draw upon them respect. It is not uncommon to hear them say, when they praise some one of their people, "outiò asatchi khisi!" namely, that man there eats well.

The *chamans* or sorcerers continue to exert a great influence on this credulous people. They feign to entertain relations with the souls of the dead, and by this means often extort from the relatives of the dead, with the pretence of obeying an injunction come from the other world, furs and even cattle. It is well known that these jugglers give themselves up to the practice of gross sorcery.

The Yacoutes have for the bear a kind of superstitious fear; they believe that in this animal the spirit survives the body. In spite of this, they do not scruple to shoot a bear and to eat its flesh; but it is by observing certain forms which they suppose have the power to turn aside the witchcraft. Imagine some Yacoutes travelling, and in crossing a forest that they should meet a bear. All begin by taking off their caps, lavishing upon him many salutations, and calling him by the name of *toïone* (lord), of worthy old man, of good father, and so on. In the meantime they beseech him, in the most humble terms, to allow them to continue their journey, assuring him, that instead of forming any bad design against his lordship, on the contrary, they entertain the greatest respect for him. But whilst addressing these fine words to the animal, our cunning Yacoutes go forward, choose a tree suitably situated, in order to be safe from behind, and then shoot the animal dead. This first point settled, they make haste to skin it, and having cut it into pieces without breaking the bones, which they put aside (it will soon be seen for what reason), they cook the said pieces. During the preparations, a man of the same party has taken care to knead with clay lightly moistened, a little statue representing *Boënai*, the Great Spirit. The meat being cooked, the caldron is raised in addressing a prayer to Boënai and to the Spirit of the forest. According to the belief of the Yacoutes, each forest is placed under the direct influence of a spirit. Then they sit down round the smoking soup, and each of the guests takes care to pour on the fire the first spoonful of gravy. Then the feast begins. Whilst it lasts, the guests often apostrophize the ghost of the bear which they have thus despatched. "No," say they, "don't believe us capable of having perpetrated such a murder. Among us, poor Yacoutes, the art of making guns and deadly balls is unknown. They are either some Russians or Toungouses who have done the evil deed." After the repast, the bones of the animal are carefully put together, wrapped up with the idol in a piece of birch-tree bark, and then hung up to a tree. "You see it well," they go on repeating during the ceremony, "far from being murderers, it is on the contrary we who gather together here the bones of this bear killed by others."

Marriage is performed without any kind of ceremony. When a Yacoute wishes to obtain the hand of a girl, he must agree with the father respecting the price to be paid for her; this purchase-money is called the *kolim*. The wedding and the banquet which accompanies it, take place in the house of the father-in-law of the bridegroom, but at the expense of the latter. The rejoicings are prolonged twice twenty-four hours. During the *kourourne* (banquet) they drink a quantity of *koumise*, a kind of fermented beverage made with mares'-milk; more rarely brandy distilled from corn, which is scarce and consequently expensive. They eat horse-flesh, beef, and moles as dishes of the first course. As a second course, they serve on the table a dish filled with drippings. This is considered the most refined dainty. The *khamiak*, which is a large spoon, goes all round, and each guest drinks plentifully of the nectar. There are some gluttons among them, who, after having crammed their stomach with meat, are still capable of swallowing a hundred spoonsful of melted fat. The bridegroom cannot take away his bride until the *kolim* has been wholly paid for; otherwise she continues to live with her father. Sometimes the debt is only discharged by instalments, paid at long intervals, and at each of these instalments, the husband comes to spend a few days with his wife.

Proposed New Route between the Atlantic and Pacific, by the River Maulé in Chili. By Capt. Walter Hall.

On Iceland, its Inhabitants and Language. By John Hogg, *Esq., M.A., F.R.S., L.S., R.G.S. &c., Foreign Secretary of the Royal Society of Literature.*

The author commenced this paper by observing, that the large volcanic land on the western boundary of Europe, surrounded by the North Atlantic Ocean, and partly within the Arctic Circle, is only known in England under the inhospitable name of Iceland. The like inhospitable name of '*Ultima Thule*' having been by some geographers assigned to it, he showed that there was no reasonable foundation for such an opinion. Mr. Hogg said, if what Solinus stated was correct, viz. "that Thule was five days' sail from Orkney," he conceived that one of the Feroe Isles would better correspond: but, on the other hand, Tacitus, in his account of the circumnavigation of Britain, writes, that the Orkneys were then discovered, and "from thence Thule was visible,"—consequently Mainland, the chief of the Shetland Isles, which is quite mountainous, would very probably be the land there discernible. No Roman remains have been found in Iceland; but if that nation had extended its conquests to its desolate shores, they would doubtless have continued their explorations to Greenland and the northern coasts of America. Such however was not the case. And since the island itself, as far as is yet known, is altogether volcanic, it may not have been in existence at that early period; but, like the ancient Isle of Thera (hodiè Santorin), or that very modern one lately called "Graham Islet," in the Mediterranean, it may have sprung up through volcanic agency, subsequently to the time of the Roman Empire. History does not state when Iceland was first discovered, and nothing certain is known of it till the ninth century of our æra; though from the Icelandic Annals it would seem that it had been before then temporarily inhabited, perhaps, as some have asserted, by the Irish.

The author briefly gave a description of the settlement there by the Norwegians, or Nordmenn of Scandinavia. He then more fully pointed out its geographical position, and compared its form and extent with those of Ireland, observing that if the latter island could be moved so as to bring its present east side with the point called "Wicklow Head," due south, the general appearance of Ireland and Iceland would better agree. He showed that both islands possess many fine bays, inlets, or fiords, and havens; also many rivers, lakes, and tracts of bog or marsh. Iceland is however very much less fertile, and is more covered with lofty mountains, which attain to between 6000 and 6500 feet in height. Those termed in Icelandic Jökulls, *i. e.* 'ice mounts,' occupy the central parts of the island, and run out to the N.W. and N.E. From their melted snows and glaciers, the Geysers and other intermittent hot-springs are principally supplied.

Mr. Hogg then compared the population of the two islands, and noted that although Ireland had been during some years, previous to the census in 1851, reduced about 20 per cent, by emigration and other causes, still it numbered rather fewer than 6,661,840 souls; and the city of Dublin itself estimated somewhat above 258,300, whereas Iceland, once possessing 100,000 inhabitants, now reckoned only 48,000 over its whole superficies, and the entire population of its capital Reikjavik does not exceed 500.

This comparative account sadly exhibited the deserted state of a country very similar to Ireland in its natural dimensions. The interior or central parts of Iceland are not inhabited, and are but little known to the traveller.

The author, after describing the general aspect of the island, and its total want of trees, added a brief description of Mount Hecla, and its three somewhat conical summits. As the poets of Grecian antiquity had dedicated one of the tops of the Bifid Parnassus to Apollo, and the second to Bacchus, so he conceived the Skalds or Bards of Iceland ought to have assigned the first summit of the Trifid Hecla to Odin, the second to Frea (Friga), and the third to Thor.

According to the recent survey and measurement of Prof. Björn Gunnlaugsson, the altitude of the highest top of Hecla is 4961 Danish feet, or somewhat above 5100 English feet. A brief description by a late traveller of the view from one of its summits was given.

The author alluded to the wonderful Geysers, and other boiling springs, which after certain intervals spout jets of water and steam high into the air, and proved that some of them had existed for at least six centuries and a half.

Then followed an account of the climate in summer and winter; the aurora borealis, and other meteorological phænomena; also of the continuance in June and July of sunshine during the night, and of the want of it in the day through the corresponding period in December and January.

An enumeration of some of the chief volcanic products and minerals was made; and the poverty of vegetation, the few wild animals, and those which are domesticated, were noticed.

Next, concerning the ethnology of the Icelanders. These were characterized as a plain, but well-made, not very robust race, of good height, with reddish hair and blue eyes. They are short-lived, content, and moral, although much addicted to drinking. They are naturally lazy, phlegmatic, and not very hospitable. Professing Lutheran tenets, they are religious, fond of their native land, and well-educated. Crimes are very rare. Owing to the severity of the climate, they are warmly clad; both sexes wearing old-fashioned garments of a coarse dark cloth, *Wadmal*. The houses, or rather huts of the lower class, are low and miserable, and from the scarcity of timber, are mostly built of lava. They are very filthy and want fresh air. Fuel is scarce; peat, as well as the remains of fish and birds, are its substitutes.

Their diet consists of salt fish, fermented milk, rancid butter; also train oil is much esteemed. Salted mutton is used, and fresh fish in summer. Wheaten bread is scarcely ever to be had; sometimes barley cakes are eaten, but the usual bread of the peasantry is made from the poor flour of the Iceland Lichen (*Cetraria Islandica*).

In summer travelling is effected on horses; in winter in sledges, which are the only carriages known.

The occupations of the Icelanders are chiefly breeding horses, cattle and sheep; fishing for cod and seals, and in certain rivers for salmon; salting and drying fish and mutton. Much attention is given to the care of Eider ducks, their down being a most valuable export. Little is done in commerce as yet, except by the Danish merchants. The other principal exports are dried salt fish, fish roe, pickled mutton, skins, fur, wool, feathers, train oil, and tallow. Brandy and salt, with most of the other necessaries of life, are imported; so are manufactured goods.

Nearly all the lower classes can read and write; and in every hut is found the Bible. During their long winter, the Icelanders spend much time in reading, at which season both sexes knit and weave. Small plots of ground are here and there cultivated for gardens, in which some common vegetables are with difficulty grown; there are no corn-fields; only meadows and pastures in the valleys adjoining upon lakes and streams.

The Icelanders have several diseases, which are very fatal*, and vast numbers of the children die when infants.

Mr. Hogg made mention of the Icelandic language, which is the original Norwegian, or Norse, scarcely at all altered by length of time, or contact with other nations. It belongs to the Scandinavian branch of the great Teutonic family of many ethnologists; or, according to Jacob Grimm, it forms a dialect of his fourth division of the Germanic language. The author is more inclined to esteem it, with Rask and later authorities, a sister language, rather than a mere cognate dialect of

* Dr. Latham observed (after the paper was read), that, according to Dr. Schleisner, the temperature of the blood of the Icelander is sensibly higher than that of any other European.

the German. It is characterized by the absence of aspirates and gutturals, and thus possesses a softer sound and pronunciation.

This dialect of the Scandinavian remained unchanged, whilst that of the Danes having altered much, it could no longer be termed Dönsk Tunga, 'Danish tongue,' as the language which prevailed throughout the North and in Iceland was at first called. It then came under the appellation of Norræna Tunga, the 'Northern tongue,' or Norse, that afterwards designated more especially the Norwegian dialect. The latter continued the same for a long time, while that of Sweden soon altered. In the ninth century the Norwegian colonists took into Iceland their language, where it continued in its purity for ages. But the ancient dialect in Norway at length experienced a great alteration in consequence of the union of the country with Denmark, and thus Norwegian and Danish soon assimilated and became the same.

Consequently, the original Norwegian, which still continued to be used in Iceland, obtained a new and more fit title, viz. Islenzka Tunga, the 'Icelandic tongue.' Indeed, this identical language is now so little altered, that the lower class of Icelanders still read and understand the Sagas and ancient Eddaic poems.

The author said, "want of time forbade him from adding any particulars concerning the structure or grammatical peculiarities of the Islenzka Tunga:" he therefore concluded by giving some examples of Icelandic words, for the purpose of showing how similar they are to the corresponding vulgar words still spoken by our common people in this part of the north of England. These had most likely been introduced by the Nordmenn—or Northmen of Scandinavia under the general term of Danes—when they spoke the same original Norwegian as the Icelanders do, during their invasions in the ninth and tenth centuries of this portion of Northumbria.

According to Adelung (Mithridates, vol. ii. p. 305), Von Troil, in his 'Letters from Iceland,' has reckoned four principal dialects (hauptmundarten) of the Icelandic. These, however, the author apprehended, only present very slight differences, except in the sea-ports where many Danish words are used, inasmuch as the same pronunciation prevails throughout the island, and is found to be, even among the lower class, nearly identical.

Mr. Hogg illustrated his observations by pointing out the localities mentioned on two recent and beautiful maps of Iceland from the collection of Icelandic maps in the possession of the Royal Geographical Society of London. These are entitled "Uppdrattr Islands," and were executed under the direction of Mr. O. N. Olsen from the measurements of Mr. Björn Gunnlaugsson, Professor of Mathematics at the College of Bessastadt in Iceland. They were published in 1844 and 1849 by the Islenzka Bókmentafèlag, or Icelandic Literary Society at Copenhagen.

Notes on a Journey to the Balkan, or Mount Hæmus, from Constantinople. By Lieut. Gen. JOCHMUS. *Drawn up and communicated by* JOHN HOGG, *M.A., F.R.S., L.S., R.G.S. &c., For. Sec. R.S.L.*

Previous to the reading of this communication, Mr. Hogg stated, that the author is Lieut.-General Jochmus, a native of Hamburg, long an officer in the army of the Sultan, and afterwards Minister for Foreign Affairs of the administrator of the Germanic Empire. It describes a journey to the Balkan from Constantinople, which was undertaken in October 1847; but the notes were written in that capital in January 1848. Time did not allow of the full reading of this valuable communication, and therefore Mr. J. Hogg was only able to submit to the Section certain passages from the "Notes" themselves, but he gave a preliminary sketch of the route pursued by the author, and of the principal objects of his journey.

Many defiles and passes of the noble Balkan range, the Mount Hæmus of antiquity, so named, probably, from *αἶμος, a wooded district,* and now called in Turkish *Emineh Dagh,* which rises to about 6000 feet above the sea, were correctly described, particularly that portion which extends from Burgas on the Black Sea to Tirnova, the capital of Bulgaria; also along the coast of that sea to Varna, the former Odessus, and thence through the territory of the ancient Triballians to Silistria (Durosterum) on the right bank of the Danube.

The General was enabled to determine some portions of the Balkan which were either before uncertain, or altogether unknown, and likewise to correct in several places the great Austrian staff map. Indeed, he has shown that there are no less than *thirteen* practicable defiles, besides many cross-roads, between the pass of Kezanlik and Cape Emineh, and not *five* only, as Von Hammer enumerates. And he observed that "the most extraordinary fact is that Marshal Diebitsch, as well as Darius, crossed the Hæmus by roads *unknown* to that most learned historian of the Turkish empire."

General Jochmus likewise establishes several ancient localities where Darius halted with his army. At Bunarhissar, near the Kuchuk Balkan, he unsuccessfully searched for the ancient inscription with the letters like "nails," mentioned by Herodotus (Melp. c. 91), and which Abdallah Aga described to him as being "in ancient Syrian or Assyrian (Eski Souriani)," and which he "maintained having seen in the Tekeh every day for upwards of the eight years which he passed there as a Dervish." But he seems to have been more fortunate in finding the clear streams of the Tearus, near the latter town, and which have been incorrectly named Teara Sugi, or 'Teara's Waters,' by Von Hammer. He has identified the ancient river Artiscus of Herodotus with that now named Teke, near the new Bulgarian colony of Dewlet Agatch, in the former territory of the Odryssæ.

Mr. Hogg said it was one of the chief objects of the author to ascertain the line of march and operations of Darius through this country, and he dwelt on the following passage: "Darius crossed the Bosphorus on a bridge of boats connecting the two continent at the site of the present new Castles of Asia and Europe (see Gibbon, and Herod. Melp. c. 87), encamped successively at the sources of the Tearus (Bunarhissar), and on the banks of the Teke, or Artiscus (at Dewlet Agatch), and following the direction of Burgas and Achioly, and subjecting the sea-towns, he passed afterwards the Balkan by the defiles parallel to the sea-coast from Mesivria to Jowan Dervish, moving from south to north, by the same roads which were chosen by Generals Roth and Rüdiger, and by Marshal Diebitsch himself, who proceeded from north to south in 1829. The Russians also in 1828, and Darius about 2300 years before them, passed the Danube 'at that part of the river where it begins to branch off' (Melp. c. 89), that is, near the modern Issatscha."

The route to the Great Balkan, the true Hæmus range, which General Jochmus, looking to the nature of the country, supposes that Alexander the Great took in his march from Amphipolis to the Danube, he has fixed, where Alexander must, either at Bogasdéré, or at the entrance of the neighbouring valley Charamdéré, at the foot of one of the wildest gorges of the Balkan, have fought the battle with the Thracians, as is recorded by Arrian (lib. i. c. 1). The aspect of those defiles, the steepness of the mountains in parts of that ascent of the Balkan, and the distance from Amphipolis, caused the author to arrive at that conclusion.

But as to the site of the battle between Alexander and the Triballians, which occurred about 335 B.C., the General, exploring the country to the west of Varna on the Black Sea, says, "the Parawadi river runs nearly parallel to the Hæmus and to the Danube, and considering that from Varna, as well as from Parawadi, the distance to Silistria is computed at twenty-four hours, or three days' march, there can be no doubt but that the Parawadi river is the Lyginos described by Arrian as 'distat id ab Istro, si quis Æmum versus proficiscatur, itinere tridui.'" The Lyginos is not stated by the historian to flow into the Ister or Danube, as the great Austrian map and other authorities have made it, "at Dshibra Palanka, between Nicopoli and Widdin, opposite to some islands. It is this collateral circumstance of the islands at the mouth of the Dshibra Palanka river which most likely caused the error, for Arrian speaks of an island of the Lyginos."

From an examination of the district adjoining upon the two lakes of Devno to the west of Varna, General Jochmus is persuaded that the isthmus between those lakes, a little west of Buyuk Aladin, is the ground of Alexander's action, it being "formed into an island by the two principal outlets of the Parawadi, or Lyginos river, which traverses" both the lakes.

Further, the General has thus determined Alexander's line of march and exploits from Macedonia to the Danube. He thinks he proceeded "from Amphipolis (Emboli), leaves Philippi (ruins of Filibè) and Mount Orbelus on its left, crosses the Nesus (Carasu), and following the high road by the present Féréshik, Dimotika, Kirklissia and Aïdos, gets to the foot of Mount Hæmus, where he arrives 'on the tenth day.' Here he fights the action with the Thracians at Bogasdéré, or Charamdéré, forces these defiles, and crosses the Hæmus (Balkan) by the main road to Parawadi, 'on the Lyginos.' From Parawadi, Alexander moves by the present high road straight on to Silistria, but hearing of the retreat of the main body of the Triballians towards 'the island of the river (Lyginos), whence Alexander had departed the previous day,' he countermarches also in search of the enemy, whom he meets and defeats on the grounds between the two lakes of Devno. Thence he arrives 'in three days' on the Danube (at Silistria), crosses that mighty river, defeats the Getæ*; repasses the Danube, and undertakes his expedition against the Agriani and Pæoni." (Arrian, Exped. lib. i. c. 1–5.) "It remains," continued the author, "to be observed, that whilst the Getæ, who in the time of the expedition of Darius against the Scythæ (Herod. lib. iv.) lived south of the Danube, are found by Alexander already on the left or northern bank of the river, in the fertile plains of Wallachia, the Triballians, on the contrary, hold the former territories of the Getæ as far south-east as Varna."

It is therefore "seen that Alexander has passed in his march on Silistria the Kamshik at Koprikoï, and the Lyginos at Parawadi, at the same points chosen by Marshal Diebitsch in his reverse operation from Silistria, against the defiles of the Balkan after the battle of Kulerdja and the capture of Silistria. Arrived at Koprikoï, the Russian army strikes off to the east, and forces those passes of the Hæmus chosen by Darius, because it lay in the plan of the Russians, as it did formerly in those of the Persians, to occupy first the 'sea-towns,' before continuing their operations, —Darius from south to north, Marshal Diebitsch from north to south. Nature has so strongly marked the best amongst the difficult passes of the Hæmus, that, at the distance of very many centuries, the three great commanders are found to operate by the same lines."

General Jochmus, returning to Varna from the isthmus between the upper and lower Devno lakes, his guide "indicated the grounds, north of the village of Jenishékoï, as the scene of the great battle of the 10th November 1444, A.D. Two tumuli were pointed out to him by the denomination of Sandshak Tépé, and Murad Tépé. They are about the centre of the line which Sultan Murad's army of 40,000 men must have occupied." The last named Tépé he holds "to be the spot where that Sultan had ordered the lance with the treaty to be exposed to the sight of his indignant army, and where King Wladislaw's head was planted by its side. The Sandshak Tépé is the neighbouring mound, where, according to the Turkish war-custom, the great imperial standard was displayed."

The ground there, as laid down in a plan in Hellert's French translation of Von Hammer's 'History of the Ottoman Empire,' was found to be "altogether fictitious;" and it is a very incorrect representation of the "battle of Varna." The General then gives further details of this great battle, and describes the present condition of the fortifications of Varna. He also mentions the attack of the Russians in 1828.

General Jochmus made many remarks of a military nature respecting the chief positions, towns, and stations in this part of the Turkish dominions; and also many accurate personal observations on the routes and natural features of the Balkan, which contribute a valuable addition at this time to our present knowledge of that mountainous range. There are likewise interspersed throughout his communication many interesting accounts of the political condition and manners of the different races whom he visited.

Three neatly drawn and coloured plans illustrated the paper; the first, a map of the Great Balkan from Varna to Tirnova, and from Varna to Burgas on the Black Sea, with the names written in Turkish; the second, a "Sketch of the Ground near Varna, 1847," showing the lakes, sites of the battles, tumuli, &c.; and the third gave a "Sketch of the marches of Darius and Alexander to the Danube, and of the passage of the Balkan by Marshal Diebitsch."

On certain Localities not in Sweden occupied by Swedish Populations, and on certain Ethnological Questions connected with the Coasts of Livonia, Esthonia, Courland, and Gothland. By R. G. LATHAM, *M.D.*

A short pamphlet 'On the Remains of Swedish Nationality in Esthonia and Livonia,' by Aug. Sohlman (*Om Lemningar af Svensk Nationalitet uti Estland och Liffland*),

* "According to Barbié du Bocage, near a place opposite to Silistria, where now is the village of Kornizel."

gives an account of certain Swedish populations in the islands, and along the shore, between Reval and Memel. In Rogö, Odinsholm, half Nuckö, half Worms, parts of Dagö, Runö, and a portion of the coast near Roslep, the population is Swedish both in language and appearance. In Nargö, the other half of Worms, half Nuckö, and a few spots on the opposite coast, there are Swedes and Esthonians mingled. In Mannö, Kynö, parts of Ösel, Moon, Dagö, and patches of the continent, the present population consists of Esthonians who have displaced Swedes. The earliest notice of these Swedes is in the laws of the town of Hapsal, A.D. 1294. Henry the Lett mentions Swedes in Reval. The local names are Swedish,—Stoorby, Söderby, Lyckholm, Kluttorp, Pärsåker, &c.; so are the personal,—Knuter, Mats, Lars, &c. Runic letters are used in their calendars. Thursday is an unlucky day to begin work on; Friday a lucky one for marrying,—notions pointing to Freya and Thor. Superstitions and legends are numerous. Dialects not fewer than 5; privileges neither a few nor unimportant.

A colony of these Swedes from Dagö has been transplanted to the parts near Berislav, in the government of Cherson; their localities being Schlangendorf, Milhausendorf, Gamle Svenskby, and Klosterdorf. The date of this is recent; that of island occupations uncertain. Probably it belongs to the 9th, or 10th, or 11th centuries, *i. e.* the great epoch of the Scandinavian piracy.

