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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD

AT PHILADELPHIA,

FOR

PROMOTING USEFUL KNOWLEDGE.

VOL. I.—NEW SERIES.

PHILADELPHIA:

PRINTED AND PUBLISHED BY A. SMALL,
NO. 112, CHESNUT STREET,
[Two doors below the Post-Office.]
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1818.

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District of Pennsylvania, TO WIT:

BE IT REMEMBERED, That on the fourth day of February, in the forty-second year of the Independence of the United States of America, A. D. 1818, ABRAHAM SMALL of the said district hath deposited in this office, the title of a book, the right whereof he claims as proprietor, in the words following, to wit:

"*Transactions of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge.—Vol. I.—New Series.*"

In conformity to the act of the Congress of the United States, intituled, "An Act for the encouragement of Learning, by securing the copies of Maps, Charts, and Books, to the Authors and Proprietors of such copies, during the times therein mentioned."—And also to the Act, entitled, "An Act supplementary to an Act, entitled, 'An Act for the encouragement of Learning, by securing the copies of Maps, Charts, and Books, to the Authors and Proprietors of such copies during the times therein mentioned,' and extending the benefits thereof to the Arts of designing, engraving, and etching historical and other prints."

D. CALDWELL,
Clerk of the District of Pennsylvania.

ADVERTISEMENT.

*OF the six volumes of Transactions heretofore published by the American Philosophical Society, some being out of print, they have Resolved, That the present Volume shall be the **First** of a New Series.*

The following are the Rules adopted for the government of Committees in the choice of papers for publication.

First.—"That the grounds of the Committee's choice of " papers for the press, should always be the importance or singularity of the subjects, or the advantageous manner of treating them, without pretending to answer, or to make the " Society answerable, for the certainty of the facts, or propriety of the reasonings, contained in the several papers so " published, which must still rest on the credit or judgment of " their respective authors.

Secondly.—"That neither the Society nor the Committee of " the press, do ever give their opinion as a body, upon any " paper they may publish, or upon any subject of Art or Nature " that comes before them."

LIST OF THE OFFICERS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

FOR THE YEAR 1818.

PATRON. WM. FINDLAY, GOVERNOR of the STATE of PENNSYLVANIA.

PRESIDENT.	Caspar Wistar.
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SECRETARIES.	Thomas C. James. Robert M. Patterson. John S. Dorsey. W. P. C. Barton.
COUNCELLORS, elected for three years. In 1816.	William White. Horace Binney. John Sergeant. William Rawle.
In 1817.	Thomas Cooper. James Gibson. N. Chapman. S. Colhoun.
In 1818.	Thomas Jefferson. William Maclure. Nicholas Collin. William Meredith.
TREASURER and LIBRARIAN.	John Vaughan.

LIST OF THE MEMBERS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

Elected since the publication of the 6th vol. O. Series, of their Transactions.

AMERICAN MEMBERS.

William Johnson, Charleston, S. C. Judge of the Sup. Court of U. S.
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Robert Adrain, Prof. Math. Col. Coll. N. York.
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George Pollok, do.
Benjamin R. Morgan, do.
John Sergeant, do.
Nicholas Biddle, do.
W. P. C. Barton, M. D. do.
William Meredith, do.
Charles Chauncey, do.
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John Syng Dorsey, M. D. do. Prof. Mat. Med. Univ. Penn.
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N. S. Allison, M. D. Burlington, N. J. (since dead).
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John G. Biddle, Philadelphia.
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Joseph Gardiner Swift, Brig. Gen. U. S. A. and Chief of the corps of Eng.
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John Gummeré, of Burlington, N. Jersey.
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William Meade, M. D. Philadelphia.
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Charles Fenton Mercer, Virginia.
William Gaston, N. Carolina.
Owen Nulty, Philadelphia.
Thomas Say, do.
Thomas Nuttall, do.
Rev. Lewis Schweidnitz, N. Carolina.
Rev. H. Steinhaur, Bethlehem, Penns.

FOREIGN MEMBERS.

Humphrey Davy, F. R. S. London.
John Hayton, M. D. F. R. S. do.
John Mason Good, F. R. S. do.
A. Vauquelin, Prof. de la Chimie des Arts au Jard. des Plantes, Paris.
Jose Correa da Serra, F. R. S. &c. &c. and Min. of H. M. F. M. of Portugal, Brazil and Algarves, to the U. States.
Andrew John Rezius, Prof. Nat. Hist. &c. Lund, in Sweden.
Constant Dumeril, Prof. Zoology, in the Jard. des Plantes, Paris.
Charles Alexander Lesueur, Paris, now in Philadelphia.
Carlo Botta, Paris.
J. C. Delametrie, Paris, (since dead).
J. P. F. Deleuze, Secret. de la Soc. des Ann. du Museum, &c. Paris.
Edward Troughton, F. R. S. London.
J. Peter Frank, M. D. Counsellor of State, &c. Vienna.
Joseph Baron Sonnenfels, do. do.
Joseph Hammer, member of various societies, do.
Johann Severin Vater, D. D. Prof. and Roy. Librarian, Kœnigsb. Prussia.
Frederick Adelung, Counsellor of State, &c. St. Petersburgh.

Conditions of the Magellanic Premium.

MR. JOHN HYACINTH DE MAGELLAN, of London, having some time ago offered as a donation, to the American Philosophical Society held at Philadelphia for promoting useful knowledge, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by the Society, to the author of the best discovery, or most useful invention, relating to navigation, astronomy, or natural philosophy (mere natural history excepted); and the Society having accepted of the above donation, hereby publish the conditions, prescribed by the donor, and agreed to by the Society, upon which the said annual premiums will be awarded.

1. The candidate shall send his discovery, invention, or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name, and place of residence of the author.

2. Persons of any nation, sect, or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention, or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention, or improvement, either in the English, French, German or Latin language.