Going beyond the details of these small localities to the ethnology of the neighbouring parts of the continent at large, we find that the displacements have been inordinately great. The Prussians and Lieflanders belong to Prussia and Livonia (Liefland) only as an Englishman does to Britain, and they are Prussians and Livonians only as Englishmen are Britons. They occupy countries that originally belonged to *Liefs* and *Prussians*, just as the Angles occupied countries which were originally British. The true and original Liefs (Livonians) were Finns, of the same branch with the present Esthonians; indeed, a few true (Finns) *Liefs* exist, at the present time, in Livonia. The Livonians, however, commonly so called, are Letts, or Lithuanians. The true Prussians were Letts or Lithuanians; the present Prussians are Germans. How far, then, did the area of the Finn population akin to the Liefs and Esthonians originally extend? Certainly into Courland; possibly at a very early period (some centuries B.C.) to the mouth of the Elbe. And how far extended the Lithuanian area? Into West Prussia at least. If so, and if the westward extension of the Finns be real, the direction of the Lithuanic must have been from some part of the interior of Europe towards the coast. Did Lithuanian tribes cross the Baltic? The general tendency of opinion is to attribute all the commercial or piratical activity of the Baltic tribes to the Scandinavian branch of the Germans. The foundation of this doctrine is the name *Goth*. Few hesitate to consider the Goths of Gothland (isle and provinces), the Jutes of Jutland, and the Gothones (Guttones) of East Prussia as populations bearing a name essentially the same. Few doubt about this name being German, and applied to Germans. Yet this fact, upon which so much turns, is more than doubtful. *a.* No Germanic population can be shown to have borne a name like *g-t*, previous to its having occupied the country of some *non*-Germanic population, so-called; so that the Germans of the several *Goth* countries were Goths only as the Englishman is a Briton, *i. e.* not at all. *b.* The population to which the term *g-t* can be shown to have been most unequivocally and undoubtedly applied is Lithuanic (*i. e.* the old Prussian of the country of the Guttones, Gothones, or Gythones). Reduce the inferences derived from this erroneous assumption to their proper dimensions, and then consider the ethnology of Scandinavia. The two provinces of Gothland, the island Gothland, the Gothland (so to say) of the Guttones, must be placed in the same category. But the Guttones can no longer be made German, on the strength of their name. The evidence of their Germanic character is reduced to the single fact of their being found in the 'Germania' of Tacitus. This is not sufficient to stand against the preponderating facts in favour of their being Lithuanians or Prussians. The author believes that Scandinavia (in the first instance Finn) received two streams of occupancy and conquest; one Lithuanic for Gothland, &c., and one German, that spread from Norway southwards and eastwards. The chief proofs of this lie in the admitted facts of Scandinavian ethnology interpreted differently. There are numerous Lithuanic words in the Scandinavian language; there are the political and other peculiarities of the Goth-lands; there are elements common to the two mythologies,

&c. Admit nothing but Finns and Germans, and all these points are difficulties. The hypothesis of Lithuanic as well as a German conquest accounts for them. Jutland was probably a land of Lithuanic settlements, intermixed with Slavonic ones from Pomerania, &c.

Ethnological Remarks upon some of the more remarkable Varieties of the Human Species, represented by individuals now in London. By R. G. LATHAM, *M.D.*

The Zulus.—These belong to the Caffre family. Between this Caffre family and the true Negro a broad line of demarcation is often drawn. The individuals in question make this line doubtful. They are certainly intermediate both in shape and colour. This is the most important point in their ethnology.

The Earthmen.—These are Bushmen who occupy a tract of which the geological character supplies natural caves which serve for habitations. In this sense only are they *Earthmen*, as opposed to the ordinary Saab (Bushman). They are Bushman-Troglodytes, or Troglodyte-Bushmen.

Australians.—Height, 5 feet 10 inches, and 5 feet 9 inches. Lower extremities inordinately thin; so much so as to show that the illustrations of Dr. Prichard are no exaggeration. Hair, somewhat more crisp and curly than is expected from the current descriptions. Language, Cowrarega.

The Astecs.—No offspring of parents like themselves, nor yet likely to be the parents of offspring like themselves; consequently no specimens of any new race (*so-called*). Probably from the part of South America to which they are referred. Their likeness to certain outlines on Mexican monuments not accidental. This accounted for by supposing that the physical or social conditions of the locality to which they are attributed, favour such degenerations as they exhibit; the tendency to them being endemic. In the point nearest to their attributed locality of which any notice is in print, Gage found the people ill-shapen and goitrous. At the same time their appearance is not that of the Cretins of Europe: of these they are the American analogues. An intermixture of Spanish (or other) blood, as suggested by good authorities, would most easily account for certain points (*e. g.* the hair) in which they differ from the American Indian, and approach the Spaniard, Jew, &c. It is doubtful, however, whether the assumption is necessary; at the same time it is compatible with the present view. The existence of Indians in a state of independence for *one* of the frontiers of Vera Paz is an actual fact. The Lacondona Indians are in this predicament. They are also inaccessible. The existence of Casas Grandes in the locality to which the Astecs are attributed is likely. Upon the whole it is believed that they come from a locality where certain tendencies to degeneration are and have been endemic, and where there may be *some* architectural remains, and *some* vestiges of independence,—facts which, even if adopted, by no means imply the truth of the so-called narrative of Velasquez, or the details of the history of the two children. As to the name *Aztec*, they are only *Astecs*, so far as they represent an outlying portion of the Astec empire as opposed to *Spanish* America.

On the Traces of a Bilingual Town (Danish and Angle) in England. By R. G. LATHAM, *M.D.*

The termination of local names in *-by* (New-*by* as contrasted with New-*ton*) is the chief characteristic of Danish, as opposed to Angle, or Anglo-Saxon, occupancy. There are other forms equally characteristic; one of those is *-caster*, as opposed to *-cester* and *-chester*. Lan-*caster* is Danish; Lan-*chester* (Ciren-*cester*) Anglo-Saxon. Danish Northampton is divided from non-Danish Huntingdonshire by the river Nene. On this stood the Roman Durobrivæ, partly (probably) on the one side of the water, partly on the other. This gave us two Roman *castra*. The modern forms of these two *castra* are, on the Northamptonshire (Danish) side, *Caistor* (not *Chester*); on the Huntingdonshire (Angle) side, *Chester*-ton (not *Caster*-ton).

Observations on the Province of Tarapaca, South Peru. By Don M. B. LA FUENTE.

Notes of an Excursion to the supposed Tomb of Ezekiel. By T. K. LYNCH.

The traveller arrived at Kiffell on the 4th of May, 1848, a palace which was traditionally supposed to be the burial-place of the prophet Ezekiel. After traversing many miles of ground, he at last came in sight of the fort, which he entered, and requested to be conducted to the tomb of the prophet. The chief of the inhabitants of the town, who were few, consequently accompanied him to the place, and, having traversed a spacious court, they entered a large hall, supported on two rows of pilastered columns, and in the recess at the extreme end of the hall was a case resembling that of a gigantic opera-glass, which contained a copy of the five books of Moses. The whole of this precious manuscript was written on a single scroll, which, for convenience sake, was rolled into one case as it was uncovered from another. Leading out from this hall, on the south side, was a little dark chamber, which contained the tomb itself—'the very grave of Ezekiel'—enclosed in a wooden case, which was covered with English chintz, by no means of the finest texture or newest pattern. Above the tomb arose the spiral dome, which internally was handsome, gilt and enamelled, and was illuminated by many small lamps, kept constantly burning, suspended over the sarcophagus. Around this hall, besides several small dark closets for private devotions, there was another mysterious chamber, which was lighted up by a single lamp, and contained three graves, said to be those of the principal Jews who accompanied Ezekiel.

On certain Places in the Pacific, in connexion with the Great-Circle Sailing. By the Rev. C. G. NICOLAY, *F.R.G.S.*

On the Interior of Australia. By AUGUSTUS PETERMANN.

At a time when the exploration of the unknown interior of Australia was earnestly thought of, the probable character of that extensive region became a subject of particular interest and of legitimate inquiry. Scarcely one-third part of Australia could be said to have been even partially explored, and by far the largest portion was therefore entirely unknown. This unknown interior of Australia had frequently been a matter of speculation, at first founded on very few facts. But as our knowledge increased, and actual facts became more numerous, the theories had been modified. One of these hypotheses was, that the interior, to a certain extent, consisted of a shoal sea. It was in 1814, only forty years since, when the exploration of inner Australia might be said to have been systematically commenced, that Mr. Oxley, the first Surveyor-general of New South Wales, a man of acknowledged ability and merit, pushed his investigations into the interior of that continent. By tracing down the rivers Lachlan and Macquarie, he was checked in his progress westward by marshes of great extent, beyond which he could not see any land. He was therefore led to infer that the interior was occupied by a shoal sea, of which the marshes were the borders, and into which the rivers he had been tracing discharged themselves. This opinion was probably supported by the fact that the mouth of the largest of the Australian rivers, the Murray, had been overlooked by Capt. Flinders, and was not discovered till fifteen years after Mr. Oxley's discoveries, by Capt. Sturt. In 1845, Mr. Eyre, one of the most distinguished explorers of Australia, announced that he had arrived at different conclusions, namely, that the interior would be found generally to be of a very low level, consisting of sand alternating with many basins of dried salt lakes, or such as were covered only by shallow salt water or mud, as was the case with Lake Torrens. He also said that it was more than probable there might be many detached, and even high ranges, similar to the Gawler Range, and that, interspersed among these ranges, intervals of a better or even of a rich and fertile country, might be met with. In 1850, Mr. J. B. Jukes, in his valuable work on 'The Physical Structure of Australia,' stated his opinion to be that the interior consisted of immense desert plains, which seemed to extend to the sea coast round the Gulf of Carpentaria on the north, to that of the great Australian bight on the south, and to stretch along the north-west coast to Collier Bay. The general opinion at present entertained on this point seemed to be very similar to that of Mr. Jukes, excepting, perhaps, that it was thought that the deserts did not reach so far to the north, and the northern parts were considered to consist of some fertile and promising regions. The chief grounds on which these deductions had been made were the known facts as to the climate and meteorology of Australia, and the absence of large rivers and other features. It was well known that the Australian colonies were subject in summer to occasional blasts of what is called the hot wind, from its extremely high temperature. This hot wind always blew from the interior; in New South Wales and Tasmania, its direction being from the north-west, and from the north in Port Phillip and South Australia. The breath of this wind was like the blast from a fiery furnace, increasing the mean temperature of a summer's day, on the westerly side of the eastern cordillera, 40°; on the eastern side, both in New South Wales and Tasmania, 25° to 30°; and while during the hot wind the thermometer rose to 100°, or even 115° in the shade, with the southerly squall there was sometimes a sudden fall of full 40° in the course of half or even a quarter of an hour. This wind swept up from the interior clouds of dust and sand, sometimes intermixed with gritty matter, large enough to strike with painful acuteness on the face. Count Strzelecki, while sailing from New Zealand to New South Wales, was prevented from making the harbour of Port Jackson for two successive days, by the violence of this hot wind. Though sixty miles from the shore, the heat exceeded 90°, and the sails of the ship were covered with a small powder by the breeze. The hot winds were, indeed, identical with the sirocco blowing from the great Sahara of Africa, and similar winds in other parts of the globe. It had been justly said that these hot winds, experienced in the southern parts of Australia, could have no other origin than by a current of air blowing over some large expanse of burning desert, and our knowledge of the adjoining regions entirely corroborated this assumption. The discoveries of Capt. Sturt, in his last expedition in particular, indicated the very nest and hot-bed of the winds. The situation of Capt. Sturt's desert was such that there was good reason to think its influences would extend to the whole of the coasts, even to those of Western Australia, which were the furthest from it, namely, about 1350 geographical miles; unless the wind blowing from it were intercepted or deflected in the intervening spaces by mountains, or else ameliorated by countries of different character. The influence of the hot winds from the Sahara had been observed in vessels traversing the Atlantic at a distance of upwards of 1100 geographical miles from the African shores by the coating of impalpable dust upon the sails. Mr. Petermann proceeded to describe the results of his investigations, which tended to point to the supposition that a great part of the interior of Australia consisted of sterile deserts; that the Torrens Basin and Sturt's Stony Desert formed the centre of the largest of these deserts, which probably extended from 200 to 300 miles around the latter, and that a fringe of 200 to 300 miles extended all along the great Australian bight to Western Australia, and along the western coast as far as the Gascoyne Basin, or even the river Fitzroy. It also appeared to him that the whole of north-west Australia, north of Fitzroy River, as far as the head of Carpentaria Gulf, was a region of the most promising character, and that from this region a spur of more or less elevated land extended as far as the cluster of mountains discovered by Sir Thomas Mitchell, which gave birth to many beautiful rivers flowing in all directions of the compass. This spur would necessarily form a bar between Sturt's desert and the Gulf of Carpentaria. It seemed to him most probable that this promising district of north-west Australia extended far to the south, to the middle of the continent, and beyond it, at least to the latitude of Gascoyne River. One significant fact supported the latter opinion, and that was the occurrence of large trees which had been floated down the rivers of north-west Australia, and found at their debouchures,—an occurrence unknown in south-western Australia. In conclusion, Mr. Petermann said that by taking his suggestion in connexion with the proposed expedition of Mr. Ernest Haug, he could not but hail with lively satisfaction the determination by which it is hoped a portion of this extensive and promising district would be explored and laid open for the benefit of mankind.

On a Second Journey to St. Lucia Bay, and the Adjacent Country in South-East Africa. By R. W. Plante.

Having explored the coast in the neighbourhood of St. Lucia Bay, Mr. Plante was desirous of going beyond that district. In the journey of which this paper was a notice, he lost no time in getting to that district; and with only one deviation to the Unga range of mountains, he passed through the Zulu country, arriving at the river Umfalosi in one month from Natal, in company of a party of about 200. From this point they proceeded on foot. Two days from Umfalosi brought them to an arm of St. Lucia Bay; here they had to ford the water, at a place two miles in width, and breast deep. The maps of this part of the country represented the mouth of the bay as communicating with the sea, whereas it runs into the river Umfalosi. The bay was estimated at about eighty miles in length, and of an average width of eight or ten miles. Flamingoes, ducks, cormorants, and other water fowls were found on its banks. After four days' journey along the banks, they diverged into the woods, where there were large numbers of land shells, and five or six new kinds of trees, the timber of which might prove commercially valuable. Two days from the bay took them into the Amatatu country, a small tribe allied to Padua, and principally distinguished from the Zulus (who are chiefly a pastoral people) by subsisting more extensively on the produce of their gardens. Next to this tribe were the Amutangus, a more powerful tribe, who combined the occupation of agriculturists and hunters. In the latter character they were particularly successful, even against the largest animals. The tilling of the ground was principally left to the women, who worked very successfully. Their basket manufacture also might vie with that of any country. The people were well-formed, and exhibited a high degree of civilization, rarely found in these districts. The next five days' travelling was highly monotonous; when they crossed the Pengola, and entered the Makasan country, a district seldom visited by the white man. The Makasans were very friendly, but very poor, through having been at war for two years with their neighbours. Dwarfs are very common in the district; one, who was a kind of factotum to the late king, being only 3 feet 7 inches high, though beautifully proportioned. Idiots, apparently from sun-strokes, were also very common. An error on the maps was noticed here. The river Pengola did not run into the sea, but into another river, called the Uzatu, so that the author asserted that no river or other water could enter the sea between Umfalosi and Delagoa. The range of the Drachimbirgo here came in view, and, at the point where the author turned back, they were not more than fifty miles from the sea. After travelling about 300 miles from the Umfalosi, they found a wood with a stream of water running through it. Sickness becoming now prevalent in the party, it was determined to return to Natal, which was effected with much difficulty, owing to the rivers having swollen to such an extent as to make it hazardous to cross them. However, this was accomplished by the assistance of the oxen, who were good swimmers, the author twisting the tail of one of them round his wrist, and guiding its progress with his other hand.

On Contributions to the Ancient Geography of the Arctic Regions. By Professor Rafns.

On the Brigantes, the Romans, and the Saxons in the Wolds of Yorkshire. By the Rev. T. Rankin.

An Inquiry into the Variations of Climate within the Tropics, in connexion with the Vertical Action of the Sun and the actual Motion of the Earth, especially with reference to the Climate of the Gulf of Carpentaria in North Australia. By Trelawny Saunders, *F.R.G.S.*

The prevailing opinion on tropical climates regards the whole area within the tropics as equally objectionable to European constitutions. But the evidence of Capt. Stokes and others on the climate in the Gulf of Carpentaria proves that the range of the thermometer in that region contributed to render it peculiarly healthful. The thermometer had been observed as low as 50°, the air cold and bracing, and the effect on health, under great deprivations, had been proved to be excellent. It was a fundamental idea, in regard to the distribution of temperature, that it graduated from a line adjacent to the equator towards the poles. Mr. Saunders proposes to show that the relative duration of the sun's vertical action within the tropics produced five distinct zones, presenting characteristic and distinguishing features. The passage of the sun's vertical action between the tropics described a continuous spiral line on the earth's surface. In passing over the 3½° adjacent to each tropic, the sun was vertical within that extent of latitude for sixty-three successive days. He was vertical for only one-sixth of that time over the same extent of latitude in any other part of his course. The result was, a band of deserts under each tropic around the earth, with exceptions which arise only from preponderating local causes. He was vertical for thirty-five days between the parallels of 10° and 20° in passing to the tropic, and after the interval of sixty-two days already mentioned, he again passed vertically over the same latitudes in thirty-four days. After leaving 10° on the passage towards the adjacent tropic, he did not return to it again until 130 days had transpired, within which period he had been twice vertical over the latitudes between 10° and 23°. But when he left 10° on his passage across the equator, to the more distant tropic, he did not return to the same latitude until 240 days had passed away. He did not return to either tropic until 365 days had elapsed. The excessive heat under the tropics arose from the long continuation of his vertical action, while he was over them. His absence from the equator never exceeded 185 days, and for that period only when he left it to go to Cancer and back. In passing to Capricorn and back, he occupied only 180 days. This difference was suggestive. Now for the result. The two extreme torrid regions under the tropics had been already noticed. The equatorial region is characterized by constant warmth and excessive humidity, producing exuberant vegetation and animal life in abundant varieties; the temperature being subject to very little variation. The regions between it and the torrid deserts, from which the vertical sun was absent for a lengthened period, present the most attractive inducements for the occupation of the human race. Lakes and rivers abound. The earth there yields abundantly, but the vegetation is free from the excessive development of the equatorial zone. The temperature varies between wide extremes.

On late Surveys in Arracan. By Capt. TICKELL.

On the Popular Notion of an open Polar Sea. Is it the Fact? By the Rev. W. SCORESBY, *D.D., F.R.S. &c.*

As far as historical records may guide us, the notion of an open sea at the Pole appears to have been the suggestion of Robert Thorne, of Bristol, about the year 1527, which led to the despatching of an expedition of two ships with the view of finding a passage northward to India. It resulted in the loss of one of the ships and the failure of the other.

After this, at least *eight* other attempts of a similar kind, taking the line of direction generally betwixt Spitzbergen and Greenland, were made; all of which, terminating with the expedition of Captain Buchan in 1818, signally failed.

The Hon. Daines Barrington, however, who held the opinion and urged the "probability of reaching the North Pole" by navigating the same route, brought forward an extraordinary collection of instances in support of his views, in which very high latitudes within the Polar Sea were asserted by different adventurers engaged in the whale-fishery, to have been reached. These records, supported by the opinion and arguments of the late Sir John Barrow in respect to an open sea around the Pole, and more recently by several of our arctic adventurers and writers on arctic research, have led, in connexion with certain theoretic considerations, to the conclusion, now popularly received as a fact, of "the open navigable Polar Sea."

This conclusion, however, as Dr. Scoresby believes, cannot be maintained on the principles and arguments by which it is assumed to be supported; on the contrary, he ventures to undertake to show, not only that these considerations are inconclusive, but that the facts or statements for the most part adduced are far more consistent with the more natural inference of the existence of perpetual ices around the Poles.

The most convenient and satisfactory course for him, Dr. Scoresby, to pursue, in the discussion of the subject of his present communication, might probably be to take up the several reasons for an open Polar Sea, as put forth in series by Mr. Petermann, in his pamphlet on the 'Search for Franklin,' who has compendiously combined the whole argument.

1. Amongst the reasons adduced in support of the popular theory, Dr. Scoresby

first noticed *the records of advances into extremely high latitudes collected by the Hon. Daines Barrington.*—If these records were facts, or if a small portion of them could be so established, of an open sea being found by many whalers up to latitudes 82° and 83°, and in certain specified cases, to 86°, 88°, 89° and 89½°, then might it be difficult to controvert the popular theory. But none of these records, Dr. Scoresby believed, had the authority of actual celestial observations registered in and derived from the journals of intelligent navigators kept at the time. On the contrary, they were mainly—the more remarkable asserted advances perhaps wholly—derived from hearsay testimony, or *recollections* of the adventurers after intervals of many years. As to the utter unsatisfactoriness, or delusiveness, of evidence of this kind, where a great or remarkable adventure was sought to be established, Dr. Scoresby gave some curious examples,—showing, on the one part, the almost inevitable tendency to assume an extreme conclusion; or, on the other part,—from the peculiar defectiveness in calling up, by special effort, long-faded memorial impressions,—the doubtfulness and the proneness to inaccuracy of such recollections. And in support of this tendency to error, instances were not wanting, in the records referred to, where the statements could be actually disproved,—as in regard to the asserted advance of a whaler, in 1773, to the latitude of 82°, the very year when the rigidly examined condition of the Greenland ices by Capt. Phipps demonstrated the impossibility of advancing beyond 80° 48′.

2. *As to mild weather being found at Cherie Island, and other places, far northward, contiguous to the open ocean, in winter.*—This fact, which is by no means a general one*, is distinctly due to the prevalence of southerly winds, or winds coming from the proximate open ocean, on the occasions referred to—an incident which had a striking parallel during the early part of a recent winter in our own island. An effect, then, derived from a source operating to the southward, can obviously yield no evidence of the condition of the climate near the Pole, any more than the fact of the water of a river flowing past us, which might happen to be warm, could justify the inference that the temperature of the sea into which it flows must also be warm!

3. *The finding of open sea on the northern coasts of Siberia and Nova Zembla, in winter.*—To the application of this fact by Mr. Petermann, in reference to his project of the practicability of a winter passage *eastward* along these shores, Dr. Scoresby was not called upon to remark, but only to object to any conclusion being drawn from such a fact,—on certain occasions experienced,—with respect to the condition of the Polar Sea far *northward.* The open water discovered, incidentally in winter, in these situations, was probably due to a previous prevalence of southerly gales setting the ice off the land. For as the polar ices afford, on their seaward margins especially, innumerable spaces amid the separate pieces, either open or occupied only by thin and easily crushable masses, there is always a yielding of the ice, in regions not confined by land, to the influence of whatever gales may blow heavily and continuously. For by reason of the hummocky character of a great proportion of the ices,—the hummocks having, in many cases, large surfaces, with an elevation often rising to 20, 30, or even 50 feet, and so acting as sails—the wind exerts a powerful influence in drifting the general body of ice away from land, or sections of lighter ice from heavier, whenever the wind blows in the proper direction. Under such an action of wind, and under like circumstances, he, Dr. Scoresby, had often witnessed the drifting away of great bodies of ice from land, or drift-ice from field-ice, with a result in opening out a *clear navigable sea* of the most surprising character. In some cases, a heavy field, previously pressed upon by a pack of drift-ice, has thus been cleared on its leeward side by a gale blowing off it, so as, in 24 to 48 hours, to leave a clear sea to leeward as far as the eye could discern from the mast-head.

Hence no conclusion in favour of the theory of a navigable Polar Sea can be maintained on the occurrence of open water to the utmost extent of vision on the face, whether northward or otherwise, of any particular coast. A southerly gale blowing hard off a Siberian or Nova Zemblan shore, might suffice, after two or three days' continuance, to clear away all ice not affixed to the shore, to the distance of very many leagues. For a pack of drift-ice, if of great extent, is always capable of compression under the force of heavy gales, even when containing no considerable

* See Account of Arctic Regions, vol. i. 335-8.

openings, by reason of the compacting of the innumerable pieces, and the squeezing up of the smaller masses upon the larger, or upon each other.

4. *As to the rise of temperature in northerly gales, in winter, observed by several of our arctic navigators in regions westward of Baffin's Bay.*—This very partial fact (partial as to the region where it has been experienced) has been applied as an argument in favour of the theory of an open Polar Sea,—as if indicating a sea to the northward of far greater warmth in winter than that of Regent's Inlet or Barrow's Strait. But, it will be obvious, on the principle of the rotatory character of storms—a fact now generally admitted—that the rise of temperature when the gale was from the north would prove nothing in favour of the theory of a mild climate about the Pole; for the rise of temperature would be explained on the obvious principle that that portion of the air had recently blown from the reverse direction, and probably had gained its warmth from the open ocean.

But a rise of temperature might perhaps be urged as a fact belonging to northerly winds generally, and not limited to the *case of storms.* If so, the argument, to be worth anything, in favour of a mild climate near the Pole, would require that the fact should be the same in all other meridians of similar latitudes. But the fact is not so. In the meridians of, and proximate to, Spitzbergen, where the sea is navigable farther north than elsewhere, the northerly winds are prevalently *colder* than the southerly. This fact, as to the months of April, May, and June, his (Dr. Scoresby's) published records of temperature, extending to some seventeen years, decidedly proved. The spring temperature, in the 80th and 81st parallels, he had invariably found was the *lowest in northerly gales.* Thus, in an extreme case, which is noted in his published journal of 1822, the temperature, April 29th, latitude 80° 30′, which, with a southerly gale, was at 32°, fell, on the gale shifting to the north, to $-2°$, a change of 34° in 16 hours! The foundation of the argument, therefore, for a mild climate near the Pole, is here completely removed. A *rise* of the winter and spring temperature, with north winds, at Melville Island, latitude 74°, cannot prove a mild climate near the Pole, when a *fall* of temperature in spring (the winter not being observed) near Spitzbergen, latitude 80° to $80\frac{1}{2}$°, occurs with the winds from the north*!

5. *As to the discovery of open and apparently interminable sea in Queen's Channel and Smith's Sound,* which have been assumed to be respectively entrances to an open Polar ocean.—This assumption, Dr. Scoresby was prepared to show, was altogether gratuitous. Capt. Penny, in the summer of 1851, saw open water to the extent of vision northward, from Baillie Hamilton Island. But such an opening-out of waters within straits, or channels, or sounds, was, in the arctic regions, the common result of summer warmth, under corresponding hydrographical and geographical configurations and conditions, and therefore proved nothing in respect to an open Polar ocean. He (Dr. Scoresby) could point to the opening-out in summer of the bays, sounds, and channels of Spitzbergen, Greenland, and the regions further west, as a very general fact, and the exhibition of what deceptively appeared to be immense seas of open water, as an usual occurrence, in certain positions of the Greenland Sea, much further north than the sea seen by Capt. Penny.

Nor does the open water seen by Capt. Inglefield northward of Smith's Sound afford any real ground for the asserted conclusion, that it was the entrance or commencement of an open Polar sea. The latitude here reached was 78° 28′, being but 45 to 50 miles further north than the marvellous attainment of Baffin in 1616. Beyond this, from N.E. to N.W., Captain Inglefield contemplated only an unencumbered sea. But what did the observed facts prove? From the mast-head of the Isabella, which could only command a view of the horizon of about 9 miles, or of ordinary floating ice, perhaps 10 or 11 miles, no ice was to be seen northward. Up to latitude 78° 38′ there was, therefore, a clear sea; but in 79° there *might* have been impenetrable ices. And this, it is almost certain, was the fact; for some of the men, as Capt. Inglefield tells us, saw an *ice-blink* to the northward, a sure indication of compact ice within 20 or 30 miles. No rational argument can be grounded on such a fact as this. An apparently open sea, with not a sign of ice northward,

* The observations of Capt. Maclure of the winter temperature at Banks' Land, in relation to the direction of the wind, have yielded a completely neutralizing result of the argument here discussed,—the greatest rise of temperature being found to be with *east* winds, not with north.

is prevalently found near Spitzbergen in spring and summer, in a much higher latitude,—in 79° or even beyond 80° N. This sea is often closed in, in the spring of the year, by a barrier of ice of 100 to 150 miles in width to the southward. On passing the barrier for the first time, and then sailing northward for two or three degrees of latitude without interruption, the navigator might naturally infer a continuance of the open sea, not improbably to the very Pole. But experience would soon teach him that the promising navigation was but limited; and certainly, before he reached the latitude of 81°, or thereabout, he would be stopped by impenetrable and apparently interminable ices.

The reasonable induction from what Capt. Inglefield witnessed was, that the apparently open sea north of Smith's Sound was but another expansion of Baffin's Bay after the manner of that succeeding to Davis's Strait, and that the open water was due to the same circumstance,—the proximity of land, as Capt. Inglefield actually observed, on both sides. Had the opening seen been the margin of an open Polar ocean, as it was assumed, the gale which drove the Isabella out of the Sound, southward, should have raised waves of 20 to 30 feet in height, of which, it is believed, there was no semblance.

6. *As to the profusion of animal life met with in Queen's Channel, and other open waters amid the arctic lands,* considered as a proof of a melioration of climate in proceeding northward.—This popular inference, it may be satisfactorily shown, is utterly inconclusive. For if the clear openings amid the northern ices just referred to are demonstrably referable to the proximity of land, then the apparent mildness of climate must naturally be explained, not by the assumption of an increase of warmth with an increase of latitude, but to the form and contiguity of land. If this were not so, then the profusion of animal life should increase, or at all events continue, in advancing in the highest attainable latitudes, whether land was there or not. But the fact is not so. When, in summer, the coasts of Greenland and Spitzbergen, for example, are swarming with aquatic birds and other creatures, let a ship proceed to the highest attainable latitude north-westward of Hackluyt's Headland, Spitzbergen, and ice will be found in the 80th or 81st parallel, with a *greatly diminished quantity of birds and other animals*; and let the navigator push his ship as far as possible into the northern ice, and he will soon, probably, find himself fast beset, and with few living creatures—possibly almost none—to cheer his solitude. This is a fact which, more than once, has been realized by personal experience,—a fact conclusive in the way of proof that the profusion of animal life met with in the adventures of our arctic voyagers, was not due to improvement of climate by reason of advance towards the Pole; for in the greatest advances northward which have ever been made far away from land, animal life becomes less and less profuse, until, in extreme cases, it almost disappears. So dependent, indeed, is the warmth of the arctic summer generally on the proximity of land, that when, in the bays of Spitzbergen, or the inlets, such as Scoresby's Sound, of Greenland, the weather may become absolutely *hot,* characterized by the appearance of living moths, and even mosquitoes, the temperature a few leagues out from the land will rarely be found higher than, perhaps, 45°.

The assumed increase of animal life northward, so strongly urged in a recent annual report of the Geographical Society, and otherwise, as a proof of a mild climate near the Pole, cannot be sustained, therefore, as a general fact. It is not the fact in regard to the highest latitudes that may be reached, nor is it the fact as to the region about Wellington Channel; for no instance appears ever to have been met with there, in the higher latitudes reached in that region, at all comparable to the wonderful extent of animal life which he (Dr. Scoresby) had shown in his publication on the 'Franklin Expedition,' pp. 68, 69, to have been met with in Regent's Inlet, three or four degrees further south. Hence this argument also necessarily falls with the failure of the assumed fact.

7. *As to the large quantity of the Greenland ices annually drifted away to the southward, and dissolved,*—a fact from which it is argued that an open sea should be left behind near the Pole.—But this inference depends on the assumptions, for which there is no foundation, of these being ices coming from the Pole, and that the ices annually produced around the Pole are cleared away year by year. On the contrary, the more probable inference is, that these ices are merely the excess of the winter production, by the severe frost of the north, carried off, under the wise and gracious œconomy ordained by the Creator, in order to prevent that vast accumulation of ices

around the Pole which otherwise might be thrust southward, in process of time, so as to render some of the loveliest regions of the earth uninhabitable, or unfit for the production of those vegetable fruits, or for yielding those admirable conditions of temperate climates, on which so much of human well-being and happiness depend.

The arguments for an open Polar sea thus far met, include, Dr. Scoresby believed, the chief of those popularly relied on, and it would be tedious to add more. But the positive reasons for a contrary conclusion might require, on such an occasion, some little consideration.

And first, he might notice the grand and unquestionable fact of the extremely low average temperature of the Polar regions as a powerful reason for assuming the existence of perpetual ices in the far north. The mean annual temperature of latitude 78°, near the western coast of Spitzbergen, has been shown, by personal researches, published in 1820 in the 'Account of the Arctic Regions,' to be as low as about 17°, or 11° below the freezing temperature of sea-water; whilst in the more enclosed regions westward, such as those of Melville Island, Regent's Inlet, &c., the existence of a mean annual temperature of about 30° below the freezing of sea-water has been determined. The normal temperature of the North Pole, too, estimated in the 'Account of the Arctic Regions' at 10°, and reduced still further by M. Dove to 2°·3, must naturally lead to the inference of an *accumulation* of ice, rather than a *lacking* of ice, in regions immediately surrounding the Pole.

But the theory, after all, of the *non-existence* of an open Polar sea, has the most decided confirmation in these unquestionable facts:—1st. That of the many expeditions expressly sent out with the view of reaching the Pole, or passing beyond it, not one of them ever attained by sailing as high a latitude as 81° N. 2nd. That all the experience of the Hull whalers, comprising within the last 80 years, as Mr. Munro has shown, 1949 ships (including repeated voyages), has yielded no fact to prove an advance within the 82nd parallel; and 3rd, that in a personal experience of 21 years, wherein the highest *attainable* latitude was proceeded to in seven to nine different voyages, no advance beyond the 81st parallel was ever made but once, when the extraordinary position of 81° 30′ was reached. And when Captain Parry reached some 70 to 80 miles beyond this, it will be remembered that from 81°·6, on his advance, the further distance was effected by ice-travelling. On the return of the party, indeed, they were able to take the water with their boats far northward of where they had left it, and gained open water in 81° 34′; but the fact could not fairly tell against the foregoing views, as no doubt this special penetrability of the ice was due to the proximity of islands on the north-east of Spitzbergen, whose apparent termination in the high latitude (80° 40′) to which they have been traced is by no means their certain limit.

Everywhere else, as already shown, an impenetrable barrier of ice has always opposed the advance of the navigator in the latitude of 80° to 81°—a barrier, as it appears in the early spring, so compact and continuous as to have led him, the author of this paper, to suggest, so long ago as the year 1815, the probability of access to the very Pole itself being had, by a transglacial journey. On the original suggestion of the scheme, favourably as it was received by scientific men in Scotland, it met with discouragement, and even contempt, from others in England. The attempt of Capt. Parry, however, in 1826, though necessarily failing because of the season of the year in which it was undertaken (the height of summer), proved how much the public opinion had changed on this subject; whilst a letter, long afterwards published by Sir John Barrow, went completely to show that the opinion was now held by the gallant officer himself, that a continuity of ice exists from the 81st parallel northward, and that the reaching of the Pole by ice-travelling, if commenced at the favourable season, was by no means an improbable nor very difficult undertaking. Such a project, indeed, it was evident, might be defeated, if the course were interrupted by mountainous land; but lofty ices, the accumulation of ages, might not improbably occur,—an idea which on the first suggestion of the scheme he had mentioned, which since then has had such singular support in the discovery of the vast cliffs of seaborne ices by Sir James Ross, in the antarctic regions of the globe*,

* Since the reading of this paper a letter has been published in the 'Athenæum' by a gentleman who had been surgeon in a Hull whaler in 1837, stating that the 'Truelove' had gone to about 82° 30′ North; but on inquiry being made at Hull of the owners of the ship and others, the statement was found *not* to be verified; the mate of the ship, the chief surviving officer, affirming that their highest latitude was below 81°.—W. S.

STATISTICS.

Some suggestions for an improved system of Currency and Banking. By Francis Bennoch.

Having explained the nature of money, and the kinds of money that are, or have been, in existence in England—viz. gold, silver, and copper coins,—bank notes exchangeable on demand with gold coins at a fixed rate of price in these notes,—and notes in which the gold coins were left free to find their market price,—he showed that gold coins were only legal tender so long as they were of proper weight, and that silver and copper coins could only be considered as tokens, because they were not intrinsically worth what they circulated for. He then argued that the pound sterling had perpetually varied in its metallic value. The gold pound in 1352 weighed 360 grains, in 1552 it weighed 174 grains, in 1650 it contained 140 grains, in 1750 129 grains, and in 1850 it was only 123 grains. So that the pound sterling in 1850 was only one-third the weight it was in 1352. As it had been found necessary to reduce the weight of the sovereign from time to time to bring it to bear a relative value with silver, so now the question would arise, when gold was becoming more abundant, whether we should increase the weight of the sovereign or decrease the weight of the silver. He contended that, inasmuch as our great national debt and every existing contract meant in reality so much weight of gold, it would be most unfair to the debtor classes to increase the weight of the sovereign. Every increase of an eighth to the weight of the sovereign would in reality increase the national debt by one hundred millions of pounds sterling. He next proceeded to show the advantages and disadvantages of our present system, and explained the third kind of money of which this country had some experience from 1797 to 1819. Instead of permitting the Bank of England to issue notes, he would have all issues of legal tender money under the control of Parliament, and that it should be limited to an amount equal to the annual taxation. Instead of the Government issuing, as now, Exchequer bills, on which were issued Bank of England notes, he would recommend the issue of Exchequer notes, which would circulate as money, and finally be received back into the Exchequer in payment of taxes. This money being for State purposes, there might also be a system of commercial money to work in harmony with it. All banks issuing paper should be obliged to place in the hands of the Government, securities which could not be touched so long as a single note was in circulation, and as each note would bear a uniform stamp, indicating its security, there would be abundant faith—runs upon banks would never be made, and panics could seldom, if ever, occur. The object in this discussion was not for the section to consider what money was, but what money ought to be. Should it be value in itself, or the representative of value? A metallic currency could never be depended upon for the due performance of its important functions; when most needed as money, it was liable to be exported as an article of commerce, or broken up for purposes of manufacture. Under a paper money system properly arranged, such as had been suggested, all sudden changes of value would be avoided, and panics unknown. The essence of money was that it should expand and contract, so as to meet every emergency without any violent action. National prosperity would be secured, because our money would have the security of the nation. Growing prosperity meant increase of trade. Increase of trade demanded extended circulation. Every advance in wages, or in the price of commodities, required more money to pay for the same quantity of labour or material than had been before necessary. The greater the amount of industrial operations, the larger the sum of money required to pay the wages. Under our present system, this necessarily withdrew bullion from the Bank; reduced the quantity of notes issued; created financial alarm; discounts were advanced in rate; manufacturers and merchants sold their goods at a reduced price to obtain the money needed; a diminution of production followed, and ultimately mills were closed and hands thrown out of work. So that out of the highest possible prosperity, our system of money managed to manufacture the direst adversity, and through panics to lead to pauperism. Mr. Bennoch concluded by declaring that a metallic currency was merely barter, and that a paper currency, based on national property, was the wisest that could be adopted, inasmuch as it constituted nineteen-twentieths of our present system; but that twentieth part had the power to disturb the whole.

Mr. Cheshire (one of the Secretaries) read a communication from Lady Bentham, widow of the late Brigadier-General Sir Samuel Bentham, on certain statements contained in a paper read before the Statistical Section at Belfast in September 1852, entitled 'Statistics of Portsea and Portsmouth Dockyard,' communicated by the Portsmouth and Portsea Philosophical Society, and published in the quarterly Journals of the Statistical Society in June and September of the present year, in which her Ladyship corrected some inaccuracies relating to the dockyard.

On the Results of the Census of Great Britain in 1851, *with a Description of the Machinery and Processes employed to obtain the Returns. By* EDWARD CHESHIRE, one of the Secretaries of the Section.

The author commenced by reciting the onerous duties of the Registrar-General. The objects of the census were explained, and the machinery employed to take it. Great Britain was apportioned into 38,740 enumeration districts, and to each of them a duly qualified enumerator was appointed. The author illustrated the extent of this army of enumerators, and the labour of engaging their services on the same day, by stating that it would take 10¾ hours to count them, at the rate of one a second, and that the army recently encamped at Chobham would not have sufficed to enumerate a *fourth* of the population of Great Britain. The boundaries of the enumeration districts, and the duties of the enumerators, were defined. The number of householders' schedules forwarded from the Census Office was 7,000,000, weighing 40 tons. The processes employed to enumerate persons sleeping in barns, tents, and the open air, and in vessels, were severally explained; also the means by which the numbers of British subjects in foreign States were obtained. The precautions taken to secure accurate returns were recited; they involved the final process of a minute examination and totaling, at the Census Office, of 20 millions of entries, contained on upwards of 1¼ million of pages of the enumerators' books. The latter were nearly 39,000 in number. The boundaries of the fourteen registration divisions were traced, and the plan of publication of the census was explained. The number of persons absent from Great Britain on the night of the 30th of March, 1851, was nearly 200,000 :—viz. army, navy, and merchant service, 162,490; and British subjects resident and travelling in foreign countries, 33,775. The various causes of displacements of the population were recited; and the general movement of the population on the occasion of the Great Exhibition was alluded to.* The number of *visits* to the Crystal Palace were 6,039,195,—and the number of *persons* who visited it was 2,000,000; nevertheless, the landing of only 65,233 aliens was reported in the year. The population of Great Britain in 1851 is subjoined :—

	Males.	Females.	Total.
England	8,281,734	8,640,154	16,921,888
Scotland	1,375,479	1,513,263	2,888,742
Wales	499,491	506,230	1,005,721
Islands	66,854	76,272	143,126
Army, Navy, and Merchant Service	162,490	....	162,490
Total	10,386,048	10,735,919	21,121,967

In illustration of this 21,000,000 of people allusion was made to the Great Exhibition. On one or two occasions, 100,000 persons visited the Crystal Palace in a single day, consequently 211 days of such a living stream would represent the number of the British population. Another way of realizing 21,000,000 of people was arrived at by considering their numbers in relation to space: allowing a square yard to each person, they would cover 7 *square miles*. The author supplied a further illustration by stating that if all the people of Great Britain had to pass through London in procession four abreast, and every facility was afforded for their free and uninterrupted passage for 12 hours daily, Sundays excepted, it would take nearly 3 *months* for the whole population of Great Britain to file through, at *quick* march,

* It is stated incidentally in the census, that in 1845 a million and a half of people on the Continent visited, in pilgrimage, the *Holy Coat* at Trèves.

four deep. The excess of females in Great Britain was 512,361, or as many as would have filled the Crystal Palace 5 times over. The proportion between the sexes was 100 males to 105 females,—a remarkable fact, when it was considered that the births during the last 13 years had given the reversed proportion of 105 *boys* to 100 *girls*. The annexed statement exhibits the population of Great Britain at each census from 1801 to 1851 inclusive :—

Years.	Males.	Females.	Total.
1801	5,368,703	5,548,730	10,917,433
1811	6,111,261	6,312,859	12,424,120
1821	7,096,053	7,306,590	14,402,643
1831	8,133,446	8,430,692	16,564,138
1841	9,232,418	9,581,368	18,813,786
1851	10,386,048	10,735,919	21,121,967

The increase of population, in the last half-century, was upwards of 10,000,000, and nearly equalled the increase in all preceding ages, notwithstanding that millions had emigrated in the interval. The increase still continued, but the *rate* of increase had declined, chiefly from accelerated emigration. At the rate of increase prevailing from 1801 to 1851, the population would double itself in 52½ years. The relation of population to mean lifetime and to interval between generations was then discussed. The effects of fertile marriages and of early marriages, respectively, were stated; also the result of a change in the social condition of unmarried women; likewise, the effect of migration and emigration, respectively, on population; the effect of an abundance of the necessaries of life was indicated, and, on the contrary, the result of famines, pestilences, and public calamities. The terms "family" and "occupier" were defined, and some remarks, by Dr. Carus, on English dwellings, were cited. The English (says the Doctor) divide their edifices *perpendicularly* in houses, while on the Continent and in many parts of Scotland the edifices are divided *horizontally* into floors. The definition of a "house," adopted for the purposes of the census, was "isolated dwellings, or dwellings separated by party walls." The following table gives the number of houses in Great Britain in 1851 :—

	Inhabited.	Uninhabited.	Building.
England......	3,076,620	144,499	25,192
Scotland......	370,308	12,146	2,420
Wales.........	201,419	8,995	1,379
Islands	21,845	1,095	203
Total...	3,670,192	166,735	29,194

About 4 per cent. of the houses in Great Britain were unoccupied in 1851, and to every 131 houses, inhabited or uninhabited, there was *one* in course of erection. In England and Wales the number of persons to a house was 5·5; in Scotland 7·8, or about the same as in London; in Edinburgh and Glasgow the numbers were respectively 20·6 and 27·5. Subjoined is a statement of the number of inhabited houses and families in Great Britain at each census, from 1801 to 1851,—also of persons to a house, excluding the islands in the British seas :—

Years.	Inhabited Houses.	Families.	Persons to a House.
1801	1,870,476	2,260,802	5·6
1811	2,101,597	2,544,215	5·7
1821	2,429,630	2,941,383	5·8
1831	2,850,937	3,414,175	5·7
1841	3,446,797	(No returns.)	5·4
1851	3,648,347	4,312,388	5·7

The number of inhabited houses had nearly doubled in the last half-century, and upwards of two million new families had been founded. 67,609 families, taken at hazard, were analysed into their constituent parts, and they gave some curious results. About 5 per cent. only of the families in Great Britain consisted of husband, wife, children, and servants, generally considered the requisites of domestic felicity; while 893 families had each *ten* children at home, 317 had each *eleven*, and 64 had each *twelve*. The number of each class of institution, and the number of persons inhabiting them, are annexed :—

Class of Institution.	Number of Institutions.	Number of Persons inhabiting them.		
		Males.	Females.	Total.
Barracks	174	44,833	9,100	53,933
Workhouses	746	65,786	65,796	131,582
Prisons	257	24,593	6,366	30,959
Lunatic Asylums	149	9,753	11,251	21,004
Hospitals	118	5,893	5,754	11,647
Asylums, &c.	573	27,183	19,548	46,731
Total...	2,017	178,041	117,815	295,856

Of these 295,856 persons, 260,340 were inmates, and 35,516 officers and servants. The excess of males in the prisons arose from the fact that crime was four times as prevalent among males as among females. The number of the houseless classes, *i. e.* of persons sleeping in barns, tents, and the open air, on the night of the census, was 18,249. The following table gives the number of these classes, together with those sleeping in barges and vessels :—

Persons sleeping in	Males.	Females.	Total.
Barges	10,395	2,529	12,924
Barns	7,251	2,721	9,972
Tents or open air	4,614	3,663	8,277
Vessels	48,895	2,853	51,748
Total...	71,155	11,766	82,921

It was mentioned as a curious trait of gipsy feeling, that a whole tribe struck their tents, and passed into another parish, in order to escape enumeration. The composition of a town was next described; also the laws operating upon the location of families. The number of cities and towns, of various magnitudes, in Great Britain was 815 :—viz. 580 in England and Wales, 225 in Scotland, and 10 in the Channel Islands. The town and country population was equally balanced,—10½ millions against 10⅓ millions. The density in the towns was 3,337 persons to the square mile; in the country, only 120. The average population of each town in England and Wales was 15,500; of each town in Scotland, 6,654. The average ground area of the English town was 4⅗ miles. The manner in which the ground area in Great Britain was occupied by the population was illustrated by a series of squares. The adventitious character of certain towns was alluded to; many had risen rapidly from villages to cities, and had almost acquired a metropolitan character. In 1851, Great Britain contained 70 towns of 20,000 inhabitants and upwards. There was an increasing tendency of the people to concentrate themselves in masses. London extended over an area of 78,029 acres, or 122 square miles, and the number of its inhabitants, rapidly increasing, was 2,362,236 on the day of the last census. The author illustrated this number by a curious calculation :—a conception of this vast mass of people might be formed by the fact, that if the metropolis was surrounded by a wall, having a north gate, a south gate, an east gate, and a west gate, and each of the four gates was of sufficient width to allow a column of persons to pass out freely *four* abreast, and a peremptory necessity required the immediate evacuation of the city, it could not be accomplished under *four-and-twenty* hours, by the expiration of which time the head of each of the four columns would have advanced a no less distance than *seventy-five miles* from their respective gates, all the people being in *close* file, *four* deep. In respect to the density or proximity of the population, a

French writer had suggested the term "specific population," after the analogy of "specific gravity," in lieu of the terms in common use, "thinly populated" and "populous." The statement annexed exhibits the area of Great Britain in acres and square miles, the square in miles, the number of acres to a person, of persons to a square mile, and the mean proximity of the population on the hypothesis of an equal distribution:—

	Area		Square (in miles).	Acres to a Person.	Persons to a square mile.	Proximity of Persons in yards.
	In Acres.	In Square Miles.				
England	32,590,429	50,922	226	1·9	322	104
Scotland.........	20,047,462	31,324	177	6·9	92	197
Wales............	4,734,486	7,398	86	4·7	135	162
Islands	252,000	394	20	1·8	363	99
Great Britain...	57,624,377	90,038	299	2·7	233	124

The 624 districts of England and Wales classed in an order of density, ranged from 18 persons to the square mile in Northumberland, to 185,751 in the East London district. In all London there were 19,375 persons to the square mile. In 1801, the people of England were on an average 153 yards asunder; in 1851, only 108 yards. The mean distance between their houses in 1801 was 362 yards; in 1851, only 252 yards. In London, the mean proximity, in 1801, was 21 yards; in 1851, only 14 yards. The number of islands in the British group was stated at 500, but inhabitants were only found on 175 on the day of the census. The early history of the more celebrated of the islands was given. The population of the chief of the group, Great Britain, had been given. Ireland contained 6,553,357 inhabitants; Anglesey, the next most populous island, had 57,318 inhabitants; Jersey, 57,020; the Isle of Man, 52,344; the Isle of Wight, 50,324; Guernsey, 29,757; eight islands ranged from 22,918 to 5,857; seventeen from 4,006 to 1,064; fifty-two from 947 to 105, and the remaining 92, downwards to an island inhabited by one solitary man. The shires, hundreds, and tythings were traced to Alfred the Great; the circuits to Henry the Second. The terms "hundreds" and "tythings" had their origin in a system of numeration. The number of reformed boroughs in England and Wales was 196, and contained a population of 4,345,269 inhabitants. Scotland contained 83 royal and municipal burghs, having a population of 752,777 inhabitants. The difficulty of tracing the boundaries of the *ecclesiastical* districts, and consequently of ascertaining correctly their population, was shown. The changes in the ancient boundaries of counties and other divisions were alluded to, and the paper concluded with a general summary of the results of the census. An appendix contained tables, showing the population and number of houses, distinguishing whether inhabited, uninhabited, or building, in England, Scotland, Wales, and the Islands respectively, at each census from 1801 to 1851; the same, in 1851, for each of the 14 registration divisions; for each of the 36 districts of London; and for each county in England and Wales, and in Scotland; also the population of each county in England and Wales, and in Scotland, at each census from 1801 to 1851, and the increase of population in the last half-century; the area in acres and square miles, the number of persons to a square mile, of acres to a person, of inhabited houses to a square mile, and of persons to a house, for each county in England and Wales, and in Scotland; the population and number of inhabited houses in the counties, and parliamentary divisions of counties, in England and Wales, and in the counties of Scotland, including and excluding represented cities and boroughs or burghs, also the number of members returned; the population of each island containing above 100 persons; the population and number of inhabited houses in *each* of the 815 cities, boroughs, and principal towns in England and Wales and in Scotland, distinguishing the municipal and parliamentary limits; the number of each class of public institutions in England and Wales, Scotland and the Islands, and the number of persons inhabiting them; the number of births and deaths, and the excess of births over deaths, in England and Wales, for each of the ten years of 1841–50;

and, finally, the number of persons who had emigrated from Great Britain and Ireland in each year from 1843 to 1852 inclusive, and the destination of the emigrants.