5. All such communications shall be publicly read, or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication; and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society having previously referred the several communications from candidates for the premium then depending, to the consideration of the twelve councellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year, (of the time and place, together with the particular occasion of which meeting, due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium: and after due consideration had, a vote shall first be taken on this question, viz. Whether any of the communications then under inspection be worthy of the proposed premium. If this question be determined in the negative, the whole business shall be deferred till another

year: but if in the affirmative, the Society shall proceed to determine by ballot, given by the members at large, the discovery, invention, or improvement, most useful and worthy; and that discovery, invention, or improvement, which shall be found to have a majority of concurring votes in its favour shall be successful, and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author pronounced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, either by word or writing, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium, for five years next succeeding the time of their presentment; except such performances as their authors may, in the mean time, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object or subject matter of the communications so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there shall then be two premiums to be awarded the next year. But no accumulation of premiums shall entitle the author to more than one premium for any one discovery, invention, or improvement.

12. The premium shall consist of an oval plate of solid standard gold, of the value of ten guineas; on one side thereof shall be neatly engraved a short Latin motto suited to the occasion, together with the words: The premium of John Hyacinth de Magellan, of London, established in the year 1786; and on the other side of the plate shall be engraved these words: Awarded by the A. P. S. for the discovery of —— A. D.

And the Seal of the Society shall be annexed to the medal by a riband passing through a small hole at the lower edge thereof.

Conditions of the Surplus or Extra-Magellanic Premium.

M. DE MAGELLAN having fixed at ten guineas, the sum to be annually disposed of as a premium, according to the *strict* terms of the donation, and the Magellanic fund having been so managed as to produce an annual surplus, the Society, with a view to promote as far as may be in their power the liberal intentions of the donor, on the 19th of October, 1804, (after giving legal notice to the members),

RESOLVED, That the Surplus Fund arising from the Magellanic Donation, that is, the interest accruing therefrom over and above the ten guineas a year, be employed in the first instance, according to the strict conditions of the donation, if a sufficient number of deserving candidates shall have applied for the same; otherwise that such surplus, or so much thereof as cannot be applied as above, be awarded by the Society (at such times, and under such regulations, as they shall adopt) to the authors of useful inventions or improvements on any subjects, within the general view of the Magellanic Donation, and that the Premium thus to be awarded shall be expressly declared to be from the surplus of the Magellanic Fund.

Regulations respecting the Surplus Magellanic Premium.

1. THE Surplus Magellanic Premium may be awarded at such stated meeting of the Society as shall be agreed to, at a previous stated meeting, due notice being given thereof to its Members.

2. Every communication which shall have been offered with a view to the Magellanic Premium and to which the same shall not have been awarded, shall, (except such as the Society shall not think at all worthy of notice) be again taken into consideration with a view to the awarding of the Surplus Premium, and if such communication shall, at such meeting be thought within the general view of the Donation and to be sufficiently valuable to deserve a public reward, a Surplus Premium may be awarded to the author thereof.

3. The Surplus Premium shall consist of a gold medal of the value of not less than twenty dollars nor more than forty-five dollars, engraved with a similar device to that of the original Premium, except that it shall contain the words "Extra Magellanic Premium," or at the option of the successful candidate the value of such Medal in money accompanied with a diploma on parchment, with the seal of the Society.

4. All the rules and regulations concerning the application for the awarding the original Magellanic Premium shall be adhered to in the case of the Surplus Premium, in so far as they are not hereby modified, or derogated from; unless in very special cases for the rewarding of some essentially useful discovery or improvement, two-thirds of the Members of the Society present at a meeting appointed for the awarding of the Surplus Magellanic Premium, shall, by their votes, taken by ballot or otherwise, direct.

5. The Society shall propose and publish as often as they think proper such a number of subjects as they shall think fit, to which they shall call the attention of the candidates for the original and Surplus Magellanic Premiums, and invite their communications thereon; informing them at the same time that although communications on such subjects will be acceptable to the Society, yet they shall not entitle their authors to a preference over

more meritorious communications on other subjects, equally within the strict or general view (as the case may be) of the Magellanic Donation.

6. Your committee are further of opinion that the Surplus Premium ought not to be exclusively applied to actual inventions or improvements, but may also extend to such valuable communications within the general view of the donation, as may lead to useful discoveries, inventions or improvements, and that they therefore recommend that the resolution of the 19th October be altered accordingly.

This recommendation was acceded to.

Philadelphia, 5th Dec. 1814.

Report of the Historical and Literary Committee to the American Philosophical Society.—Read, 9th Jan. 1818.

IN obedience to the orders of the Society, the Committee of History, Moral Science, and General Literature, have the honour to report the progress that they have made towards the attainment of the objects of their Institution.

It is now upwards of two years since this Committee or Class was added to the six* of which the Society was originally composed. Until that time, the Physical and Mathematical Sciences had been the almost exclusive subjects of our labours. It was then thought that the sphere of our exertions might be usefully enlarged by turning our attention to those sciences which may be called "moral," in contradistinction to those which have the material world for their object.

Among the various branches of knowledge which this circle embraces, the History of America in general, and of Pennsylvania in particular, was pointed out to your committee by a special resolution of the Society, as an object claiming their immediate regard. The humble, but useful task, was committed to us, of collecting as many as possible of the public and private documents scattered in various hands through the union, with leave to publish, from time to time, such selections from them as might, in our opinion, be interesting to the public, and of use to the future historian. Your committee, considering these intimations of the Society in the light of express directions, lost no time in taking measures to comply with their wishes. They were no sooner organised,† than they published an appeal to their

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* Those Committees or Classes are:
1st. Of Geography, Mathematics, Natural Philosophy, and Astronomy.
2d. Of Medicine and Anatomy.
3d. Of Natural History and Chemistry.
4th. Of Trade and Commerce.
5th. Of Mechanics and Architecture.
6th. Of Husbandry and American Improvements.

† The organization of this committee is simple. Their only officers at present are a Chairman, a Corresponding Secretary, and a Recording Secretary. Sub-committees are appointed only on special occasions as they arise.

fellow citizens, a copy of which is subjoined,* soliciting the communication of papers of the above description, and offering the archives of the Society as a safe repository where they might be deposited for the public benefit and the advantage of posterity. Your committee, however, soon found that they had little to expect from this general call, and were satisfied that they must relinquish their object, unless they had recourse to more efficient means.

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* *LITERARY NOTICE, published by the* HISTORICAL AND LITERARY COMMITTEE *of the American Philosophical Society, on the 15th of August,* 1815, *and referred to in the preceding report.*

The American Philosophical Society, being desirous of extending the sphere of its usefulness, and calling into action the talents of those of its members, whose pursuits have been more particularly directed to the moral branches of science, has lately added to the number of its standing committees, *a committee for history, moral science, and general literature.* The number of persons composing this committee is indefinite; every member of the Society has a right to enrol himself within it. Many of our associates having evinced a desire to participate in its labours, the committee has organised itself, appointed its officers, and is now sedulously engaged in promoting the objects of its institution. Among those, the means of obtaining a correct historical and statistical knowledge of our country have appeared to them not the least deserving of their immediate attention. Sensible of the eminent usefulness of the exertions of the societies established in some of the states, for a similar purpose, and particularly in Massachusetts and New York, they are anxious to concur in their patriotic pursuits, and, with that view, have already collected and rescued from oblivion several interesting documents illustrative of the history of the United States and of Pennsylvania.

These will be given to the public in due time, either at large, or by extracts, in the transactions which the committee is authorised by the society to publish under its own responsibility. Meanwhile, they think it their duty to solicit the aid of men of information throughout the Union; but more particularly in Pennsylvania, and those of the other states where no analogous establishments have been formed. The historical memoirs of individuals, public documents, scarce pamphlets, manuscript notes, public and private letters from eminent men, and from men of knowledge and observation; in short, every thing which may be considered as interesting to this country, in an historical, statistical, geographical, or topographical point of view, will be thankfully received, either as a gift to be deposited among the archives of the Philosophical Society, or as a loan, to be returned, after a certain time, to the owner. Communications of interesting facts, known to individuals by their own observation, tradition, or otherwise, are also respectfully solicited.

To their fellow citizens of Pennsylvania, the committee particularly address themselves. Many interesting points of the history of our own state remain to be elucidated. Many important details are yet to be collected respecting the aboriginal Indians, the emigrations from various countries which have so largely contributed to the increase of our population, the history and peculiar tenets and rules of discipline of the different religious sects that are established among us. Information respecting these and other matters connected with the history of this state, and particularly every thing relating to our venerable patriarch and founder, William Penn, and his first associates; their history in Europe and in this country; their political opinions and views of civil government and policy, and the foundations which were laid by them for the prosperity and happiness which we enjoy, will be received with peculiar gratitude.

Our views, however, are not limited by the bounds of any particular state, this appeal is made to the citizens of the United States at large, and we confidently expect, that those members of the American Philosophical Society, who reside in different parts of the Union, remote from the city of Philadelphia, will zealously co-operate in promoting the objects of the committee, who will be happy to see their names inscribed on their roll, and will inscribe them whenever requested.

All communications are to be addressed to the Chairman, or either of the Secretaries.

WM. TILGHMAN, *Chairman.*
PETER S. DUPONCEAU, *Corresponding Secretary*
JOHN VAUGHAN, *Recording Secretary.*

Philadelphia, 14th August, 1815.

Your committee, therefore, after mature deliberation, determined on taking a more direct method to obtain the desired aid. They opened an extensive correspondence with individuals, not only in Pennsylvania, but in other parts of the United States, selecting those in preference whom they thought the most likely to second their views. Although a great number of their applications produced no result, yet they are happy to state that, upon the whole, they have been more successful than they had anticipated, and that they have reason to expect that this system will be productive of still greater advantages in future.

The genuine friends of literature and science, those in whom the love of knowledge is a predominant passion, and who have sufficient leisure to devote a considerable part of their time to its acquisition and advancement, are not very common in any country. It cannot, therefore, be a matter of astonishment, that they should not yet be very numerous in these states, where society has so many calls for the exertions of its members in the more indispensable employments of human life. Your committee, however, have great pleasure in being able to assure the society, that they have found a considerable number of their fellow citizens, able and willing to aid in the promotion of their objects, and from whom they have, in fact, derived very important assistance.

Among those enlightened and truly patriotic citizens, they beg leave, in the first place, to name the late President of this Society, THOMAS JEFFERSON. From the first establishment of this committee, he was pleased to honour us with his valuable correspondence, and has spared no exertions to forward the objects of our institution. To him we are indebted for many important MSS. documents, calculated to throw light on the history of our country, on the customs, manners, and languages of the Indian nations, and various other interesting national subjects. He has lately directed to be placed in our hands several as yet unedited MSS. volumes of scientific notes and observations by Messrs. Lewis and Clarke, made in the course of their journey to the Pacific Ocean. The names of the authors of these volumes sufficiently vouch for the interest of the matter which they contain.

Next to this venerable patron of science, your committee find themselves in duty bound to mention as one of their most zealous as well as useful friends and supporters, Doctor GEORGE LOGAN, of Stenton. He has opened to them the treasures of his family archives, which contain a great number of interesting documents relating to the early periods of the colony of Pennsylvania. Among these, not the least valuable, is the familiar correspondence which was carried on for many years between our illustrious founder, William Penn, Hannah Penn, his interesting wife, and James Logan, the Doctor's grandfather, who, it is well known, was the proprietor's confidential friend and secretary. A lady of the Doctor's family, eminently qualified for the task, has undertaken to arrange those letters in a regular order, and has already communicated to your committee the first MS. volume of the collection, which she has enriched with notes and with introductory matter of much interest. The remainder is in a course of preparation, and when the whole collection is thus completed, it will (if your committee can obtain her permission to publish it) exhibit in a more satisfactory manner than has yet been done, the private character, manners, and habits of the legislator of Pennsylvania, as well as the political line of conduct which he pursued in his government. It will also make us more intimately acquainted with his faithful friend and counsellor, James Logan, of whose classical turn of mind and literary attainments, the library which bears his name, and which he generously gave to the city of Philadelphia, affords sufficient testimony.