Statistics relative to Nova Scotia in 1851. *By* Edward Cheshire.

The author commenced by a short sketch of the history of Nova Scotia; he defined the boundaries of the province, and described the geographical features of the country and its climate. The census of 1851 gave a population of 276,117, and exhibited a remarkable equality between the sexes, viz. 137,677 males to 138,440 females. A statement of the social condition of the people showed an excess of 3678 widows over widowers, or 160 per cent.—a result arising, probably, from the risks incurred by the men (10,000 in number) engaged in the fisheries. The bachelors exceeded the spinsters by 2367, or 4 per cent. The spiritual wants of the people were well provided for, there being one clergyman to every 1000 of the population, but a lawyer and a doctor to every 2000 only. The number of afflicted persons in the colony was as follows:—Blind, 136; deaf and dumb, 230; idiots, 299; lunatics, 166; total 831. Deafness and dumbness were 35 per cent. more prevalent among men than among women, and idiotcy 43 per cent. The number of Indians and coloured persons in the colony was 5964. As regards land, 5,000,000 acres were available for tillage, of which only 1 in 26 was under cultivation. The following statistics relating to the fisheries possess interest at the present time:—Number of vessels employed, 812; their tonnage, 43,333. Number of boats, 5161; men, 10,394; annual value of smoked herrings, 217,270*l.*; number of nets and seines, 30,154; annual value of fish oil, 17,754*l.*; quantity of salmon, 1669; shad, 3536; mackerel, 100,047; herrings, 53,200; alewives, 5344 (the five latter are in barrels). Mining was an important branch of employment. Manufactures and shipping were respectively passed in review; and the author concluded with a sketch of the constitution of the province, and a statement of the various religious denominations: the latter showed that one-eighth of the inhabitants were of the Established Church, and that one-fourth were Roman Catholics.

Summary of the Census of Switzerland. By Prof. Paul Chaix.

On the Mortality of Hull in the Autumn of 1849. *By* Henry Cooper, *M.D. Lond.*

This paper was prepared from the official documents of the late Mr. Thorney (to whose memory the reader paid a tribute of thanks and deep regret), and of Mr. Chatham. Tables were shown to exhibit, first, the total number of cholera and diarrhœa cases—the former, viz. 1860, or 1 in 43 of the whole population; the latter 256, or 1 in 355. The number of cases occurring in males was 885; in females, 975. Yet allowing for the difference of number between the excess in the whole population, the female mortality was the greatest, one male having died to 1·1 female; while, in the whole population, there is one male living to 1·14 female. The diarrhœa return showed no difference in the number of the sexes. The cases were next analysed as regards age, and it was shown that in cholera the infant mortality, though very high, was not higher than that which occurs from ordinary causes of death at the same age. The greatest mortality, compared with the annual average, appears to have occurred in the prime of life (from 30 to 35), where the ordinary mortality is very low. There is also an excessive mortality about 60; while the greatest immunity seems to be enjoyed from 15 to 25, and from 40 to 60. In diarrhœa the important feature is the great excess of infant and old age mortality. The localities in which there had been the greatest mortality were indicated by marking each death upon a map in the place in which it occurred. The map was tinted in shades, showing by deeper shades the parts of the borough where the levels were the lowest, and in which, therefore, the hygienic condition, as regards moisture and drainage, might be presumed to be the most defective. Three principles were found to govern and determine the position of the greatest mortality—the level, the density of the population, and their physical and social character. These points were illustrated by specifying certain localities, in which the number of markings showed the disease to have been rife. The last analysis shown was that of occupation, which showed several curious results. The general inference from this analysis was that 1738 of the labouring classes, and 122 of the gentry, traders, and well-to-do classes had suffered; and, assuming the former class to amount to 67,000, and the latter to 13,000, it follows that 1 in 40 of the labouring class, and 1 in 131 of the well-to-do class were victims.

On the Prevalence of Diseases in Hull.
By Henry Cooper, *M.D. Lond.*

A few remarks were premised on the state of mortality in Hull, which has never been stated officially for the whole borough, as the parts for which it has been given have been separated in the returns, so as to give results likely to lead to false impressions. Hull, including the Humber, St. Mary's, and Myton registration districts, is given in one return; Sculcoates, including the two Sculcoates, in another; the whole parish of Sutton, of which only part is in the borough, in a third, and Drypool and Southcoates in separate returns. But the term "Hull" is popularly applied in an extended sense to the whole borough; so that the rate of mortality of the *part* so named in the returns, and which, on several accounts, yields more than its average of deaths, is erroneously attributed to the *whole*. The rate given for Hull is 1 death in 29; for Sculcoates, 1 in 42; when the borough in its entirety is taken, the rate is 1 in 33; and there is reason to believe that in the present season it is considerably below this. Tables were then shown to exhibit the relative prevalence of eight of the most common diseases not necessarily fatal, viz. fever, rheumatism, pulmonary diseases, dyspepsia, neurosis, cachexiæ, uterine diseases, and diarrhœa. These tables were founded on a calculation of 21,712 cases of these diseases presenting themselves at the medical charities of the town during a period of ten years; and the proportion per cent. of each disease to the whole number observed, noted under each head. A great prevalence of chest affection, of dyspepsia and rheumatism is found to exist, and fever is a comparatively rare disease. A second table shows, by curves, the prevalence of the four more important of these diseases, viz. pulmonary diseases, dyspepsia, rheumatism, and fever, and the effect of the seasons of the last ten years upon their intensity. Pulmonary diseases, commencing high, rise to their culminating point in May, then fall to their minimum in August, and again rise to the average winter level. Dyspepsia, coinciding with pulmonary diseases, in its time of attaining its height, rises to a much higher point, and falls rapidly through the autumn. Rheumatism has its maximum in winter, with an exacerbation in August and November;—fever is singularly equable and remarkably low for a large town, not favourably situated nor well-drained; its maximum is also in May or April. Zymotic diseases were excluded from the calculation, as the cases are not received into the hospital, and not treated in the dispensaries in such proportion as to give anything like an adequate idea of their prevalence. The results tallied very accurately with the practical experience of medical men, which thus acquired confirmation and exactness from the application of the numerical method.

On the Education of the Poor in Liverpool.
By the Rev. A. Hume, *D.C.L, L.L.D., F.S.A.*

I. *Population of the Borough.*—The borough consists of five great portions, the parish or ancient parliamentary borough, and four adjacent townships or portions of townships. From a moderate estimate of the addition to the population since the last census, the present population of the borough and of each of its constituent parts is reached. The result is shown in the following table:—

	Increase from 1841 to 1851.	Population in 1851.	Probable increase since.	Estimated present population.
Parish of Liverpool.	35,343	258,346	8,836	267,182
Toxteth-park........	19,708	59,941	4,927	64,868
Edge-hill	12,242	22,002	3,061	25,063
Everton	16,662	25,833	4,165	29,998
Kirkdale	5,625	9,893	1,406	11,299
	89,580	376,015	22,395	398,410

Again, the town is situated on the side of a hill rising from the river side; the inhabitants of the lowest portion consist mainly of the poorest or utterly destitute classes, those of the middle portion of the middle or less affluent classes, and those of the townships of persons who are wealthy, or at least in comfortable circumstances. The first and most necessitous of these sets may be estimated at 180,000; hence there are about 87,000 in the second, and 132,000 in the third.

II. *Educational Demand.*—It is estimated from careful inquiry that *two-thirds* of these, though not all belonging to the class "poor," take advantage of the education which is provided for the poor, or which is not self-supporting. Hence, the children in a mixed population of about 266,666 require to be provided for. The writer has also found from a statistical inquiry on the spot, that in a mixed population, exactly 25 per cent. are of the ages most likely to attend school, viz. from 3½ to 12. Thus the educational demand is fixed at 66,666.

III. *Educational Supply.*—This was examined under the four heads of (1) Church Schools, (2) Protestant Dissenters' Schools, (3) Roman Catholic Schools, (4) General Schools, or those unconnected with any religious denomination. By all sections of the community the details had been furnished with great readiness.

The Church Schools consist of two kinds, those that are *practically* so, *e. g.* connected with public institutions, and those which are *formally* so, *e. g.* connected with district churches and their congregations. The following table shows the special efforts of the church in the education of the poor :—

	No. of districts.	Population.	Existing Schools.			Schools required.		
			Districts.	Accommodation.	Population.	Districts.	Temporary schools.	Population.
Liverpool parish..	31	267,182	20	10,010	182,882	11	4	84,300
Toxteth-park	6	64,868	6	2,660	64,868	...	...	...
Edge-hill	3	25,063	2	1,350	19,063	1	1	6,000
Everton	5	29,998	4	2,220	19,998	1	...	10,000
Kirkdale............	1	11,299	1	150	11,299	...	...	...
	46	398,410	33	16,390	298,110	13	5	100,300

The rate of progress in the founding of these may be seen from an examination of only ten years. It is one school and a half annually.

In 1843, there were .... 23 district schools.
,, 1846 ,, ,, ... 27 ,, ,,
,, 1853 ,, ,, ... 38 ,, ,,

The accommodation and attendance at the schools of Protestant dissenters was derived from a statistical return made in the beginning of the year. Including Jews and Latter Day Saints, indeed all who are not either Churchmen or Roman Catholics, the attendance is 3895, and the accommodation 4869.

The following table shows the same facts respecting the schools of the Roman Catholics, and at the same time exhibits the rate of their increase. Of the three which are given separately two were to be opened in 1853, superseding a part of the existing accommodation, and the last is yet in progress :—

		Present Accommodation.	Attendance.
1816 ...	Copperas-hill (500 original accommodation)	880	880
1828 ...	St. Patrick's, Park	1200	1200
1830 ...	Seel-street	750	620
1833 ...	St. Antony's	625	500
1846 ...	St. Vincent de Paul	500	500
1846 ...	St. Joseph's	375	300
1847 ...	St. Mary's, Ray-street	625	500
1849 ...	Holy Cross	650	700

1850	... Sisters of Mercy, Mount Vernon	500	....	400
1850	... Spitalfields	238	....	190
1852	... Eldon-street	312	....	250
1852	... St. Anne's, Edge-hill	800	....	400
1853	... Edgar-street ... (1200—300)=900			
1853	... Fontenoy-street (1450—700)=750			
1853	... St. Francis', Everton =820			
		2470		
1850	... Blackstock-street	738	....	590

The schools under general management afford accommodation for 4451.

We can now obtain a connected view of the entire provision that has been made for the education of the poor in the town. It is the following:—

1. Church Schools—Districts	permanent	16,390	
,, ,, ,,	temporary	1,021	
,, ,, ,,	Not in District Schools	3,075	
			20,486
2. Protestant Dissenters' Schools			4,869
3. Roman Catholic Schools			8,193
4. General Schools			4,451
	Total accommodation...		37,999

We can also compare the supply with the demand, in the form of an ordinary account:—

Total school accommodation *required,* per previous calculation		66,666
Ditto ditto *provided* from all sources, per actual enumeration	37,999	
Balance still required to meet the deficiency	28,667	
		66,666

The general result is, that the entire community have yet discharged little more than *half* their duty on this subject, the existing accommodation amounting to only 57 per cent.

IV. *Distribution of Educational Facilities.*—The facts connected with this part of the subject cannot but leave a painful impression on the mind; for it is found that *the local accommodation in schools is in inverse ratio to the necessities of the town.*

The following facts refer to Church Schools. (1) Of fifteen ecclesiastical districts in the townships, thirteen have permanent schools; of sixteen districts wholly or partially in the middle portion of the town, twelve have permanent schools; of fifteen districts in the lowest part, embracing nearly the whole of the perishing poor, only eight have permanent schools. (2) Of six districts in the lowest portion of the town, forming a continuous belt from north to south of nearly two miles and a quarter, *not one has a permanent set of schools connected with it.* These contain almost all the merchants' offices in the town, and some of the principal shops; the Town-hall, Custom-house, Exchange, Post-office, railway station, and eleven or twelve of the docks. It is a fact worth knowing that four of these districts are connected with churches built by the corporation. (3) If the Exchange flags be taken as a centre, and a semi-circle be described with a radius of 800 yards, it will contain five districts wholly and seven partially, and will comprise a population of 70,000. Of these, four have no schools whatever; two have only temporary ones, and exactly the half are permanently provided for. (4) A stranger entering the port, can walk from the landing-stage on the river right up through the heart of the town, to Everton and Edge-hill, without passing through a single district that contains a permanent set of schools!

The schools of Protestant Dissenters are in general very ill-placed; for the schools follow the chapels, and these are removed from time to time, following the more respectable portion of the population. Hence, of the 4869 for whom they provide accommodation, only 350 are provided for in the lower part of the parish or among the perishing masses of the population!

In general, the Roman Catholic schools are very well placed; and the same may be said of those that are of a general character.

The distribution of school accommodation is exhibited in the following table:—

	Townships.	Parish. Upper Part.	Parish. Lower Part.	Total.
Church schools	6,380	4,700	5,310	16,390
Dissenters' schools	1,981	2,538	350	4,869
Roman Catholic schools	2,500	2,080	3,613	8,193
General schools	1,131	850	2,570	4,451
	11,992	10,168	11,843	33,903
Population (general)	131,228	87,182	180,000	398,410
Estimated number of poor	52,075	44,591	170,000	266,666
Ratio of education among the poor	1 in $4\frac{1}{3}$	1 in $4\frac{1}{2}$	1 in 14	1 in 8

Thus, if each of the three great divisions of the town be regarded as a separate unit, the school accommodation in the townships and in the upper part of the parish is almost sufficient; while that in the lower part of the parish is between a third and a fourth of what it ought to be. The better parts of the town, some sections of which do not possess a single poor family of the most destitute class, have educational facilities almost thrust upon the people, until the noble feeling of self-dependence is endangered, if not gradually broken down. On the contrary, in that part of the town where the "people are destroyed for lack of knowledge," though its necessities amount to *two-thirds* of the whole, the various religious communities have provided for it only *seven, thirty-two, and forty-four per cent. of the whole*!

In one of the more respectable portions of the Borough, the township of Everton, there are public institutions capable of accommodating nearly 2000 pupils, independent of about thirty private schools. All these are self-supporting. For the poor there is school accommodation to the extent of 3,350; while an increase is in progress, amounting to 1,270. Now, a school accommodation for 4,620 of this class, represents a mixed poor population of 18,480, and a general population in this township of nearly 37,000. It is probable that Everton will not contain this number till about the period of the next census; so that *while the really poor are perishing in ignorance, one of the best parts of the town is over-schooled.* Three sets of schools in it, built by Protestant Dissenters, Churchmen, and Roman Catholics respectively, have cost about £10,000, and afford accommodation for 2,600 pupils; but they lie in a straight line, the entire length of which is 230 yards!

V. *Remedies Suggested.*—These followed naturally from the previous statement of facts. They were, (1) that the Church should establish a set of schools in every ecclesiastical district of the town which is not so provided for; (2) that Protestant Dissenters should combine to establish schools in the most neglected parts of the town, which might be *denominational* but not *congregational*; and (3) that the Roman Catholic schools, and especially those under general management, should be increased in number. Efforts of this kind, if well-sustained, would bring up the supply nearly to an equality with the demand.

VI. *Support.*—The irregular distribution of funds in school buildings is more than equalled in this matter; for as a general fact the merchants do not subscribe to educate those near their *offices*, but those near their residences. Hence while the necessities of district A are ten times those of district B, the school subscriptions for B are obtained ten, twenty, or thirty times as readily as those for A. In other words, if the two districts are to be brought to the same educational level, the labour in the one case is 200, 300, or 400 times as great as in the other:—that is to say, while something or even much may be done, educational equality is a practical impossibility. This arises from treating parts of a great town, which only serve partial purposes, as if they were complete wholes.

While the voluntary system in education affords a very unequal relief, it imposes a most unequal burden. As the facts now stand, the intelligent and benevolent man is heavily taxed for the possession of virtues that are somewhat rare, while the ignorant and selfish man, who has perhaps added rudeness to his negative in the case of some strong appeal, is rewarded for the coarseness of his moral sense by a perpetual exemption from claims. It has been estimated that so many as 15,000 persons ought to subscribe in Liverpool for the promotion of education, and that not more than 2500 actually do so. In eighteen Church District Schools there are 8180 children educated, and the entire subscribers are only 810. Probably not more than 1200 churchmen in all subscribe to any school whatever. For the education of 7000 Roman Catholic children, there are *not fifty* principal subscribers; the remaining expenses are met by the children's pence, congregational collections, and very small contributions. The writer of the paper, therefore, is anxious to see the system of *Local Rates* introduced, the working of which may be inferred from the following analysis of persons rated to the relief of the poor in the borough:—

	Rated under £8.	£8 and under £12.	£12 and under £20.	£20 and upwards.	Total.
Parish of Liverpool..	8,323	12,679	9,408	12,270	42,680
Toxteth-park	4,999	2,904	2,540	1,206	11,649
Edge-hill	993	1,486	1,153	977	4,609
Everton	1,093	1,140	1,367	1,180	4,780
Kirkdale.............	307	596	520	301	1,724
	15,715	18,805	14,988	15,934	65,442

A brief comparison of Liverpool with New York showed that the educational facts are much more satisfactory in the latter; and it appeared that, in Massachussetts, 90 per cent. of all those who ought to be at school attended in the summer, and 75 per cent. in the winter.

Electoral Statistics of the British Empire. By JAMES EDWARDS.

Ireland's Recovery; or, Excessive Emigration, and its Reparative Agencies. By JOHN LOCKE.

The panic caused by the potato-blight and famine of 1846 gave the first impulse to the exodus. Within six years, ending 31st Dec. 1852, 1,313,226 persons have emigrated from Ireland. 1851 was the culminating year of the exodus, which, since that period, has been decreasing in geometrical ratio; although the remittances from emigrants have increased from £990,000 in 1851 to £1,404,000 in 1852.

The three principal reparative agencies:—1. Decrease of pauperism concurrent with general diffusion of employment. 2. Establishment of civil and social order, evidenced by decrease of crime. 3. Increasing solvency of the landed proprietary, concurrent with improvement of agriculture.

1st. Total Poor-law expenditure of 1852 one-fourth less than that of 1851. Successful results of the workhouse industrial system, and general improvement of the labour market.

2nd. Decrease of crime, $28\frac{1}{2}$ per cent. in 1852 less than in 1851. Exemplified in the moral improvement of the peasantry of Tipperary and Limerick. Economic results anticipated.

3rd. Ruined condition of the landed interest previously to the famine. Beneficial effects of the Incumbered Estates' Commission, by establishing a middle class, by encouraging investment of British capital, and immigration of British farmers into the south and west of Ireland. Improvement of agriculture, and increasing number and solvency of the landed proprietary. Conclusion. Providential design of emigration.

On Progressive, Practical, and Scientific Education. By the Rev. F. O. MORRIS, *B.A.*

The author commenced by mentioning various proofs which had come under his own observation of the instability and insufficiency which at present characterized

Mechanics' Institutions, almost the only existing means for the education of the adult population. He corroborated his statements by reference to similar remarks made in the report of the Yorkshire Union of Mechanics' Institutions, by the Mayor of Chester and the Rev. H. Gunn at the recent conversazione of the Lord Mayor of London. He then noticed that a beginning had been made for such an advance as he advocated, by the Act just passed for extending the operation of the Public Libraries Act of 1850 to Ireland and Scotland, so that town councils and boroughs, the population of which exceeded 10,000, can now adopt proceedings to establish public libraries and museums throughout the United Kingdom. He also remarked upon the aid at present afforded to national and other schools as a step in the true direction, and argued that government aid, instead of giving any establishments an eleemosynary character, gave them a status and a position rather likely to be overrated than otherwise.

He went on to point out some of the ways in which it seemed to him that government assistance might possibly be furnished, not only to a general museum of art in the metropolis, but to all country towns, in proportion to their own contributions either by subscriptions or a rate, as afforded at present to schools for the young; first premising that he thought it a thing of far more importance than it might at first sight appear, to devise some good name by which such establishments should be called. It is obvious that the name of Mechanics' Institutions is no longer applicable to those associations, which nevertheless continue to bear it—actual mechanics form but a minority of their members. Possibly part of their failure may have been caused by this "defect of title,"—the name "National Colleges" might perhaps be suggested as the natural sequence of the "National Schools."

Acting, then, on the principle already adopted in regard to grants to schools in proportion to local funds raised, he would have in London a general British Museum of all works of art as well as the one that already exists for the works of nature—one whose library, specimens, casts, patterns, models, plans of houses, apparatus, maps, illustrations, and examples of all hints for improvements should be easily accessible to the community at large, on conditions similar to those already adopted by the sister institution for admission and inspection—it should be a source of example, advice, instruction and communication. All this of course implied a larger annual educational grant, and a tenfold amount to that at present voted would in all probability by the elevation of the people tend to their comfort and well-being in various ways, and so to their being more universally beneficial to and not a burden upon the state. He would then desire to see throughout the country buildings of respectable or where possible of handsome appearance, and at the same time adapted internally to the convenience and comfort of those resorting to them. These buildings should, if carried out to a complete extent, contain a museum, library, reading-room, lecture-room, room for philosophical experiments, and various other adjuncts carefully enumerated; a taste for scientific pursuits would be fostered by the sight of specimens of natural or artificial objects; the first sight of a butterfly or a bird might excite the dormant spirit of a Le Vaillant or Audubon, or the model of an engine some otherwise "inglorious" Fulton or Watt. Lecturers should be appointed and partly paid by government, and a certificate of attendance on a three years' course of lectures, and of adequate proficiency at the close of each year after due examination, might be a ground for a diploma for a license to lecture.