Nor should your committee omit paying the tribute of their thanks to our worthy associate, the Rev. JOHN HECKEWELDER, of Bethlehem. The intimate knowledge which this respectable missionary is known to possess of the languages and manners of various Indian nations, among whom he resided more than forty years, pointed him out to us as a person from whom much interesting information could be obtained, nor were our hopes deceived. In answer to the enquiries of your committee, he laid open the stores of his knowledge, and his correspondence gives us a clear insight into that wonderful organization which distinguishes the languages of the aborigines of this country from all the other idioms* of the known world. Through his means your committee obtained the communication of a MS. Grammar of that of the Lenni-Lenape or Delaware Indians, written in German, by the late Rev. David Zeisberger, well known as the author of a copious vocabulary of the same language. This is the most complete Grammar that we have ever seen of any one of those languages which are called *barbarous*. It gives a full, and we believe, an accurate view of those comprehensive grammatical forms which appear to prevail with little variation among the aboriginal natives of America, from Greenland to Cape Horn, and shews how little the world has yet advanced in that science which is proudly called *Universal Grammar*. Through the same means, we are promised the communication of an excellent Dictionary, by the same author, of the Iroquois language, explained in German, which is in the library of the Moravian Brethren at Bethlehem. Your Committee have procured a translation of Mr. Zeisberger's Grammar into English,† and will endeavour to do the same with the Dictionary when received.

Mr. Heckewelder, at the request of your committee, is now engaged in committing to writing the observations which he made in the cause of a long life on the manners and customs of the Indians. To him and Mr. Jefferson we are also indebted for a considerable number of vocabularies of the languages of various Indian nations, particularly of those of the southern tribes, hitherto but little known, of which your committee intend to make a proper use in due time.

Mr. REDMOND CONYNGHAM, a member of the legislature of this state, has testified his zeal for the advancement of knowledge, by procuring for your committee with much labour and some expense, from the office of the Secretary of State at Harrisburg, copies and extracts of the most interesting records of the executive branch of the government, anterior to the period of the American revolution, which will be of great use to the future historian of this commonwealth.

Your committee would have to trespass too long on the attention of the

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* Except, perhaps, the language of the Biscayans or Basques, which professor Vater conceives to be formed on the same model with those of the aborigines of America.

† See the Catalogue of Donations at the end of this book, letter D. p. 440.

Society, were they to attempt to do justice to all those who have contributed their liberal aid to the promotion of their endeavours; they cannot, however, avoid mentioning our associates, Messrs. **William Rawle** and **Joseph P. Norris**, from whom they have received several curious and interesting MSS. documents relative to the early history of this state. From **John D. Coxe**, **Joseph Reed**, and **James Robertson**, Esqs. and the Rev. Dr. **Wm. Rogers**, all of this city, they have to acknowledge the receipt of a great many scarce books and pamphlets, which are indispensably necessary for a correct knowledge of the history of that period. Mr. **Wm. Graham**, of Chester, has presented us with a complete set of the Journals of the general assembly of Pennsylvania, from the first settlement of the colony down to the revolution, now become very scarce. The numerous donations of historical and statistical works which, within the last two years, have been made to the Society, attest the exertions of your committee, and the zeal and liberality of its friends.

Your committee are continuing to pursue the same course with unabated ardour. They are gradually extending their correspondence, indulging and soliciting the utmost freedom of literary intercourse, by which means as they increase their own stock of knowledge, they hope to contribute to keeping up that laudable spirit of enquiry and research, which the observing eye cannot but perceive to be increasing in our country.

Your committee are well aware that they are sowing seeds which cannot be expected to produce immediate fruits. Yet they cannot resist the pleasing hope that in consequence of their unremitted exertions, from the bosom of this Society may arise future historians, and other literary characters, who will one day do honour to the land that gave them birth.

To facilitate the labours of such men, your committee intend to avail themselves of the permission which the Society has given them, of publishing, from time to time, under their own responsibility, selections from the materials which they have on hand, and may hereafter obtain. The praise of zeal and industry is all to which they can aspire; it will be the task of genius to prove hereafter to the world that their labours have not been entirely useless. With this flattering expectation, they feel supported and encouraged to go on with the performance of the duty assigned to them.

All which is respectfully submitted.

By order of the Committee,

WM. TILGHMAN, Chairman.

PHILADELPHIA OBSERVATORY.

THE following ordinance of the Select and Common Councils of the City of Philadelphia, granting a large and elegant public building, in the Centre Square of this City, as an *Astronomical Observatory*, was passed in consequence of a memorial on the subject, presented by the American Philosophical Society.

This building is situated in the centre of a circular area of 520 feet in diameter, at the intersection of Market and Broad Streets, the first running east and west, 100 feet in width; the second north and south, 113 feet in breadth, so that the view towards the four cardinal points is not intercepted. It is erected on a ground plan of 60 feet square, on which is a basement story 21 feet in height, having porticos on the east and west fronts; from this basement, as a pedestal, rises a circular building or rotunda, 40 feet in diameter and 59 feet in height, pierced with sixteen windows and surmounted by a dome. This building was originally constructed to contain machinery for the introduction of water into the City, but late arrangements adopted for this purpose, have rendered this application of it unnecessary. It was designed by Mr. Latrobe, and built entirely of Pennsylvania marble. It is believed that it may be made very suitable for the object for which it is now appropriated, and the Society are at present occupied in making the necessary arrangements for this effect.

AN ORDINANCE

Granting to the American Philosophical Society, held at Philadelphia, for promoting Useful Knowledge, the use of certain parts of the Centre Engine House, for an Astronomical Observatory.

SECT. I. BE it ordained and enacted by the Citizens of Philadelphia, in Select and Common Councils assembled, That the City Commissioners shall, from and immediately after the passing of this ordinance, demise and let to the American Philosophical Society, held at Philadelphia, for promoting useful knowledge, for and during the term of seven years from the execution of the said lease, for the yearly sum or rent of one dollar, to be paid at the expiration of each and every year, the herein after-mentioned parts of the building at the Centre Square, known by the name of the Centre Engine House, to be used by the Society as an Astronomical Observatory; that is to say, the south-east and north-west rooms in the basement story, together with the use of the passage between the said rooms; so much of the circular part of the said building as is above the basement story, and the roof of the said story.

Sect. II. Be it further ordained and enacted, That in order that the before-mentioned parts of the said building may be rendered suitable for the purposes aforesaid, it shall and may be lawful to and for the said American Philosophical Society, at the proper cost and charge of the same, to make and cause to be made the herein after described alterations in the parts of the said building, to be so as aforesaid demised and let to the said Society; that is to say, they may remove and take away any part, or the whole of the arch forming the ceiling of the south-west room in the basement story of the said building, and make and construct in the said room a stairway, leading to the roof of the said story; also to make, construct, and build upon the said roof, a flat terrace roof; *provided*, the same shall not be raised higher than the top of the lowest part of the parapet wall, as the same now is; and also to make, form and construct in the circular part of the said building a floor, which shall be upon a level, or as nearly so as may be, with the before-mentioned terraco roof.