The true and legitimate result of thus raising the mental culture of the people at large is to elevate and refine the mind, and make it more susceptible of high and holy impressions. The discoveries of Herschel do not lead men to disbelieve in God, nor do the compositions of Handel act as a hindrance to the singing of His praise in worship.

Mr. Morris further advocated a large provision for the healthy and rational amusement of the people in connexion with the foundations he had been speaking of, and after complaining of the low state of the taste of the people at large, showed that it must be raised by general and not by individual means. A little knowledge is then only a dangerous thing, if it be rested in as the end instead of being used as the means to further improvement.

Statistics relative to the Northern Whale Fisheries from 1772 *to* 1852. *By* HENRY MUNROE, *M.D., M.R.C.S., L.S.A. &c.*

The first attempt by the English to capture the whale was in 1594. The Hull merchants fitted out ships for the whale fishery as early as 1598, and at a very early period discovered Jan Mayen or Trinity Island. The British legislature, to encourage the prosecution of the whale fisheries, enacted in 1749 that the original bounty of 20*s*. per ton should be increased to 40*s*. per ton. In the year 1785, £94,558 were paid in bounties. From 1796 to 1821, a period of 25 years, the number of vessels sent out increased to 64, the largest number ever sent. From 1821 to 1833 the number of vessels sent out began to decline, owing probably to the year 1821 being a disastrous one, 10 vessels having been lost. The year 1833 is the most prosperous recorded, 27 ships bringing home the great amount of 5024 tons of oil, being on the average of 186 tons per ship, whilst the average return per ship for the last 80 years was only 88 tons. During the last 80 years 194 ships have been fitted out for the fisheries. Out of this number 80 have been lost, and six more taken in war-time. Some of the ships have been as often as 58 voyages to the fisheries. For 10 years between 2000 and 3000 sailors were annually sent in the whaling ships; for 40 years above 1000 were sent at the average of 44 men per ship. During the period of 80 years the Hull whaling ships have taken 85,644 men; on an average of 1070 per year. During the period of 80 years the returns of oil per year have varied from 5 tons to 7976 tons of oil. The largest cargo of oil brought home was 285 tons. During the last 80 years the gross amount of oil brought home was 171,907 tons. The highest price obtained for oil was in 1813, when it was sold as high as £55 per ton, and the lowest about 1805, when it was sold for £20 per ton, being on the average of £30 per ton for the last 80 years. The greatest amount of money realized in one year by oil and bone was £318,880. For 12 years the amount returned was above £200,000 per year, and for 16 years above £100,000. The gross value of oil and bone brought home from the whale fisheries for the last 80 years amounts to £6,847,580, being on the average of £85,594 per year. The average success of each ship for the last 80 years was £3,513 per annum.

An Analytical View of Railway Accidents in this country and on the Continent of Europe in the twelve years from 1840 *to* 1852. *By* F. G. P. NEISON.

The paper was illustrated by a series of elaborate tables, showing the average fare per mile for each class, the number of passengers who have travelled by each class, the moneys received from passengers by each class, the total mileage of each, the average distance travelled by passengers in each class, the average distance travelled by all classes of passengers, and the total number of miles travelled by all the passengers collectively in each year. For first-class passengers the *minimum* scale of fares was charged in the year 1846, but for the second and third class passengers the *minimum* charges were made in the year 1847. Under these dates the scale of charges gradually and pretty uniformly decreased, but since then they have fluctuated at a somewhat higher price, and are recently showing a tendency to increase. The average distance travelled by the passengers was shown by the tables to be yearly becoming less and less. This is particularly observable in the second, third, and parliamentary classes since the year 1844. In the period of 1844–47 the distance travelled by all classes was 17·7; in 1848–51 it was 16·3; and in 1852 it had diminished to 15·8 miles. A most important feature shows itself in connexion with the operation of cheap fares, not only on the average distance travelled by each passenger, but also on the number of passengers. In the parliamentary class the average distance exceeds that for either the third or second classes, and the number of such passengers since 1847 (the period within which the parliamentary trains may be said to be in regular operation) exceeds that of all the other classes with the exception of the second class, and in the year 1852 very nearly equalled the number of the second class; while in the last year the mileage of the parliamentary class actually exceeded that of the second class by 13,500,000 miles. In the period of 1840–51 the number of railway passengers was 478,488,607, of whom 237 were killed and 1,416 injured, showing a ratio of 1 killed in 2,018,939, and one injured in 337,916. Of engine-drivers, stokers, and guards, the number killed was 275, and the injured 274, out of 40,486, showing a ratio of 1 killed in 177, and 1 injured in 148. Number of porters and other servants, 359,683, of whom 683 were killed and 343 injured; the ratio being 1 killed in 527, and 1 injured in 1058. During the years 1844–51, 7,044,469,484 miles have been travelled by passengers, and 176 deaths have happened through accidents from all causes. Hence one passenger has been killed for every 40,025,395 miles travelled. Supposing a person to be always in motion on a railway, and travelling at an average speed of 20 miles per hour, including stoppages, he would travel 175,200 miles yearly, and he must constantly travel 228 years to be killed by accidents from all causes. The period for which he must constantly travel to be killed by accidents from all causes under the control or the companies is 490 years; and he must be constantly travelling 426 years to be killed by accidents from causes beyond the control of the companies; but if the person is supposed to travel 12 hours only per diem for each of the 365 days in the year, then in 456 years he will be killed by accidents from all causes; in 980 years he will be killed by accidents from causes under the control of the companies; and in 852 years he will be killed by accidents from causes beyond the control of the companies. Of the 237 passengers killed in the period 1840–51, 103 were killed by causes beyond, and 134 by causes under, the control of the companies. Of the 1416 persons injured, 188 were injured by causes beyond, and 1228 from causes under, the control of the companies. It was a popular error to suppose that third-class passengers were the principal sufferers from railway accidents, the fact being that the greatest proportion of accidents took place among the first-class passengers. Taking the number of persons travelling, the number of miles opened, and judging of the fact by every test, it appeared from the tables that there was a gradual diminution in the loss of life on railways; and, without any wish to defend the management of railway directors, Mr. Neison considered it satisfactorily proved that there was a great improvement in the railway system. As an instance of the rashness of passengers, he stated that three persons had been killed, and seven injured, by leaping from the train while in motion, for their hats. The tables show that the deaths from collisions and from trains running off the line, which have constituted a large portion of the whole, have been diminishing, while deaths from passengers falling from the trains had scarcely varied. The death from axles breaking in the four years 1840–43 formed 8 per cent. of the whole; but since 1844 not a single death has happened from this cause; and in regard to death from the breaking of other parts of the machinery none have taken place since 1847. The deaths occasioned by passengers jumping from trains while in motion have much increased since 1840, as well as the deaths from passengers mounting trains while in motion. The deaths from causes beyond the control of the companies form 54·8 per cent. of the number of injuries; but the deaths from causes which are under their control form 10·9 per cent., so that the tendency of accidents which may be considered to arise from details of management is to inflict bodily injury rather than occasion death; for out of every 100 injuries about 11 deaths happen, while among the accidents due to causes within the influence of the passengers themselves, for every 100 injuries 55 deaths take place. In the period 1840–43 the deaths from causes under the control of the companies was 62·50 per cent. of all the deaths; in 1844–47 they were 51·56 per cent.; and in 1848–51 only 43·16 per cent., so that it was evident that the class of accidents under the control of the several companies was decreasing in relation to the total accidents in a most satisfactory and very rapid manner. Referring to the German railways, Mr. Neison gave the following results for the years 1848, 1849 and 1850:—length of railways open, 8480 miles (English); number of passengers, 51,713,297; number of miles travelled, 1,155,436,890. During this period only one passenger was killed, and 14 injured; 53 railway *employés* were killed, and 88 injured.

On new Supplies of Gold. *By* WILLIAM NEWMARCH.

The quantity of new gold produced in California and Australia to the end of 1852 is equal to at least 10 per cent. of the total quantity of gold existing in Europe and America in the early part of 1848, or immediately previous to the first appearance of the Californian supplies. We have seen also that the annual production of gold from all sources,—which in 1848 was equal to 2 per cent. on the total quantity of gold then existing in Europe and America,—had risen in 1852 to 7 per cent. on that quantity.

So far the whole, or nearly the whole, of the new supplies of gold have been absorbed as coinage in America, in this country and Australia, and in France. And not only has there been a large increase of the gold coinage in these countries, but the amount of the convertible paper circulation—probably in each of them, certainly in three, viz. England, France and Australia—has been considerably increased within the last twelve months; and it appears that the increase in the circulation of coin and paper has arisen almost wholly from a prior increase in transactions. It is a question, however, for investigation, whether the absorption of the new gold as coin can proceed to a much greater extent without affecting the value of gold as compared with a larger or smaller number of commodities.

In this country there has been, since the summer and autumn of last year, a marked increase in the price of several descriptions of commodities; and it does not appear that that increase of price can in all cases be adequately explained as concerns the commodities themselves by considerations of supply and demand; nor, on the other hand, does it appear that we are justified by the evidence in attributing to the influence of the new supplies of gold any extensive or decided influence in raising prices in this country. The facts, however, do justify us in believing that the new supplies have certainly begun—indirectly and perhaps directly also—to operate in this country in a manner which does, and will, lead to higher prices.

As regards wages, the indirect and direct operation of the new gold in establishing higher rates is manifest and unquestionable; and since the autumn of 1852 the rise in the wages of artisan and manual labour in this country is equal to between 12 and 20 per cent.

It seems to be established by the evidence, that whatever effects may have been produced in the United Kingdom, in raising wages and prices and in extending and increasing trade, have been accomplished by means of reductions in the rate of discount and interest and by advances of capital, and not in any way through the medium of the circulation. It appears also that the effect of the new gold in depressing the rate of discount was essentially of a temporary character, and was confined to the period during which the new gold was lodged, chiefly in the Bank of England, in its progress from the mines to the general markets of the world.

Since those temporary effects have disappeared, the increased demands for capital, excited by the low rates of discount and arising out of an extending trade, have raised those rates to fully their previous height.

In the Australian colonies the effect of the new gold has been to add the stimulus of a very low rate of interest, and of an abundance of capital, to the other great and manifold causes of rapid development which they previously possessed.

And, generally, we are justified in describing the effects of the new gold as almost wholly beneficial. It has led to the development of new branches of enterprise, to new discoveries, and to the establishment in remote regions of populations carrying with them energy, intelligence, and the rudiments of a great society. In our own country it has already elevated the condition of the working and poorer classes; it has quickened and extended trade; and exerted an influence which thus far is beneficial wherever it has been felt.

Such are the conclusions justified by evidence and facts.

There still remain the conclusions which seem to be justified by speculation, and these may be compressed within a smaller compass.

Apparently there is good reason for believing that the future results of the new supplies of gold will be, on the whole, not less devoid of evil than they have been hitherto. There seems to be no authority for expecting that, under contracts now existing, creditors will be sacrificed to debtors; that the recipients of fixed incomes will be hopelessly impoverished; or that capital will cease to command a reasonable rate of interest. On the contrary, the great revolution pursues its course so gradually; it is moderated and checked in modes so infinite and subtle, and moulded by influences too delicate to be laid bare by any appliance of statistics;—that, so far as we can judge of the future by that which now occurs around us, we may contemplate without fear a change in the economical condition of the world,—new and startling, doubtless,—but already adjusting itself, without shocks or convulsions, to the expanding intelligence and resources of mankind.

On a proposed Plan for Decimal Coinage. By THEODORE WM. RATHBONE.

On the Causes, Extent, and Preventives of Crime; with especial reference to Hull. By the REV. JAMES SELKIRK, *M.A., Chaplain of the Hull Gaol.*

The subject of crime in the country in general is in these days attracting the attention of all classes of society. The *causes of crime* are almost the same everywhere, and may be reduced to a very few.

I. (1) The most prolific source of crime is beyond all doubt *drunkenness.* Testimonies to the truth of this are borne by judges, magistrates and gaol chaplains, and others who have had opportunities of investigating it. In 1851, 10,000 persons who were tried at assizes and sessions in England were brought into that deplorable condition by drunkenness, and upwards of 50,000 were summarily convicted in the same year by the magistrates from the same cause.

In the last three years in Hull 1325 cases of drunkenness have been taken before the magistrates, and more than 1000 other cases of crimes chiefly occasioned by the same vice.

(2) Another source of crime is the *neglect of children by their parents.* This will be obvious to all who are in the habit of visiting the streets inhabited by the more degraded part of the population, whose children, in ignorance, dirt and rags are begging about the streets. Besides this, the filthy and confined and ill-ventilated state of the abodes of this class has a tendency to promote crime, from the absence of all possibility of decency and self-respect.

(3) A third source of crime is the *numerous low and ill-regulated places of amusement,* which are particularly attractive to, and frequented by, the lower orders. As one proof of this it may be mentioned that the chaplain of the Preston House of Correction sent officers to visit one of these places, and their report describes 700 boys and girls collected together to have their bodies poisoned with smoke and drink, and their minds poisoned with ribaldry and obscenity. Unhappily these places are numerous in Hull, and attended by youth of both sexes.

(4) The *associations formed at low lodging-houses* is another source of much crime. It is here that destitute and profligate persons are brought together in dense masses, and spend their time chiefly in corrupting each other.

II. *The Extent of Crime.*—The average number of committals every year in England is about 115,000, and in Scotland about 24,000. The average number of murders in the last ten years does not seem to have increased. It is about 67. Compared with the increase of the population, very grave offences are rather diminished than otherwise. The greatest number of crimes are committed by persons between eighteen and forty years of age, and many of these are by persons who have not been brought up to any regular occupation. The education of a large proportion of criminals is very meagre and limited, and particularly among the females. More than 20 per cent. of the persons taken into custody in Hull in the last three years are of this class.

The number of persons that pass through the Hull gaol in a year is between 700 and 800.

III. *The Preventives of Crime.*—(1) This very important part of the subject has of late years much engaged the attention both of the legislature and of philanthropic individuals. *Ragged and Industrial Schools,* which have been established in the metropolis and in the destitute and depraved districts of other large towns, have proved a seasonable check to crime among the juvenile portion of the community. Those which were established by Mr. Sheriff Watson in Aberdeen twelve years ago have proved eminently successful. There has been a great decrease in the number of juvenile offenders, and a mendicant child is almost unknown.

The one established in Hull contains ninety boys and forty-four girls, and such of them as have been placed out in situations are doing well and giving satisfaction to their employers.

Great success has also attended the establishment of Reformatory Schools for young criminals at Mettray in France, at Hamburg, and the one lately founded at Red Hill, near Reigate, in Surrey.

(2) Another means of preventing crime is the *extensive circulation of religious and moral publications,* in a cheap form and in easy language.

(3) The *establishment of places of refuge* for the reception of liberated prisoners who have behaved well in gaol and express a desire for reformation. The number of prisoners of this description is much larger than is generally supposed. It has been calculated that three-fourths of the liberated prisoners never return to prison, and that in the country at large 90,000 criminals in a year, whether deterred by punishment or really reformed, against extraordinarily great disadvantages, do actually return to a better course of life after legal imprisonment.

The refuge for discharged prisoners at Durham, which has existed for the last five years, has been attended with the best results. Out of 804 prisoners, 747 have been reclaimed. The cost of the Institution has not exceeded £60 annually, which is about eight shillings for each reformed prisoner.

It is the careful uptraining of the young in sound religious and moral instruction that will do more to lessen the prevalence of crime than any mode that can be devised. Let all public temptations to crime be lessened; let the prisoner be treated with kindness and consideration, as a man, though fallen; let a spirit of Christian love rule in the heart and be seen in the conduct of all who are employed around prisoners; and let the unhappy man or woman see that it is their restoration to society as healthy members of the same, and not simply their punishment, which is the thing aimed at; we may then expect a great diminution of crime, and a vast amount of real permanent good to attend our labours. The effect of this Christian treatment of prisoners is no chimerical thing. *It has been accomplished,* and God's blessing may always be expected to attend labours undertaken and carried on in dependence on His promised aid.

MECHANICS.

Description of some of the large Valves and other Machinery which have been employed for the discharge of Water at the Manchester Waterworks. By J. F. BATEMAN, *C.E., F.G.S.*

On the Tubular or Double Life-boat, invented by HENRY RICHARDSON, *Esq. of Aber-Hirnant, Merioneth. By* Colonel CHESNEY, *Royal Artillery, D.C.L., F.R.S.*

Parent Life-boat.—The parent life-boat of Mr. Greathead only appeared in 1790, but although a parliamentary grant of £1200 and other rewards were liberally bestowed upon this individual in consequence, public encouragement appears to have been dormant until 360 plans and models were produced by the liberal reward of his Grace the Duke of Northumberland.

Failure of the Prize Life-boat.—The prize was given to Beeching's boat, but her failure on three occasions, with a lamentable loss of life at Rhyl and Lytham, shows that no safe life-boat has, as yet, been adopted; nor are such boats in sufficient numbers for the wants of the community, even if they were perfectly efficient.

Want of Life-boats and consequent Loss of Life.—Captain Washington, R.N., makes known the astounding fact, as regards a maritime nation, that in 1500 miles of the Scottish coast there are only 8 life-boats established; and that no more than 75 are provided for 2000 miles of the English coast; whilst 8 life-boats are all that belong to Ireland. Capt. Washington shows, at the same time, that in 1850 there were 680 shipwrecks and 780 lives lost on the coast of Great Britain.

But numerous as were these calamities at that time, they have greatly increased subsequently; for 800 seamen perished on the east coast of England during the calamitous winter of 1852–53, and an aggregate of 2000 British seamen on our coasts elsewhere.

Efforts of Public Bodies.—Since the efforts of the Trinity Board, the Shipwreck and other Societies, however great and meritorious, can only be partial, a centralized system under Government, with funds voted by Parliament, seems to be absolutely necessary; and since every seaman pays 3*d.* annually from his limited earnings, he has every right to expect that the funds so raised should be turned to the best account.

Life-boats should be a National object.—But the momentous question of efficient life-boats can only be safely dealt with after the most patient consideration, founded on extensive experiments as to the construction of the boats, and the rewards to be given to those individuals who overlook the chance of salvage in order to save life, and thus make a sacrifice.

Life-boat of Mr. Richardson.—The boat to which I invite your attention, as being safe under (it is believed) all circumstances, dates from the year 1830, when a wreck at Weymouth, and the examination of Blanshard's pontoons, gave rise to the tubular boat.

Description, &c.—She is formed of two tubes of tinned iron, 40 feet in length by $2\frac{1}{2}$ feet in diameter, tapering at the ends, and thus giving the appearance of shears, as they rather approach one another towards the extremities. Iron frame-work, securely riveted, unites the whole into one mass, which is further strengthened by longitudinal bars of iron hoops within; likewise, iron keels running from end to end of the tubes. The latter, as an additional security, are divided into water-tight compartments occupied by air-proof bags. A cork fender surrounds the fabric, on which a platform is placed for the rowers and those who may be saved. She rows exceedingly well, steers with facility, and is fast under sail. Sliding keels are proposed to be added to increase the stability.

Experiments made with this Boat.—After the most trying experiments, such as landing through surf, and re-embarking on a lee-shore, towing in stormy weather behind a steamer, without any one in the boat to steer, &c., Mr. H. T. Richardson circulated a challenge to the Shipwreck and other Societies, and upwards of 50 life-boats, and then made a voyage from Liverpool to Woolwich, expressly to meet and compete with any boat that might be disposed to make a trial; but not one ventured to do so.

Published Account of the Life-boat.—During this voyage of the Challenger life-boat, which has been published by Pickering, she was subjected to various experiments alongside the Leander frigate, and in presence of the Port-Admiral, Sir John Ommaney, at Plymouth. Two officers then belonging to that ship thus speak of the boat:—

Naval Opinions of the Life-boat.—"I think Challenger the only thing built, at least that I have heard of, deserving the name of life-boat. She has no capacity to retain water; she cannot sink or capsize, as was fully proved when 80 men of the Leander stood upon one tube. I would willingly take a boat of the same dimensions as one of our cutters or quarter life-boat at sea, and feel convinced that many a valuable life would be saved if a ship had such a boat belonging to her."

"I witnessed," says the other writer, "one of the *most severe trials* that possibly could have been put to any boat in the world, and she *behaved admirably* when tried alongside H.M.S. Leander, June 5, 1852."

The Tubular can scarcely be capsized.—Hitherto it has been found impracticable to capsize the tubular boat, because, not having a sea-bottom, the force of the waves passes off and through the space between the tubes. But were she overturned, her buoyancy would be as great or even greater than before, and with some little arrangement, she would, as may be easily proved, be a serviceable boat with the bottom upward.

Examination and Competition sought by Mr. Richardson.—We may therefore hope that a real life-boat has at length been constructed, as patented by Mr. Richardson, who would be the first to condemn her if she prove unworthy. What is sought is a full examination by the authorities, and competition with the best existing life-boats; with which object Mr. Richardson has recently expressed to the Shipwreck Fishermen and Mariner's Benevolent Society his readiness to meet any of their boats for the purpose of trial, *at any time and place* between the Land's-end and John o'Groats House, or on the west coast of Ireland, between Cape Clear and the Causeway; and thus to prove practically whether the tubular is or is not the best life-boat at present in use to save life, as she would undoubtedly be the cheapest construction, if the chivalrous object of the inventor shall be accomplished.

On Reaping Machinery. *By* A. Crosskill, *Beverley.*

After some observations relative to the reaping-machine of the ancients, he remarked that, in taking a brief review of what had been done in modern times to produce a reaping-machine, they might pass over some vague accounts which had been handed down from the past century, but which recorded nothing successful; and they came to three inventors—Boyse, Plunkett, and Gladstone—who, about the year 1806, made reaping-machines, all modifications of a large circular cutter 5 feet in diameter; but they were soon laid aside, principally for want of sufficient modes of gathering the cut corn. In 1812, the late Mr. Smith, of Deanston, brought out a reaping-machine, which appeared at intervals with different modifications, until the year 1835, when it worked very successfully at the meeting of the Highland Agricultural Society at Ayr, after which time it was laid aside, and had not since been brought forward. There was another invention to which he would draw their attention, on account of the great resemblance it bore to M'Cormick's Virginia reaper, which had attracted so much notice during the last two years. In 1822, a Mr. Ogle of Remington, near Alnwick, invented a reaping-machine, which was worked upon wheat and barley; but, as it received no encouragement, only one was made. A description and drawing of it were published in 1826; and it was rather a remarkable circumstance that this description answered in almost every particular to M'Cormick's machine, which was invented ten years later, and at a distance of 5000 miles. They need be at no loss for an explanation of the failure of all these schemes, many of which possessed considerable merit. Until the last two or three years manual labour had been easily obtained in this country; and at harvest time especially, a large number of Irishmen came over to England, and obtained a livelihood by assisting the farmers to gather in their crops. Owing to the rapid increase of emigration, however, this temporary assistance was becoming every year more and more precarious, and would in all probability entirely cease; and by a fortuitous coincidence, the demand for reaping-machines, thus occasioned, occurred at a time when public attention was directed to them, in consequence of the prominent position they occupied in the Great Exhibition of 1851. Amongst the American contributions there were two reaping-machines, one invented by M'Cormick of Chicago, and the other by Hussey of Baltimore. They were by no means the only reapers in use in the United States, the great demand in that country having called into operation numerous inventions for that purpose, but the two mentioned were very extensively patronized. These two machines had been repeatedly tested, both in this country and in the United States, and the question of superiority between the two was far from being decided; both had warm advocates, and they had received an equal share of honour and prizes at various agricultural meetings and trials. In the year 1826 the Rev. Patrick Bell invented and constructed a reaping-machine, and succeeded in making it work so well, that, in the year 1829, the Highland Agricultural Society awarded to him the sum of £50 for his invention. Most of these machines were gradually laid aside. In 1852, when the American reapers were sent northward, Mr. Bell put his old machine into thorough repair, and met Hussey's at the meeting of the Highland Society at Perth. The superiority of an implement with self-acting delivery over one which required the assistance of a man to take the corn off the platform was so evident that the judges unanimously awarded the prize to Bell's machine, and the same result had occurred at every trial in which it had since been engaged. This machine was different from both the American machines, and certainly Mr. Bell was entitled to praise for the novelty of his invention, no resemblance existing between it and Smith's, Mann's, Orme's, or any other that had been made before it, except that the horses followed the machine, a mode of propulsion which was in use at the time of the ancient Romans. In acknowledging their debt of gratitude to the Americans for bringing over their machines and directing public attention to the subject, and also for demonstrating, in a manner that must have convinced the most sceptical and prejudiced, that reaping by machinery was as practicable as thrashing, it must be a source of national pride to find that they had in Great Britain an implement superior to any brought from foreign countries, and which only required an opportunity to be fully appreciated. In looking forward to the improvements to be made in reaping-machines, it must not be forgotten that the hasty flight of the seasons rendered a succession of experiments almost impossible. Reaping by machinery was yet new to implement-makers, but no one has had much experience to bear upon the subject; and they might reasonably expect that, for some time to come, every harvest would add something to our stock of knowledge; and continuous improvements would doubtless be made in the construction of these implements before they arrived at that perfection to which machinery in all its branches was brought in this country. Models of Bell's, M'Cormick's and Hussey's reaping-machines were exhibited and explained by Mr. Crosskill.