Provided always, That the said alterations, or any of them, shall not in any manner whatever change the present external appearance of the said Centre Engine House; *and also*, that the demised parts of the same shall, during the term for which they shall be in the occupancy of the said Society, be kept and maintained in repair at the proper cost and charge of said Society.

Enacted into an Ordinance at the city of Philadelphia, this twenty-sixth day of December, in the year of our Lord one thousand eight hundred and seventeen.

JAMES S. SMITH,
President of the Common Council.

ROBERT WALN,
President of the Select Council.

JOHN C. LOWBER,
Clerk of the Common Council.

Hall of the Society, 9th Jan. 1818.

AT a meeting of the American Philosophical Society, held at Philadelphia, for promoting useful knowledge, this day specially convened, it was

Resolved, That the Society feel a high sense of the liberality of the City Councils in the grant which they have made of the building in the Centre Square for an Astronomical Observatory, and that the president, Caspar Wistar, be directed to present to the Councils the sincere acknowledgments of the Society for the aid which they have thus afforded to the advancement of science.

True extract from the minutes.

R. M. PATTERSON, *Secretary.*

OBITUARY NOTICE.

SINCE the publication of the last volume of Transactions, the Society has had the misfortune to lose several of its most valuable members. Our two vice-presidents, Dr. BENJAMIN S. BARTON, and Gen. JONATHAN WILLIAMS, died within a short time of each other. The former by his extensive Botanical knowledge, and his various Philosophical and Philological writings, widely spread among foreigners the literary reputation of this country. The talents of the latter, though not unnoticed abroad, were best known to his fellow-citizens, to whom his virtues had peculiarly endeared him.

In the death of Dr. BENJAMIN RUSH, humanity has suffered a loss, as well as this Society, and our country. The memory of this eminent physician will be preserved as long as science and genius are held in honour among us.

ROBERT FULTON and ROBERT R. LIVINGSTON have also left us for a better world. Who can calculate the benefits that will result to mankind from the successful application of the powers of steam to the navigation of rivers, lakes, and seas, for which we are indebted to the genius of the one, and the patriotic enterprise of the other? Already the most distant parts of our extensive territory are brought into contact, as it were, with each other; and in this happy effort of talent and perseverance, we see an additional bond to the union of these states.

The mournful list is not yet closed. Other eminent men whom we were proud to number among our associates, claim the tribute of our sorrow. The reader has already anticipated the names of those great lawyers and statesmen, THOMAS M'KEAN and ALEXANDER JAMES DALLAS. To them we must add RAMSAY, the Historian of the United States, and DUNBAR, the self-taught Astronomer of the woods, whose communications have so often enriched our volumes, and reflected credit on the Society. We have also to regret the loss of WILSON, the American Ornithologist; the Botanist MUHLENBERG; LEWIS, the successful explorer of the vast tract of country that lies between us and the Pacific Ocean; BARLOW, who first attempted to tune the American lyre to heroic sounds; KUHN, the pupil of Linneus, who ranked so high among the eminent physicians of this city; and MILLER, of New York, no less famed for his medical knowledge.

Nor must we omit to pay due respect to the memory of our learned and amiable associate DU PONT DE NEMOURS, who at the close of a long life left a country which he honoured, to end his days in the bosom of his American friends and of this Society, for which he always felt and expressed a peculiar predilection. Not the allurements of his native home, nor the distinguished honours lavished upon him by his discerning sovereign, could shake his firm resolve to live and die among us. He has left us his ashes, the memory of his worth, and the care of his honourable fame.

If a strong attachment to our country, evidenced by the most unequivocal acts, has entitled Du Pont de Nemours to be classed among our *American associates,* may we not justly pay the same tribute of respect to the memory of the learned Professor C. D. EBELING, of Hamburg, who made America the almost exclusive subject of his interesting labours? At a great expense, and by means of an extensive and unremitted correspondence with literary characters and others in this country, he procured the largest and most valuable collection, perhaps, that exists in the world, of documents relating to American affairs, and by that means was enabled to compose and publish his Geography of the United States, of which he has left us only seven volumes, containing the description of the states from New Hampshire to Virginia, inclusive. He had provided materials for describing in the same manner the southern and western states, and had in contemplation to revise the whole work when death arrested his labours. His memory justly deserves to be held by us in grateful remembrance.

By this summary notice it is only intended to recal to our minds the memory of the great and good men whose loss we deplore, and to point them out as examples worthy of imitation.

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Since the above was sent to the press, the Society had to lament the loss of their venerable president, Dr. CASPAR WISTAR, who died on Thursday the 22d of January, of a severe attack of typhus fever.

Dr. WISTAR was elected a member of the Society in 1787; was chosen a vice-president in 1795; and, on the 2d of January, 1815, was raised to the presidential chair, in the room of *Thomas Jefferson,* who had declined a re-election.

The Society, desirous of testifying their deep sense of the loss which they have sustained in the death of their late president, and of paying a deserved tribute to his talents and virtues, have resolved, that a Funeral Oration be pronounced in honour of his memory, and have appointed William Tilghman, chief justice of the state and one of their vice-presidents, to perform this melancholy duty.

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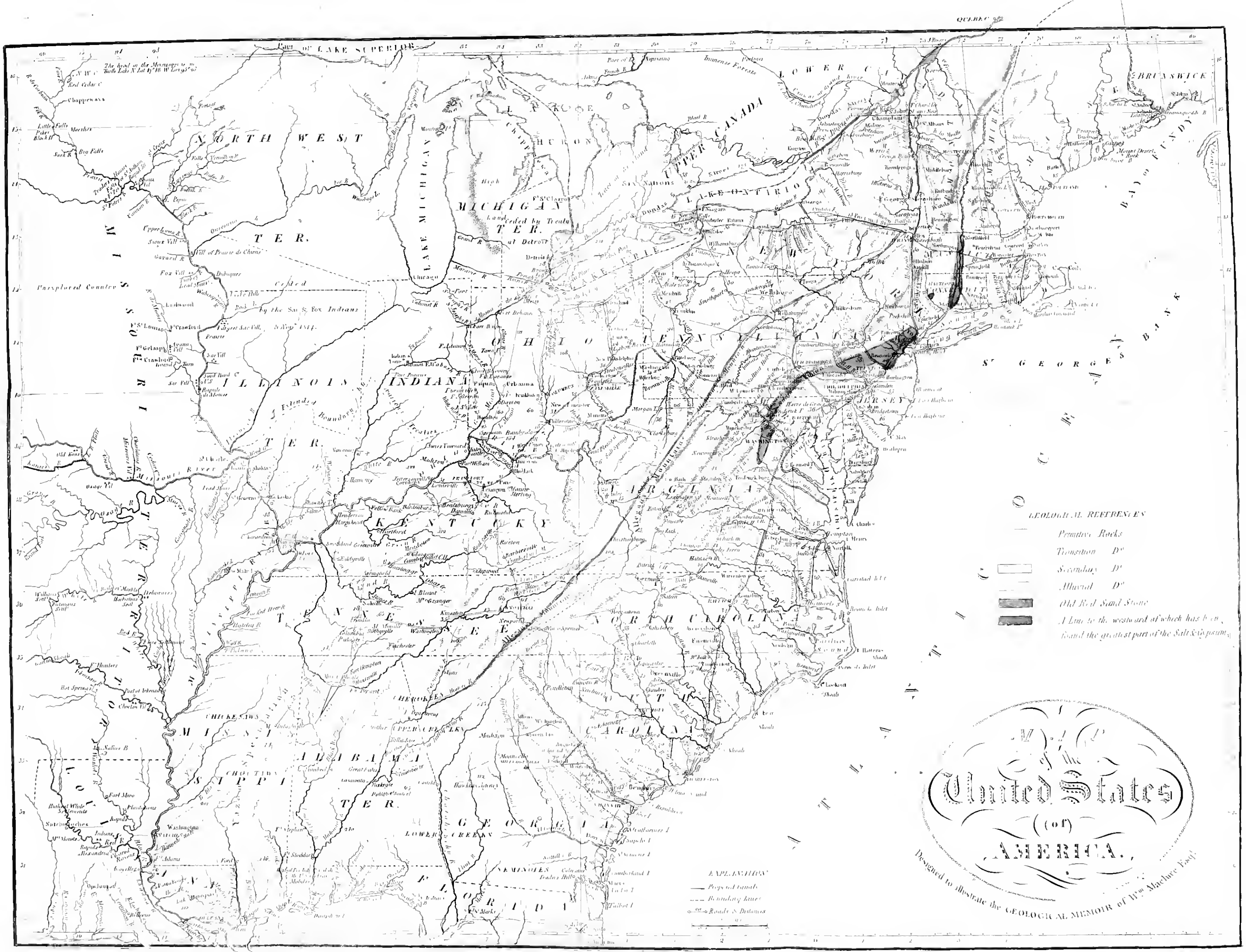

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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

NEW SERIES.

No. I.

*Observations on the Geology of the United States of North America; with Remarks on the probable Effects that may be produced by the Decomposition of the different Classes of Rocks on the Nature and Fertility of Soils: applied to the different States of the Union, agreeably to the accompanying geological Map. With two Copper Plates. By William Maclure.—Read May 16th, 1817.**

PRELIMINARY OBSERVATIONS.

ALL inquiry into the nature and properties of rocks, or the relative situations they occupy on the surface of the earth, has been much neglected. It is only since a few years that

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* Report.—The committee to whom has been referred Mr. Maclure's Observations on the Geology of the United States, beg leave to report:

They are fully aware that a former edition of this gentleman's observations on the geology of our country, has already been published in the last volume of the memoirs of this Society. Since that period, Mr. Maclure has visited a great portion of Europe as a geologist, and has also travelled over some parts of the United States expressly to re-examine and correct his acit has been thought worth the attention of either the learned or unlearned; and even now, a great proportion of both, treat such investigations with contempt as beneath their notice.

The Germans were amongst the first who began to make accurate observations in this branch of science. **Werner** reduced the nomenclature to some regular form, and founded his system on the relative situations of the different classes of rocks. Although subject to all the errors inseparable from systems founded upon a speculative theory of origin, the system of Werner is still the best and most comprehensive that has yet been formed.

Why mankind should have so long neglected to acquire knowledge so useful to the progress of civilization—why the substances over which he has been daily stumbling, and without whose aid he could not exercise any one art or profession, should be the last to occupy his attention—is one of those problems, perhaps only to be solved by an analysis of the nature and origin of the power of the few, over the many.

The science of Geology, until lately, has been confined to speculative theories on the origin and formation of the earth. Whether they have made any progress toward the discovery of that hidden mystery, or whether the last theory is nearer the truth than the first, is difficult to decide; for we have no data, no scale by which we can measure their relative merits. Each new theory is ushered in, by its author attempting to refute all former theories; but it is still doubtful whether success will repay the labour of so many men of brilliant imaginations, who have exerted their talents to make the discovery

count of the geology of those portions of the country. The former memoir has accordingly received many additions and improvements which hardly admit of being published separately. Under these circumstances, the committee are of opinion that the memoir in its present form, is highly deserving of being inserted in the Society's volume, as a deliberate, well considered account of the geology of the United States, corrected by eight years additional observation and reflection, since the former edition; and they recommend its insertion accordingly.

May 22d, 1817.

CASPAR WISTAR.
THOMAS COOPER.
ZACCHEUS COLLINS.

of the earth's origin. Meanwhile, the useful application of the substances found on the earth's surface, to arts, manufactures and science, has been rapidly progressing in proportion to the increase of positive knowledge; following in this respect, during great part of the last fifty years, the usual steps of rational civilization.

In all speculations on the origin, or agents that have produced the changes on this globe, it is probable that we ought to keep within the boundaries of the probable effects resulting from the regular operations of the great laws of nature which our experience and observation has brought within the sphere of our knowledge. When we overleap those limits, and suppose a total change in nature's laws, we embark on the sea of uncertainty, where one conjecture is perhaps as probable as another; for none of them can have any support, or derive any authority from the practical facts wherewith our experience has brought us acquainted. The equator has been supposed to have been once where the poles are now, to account for the bones of the animals now living near the tropics being found in the higher latitudes; yet without any change either in the poles or equator, it is certainly not impossible but even probable, that these animals, before their tyrant man obstructed their passage, might migrate to the north during nearly three months of the summer; and might have a sufficient quantity of heat, and a much greater abundance of nourishing vegetable food, than the torrid zone could afford them at that season.