On the progress of Mechanical Science. Address delivered by the President of the Section, WILLIAM FAIRBAIRN, *C.E., F.R.S., on the opening of the business.*

After briefly alluding to the progressive improvements that have taken place in this country and America during the last half-century, Mr. Fairbairn observed, that at the meeting of the Association at Belfast, several interesting papers were discussed, such as those 'On Telegraphic communication by Land and Sea,' 'Improvements on the permanent way of Railways,' 'On Lattice Girder Bridges,' 'On the Evolution of Gas in Coal Mines,' 'On the Vortex Water-Wheel,' 'Iron Sleepers,' 'Tubular Boilers,' &c. All those he considered as additions to our knowledge in the useful arts, and calculated to promote the advancement of practical science.

In his view of the progress of the mechanical arts for the last twelve months, he alluded to the advices received from America on the subject of steam navigation, and the wonders that were likely to be achieved by Capt. Ericsson in the completion and substitution of the caloric for the steam-engine. The public, and particularly the engineering world, were greatly interested by a question of such vast importance as a new motive power; and Mr. Fairbairn (although he did not participate in the belief of its success to the same extent as some of his scientific friends), nevertheless, was bound to admit the possibility of great improvements being effected by Capt. Ericsson, upon those already introduced into Dr. Stirling's air-engine ten years ago. It was much to be regretted that after two years' trial, the scientific world were not yet in possession of results sufficient to assure the ultimate success of the invention.

In other respects the country had reasons for congratulation in the improvements that had taken place in our ships of war, as well as our mercantile navy. The introduction and successful application of the screw propeller, the concentration of the moving power, the saving of space and other advantages which distinguish the steam flotilla of this country, were doubtless the precursors of a new æra in naval history.

To be convinced of the changes now in progress, it was only necessary to notice the splendid sight which occurred at Spithead a few weeks since—to witness ships such as the Duke of Wellington, of nearly 4000 tons burden, 1100 men and 131 guns of large calibre, moving in and out of position—regardless of wind or tide—with a facility that would have astonished the Rodneys, Howes and Nelsons of former days, and left the impression of a complete revolution in the naval tactics of the present as compared with the past.

That improvements such as described had been effected did not admit of doubt, and in Mr. Fairbairn's opinion still greater changes were in progress in the application of steam upon a much more extended scale; and he was persuaded that a few years would witness in ships of war as well as merchantmen a different description of engines than those now in use, where steam might be used at a pressure of 120 to 130 lbs. on the square inch, and where a great saving of weight and space would be effected, and much increased speed obtained.

In speaking of steam navigation, Mr. Fairbairn could not omit to notice one of the most gigantic undertakings that had ever yet been attempted in this or any other country, namely, the Mammoth ship now in process of construction by Mr. Brunel and Mr. J. Scott Russell. The quoted dimensions of this vessel he gave as 680 feet long, 83 feet beam, 58 feet deep, and an aggregate nominal power of 2600 horse. This immense vessel would be constructed entirely of iron, and the hull or ship's bottom to the extent of 6 feet above the water-line would be double and of the cellular construction, so that any external injury would neither affect the tightness nor safety of the ship. The upper deck would also be strengthened on the same principle, so that the ship would be a complete beam, similar to the tubes of the Britannia Bridge. The vessel (according to the account) would be divided into ten completely water-tight compartments, which would admit of further subdivision up to the lower deck, being from 4 to 8 feet above the water-line. Separate sets of engines, as well as separate boilers, would be applied to work the screw distinct from those working the paddle-wheels; so that in the event of the derangement of any of the engines, those in working order would be available for the ship's progress.

Railways.—In this department of practical science Mr. Fairbairn noticed several improvements that had been effected in the extension of power to the rolling stock. On the London and North-Western and Great Northern Railways, several large and improved engines had been made to meet the demands of the greatly increased traffic on each line, and the accumulating passenger traffic on the southern division of the London and North-Western had been met by the introduction of an improved and immensely powerful engine of an entirely new construction invented by Mr. J. E. McConnel, the Company's engineer. Other lines were progressing in a similar ratio both in this country and in Ireland, and steam locomotion, the great promoter of civilization, was now extending itself in every direction and amongst all the nations of the earth.

Manufactures.—In this branch of known industry the same spirit of progress had been observable as in other departments of practical science. The cotton, wool, silk and flax manufactures, were never in a more flourishing condition. New mills were rising in different localities, and Mr. Fairbairn stated that the industrial classes were never at any former period so well paid for their labour, or in such comfortable circumstances as they had been for the last two years; and this great and important measure of comfort and prosperity was in a great degree owing to the improvements in machinery, and the power which had thus been given for producing every description of manufacture at a cheap rate. Amongst the most recent and probably the most important improvements that had taken place in the manufacture of the textile fabrics, was the new combing machine, which appeared to apply with equal effect to cotton, flax and wool. This machine was of French origin, ingenious in construction and beautiful in performance.

In reference to national industry, Mr. Fairbairn noticed one of the most extensive erections ever undertaken by a single individual or even by a company, in this or any other country, the splendid manufactory then erecting by Mr. Titus Salt, at Saltaire, near Bradford. This magnificent building covers an area of six acres, comprising one large mill or building 550 feet long, 50 feet wide and six stories high, besides offices, warehouses, weaving and combing sheds, and other erections which would render it one of the most remarkable and most convenient buildings in the kingdom.

It was intended for the spinning and manufacture of mohair and alpaca wool, and other mixed fabrics in that new and important description of manufacture. Motion was given to the machinery by steam-engines of 400 nominal horse-power, but of sufficient strength to be worked to 1250 horse. The establishment would employ about 3000 hands.

Mining and the Manufacture of Iron.—These, like many other branches of industry, have greatly increased in value, and the different mechanical and chemical applications which had been brought to bear upon the subject, have not been without their use and influence upon the community. Amongst other improvements was that of Mr. Crace Calvert of Manchester, for removing the sulphurous vapour from coal and coke during the process of smelting the ores in the furnace and the meltings in the cupula; by this process not only a considerable increase of strength was obtained, but a great saving in the iron was effected. In the application of the purified coke to the cupula, the increase of strength was found, by carefully conducted and repeated experiments, to be as the numbers 233 and 193, an increase of strength of about 20 per cent.

On Improvements in Organ Machinery. *By* J. A. Forster, *Hull.*

The first great principle to be kept in view in all machinery is *simplicity*; but in a large organ, where there are *thousands* of small pieces of wood and metal, joined together by means of centres, it is of the greatest importance. The second, is to avoid friction as much as possible and to prevent stickings and cypherings; and lastly, to make the touch light and elastic to the organist's finger, at the same time avoiding all noise. Many attempts have been made to lighten the touch of large organs, and with various degrees of success. In 1831, Mr. Hamilton of Edinburgh, and Mr. Barker of Bath, each invented a pneumatic machine to act upon the manual valves, and, singular to say, they were both on the same principle, both had the same defects; viz. after the key was pressed down, a moment of time was lost before the corresponding pipe emitted any sound; this, in rapid music, although an apparent trifling difficulty, must account for its not becoming in general use for large organs. The model by Mr. Hamilton was exhibited before the members of the British Association at their meeting in Birmingham in 1831. Mr. Barker (now resident in Paris) took out a patent for his machine in France, since which he has made several improvements to it; further improvements have been made to it by the Chevalier Cavallée.

The improvements now offered consist of a regulating screw and ball-valve, by which means a more certain and instantaneous action is acquired; also a perfectly new system of centring the action, which is applicable to other parts of the mechanism in organs, and by which means the friction is reduced to a nominal amount, and noise entirely obviated.

By the use of a peculiarly formed drill, where two pieces of wood are to be attached together by means of a centre to form a moveable joint, the part that works in the mortice has the surface completely cut away, with the exception of a small portion, where the wire-centre passes through, which stands up rather proud, like a small washer, on either side of the tenon; thus the large surface of the tenon is prevented rubbing in the mortice at every movement of the joint. This drill (made either for large or small work) may be used with very great advantage in the whole of the mechanism of our organ, where two pieces of wood form a moveable joint.

The next improvement is the introduction of a small stud, by which each lever or square connected with the keys can be fixed separately; the old system is to pass a wire through a range of from fifty to sixty squares or levers, which wire is secured to a bar of wood by means of staples driven in fast. Should an accident occur to a lever in a range or set, the whole of the machinery would have to be detached to get to the damaged part, and this, in some instances, at a loss of several days' labour; whereas, by the new or improved system, the damaged part would be removed by taking out a single screw, and replaced in as many hours as the old system would occupy days.

The next improvement is a new pedal-valve for large pedal pipes, to which I have given the name of the "universal pedal-valve," in consequence of its being applicable in any position in a simple *box* or wind-trunk, thereby doing away with the necessity of a pedal sound-board with grooves. The advantages of this pallet is the large quantity of wind it will allow to escape when open, and, being a ball-valve, the resistance of the wind is in a great measure obviated: the expense of making it is less than the old pedal-valve.

On the Steam-Engine Indicator.

By JOSEPH HOPKINSON, *Engineer, Huddersfield.*

The indicator is a quarter of a square inch, and each tenth of an inch on the index represents one pound pressure to the square inch on the piston of the engine. The spring compressed is the steam pressure, and distended, is the atmospheric pressure upon the piston of the indicator. This spring is so adjusted as to meet the requirements of the pressure as it increases. When the steam exceeds twenty-five pounds to the square inch above the pressure of the atmosphere, there is an additional spring enclosed in a case for higher pressure up to seventy-five pounds to the square inch or any other pressure required, to be screwed on the top of the casing. The piston rod of the indicator passes up the centre of the spring and comes in contact with the top attached to the second spring, so that instead of the resistance of only one spring, there is a resistance of two springs for high pressure steam. On the scale for high pressure the distances are marked thirty to the inch for steam above twenty-five pounds, and one-thirtieth of an inch represents one pound pressure to the square inch on the steam side. The scale on the vacuum side is ten to the inch, or one-tenth of an inch represents one pound pressure to the square inch, as before with high or low pressure steam; there is a hole in the side of the tap; when the tap is open the hole is turned with its perfect side against the plug; but when the tap is closed, the hole communicates with the piston of the indicator and allows the pressure of the atmosphere to the piston. The paper is fixed round the body of the instrument so as to be firm; the pencil holder is then parallel with the cylinder, so that any yielding of the pencil will not affect the pressure but the length of the diagram; the pencil screws backwards and forwards to adjust the pressure on the paper. The diameter of the cylinder of the indicator is two inches and three-quarters, so that a diagram may be obtained seven inches long, which will enable the operator to read off more quickly and accurately than from the ordinary indicator.

On a Patent Safety Alarum for Steam-Boilers. *By* JOSEPH HOPKINSON, *Engineer, Huddersfield.*

The safety alarum is one of those precautionary contrivances to give warning, should any derangement take place within the boiler, either from want of water, or too much water, or an over-pressure of steam.

Numerous have been the methods resorted to, to give the alarm and call the attention of the stoker. The steam-whistle has often been applied for this purpose, but so attached to the float-wire that it has been tampered with, and was soon out of order. The safety alarum is free from those objections; it is similar in principle to the compound safety valve, the one already brought before this Section. It is so constructed that when the water in the boiler gets to an extreme distance below or above the level fixed, the alarm instantly commences by a steam-whistle, sufficiently loud to be heard on any part of the premises, which will not cease until the water has gained its proper level. Should the steam get too high, the same whistle commences with a loud noise different in its tone, that it is easily distinguished whether it be from want of water or from an over-pressure of steam, and it is out of the power of any person to prevent its operating when any of these casualties take place.

The simplicity of the apparatus is such that it is not liable to derangement, there being no stuffing-box or float-wire, or parts liable to be tampered with; it is free from the objection against the alarm-whistle to steam-boilers when connected to the float wire or to a hollow float; the weight on the valve is locked up inside the dome, and the key in the proprietors' possession, which makes it a complete check, and renders it impossible for the steam to be raised above the proper pressure, or the water to be below the level fixed, without being detected, for the power of detection is the only real check against wilful and negligent conduct on the part of those in charge.

On an improved Compound Patent Safety Valve for Steam-Boilers. *By* JOSEPH HOPKINSON, *Engineer, Huddersfield.*

The valve is intended to provide against two contingences—over-pressure of steam and deficiency of water in the boiler. There is a separate arrangement for securing these objects. The valve is an ordinary flat or concave disc, but there is some novelty in the fittings. All the weight is placed within the boiler and suspended from the underside of the valve; over the valve is a lever (and fulcrum), and at its extremity a spring balance, which, by a screw, can be regulated to press down heavily or lightly, according to the pressure required. This spring balance, however, operates precisely the reverse of those which may be seen on the top of locomotive engines. The maximum weight to be carried is within the boiler, and the effect of weighting the external lever is only to decrease the internal weight and thus to diminish the pressure of steam at which the valve will open; should any additional weight be clandestinely applied within when the boiler is being cleaned, the spring balance will indicate the fraud. The contrivance for preventing the dangerous consequences of deficiency of water, consists of a long lever, suspended from attachment inside the valve tube. At the end of the long limb of the lever is the float, and at the opposite end a weight which counterbalances it, so long as the float remains immersed in the water; should there be a deficiency to a dangerous fixed point, the short limb of the lever will push up the safety valve, and thus allow the steam to escape. This is an important feature of the invention and promises to be of service. It thus renders the working of the boiler, when the water therein is deficient, absolutely impossible, and thus affords the most valuable means of preventing steam-boiler explosions hitherto applied. The compound safety valve is wholly beyond the control of the stoker or the engineer.

On an improved Patent Steam-Engine Boiler designated the Greatest Resistance Steam-Boiler. By JOSEPH HOPKINSON, *Engineer, Huddersfield.*

The boiler is a combination of three circular boilers laid horizontally to form the furnace. The two side boilers or generators, forming the fire-box, are each 4 feet in diameter. The upper boiler is of the same diameter, with a dome at the end forming a reservoir for steam. There is also an inverted dome; to this part of the boiler the sediment settles, and is blown out. The action of the flame from the furnace is diverted by the inverted dome towards each side boiler, and made to enter the tubes. Each side boiler is provided with seventy-five tubes 3 inches in diameter. The length of each side boiler is 8 feet; the upper boiler is longer than the side boilers by the diameter of the dome. The front end of the upper boiler is egg-shaped, and projects past the side boilers the length of the egg end, making the extreme length of the upper boiler 14 feet. The centre boiler with the dome forms the principal steam-chamber; and the form gives plenty of space for this purpose, thus preventing to a great extent that priming to which boilers with contracted steam room are much subject.

The space occupied by this boiler in width is 11 feet 3 inches, and its height from the floor to the upper surface, exclusive of the dome, is 6 feet; the width of the furnace is 4 feet 6 inches, and the length of the grate-bar 6 feet; making the area of the grate surface 27 superficial feet. The effective heating surface of the fire-box and boiler, independent of the tubes, is 140 superficial feet; seventy-five tubes in each boiler, of 3 inches in diameter and 8 feet long, gives 900 superficial feet of tube surface; and the total amount of fire-box and tube surface is 1040 superficial feet, allowing 16 superficial feet of heating surface per horse power: this boiler, though so small of itself, will be sixty-five horse power.

The largest diameter being 4 feet, if made of $\frac{1}{4}$-inch plate, is equal in strength to a 6-feet boiler made of $\frac{3}{8}$-inch plate, and equal to a boiler 8 feet in diameter made of $\frac{1}{2}$-inch plate; the whole weight, including the 150 tubes, will not exceed five tons.

The advantages to be derived by the use of such a boiler are, that the form and combination allow of simple construction, and avoid complication; no angle irons or stays are required; small diameters are placed in such a position as to form a large fire-box. Each part is separate and easily connected or disconnected. Any single part can be removed without injuring the other parts; and any one part can be replaced with a new portion, independent of the other portions, for transit to any part of the world: this boiler offers peculiar advantages, as a powerful boiler may be conveyed in separate portions, and put together with little trouble. Another advantage in this construction of boiler, is a large furnace, consequently the stoker is enabled to place large quantities of fuel in the furnace each time he fires; thus the doors may be kept closed longer than with ordinary firing, thus preventing cold air from entering the tubes, a very important consideration with tubular boilers. A large furnace also affords unusual facilities for smoke consuming. Another important feature is, the first cost is considerably reduced.

For marine purposes, with slight modifications, this boiler presents many advantages; the principle of true construction will enable the expansive principle to be further carried out in marine engines, and thereby reduce the consumption of fuel. For war steamers these boilers can be so constructed, that should any single part become damaged, it could be shut off from the other, allowing the full power of the remaining portions to continue.

The small space occupied in the height with this boiler, would also be of advantage, it being considerably below the water-line of a war steamer.

A brief Description of Locking *and* Cook's *Patent Rotatory Valve-Engine, and of its Advantages.* By GEORGE LOCKING, *Hull.*

The principal feature in this engine consists in one valve doing the work of two slide-valves and with fewer rubbing surfaces. All eccentrics, levers, &c. are dispensed with. The valve is placed between two ordinary rectilineal cylinders, and the rotatory motion is effected by means of bevel gear fixed to the crank-shaft and valve-spindle; the pinion on the crank-shaft being to the bevel-wheel on the spindle in the proportion of three to one, *so that the valve makes only one revolution in the same time that the crank takes to revolve thrice.* The valve is a plain disc, perforated with three apertures or steam-ways, beneath which, in the face of the seat upon which the valve works, are also four steam-ways, two each for the right and left-hand cylinders. The valve in its rotatory motion is so constructed, that the steam-ways through it pass over those in the seat, giving (during the time it takes to pass) free access to the steam from the chest to the cylinders alternately above and below the piston. Like the slide-valve, it is chambered, and the steam escapes to the exhaust-pipe or the condenser as in ordinary engines.

Reversing is effected by a lever and sliding-box, each end of the box having a slot, one of which is *straight*, the other *diagonal*, the length of each being equal from point to point on the box longitudinally, the transverse distance of the diagonal being one-sixth the circumference of the box. Through these slots are pins or drivers, made fast to the valve-spindle, which keep the box in its position, allowing it to move up and down when the lever is lifted or pressed, the spindle being in two parts and forming a junction immediately between these pins in the centre of the box. By moving the lever up or down, the spindle on which the diagonal slot is placed alters its relative position to the other with the straight slot: thus the valve is carried round one-sixth of its circumference, thereby changing the position of the steam-ways and reversing the engine.

The arrangements of the patent valve reduce the working parts, render the engine more simple, lessen the friction, so obtaining a saving of power and rendering less fuel necessary; and as there are fewer working parts, the wear and tear will be diminished, and less oil, tallow, waste and labour required.

Both cylinders will receive and cut off the steam at the same point. Another important advantage of the patent valve is the mode of working the steam expansively and cutting it off at any point of the stroke, the valve requiring no additional power to work it. The cost of the patent engine will be less than that of those now in use; consisting too, as it does, of little more than cylinders and cranks, it will be much less liable to get out of order, and will occupy less room. A singular advantage is the great ease with which it may be reversed when the steam is full on, for the engineer by the use of a single lever can regulate to a nicety the quantity required, and ease, stop, or reverse at pleasure.

On certain Improvements in the Construction of Steam Ships, Life-boats, and other Vessels; also in Steam-Boilers, Propellers, Anchors, Windlasses, and Metallic Casks. By RICHARD ROBERTS, *C.E.*

On Recent Improvements in Machines for Tilling Land. By BERNARD SAMUELSON, *Banbury.*

The plough, which has so long been the principal, and will probably remain for a long time to come a most valuable implement of husbandry, has (among others) this inconvenience, that whilst it loosens and reverses the top soil, it compresses the bottom of the furrow in its progress. A partial remedy was applied to this evil at considerable expense by the use of the subsoil plough, which bursts the ground immediately below the furrow.

It has been sought to avoid the use of the plough entirely, in those cases where the complete inversion is not needed, and hence the introduction of various pulverizers, grubbers, &c., which have of late been used, no longer as auxiliaries, but as principals in cultivation. For the same reason digging with the spade or fork, hitherto confined to the operations of the gardener, has been practised recently with great success by many farmers, amongst whom may be mentioned Mr. Mechi on the larger, and the Rev. S. Smith, of Lois Weedon, on a more experimental scale. Horse and hand-hoeing are becoming more regular every year, not merely for the purpose of destroying weeds, but also of exposing fresh particles of soil to decomposition, thus constantly increasing and renewing the supply of food at the disposal of the growing crop. Not content with these amplifications of the use of the accustomed farming tools, other more expeditious and more complete machines of cultivation have been sought after and invented. Omitting the various clod-crushers and harrows, these may be conveniently divided into—1, ploughing machines drawn by stationary steam-engines; 2, locomotive steam-ploughs; and 3, machines, chiefly rotatory, for pulverizing by means of forks, spades or claws.

Amongst the first class, the most remarkable are the ploughing-frames of Lord Willoughby d'Eresby and of the Marquis of Tweeddale, differing in their details, yet both attended, more or less, with some of the inconveniences of the horse-plough; but successful, inasmuch as they substitute a more expeditious and powerful agent for animal traction. The Marquis of Tweeddale's ploughing machine consists of a frame, containing two double ploughs, resembling the common turnwrist plough, one half of each being in the air, whilst the other half is in the ground. The frame is drawn across the field by wire ropes attached to two steam-engines stationed at opposite headlands; both ploughs being reversed at each turn, so that the slices are always laid in the same direction. The work of each plough is 15 inches deep and 13 inches wide, equal to 26 inches in the frame, and the execution is faultless. By means of a beam about 18 feet long, projecting from each engine at right angles to the ploughing-frame, and a simple apparatus attached to it, the ploughs are lifted at each turn and deposited two furrows, or 26 inches, in advance of their previous position. Thus the frequent removal of the engines is avoided. They are, however, locomotive and run upon wooden rails laid for the purpose. The machine ploughs three acres per day, and requires four men to work it, besides a man and horse to bring water. The depth ploughed (15 inches) is unprecedented except by the horse-ploughing of the Marquis himself, who, by the aid of the latter, so improved the fertility of two entire farms as to have raised their annual value in five years from 7*s*. 6*d*. to 3*l*. per acre.

A more decided advance in steam-ploughing has been made by Mr. Usher of Edinburgh, who boldly abandoned the old mode of traction altogether, and caused his steam-engine to cross the land on a broad roller, attaching to it a cylindrical framework of plough-points and mould-boards, which, whilst being lowered into the ground to the required depth, is made to rotate, disintegrating the soil more completely than the ordinary plough, without compressing the bottom of the furrow, the thrust of the mould-boards at the same time aiding the forward motion of the engine, and enabling it to mount inclinations which it could not cope with by the mere adhesion of the roller. As at present constructed, the power is about 10 horses, and when worked to a depth of seven or eight inches, it will plough about six acres per day. Its great weight, about six tons, is a serious drawback, but that may be considerably reduced; and no other rotatory machine so successfully inverts the soil, though it is still excelled in that respect by the ordinary traction ploughs. Usher's steam-plough has been repeatedly worked in the Lothians, and its use was not attended with any difficulties beyond those which must be expected in all new inventions.