There does not appear to be any thing either in the climate or food that could prevent the elephants, rhinoceroses, &c. from following the spring into the north, and arriving in the summer even to the latitude of 50 or 60 degrees, and retiring to the warmer climates on the approach of the winter; on the contrary, it would appear to be the natural course of things, and what I believe our buffaloes in the uninhabited parts of our continent still continue to do; that is, to migrate in vast droves from south to north, and from north to south, in search of their food, according to the season.

The birds and the fish continue their migrations, passing by roads out of the reach of man; the natural change of place which their wants require, has not been barred and obstructed by the united power and industry of the lords of the creation.*

To specify the many practical advantages arising from the knowledge of the nature and relative positions of the rocks which cover the surface of the earth, would require volumes. Here, it is only proposed to mention a few, which almost every man, during some period of his life, may find the necessity of resorting to.

First, from the knowledge of the relative situation of rocks and from an accurate investigation of the usual succession of one species of rocks to another, we are guided in our search for coal, gypsum, salt, limestone, millstones, grindstones, whetstones, &c.; as well as the probable places where to look for all kinds of metallic veins and repositories: for example, coals have not been found under any species of primitive rocks; of course, we should not look for them in that class, and if when digging for coal, we should come to the primitive rocks, we should desist. Coals have not been found in any profitable quantities under any considerable bed of limestone, &c. &c. Wolfram accompanies tin in the greatest part of the tin mines; of course the appearance of wolfram is a sign, that most probably tin may be found in the vicinity, &c. Great sums of money have been lost in the United States, and in other countries, by digging for substances among classes of rocks, which have never been found to contain them elsewhere; and of course the probability was against their being found in that class of rocks here.

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* Until lately we have restricted nature to two modes of acting; by fire, and by water: now, it is found, that she can change and metallize rocks in the dry way, without any solution or fluidity; and the galvanic pile may be formed in the stratifications of a mountain, as well as in a chemist's laboratory. These are two other modes wherein we must now allow her to change and modify the surface of this earth? and who can say how many more means yet unknown, she may possess; each of which, when found out by accurate and impartial observation, must make a change in former theories.

A knowledge of the nature and properties of rocks, and the results of their decomposition, enables us to judge of their hardness, easy or difficult decomposition, their component parts, mode of splitting, *&c.* by which we judge of their fitness for house buildings, roofing, road making, burning for lime, china or pottery, brick making, glass making, hearths for forges and furnaces, *&c.* We likewise know, by previous experience, the nature and richness of any metallic ore that may be found, and can calculate from the expense of procuring any ascertained quantity, whether the mine will pay for the working. It is thus we may avoid the losses of digging for species of ore, such as pyrites, that is worth little or nothing; as well as expending money in working a mine that was not rich enough to pay the labour. Much money might be saved by this kind of knowledge, in road making, where it frequently happens that a rock, such as limestone, slate, serpentine, *&c.* which would not perhaps last three months, is taken in preference to a quartz or hornblende rock, that would wear one or two years. Expense is often incurred by making and burning bricks, that are useless from the clay containing too great a quantity of calcareous matter; or of burning lime when the stone attempted to be burned contains too little of calcareous, and too much of argillaceous or other foreign matter, which prevents it being reduced to quicklime; all which, the proper application of a small quantity of acid might prevent.

It may be objected, that there are professional men who will give advice on these subjects, on better terms than we can acquire ourselves the necessary knowledge; but it is sometimes the case with all kinds of counsellors, that they are more interested in the profits of the process, than in the profits of the result: and when it is considered, that less than half the time necessary to give a smattering of any of the dead languages at our academies, would be more than sufficient to give our youth a complete knowledge of the common and useful applications of earths and rocks, we may reasonably hope that ere long some portion of time will be appropriated in our colleges and universities, to studies of undisputed utility; and that a knowledge of substances, their properties and their uses, will be permitted in some degree to encroach on the study of mere words. The time seems fast approaching when what is called learning will not in all cases be deemed, as it has been in too many, synonymous with knowledge.

The greatest part of the first and second sections of these observations was published in the sixth volume of the Philosophical Transactions, at Philadelphia, with the geological map. This was afterwards translated into French, and published in the Journal de Physique, for February, 1812, accompanied also by a geological map; since which we are indebted to the active attention of Dr. S. L. Mitchill,* for the only correction that has since been made, which consists in extending the alluvial over the whole of the east end of Long island, whereas we had supposed that the alluvial of the northern skirts of the island had rested on primitive. During an excursion last summer, an opportunity was afforded of ascertaining and extending the limits of the transition in the states of Pennsylvania and New York, as well as the boundaries of the great primitive formation, north of the Mohawk; and fixing the limits of the transition on Lake Champlain and in the state of Vermont with more precision.

The third and fourth sections, are an attempt to apply Geology to agriculture, in showing the probable effects the decomposition of the different classes of rocks may have on the nature and fertility of soils. It is the result of many observations made in Europe and America, and may perhaps be found more useful in the United States than in Europe, as more of the land is in a state of nature, not yet changed by the industry of man.

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* Dr. Bruce's Mineralogical Journal, vol. i.

CONTENTS.

SECTION I.

General Remarks on the Method of pursuing Geological Researches, with a few Observations on the different Chains of European Mountains, compared with those of the United States of America.

The examination of the different substances which cover the exterior of the globe, may be commenced and pursued in two ways, both leading to the same point, though by opposite roads. The *first*, beginning by an accurate investigation of a small portion of the surface, describing exactly the different rocks, with their immense variety of arrangement in the position of their component parts, detailing the changes accidental or natural constantly occurring in their relative situation, and endeavouring to reduce the whole into some regular series of arrangement. This method necessitates the reunion of a great number of those portions, before any correct general ideas can be formed.

The *second*, beginning with the great outlines, traces the limits which divide the principal classes of rocks, and their relative situations and extents; leaving the examination of the vast variety, contained in each class, to be regulated by the general principles previously acquired.