With reference to machines for digging by means of spades, the author is not aware of any that have been put into actual operation. The machine exhibited by Thompson, in the agricultural department of the Crystal Palace of 1851, consisted of two series of spades at right angles to each other, the second series covering the spaces left by the first, and both being forced into the ground by a cranked shaft, borne in a rectangular frame.

The last, and apparently the most promising division, is that of the rotatory forking or clawing implements.

A light machine of this kind was constructed so long as thirty years back by Morton of Leith; but it comes rather under the class of revolving harrows than of cultivators properly so called. Foremost amongst the latter in point of date is that of Lady Vavasour, exhibited at the show of the Royal Agricultural Society at Bristol, which, though unsuccessful, may be regarded as the precursor of the more practical rotatory forking and subsoiling machines that have since been constructed. Lady Vavasour's implement consisted of a cylinder studded with prongs set spirally around it, which penetrated the ground by the weight of the cylinder and framing, and broke or tore it up as the latter was drawn forward.

It was succeeded, after an interval of some years, by the cultivators of the Hon. Mr. Clive and of Josiah Parkes. One of the latter has been used in subsoiling the estate of Mr. Marshall, at Patrington near Hull Here the cylinder of Lady Vavasour, which had the inconvenience of forming, as it were, a taking-up roller, round which the earth wound itself, until it formed a solid mass, in which the prongs entirely disappeared, is replaced by a number of discs revolving independently of each other; the prongs also being made so long that the earth cannot easily reach their roots. Another step was the addition of cleaning or doffing bars, for stripping the soil from the prongs. Of these, Roberts' machine affords an example. Its chief peculiarity, however, consists in the prongs being made to feather, somewhat like the floats of Morgan's paddle-wheel, the motion communicated to them resembling that of the fork in the hands of a man.

The labours of Hoskyns, the author of the 'Chronicles of a Clay Farm,' must not be forgotten. He has described graphically the "points" which are requisite to make a perfect steam cultivator, and consequently divested the subject, to the machinist, of one of its chief difficulties.

Besides a modification, proposed by Usher, of his steam-plough, in which he substitutes rotatory prongs for his points and mould-boards—involving, however, the difficulty, that he loses the aid to progression which the latter afford him—two other steam cultivators have been projected, both of which possess, in common with that suggested by Hoskyns, the distinctive feature that the rotation of the cultivating tools is not derived from the progress of the carriage. The first is that of Stephen Brown, who has two series of rotatory cutters, the second set working in intervals left by the first, and both driven through cross shafts from a small locomotive steam-engine forming part of the implement, and which may either work its way across the field by its own adhesion, or be drawn by horses. The second is the Canadian machine spoken of by Mr. Mechi in a recent letter to the 'Times.' It does not differ greatly from the preceding in its mode of operation, its novelty consisting in the arrangement of the parts, and in the adoption of a very light and compact form of engine.

The most recent rotatory cultivators that have been put practically to work are Bleasdale's and Mr. Samuelson's. The former somewhat resembles Parkes' subsoilers, but being calculated only to pulverize the surface soil, its weight is only about one-half that of Parkes', and that weight (1 ton), instead of resting on two discs only, is distributed over seven. The chief novelty in it is the cleaning apparatus, consisting of an additional cylinder, suspended at an angle of about 45° above, and driven from the shaft of the primary or digging cylinder, and therefore revolving in the opposite direction to it. Its prongs act as a rotatory comb in stripping the earth from those of the former. This machine was exhibited at the Gloucester meeting of the Royal Agricultural Society, and on land previously broken by the plough acted admirably as a pulverizer and a weed extracter.

Whilst engaged in some experiments with a machine somewhat resembling that of Parkes', Mr. Samuelson's attention was directed to the steel digging-forks which have lately been substituted with so much advantage for the old trenching-fork, and it occurred to him that, by substituting light steel prongs for the wrought or cast metal ones hitherto used in rotatory implements, an efficient cultivating machine for horse power, strong yet comparatively light, could be made. In following out this idea, he has constructed his digging, or more properly, forking machine, not altogether unsuccessfully, as may be inferred from the number of them which are already in use, notwithstanding the recent date of its introduction.

The forks of the digging machine are made of the best cast steel that can be procured, of a square section, slightly tapered, bent on the angle and in pairs, at a cherry heat, and allowed to cool gradually. They are curved, so as to enter the ground easily, but to lift the soil as they come out.

The upper portion of six such pairs being laid between two half-discs of cast iron, grooved to receive them, the half-discs being afterwards united by bolts, form a digging wheel of which the discs represent the boss, and the points of the forks the spokes; the hoop or tyre is absent. A number of these digging wheels (seven in a full-sized machine) are hung on a bar, around which they rotate freely. Between each pair of wheels and on the same bar is hung a ring, which keeps them apart, and cleans the sides of the bosses. The frame containing the bar with the digging wheel also holds a number of cleaners, the ends of which scrape the soil from the circumference of the bosses and force it from the prongs. This frame, to which the shafts and draught links for the horses are also attached, is itself hung in front on another bar, connecting two segmental frames, one on each side of the digging frame. These contain the wheels on which the implement rests when it is not in action, and which also serve to regulate the depth to which the forks of the digging frame are allowed to penetrate the ground. The segments at the back of the travelling wheel frames being toothed, two pinions gear into them, the place of which on the segments determines the height at which the digging frame is sustained; a winch attached to the latter works the pinions.

When the horses move forward, the attendant throws out of gear a pawl, which holds the pinions at any given point; the digging frame runs down by its own weight, the prongs enter the ground, and the depth of their penetration is increased or diminished by turning the winch in opposite directions, thereby causing more or less weight to rest on the travelling and digging wheels respectively. Meanwhile the resistance offered by the earth in front of the prongs causes the latter to revolve, and portions of the soil to be detached, which are thrown back, after having been lifted and broken by contact with the cleaning bars.

A full-sized machine weighs a ton, and breaks up (to a depth not exceeding 10 inches) a breadth of 3 feet at a time, equal to that of four ploughs, and equivalent to about five acres in seven hours.

The draught required varies, with the nature and state of the soil, from four to seven horses. A smaller implement is made for occupiers of land whose horse-power is limited, capable of working about three acres in the same time with three or four horses.

About thirty digging machines, corresponding with the description here given, are at work in various parts of this country; one of them in this immediate neighbourhood, on the estate of Mr. Robert Harrison of Benningholme Hall.

Whilst speaking of the digging machine, it is right to state that it possesses, in common with all other rotatory implements hitherto made or proposed, this disadvantage, as compared with the plough, that it does not completely invert the soil. However, the occasions for such inversion are much more rare when we work with an instrument which leaves the ground broken, hollow and mixed, like the digging machine, than with one which, like the plough, cleaves off a slice and exposes its superficies only to the air; there being, in fact, this essential distinction between the two machines, that one allows the air and water to descend, whereas in the other, fresh soil must be brought up, if it is to be acted upon by the elements. Hence also an inconvenience is avoided by forking, which often accompanies the attempts to deepen the mould, by means of the plough, in plastic soils; namely, that the fresh soil so brought up forms a compact coating, and is consequently for several reasons injurious instead of beneficial to vegetation. Even were as many horses required for a given acreage with the digging machine as with the plough, there would still be a great gain both of horse and manual labour by the use of the former, since it effects at one operation the work of several ploughings and harrowings, or scufflings; but in fact it succeeded, during the dry weather in June, in preparing the ground for a crop on the strong clays in the vicinity of London, where a combination of the best implements previously in use could make no impression upon it.

The forks tend to pull out and leave the weeds on the surface, and it is therefore useful in eradicating the couch-grass, the vegetation of which, the action of the plough or scuffle, by cutting the tendrils, is calculated to promote.

Whilst these improvements have been in progress, the spirit of invention has not slumbered even at the antipodes; and we shall shortly see exhibited in this country an Australian forking machine, not differing very greatly from some of those which have been noticed. Mr. Wilson, the inventor, appears to have taken his hint from noticing in a track of a waggon-wheel on soft ground that the side of the tyre tends to abrade and throw back the earth. He prolongs the spokes of his wheels beyond the tyre in the form of spuds, which are segments of an epicycloidal curve, with a view to their encountering the least resistance in front or behind as they enter the ground.

Whatever may be the success of all or any of the cultivating machines which have been brought under notice, enough has certainly been done to demonstrate that we have entered upon a new epoch in the mechanics of tillage, and that how long soever the dominion of the plough may be destined to last, it is not henceforth to reign alone. Meanwhile the author was anxious to direct the attention of machinists to a branch of their profession, than which none stands more in need of cultivation, and none will more amply repay it.

We are dealing with a department of industry, which, until lately, was oppressed with an excess of human labour, whilst the whole of its produce was liable to be depreciated far more than any other in value, by a comparatively trifling increase in its amount. But now the tables are turned; the supply of agricultural labour diminishes daily, whilst consumption is extending beyond all precedent, and the cultivator of the soil looks eagerly to the mechanic to cheapen his operations, and, jointly with the chemist, to aid him in making two blades grow where one only grew before.

On Railway Accidents by Collision, and Suggestions for their Prevention. By WILLIAM SCORESBY, *D.D., F.R.S. L & E.*

The absorption of previously existing modes of travelling, for the most part, by that of railway locomotion, has given to this method, in respect to its degree of risk of personal injury, a vast measure of public importance. Each one of us, indeed, is interested in the inquiry, of what may possibly be done to diminish these risks and damage?

It is not assumed by me that railways are necessarily or practically more unsafe than former modes of conveyance; on the contrary, estimated proportionally, or dividing the number of miles travelled by the amount of injury sustained, we should have a result, I doubt not, still greatly in *favour* of railway travelling. For in estimating the results of accidents, comparatively, we should remember that accidents by coaches, involving occasionally fatal cases, were extremely numerous, and that of these numerous accidents few became publicly known; but accidents by railways, no doubt sometimes very calamitous, are all recorded and generally become publicly known; whilst the enormous increase of travelling, ordinarily involving increase in the number of accidents and quantity of injury, gives an apparent aggravation of the comparative dangers. At the same time, accidents, it is notorious, are lamentably prevalent, and far more so, doubtless, than are due to essential and unavoidable risks.

The prevalent sources of accidents may be considered as divisible into three characteristic classes:—1st, accidents from incaution or recklessness of passengers and workmen; 2nd, accidents from the giving way of machinery whilst the train is in rapid progress, or from the engine or any carriage getting off the line; and 3rd, accidents from the collision of trains or carriages.

It is to this latter source of accidents, yielding, I believe, in respect to *passengers* a considerable, if not a preponderating proportion of the injury referable to management, to which I have now to direct the attention of the Section. And to this particular source of accident, presenting in its results catastrophes of the most appalling character, a simple, and, as far as I am able to anticipate, effective remedy is capable of being applied. The plan I have to submit for this most desirable and important end comprises two leading points; the systematic employment of the electric telegraph, with a separate wire from station to station for management purposes only, and the securing and maintaining thereby a clear line from any one station to beyond the next before a second train should proceed,—a plan which, if fairly carried out, appears to be calculated, unless by the most wilful carelessness or desperate recklessness, to render collisions, if not impossible, certainly most rare.

It may be sufficient for explanation here to take a particular case of a railway, having considerable traffic,—suppose that of the down-line,—and in reference to a series of stations, which we may designate C, D, E, &c.

I. *As to the Arrangements.*

1. That there be an electric telegraph at each station, or intermediately, so as generally not to exceed a distance of three or four miles.

2. That there be a separate set of wires, to be used for station or traffic purposes only, worked by a supplementary battery, with a simple single-lever telegraph.

3. That the wires be disconnected at each station, so that station D should communicate with C above and E below only, with a warning bell, separately, at the termini, indicating at once whether the message is from above or below.

4. That a time-piece and register-book or journal be kept at each electric station, the book properly ruled for notifying the passing of each train clear of the stations above and below, respectively, in the column prepared for the several entries, *i. e.* the particular train, whether express, slow, goods, &c.

5. That the semaphore for the guidance of the engine-drivers of trains on each line of rails be worked from within the electric-office by the attendant there, showing —1. "A clear line to and beyond the next station." 2. "An encumbered line," for caution. 3. "Danger," for stopping the passing train as soon as possible. And to prevent interference, any ordinary signals for other management purposes might be made at a distance from the station above and below.

II. *General Management.*

To be peremptory on all officers and men, but with a discretionary power with the station-master only.

Suppose the case of management at station D, in respect to signals to and from C and E.

1. That in respect to management at station D, the departure of each train from D, as soon as it has gone *quite clear* of the station and is fairly on its way, be notified to C and to E, and reciprocally from C and E to D, the quality of the train being indicated, and the time being registered in the journal at each of the stations.

2. That no second train be allowed to start from C until notice has been received that station D is clear, so that at C it may be known that *the whole line betwixt the stations and beyond the next station is clear,* and collision, whilst no new obstacle is allowed, rendered impracticable.

3. That in the case of express trains passing C without stopping, warning of an encumbered line be given by the semaphore whenever a train is intermediate betwixt C and D, that the engine-driver may bring his train to hand-speed.

4. That no new obstacle be allowed at station D, or on the line near it (except in a side line), without previous notice to C, waiting a reply indicating "all right." This will apply to shifting of carriages by shunting branch lines, crossing lines or junctions.

5. That, for security at junctions, crossing lines, &c., there be always an electric station at, or within commanding view and range of such junction; and that all trains and carriages arriving therein should come up at slow speed, and never enter on the main line till the signal of "clear line and station" be seen.

6. That the telegraphing station at junctions communicate with the next station thereon, as D with d, as well as with those above and below.

7. That no train pass any important junction but at slow speed.

8. And that response be made to each signal, to intimate that the announcement is observed and understood.

Several of these rules, it is well known, are already prevalently in use, but not as a general system. But under the arrangements on the system suggested, regulating the progress of trains so as to leave a clear line up to the next station and beyond it, and allowing no new obstacle without a previous signal to the backward station, and the response of "all right," it seems hardly possible, within the ordinary range of circumstances, for any collision to occur. And it will be obvious, that had such regulations been in force, some of the most calamitous results from this fearful source of accidents which have hitherto occurred could not have happened.

III. *As to Discretionary Powers with the Station-master.*

It being admitted that a stringent regulation after the manner of the plan suggested might retard the business operations on lines of great traffic, a discretionary power with the station-master, to be exercised on his personal responsibility, would be desirable, and might be necessary.

By means of the time-book or journal, however, he could always ascertain with tolerable accuracy the time he had certainly at command, and by enforcing the rule of a hand speed in the following trains, he might provide (except in tunnels where more special rigidness of rule might be called for) against the risk of running into a foregoing train.

The carrying out a plan of this kind would obviously involve expense; but it may be questioned whether the results in damage to carriages and costly engines, and awards of damages by juries, in regard to collisions, with the restraining of travelling by apprehension of personal danger, have not on the whole been as great or greater in expense and loss. But in any case the public might fairly pay for the additional security, for which a very trifling advance on the fares would be sufficient to compensate.

In regard to the importance of an additional or special electric telegraph and attendance, which constitute the basis of all the suggested arrangements, it may be observed that such addition is urgently called for on many lines of great communication, by reason of the almost perpetual employment, at certain times, of the common telegraph for its variety of purposes. This must necessarily embarrass the best of the existing arrangements, and cause recourse to the telegraph, either as to intelligibleness or promptness, often to fail in its intention.

In regard to the effect of the plan proposed on the speed of fast trains, it would probably do little more than regulate the distribution of the other trains more systematically. Yet the public safety is of such paramount importance as would be well worth some little sacrifice of time were it found necessary.

As to the probable effectiveness of a system of the nature of that now suggested, we may refer to a recent case of collision, which from the alarming risks involved in it, may emphatically serve us in the way of illustration. In the case of the recent collision at Hornsey, by the obstruction of the line by an accident in shunting, the proposed plan must have been an effective preventive; for before the shunting, notice must have been given to the station at King's-cross, so that if the express train had started, the shunting would have been delayed; or if the shunting had been sanctioned, the express must have been delayed (or gone on hand speed only) till a "clear line" had been announced. Such an accident, therefore, in this case would have been impossible.

In regard to the provisions of this plan for the guidance and protection of trains by the semaphore and other signals, I may, in conclusion, merely refer to one for night-signals, being the employment (if it might be deemed of sufficient importance) of a wire, with explosive or illuminating combustibles attached to different parts of it, which could be ignited by the galvanic battery after the manner employed in blasting.

The fearful calamity on the Great Southern and Western Irish Railway, which occurred on the 5th of October (within a month of the reading of the above communication), may still further illustrate the character and probable effectiveness of the plan here suggested for safety.—A passenger train was accidentally brought to a stand betwixt Sallins and Straffan stations. A cattle-train, unwarned, runs into it with a most appalling result. But, on the plan suggested, no such accident could have occurred. The cattle-train would not have been allowed to leave Sallins station till the line beyond Straffan was announced to be clear; or, if it were passing Sallins, without stopping, warned by the danger-signal there, it must have immediately brought up its speed and awaited the signal "clear line." Thus a catastrophe, involving the loss of fourteen or fifteen lives, with other serious personal injuries to the unfortunate travellers (besides the heavy loss and damage ensuing on the Railway Company), must, on the system suggested in this paper, have been prevented.

On the Consumption of Smoke in Furnaces and Manufacturing Premises. *By the* Rev. Francis F. Statham, *M.A.*

Mr. Statham commenced by adverting to the fact, that all smoke consists of imperfectly consumed carbonaceous matter, and then proceeded to comment upon the various plans which have been suggested for its more complete consumption, which may be said to resolve themselves into one or other of the following systems:—

1. The more careful feeding of the furnace or fire, so as to ensure a gradual and therefore more perfect consumption of the fuel employed.

2. A skilful admixture of atmospheric air with the incandescent mass, so as to effect a higher degree of heat, by which the smoke may be completely burned.

3. The application of steam or water in fine jets, which seems to operate in a twofold way, partly by chemical and partly by mechanical action.

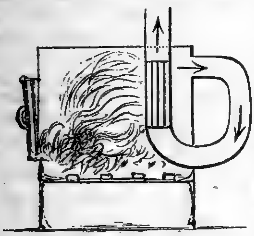
And, lastly, by a process which it was the more immediate object of the paper to explain, viz. by a subdivision of the current of smoke into small columns, each of which may be dealt with more effectually than when united in one dense fuliginous mass.

For the suggestion of the first method, viz. the more careful feeding of the furnaces, we are probably indebted to the illustrious Watt, who obtained a patent in 1785 "for a method of constructing furnaces in such a way as to cause the flame of the fresh fuel, in its way to the flues of the chimney, to pass, together with a current of fresh air, through, over, or among fuel which has already ceased to smoke, or which is converted into coke, charcoal, or cinders intensely hot." This plan, which is a very obvious one—one, indeed, so obvious as to be the guiding principle in each one's proper management of a parlour or study fire—has been much improved in more recent patents; as, for example, in that of Heel, described in the Report of the Parliamentary Committee which sat on this subject in 1819-20, and again still further in the patent of Brunton and some more recent engineers. The principle common to most patents of this kind is the arrangement of a hopper or a feeding machine discharging its supply of fresh fuel upon a shelf or ledge in the front part of the furnace, in such a way as that the fuel so supplied shall gradually be converted into coke, the smoke and vapour arising from which, being made to pass over the inclined surface of the rest of the blazing mass, are gradually consumed before they reach the chimney. When sufficiently baked or coked, the supply of fuel on the ledge or shelf is, by a simple mechanical contrivance, pushed forward or shot out on to the surface of the already incandescent body of fuel, and a fresh supply is admitted by the hopper or feeding cylinder, to be acted on as before. Many advantages result from this plan: a great saving of fuel is effected, because no portion of the carbon is left unconsumed; the great bulk of the surface of the fire is always in a highly heated state, for the gas given off from the coking fuel tends to keep up a constant blaze; and, finally, the chimney no longer ejects its dense volumes of blackening vapour, but serves to carry off all the sulphurous and heated air, and helps to maintain the draught necessary for the proper working of the furnace or fire. But it is asserted, on the other hand, that this plan labours under the disadvantage of not keeping the whole surface of the fire unimpeded (a matter of great moment where a boiler is to be placed immediately above), and that the introduction of the draught above, necessary to direct the stream of smoke from the baking coal, interferes with the draught from beneath, and so diminishes the intensity of the heat.

The second plan is employed with considerable effect in the pottery districts of Staffordshire. In this arrangement, the grating of the fire-places is made to incline, rising from the back towards the front of the furnace, at an angle of about 45°. By this means, the mass of the burning fuel is kept away from the mouth of the furnace, where there is only a comparatively thin stratum of incandescent material, through which the air from beneath can find easy play. Immediately above this thin layer of heated fuel, a horizontal slit is opened, by means of which a rush of fresh air is continually supplied from the exterior, and this, mingling with the now heated air from below, traverses the body of the fuel with considerable velocity, and raises the temperature of the whole mass to such a degree, that every particle of smoke arising from the surface is entirely consumed. The fuel is supplied at intervals, and with discrimination, from above, and is scattered equally over the whole surface of the fire by means of rakers and other contrivances. The only objection to this, which is called "Whalley's Patent," is the evident and enormous consumption of fuel; but as coal, being mined in the neighbourhood, is extremely cheap, this does not constitute so serious an objection, in those localities, as might at first sight appear; and there is every reason to believe that if this system were universally adopted in the Staffordshire potteries, the neighbourhood, which is now completely begrimed by the volumes, not to say *torrents*, of smoke which are continually poured forth from the conical chimneys meeting the eye in all directions, would be as cleanly and as fresh as any other locality, in spite of the enormous amount of manufacture which would still be as effectively carried on.

But by far the most popular of the expedients which have hitherto been devised for consuming smoke is the agency of steam. It is extensively employed in Glasgow and in the north generally, and is certainly deserving of the highest praise for ingenuity and scientific aptitude. Ivison's Patent, which is the most effective exponent of this system, consists in the arrangement of a system of machinery by which jets of steam are thrown through apertures of about $\frac{1}{12}$th of an inch in diameter, pierced in a kind of fan-shaped distributer, into the mouth of the furnace. The quantity of steam thus admitted is very trifling, and being divided into comminuted streams, it becomes rapidly mixed up with the rising smoke, and causes its speedy disappearance. The theory of the process is more a matter for consideration with philosophers than with practical men; but the actual results are found to be of the most encouraging kind. The draught of the furnace is enormously increased; so much so, as to render the tall ungainly chimneys which we so commonly see entirely unnecessary; and the smoke is so perfectly consumed, that not a particle is visible arising from the chimney-top, except just at the period when a new supply of fuel is being thrown on, and this creates but a partial smoke for a few moments.

The fourth and last plan to which attention was called is one which occurred to the author about eighteen years ago, when reading through a course of chemistry. As he did not confine himself to the mere conception of the idea, but carried it out into execution, and found it, so far as the experiments tried were concerned, perfectly successful, he ventured to introduce it as a plan which might be adopted with success, and easily modified to suit any existing state of circumstances. The principle upon which this plan proceeded was to *convert the chimney itself* into a smoke-consuming apparatus. For this purpose, it was supplied with a series of crucible-ware pipes, packed close together, so as to present the appearance from above of a honeycomb, or of a magnified section of some plant of the cane tribe. The chimney thus arranged was made to bend and return through the furnace in such a manner as that the earthenware tubes might be exposed to the heat of the fire and kept in a state of red heat. When once this condition was effected, the smoke which arose from the surface of the fuel was completely consumed; so much so, that though a quantity of small coal was thrown on, the dense vapour was entirely consumed in its passage through the cellular chimney, and nothing but sulphurous and heated air escaped from the vent. The experiment was tried on many different occasions, and always with the same successful results. The furnace employed was one of Stourbridge bricks, having an inner diameter of about 12 inches; but in this experiment the comparative smallness of the apparatus would tell, not in favour of but against the success of the trial, inasmuch as a higher temperature could have been procured with apparatus on a larger scale. From the issue of the trial on a small scale, the author believes that it would be equally successful on a larger one, and he will gladly hear of the adoption of this principle in any manufacturing premises of an extensive character, calculated to test the invention to the full, and to prove the desirableness of its universal adoption.



On Railway Collisions, with Suggestions for their Prevention. *By the* Rev. Francis F. Statham, *M.A.*

The author expressed his belief that the greatest security of the public in railway travelling would be found in *precautionary measures*, in the selection of careful and steady men as pointsmen, signal-keepers, guards and engine-drivers, and in the constant supervision of all the working machinery; but he still thought that some additional contrivances might be devised, *connected with the moving train itself*, which might render considerable service in avoiding collisions. The present modes of avoiding railway collisions are almost totally ineffectual. The use of the railway-break, and the expedient of shutting off the steam and reversing the locomotive, would not bring a train moving at the velocity of 30 miles per hour to a state of rest under 300 yards. The problem to be solved was one, then, of *retardation*, and the contrivance desired one which should reduce this stopping distance of 300 yards to the minimum, —say to 200, 100, or even 50 yards. He showed that an *immediate* stoppage would be almost as fatal as a collision, and suggested that men of inventive genius should be stimulated to seek retarding agents by the offer, on the part of government, of some adequate premium. He commented on the importance of having some *public experiment-ground*, duly fitted up with rails, locomotives, and carriages, for the trial of promising schemes, and observed, that if, after two years' trial, no sufficient remedy could be devised, the public would still have the satisfaction of knowing that their lives were not imperilled without all the resources of modern science having been ransacked in vain. The author expressed his firm conviction that some adequate contrivance would hereafter be invented, and urged the importance of striving to hasten the time when it might be made known and brought into active use.

Mr. Statham suggested for consideration the resistance to be gained by opposing a larger surface than that of the ordinary train to the action of the air. The state of the wind was found already to influence the velocity of railway trains. Why should not its resistance be made available in a case of apprehended danger? For example, let shutters or solid doors, of the height of the train itself, be fixed along at intervals, and at a distance of about three or four feet on each side of each railway carriage. Let a rod or a series of rods run along the floor-line of the whole train, by the motion of which the engine-driver might instantaneously cause the whole of these doors or flaps to fly open and *remain at a fixed angle* immediately that he sees any danger of a collision. Could it be doubted that such a contrivance would materially impede the speed of the moving train, and assist in its retardation? He suggested, as an additional *retarding* agent, a large fan of strong wood-work, which might be made to lie folded at the back of each railway carriage, but which, by the contact of another rod, might be made to fly open simultaneously with the shutters or flaps before described.

Another idea which had suggested itself to the author's mind, was *the employment of electro-magnetism* as a retarding agent, making the iron rails themselves the basis of operations. He then proceeded to detail minutely a plan for fitting up in the last carriage of each train an electro-magnetic battery of soft-iron magnets, which magnets could be charged or uncharged by the single contact of a piece of connecting wire with a galvanic battery, to be placed in the charge of the engine-driver or his assistant. A downward pressure of several tons might thus be easily gained, which might be brought to bear on the surface of the iron rails, and which would have this additional advantage, that it might be applied either instantaneously, or, by a simple arrangement, magnet by magnet, as desired. And, finally, the author concluded by suggesting an improved method of turning off the steam, so as to drive it through a series of minute jets facing the front of the train, by which he anticipated a small additional amount of resistance, on the principle of the æolipile of the ancients, or Barker's hydraulic mill of modern times.

On an Experimental Apparatus constructed to determine the Efficiency of the Jet Pump; and a Series of Results obtained. By James Thomson, *A.M., C.E., Belfast.*

Mr. Thomson had last year given, at the Mechanical Section, an account of a very simple machine which he had contrived for the purpose of raising water from beneath the lowest available level of discharge, by means of a supply of other water coming from a higher level. This machine he designated a Jet Pump, because it raised water by the action of a jet. A drawing and an explanation of it, in its original form, are to be found in the Report of the Transactions of the Mechanical Section for last year. The machine is remarkably simple and free from liability to derangement, having no valves, pistons, or other moving mechanisms. It consists indeed only of pipes with an internal jet, and is capable of working properly when left entirely to itself without the care of an attendant. It had at first been intended chiefly for one especial purpose, namely, to empty the pits of his own patent vortex water-wheels, or other submerged turbines, when access to them is required for inspection or repairs. During the progress of the trials, however, which were made of it for this purpose, it soon gave indications of being suitable for much more extensive uses, and of being likely to prove, in certain cases, an advantageous machine for draining swampy lands or shallow lakes. The cases of this kind for which its employment was contemplated are those in which the low ground to be drained happens to have, adjacent to its margin, streams or rivers descending from higher ground. With a view to determine its efficiency and its applicability in any particular cases of this kind, Mr. Thomson had recently constructed an experimental apparatus in which a jet pump could be made to act subject to great variations in the ratio of the height of lift to the height of fall; and which was suited for indicating accurately the quantity of water lifted, and the height of the lift, corresponding to each quantity of water allowed to fall through any given distance within the working range of the apparatus. The results obtained give higher efficiencies than had been anticipated previously to the experiments, and remove all doubt as to the quantity of water which can be raised in any ordinary cases of its employment for the drainage of swampy land. They give, in fact, when taken in conjunction with known laws of the flow of fluids through orifices, the means of calculating, with full confidence, the requisite dimensions and proportions of a machine for the performance of a stated amount of work in the raising of water.

With respect to the nature of the experiments, a statement of a few principal points will here suffice, as the form and construction of the apparatus cannot be minutely explained in the absence of the drawings, which were exhibited in the Section by the author.

One of the chief difficulties anticipated by Mr. Thomson, in his attempts to find good modes of experimenting, had reference to the determination of the quantity of water lifted by the pump from the low level to the discharge level, and of that let down from the high level to the discharge level. A very simple and effective mode of obviating the difficulty was devised, as follows:—An apparatus was arranged, not for measuring the absolute quantities of water lifted and let down in various experiments, but only the ratios of these quantities to one another; and it is to be observed, that, for the purpose in view, precision in the ratios of the quantities, rather than in their absolute amounts, was to be desired.

A vessel or cistern was provided and set up at a level above the jet pump; and all the water to supply the pump, as well as all the water to be lifted by it, was made to pass through the cistern, and to issue by a slit in its bottom, about one foot long, and of a width which could be varied at pleasure, but was usually about one quarter of an inch. The water thus issued in the form of a thin sheet one foot wide and about one quarter of an inch thick descending vertically. Out of this sheet of water any portion desired could be taken and conveyed away by means of a small moveable wedge-shaped vessel made to slide in below the slit of the cistern. The water thus abstracted was conveyed down to the low level to be lifted by the jet pump, and the remainder was used for supplying the power in the jet pump. By observation of the width of the portion of water abstracted from the sheet, and comparison of that with the width of the whole sheet, the ratio of the two quantities was determined.

The absolute quantities of water could be varied at pleasure, without any alteration of their ratio, by increasing or diminishing the depth of water in the supply cistern from which the sheet of water issued. Thus the absolute quantity was adjusted so as to make either the high water supplying the power, or the low water lifted by the pump, stand at any desired level while the pump was in continuous action. The one of those two levels being thus fixed, the other, after some fluctuations, soon adjusted itself to its permanent height, and the two permanent levels were then observed, and so one experiment was completed. The series of experiments was made by successively cutting out various portions of the sheet of water to be conveyed to the low level; and then observing the height of lift, and the height of fall, which corresponded to each ratio of the quantity sent to be lifted, to the quantity sent to supply the power.

The following table gives a summary of the chief practical results obtained. It is derived from two sets of experiments made on a jet pump with a jet of seven-eighths of an inch diameter. The height of fall varied from twenty-one inches to twenty-eight and three-fourths inches, and the height of lift from six inches to thirty-six and a half inches.

Ratio of lift to the fall	Quantity of water lifted if the water supplying the power is 100.	Mechanical work performed in the raising of water if the work due to the fall is 100.	Ratio of lift to the fall	Quantity of water lifted if the water supplying the power is 100.	Mechanical work performed in the raising of water if the work due to the fall is 100.
0·2	51	10·3	1·0	18	18·0
0·3	44	13·2	1·1	16	17·9
0·4	37	14·8	1·2	15	17·6
0·5	33	16·3	1·3	13	17·3
0·6	29	17·3	1·4	11·5	16·3
0·7	26	18·1	1·5	10·2	15·3
0·8	23	18·2	1·6	9·0	14·2
0·9	20	18·1	1·7	7·7	13·2

On an Electric Semaphore for Use on Railways. By W. SYKES WARD.

The object of the communication was, to show that a semaphore consisting of a disc might be constructed to make a partial revolution, so as to take different positions exhibiting three distinct signals, and that its motion might be regulated by electro-magnets worked by a contiguous supplemental battery, of which the circuit is opened, closed, and changed by an electro-dynamic coil, which is moved by means of a current communicated from a distant station, through a single wire. Thus what is mechanically effected at the distance of about half a mile, may, by the proposed apparatus, be effected at any required distance, and at any number of stations simultaneously.

On a New Wheelbarrow. By Capt. F. Wilson.

This barrow differs from those in ordinary use in the wheel being placed underneath and sunk into the floor of the barrow; the weight is thrown on the wheel, instead of being entirely between the hand and the wheel, an arrangement which allows of doubling the load.

The projection of the wheel inside the barrow is covered with an iron curved cap with wooden sides, which to a certain extent may interfere with the free movement of the spade; but it is so seldom used for such purposes, and the inconvenience so slight, as not to require consideration.

The floor of the barrow is broader at the handle than at the wheel. The handles are a separate joint from the framework of the barrow, and are raised so as to decrease the first lift as much as possible.

A brass pin is placed in the middle at the top of the pent-board, directly in a line with the wheel, so that it will serve as a guide to the labourer, where he requires accuracy in his work. A wooden frame can be attached to the top of the barrow, should the bulk of the load be disproportioned to the space. A scraper is placed close to the wheel, to prevent it clogging the cap.

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CONTENTS:— Report of the Committee appointed to conduct the co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—J. Richardson, M.D., Report on the present State of the Ichthyology of New Zealand;—W. S. Harris, Report on the Progress of Meteorological Observations at Plymouth;—Second Report of a Committee appointed to make Experiments on the Growth and Vitality of Seeds;—C. Vignoles, Report of the Committee on Railway Sections;—Report of the Committee for the Preservation of Animal and Vegetable Substances;—Lyon Playfair, M.D., Abstract of Prof. Liebig's Report on "Organic Chemistry applied to Physiology and Pathology;"—R. Owen, Report on the British Fossil Mammalia, Part I.;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—L. Agassiz, Report on the Fossil Fishes of the Devonian System or Old Red Sandstone;—W. Fairbairn, Appendix to a Report on the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast;—D. Milne, Report of the Committee for registering Shocks of Earthquakes in Great Britain;—Report of a Committee on the Construction of a Constant Indicator for Steam-Engines, and for the determination of the Velocity of the Piston of the Self-acting Engine at different periods of the Stroke;—J. S. Russell, Report of a Committee on the form of Ships;—Report of a Committee appointed "to consider of the rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis;"—Report of a Committee on the Vital Statistics of large Towns in Scotland;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Lord Francis Egerton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTEENTH MEETING, at Cork, 1843, *Published at* 12*s*.

CONTENTS:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and of Various Temperatures, upon Cast Iron, Wrought Iron and Steel;—Report of the Committee appointed to conduct the co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee appointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W. Thompson, Report on the Fauna of Ireland: Div. *Invertebrata*;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Earl of Rosse's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FOURTEENTH MEETING, at York, 1844, *Published at* £1.

CONTENTS:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lt.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions and Œconomy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas Furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the recent Progress and present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, with descriptions of certain Fossils indicative of the former existence in that Continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Report sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S. Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Dean of Ely's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTEENTH MEETING, at Cambridge, 1845, *Published at* 12*s*.

CONTENTS:—Seventh Report of a Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lt.-Col. Sabine, on some points in the Meteorology of Bombay;—J. Blake, Report on the Physiological Action of Medicines;—Dr. Von. Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-Registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings' Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phænomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s*.

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck, on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—J. Percy, M.D., Report on the Crystalline Slags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18s.

CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phænomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables; with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9s.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn, on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10s.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phænomena of Plants and Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s*.

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phænomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840 to the 31st of December, 1849;—R. Hunt on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phænomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Œconomical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phænomena;—Letter from Prof. Henry, to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850, to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Professor Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phænomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain, at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Œconomy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

THE STATE OF THE BOILER AFTER THE EXPLOSION.

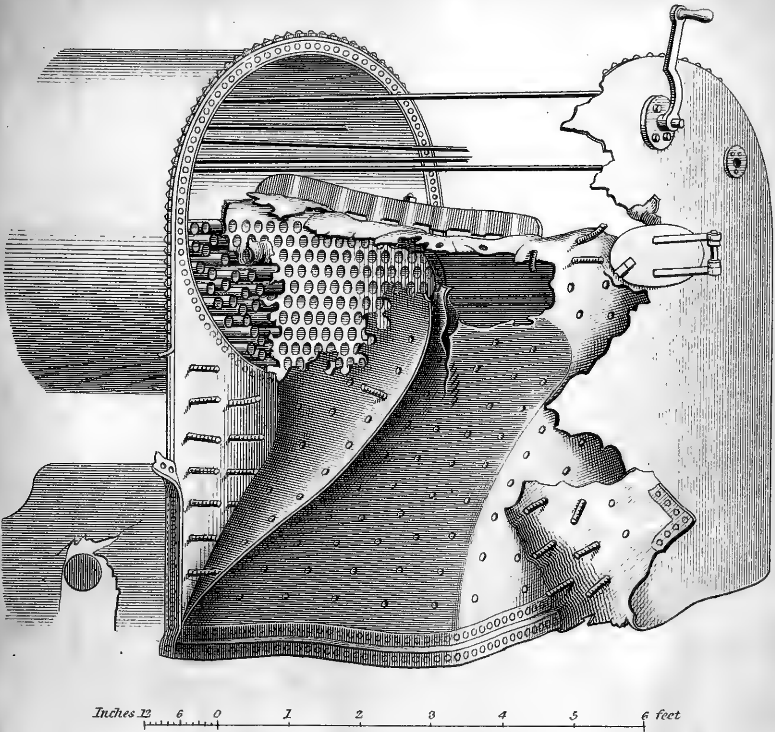
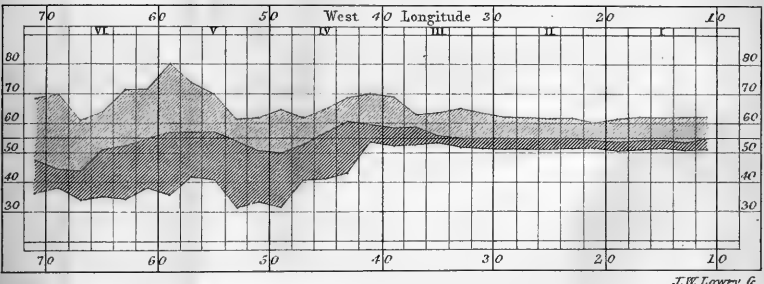
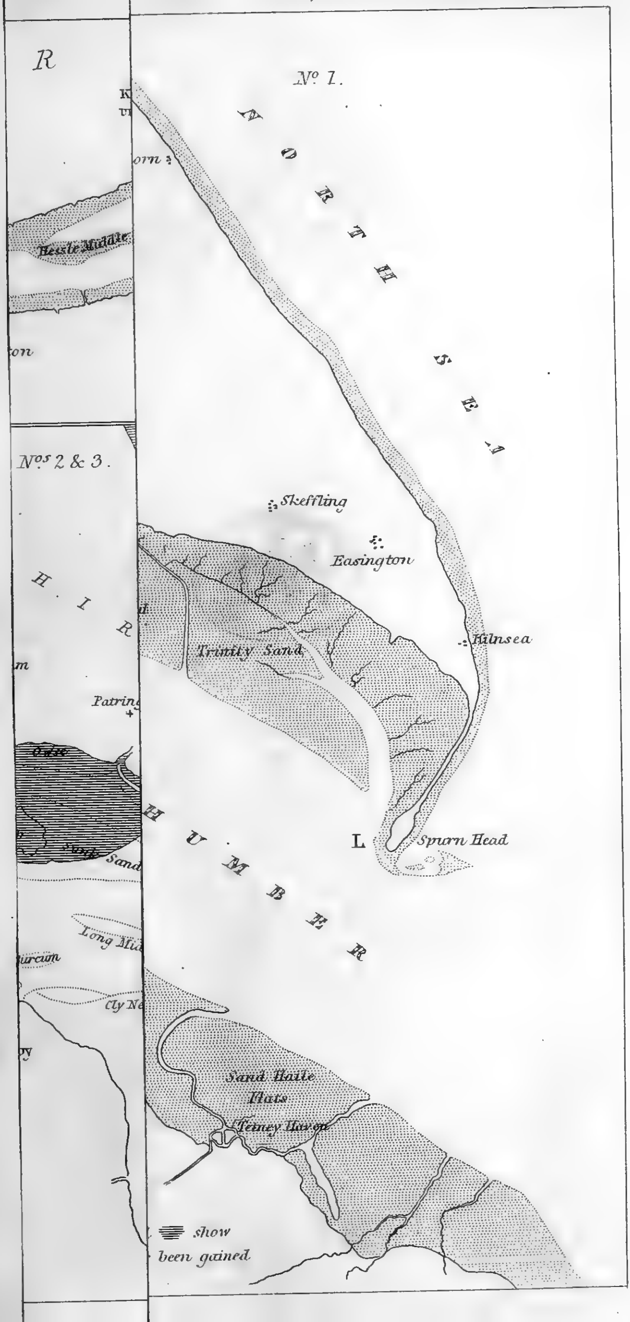


Diagram of the Surface Temperature of the N. Atlantic as derived from 13 passages betwixt the British Channel & New York.



J. W. Lowry sc.

Explanation *The lower zig zag line represents the lowest Temp. recorded in the several meridians traversed within the 13 transatlantic Passages. The middle uneven line, the mean Temp. of all the Observations within each 2° of long. the upper uneven line the highest temperatures observed. The dark straight line represents the mean surface temp. from 1400 observations. The portion shewn by the darker shading represents the range of temp. below the meridional averages the lighter shading that above the special means.*


R
No. 1.
NORTH SEA
Bessle Middle
Nos. 2 & 3.
Skeffling
Easington
Trinity Sand
Kilnsea
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Spurn Head
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HUMBER
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Sand Haile Flats
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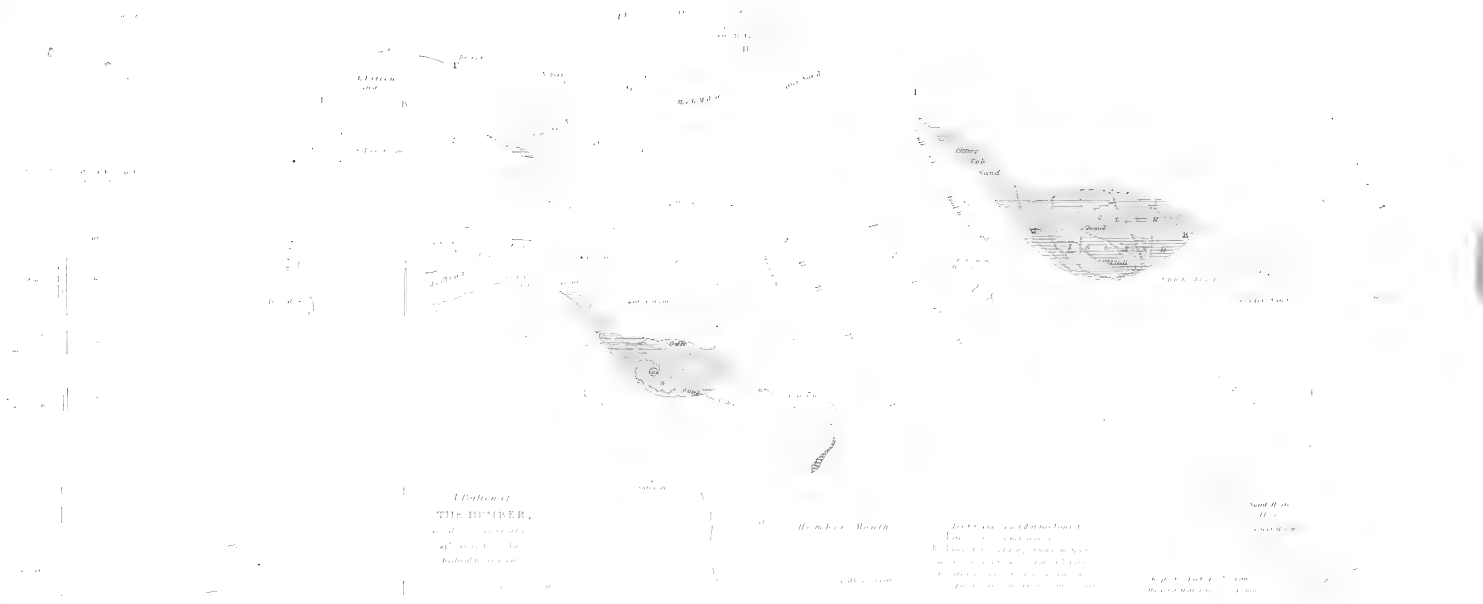
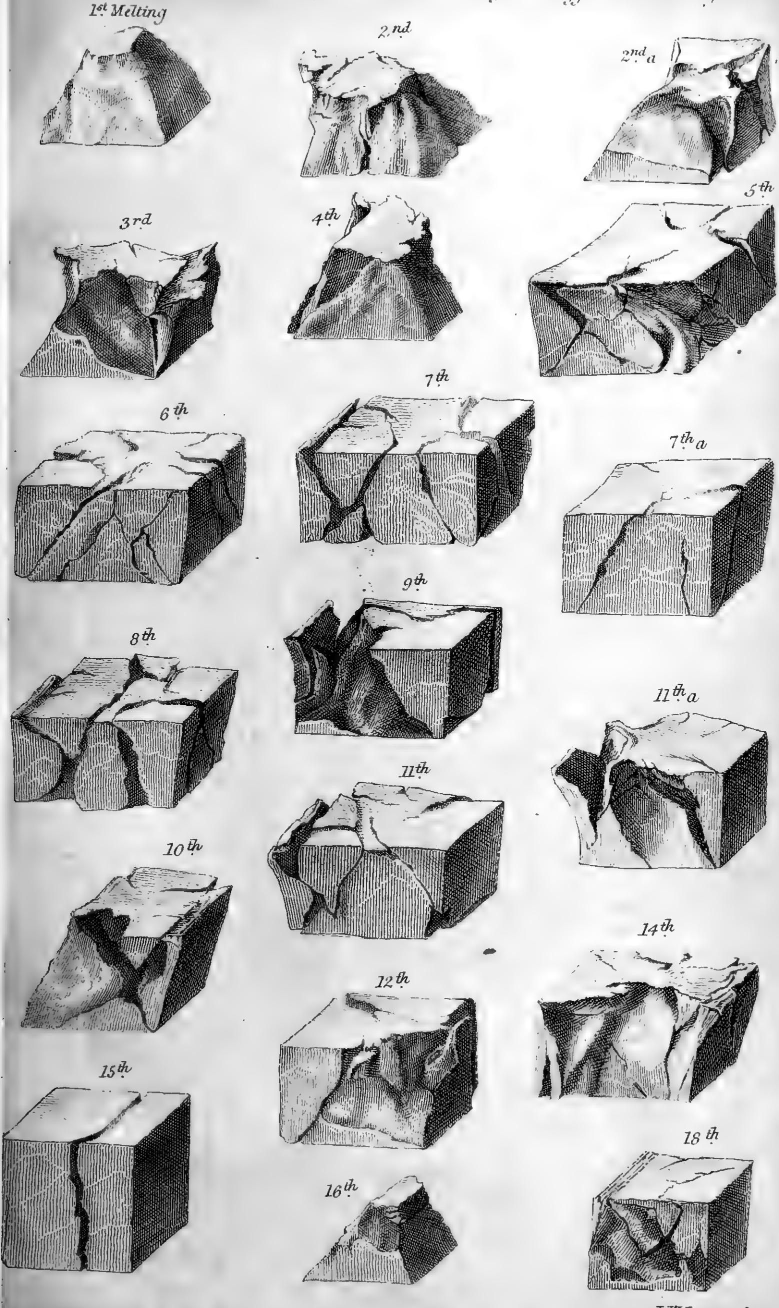

THE HUMBER.
Humber Mouth

Exhibiting the crushed or fractured parts of the different Meltings.



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