The method founded on accurate observation, though limited in extent, would appear to be the best, and confirmed by the practice of acquiring all the other sciences; and yet on a further examination, there are serious objections arising from the difficulty of the execution, on account of the great variety and imperceptible shades of gradation from one kind of rock to another; which would render the nomenclature extensive and intricate, necessitating long and voluminous descriptions, conveying imperfect ideas, that rather fatigue than instruct: for example, it would require a volume to describe all the varieties of rocks found in a range of forty leagues of the primitive formation; and in two leagues, either to the right or left of the same range, the changes would fill another volume.

In tracing the outlines of the different formations in most countries, there is less confusion and embarrassing description necessary; the limits once ascertained, a few pages define the boundaries, and explain the relative situations to the comprehension of every reader. For example: in the north of Europe, Norway is primitive with a few exceptions, the greatest part of which is the basin surrounding Christiania, which is transition. Sweden is primitive, except the southern part in Scania, and part of the coast of the Categat, with some of the borders of the great lakes, which are secondary. Both sides of the gulf of Bothnia to the North cape, and from thence through Finland to St. Petersburg are primitive. From St. Petersburg to the secondary limestone of the Crimea is alluvial, except in three places, a narrow bed of chalk at Sewsk, twelve posts south-west of Tula, between Bogouslaw and Corsoun, eight posts south of Kiew, and from Elisabethgrad four posts to Wodinaria, where the primitive appears in the beds of the rivers. The secondary limestone of the Crimea is succeeded by the transition, about one and a half league south of Simphiropol, and the whole range of mountains along the Black sea on the south side of the Crimea is transition.

The south side of the Baltic is an extensive alluvial formation, bounded in Poland by the secondary limestone at the foot of the Carpathian mountains, in Silesia and Saxony by the edge of the secondary limestone that covers the foot of the Bohemian mountains, and so along the Thuringwald and Hartz to the North sea. Between these mountains and the Baltic, is one continued plain of alluvial with few or no exceptions, the exact limits of which would be easily ascertained, and still more easily described, to the understanding of every one; even the omission of some exceptions would not materially affect the utility, as they would be rectified by the next observer.

Another inconvenience seems to arise out of the method of examining minutely a small portion, or part of one range of mountains, and that is the formation of a system which, though according exactly with the structure of the country examined, is too often in contradiction with the nature and formation of most others; tending in very many cases to perplex the reader, and throw the whole into discredit. In the present state of geological knowledge, an accurate definition of the rocks, commonly found united in great and extensive masses, with the limits of separation between them and rocks of the other great classes or formations, might perhaps be the plainest and most certain mode of increasing our knowledge, correcting the errors of the vast number of old, and throwing more light on the formation of new systems.

The short period of time that mankind seem to have been capable of correct observation, and the minute segment of the immense circle of nature's operations, that has revolved during the comparatively short period, renders all speculations on the origin of the crust of the earth mere conjectures, founded on distant and obscure analogy. Were it possible to separate this metaphysical part from the collection and classification of facts, the truth and accuracy of observation would be much augmented, and the progress of knowledge much more certain and uniform; but the pleasure of indulging the imagination is so superior to that derived from the labour and drudgery of observation—the self-love of mankind is so flattered by the intoxicating idea of acting a part in the creation—that we can scarcely expect to find any great collection of facts, untinged by the false colouring of systems.

The peculiar structure of the continent of North America, by the extended continuity of the immense masses of rocks of the same formation or class, with the uniform structure and regularity of their uninterrupted stratification, forces the observer's attention to the limits which separate the great and principal classes; on the tracing of which, he finds so much order and regularity, that the bare collection of the *facts* partake somewhat of the delusion of theory.

The prominent feature of the eastern side of the continent of North America, is an extended range of mountains, running nearly north-east and south-west from the St. Lawrence to the Mississippi, the most elevated parts as well as the greatest mass of which consists of *primitive* as far south as the Hudson river, decreasing in height and breadth as it traverses the state of New Jersey. The primitive occupies but a small part of the lower country, where it passes through the states of Pennsylvania and Maryland, where the highest part of the range of mountains to the west consists of transition, with some intervening vallies of secondary. In Virginia, the primitive increases in breadth, and proportionally in height, occupying the greatest mass, as well as the most elevated points of the range of mountains in the states of North Carolina and Georgia, where it takes a more westerly direction.

Though this primitive formation contains all the variety of primitive rocks found in the mountains of Europe, yet neither their relative situation in the order of succession, or their relative heights in the range of mountains, correspond with what has been observed in Europe. The order of succession from the clay state to the granite, as well as the gradual diminishing height of the strata, from the granite through the gneiss, mica slate, hornblende rocks, down to the clay slate, is so often inverted and mixed, as to render the arrangement of any regular series impracticable.

No secondary limestone has been found on the south-east side of the primitive, nor any series of other secondary rocks, except some partial beds of the old red sandstone formation, which partly cover its lower edge; in this, it seems to resemble some of the European chains, such as the Carpathian, Bohemian, Saxon, Tyrolian and Alpine or Swiss mountains; all of which, though covered with very extensive secondary limestone formations on their north and west flanks, have little secondary limestone on their southern and eastern sides.

The old red sandstone above mentioned, covers partially the lower levels of the primitive, from twelve miles south of Connecticut river to near the Rappahannock, a range of nearly four hundred miles: and though often interrupted, yet retains through the whole distance that uniform feature of resemblance so remarkable in the other formations of this continent. The same nature of sandstone strata is observable, running in nearly the same direction, partially covered with wacke and greenstone-trap, and containing the same metallic substances. The above uniformity is equally observable in the great alluvial formation which covers the south-east edge of the primitive, from Long island to the gulf of Mexico, consisting of sand, gravel, &c. with marsh and sea mud or clay, containing both vegetable and animal remains, found from thirty to forty feet below the surface.

Along the north-west edge of the primitive, commences the *transition* formation, occupying, after the primitive, some of the highest mountains in the range, and appears to be both higher and wider to the west in the states of Pennsylvania, Maryland, and part of Virginia, where the primitive is least extended, and lowest in height. It contains all the varieties of rocks found in the same formation in Europe, as the mountains in the Crimea, &c. and resembles in this the chain of the Carpathian, Bohemian and Saxon mountains, which have all a very considerable transition formation, succeeding the secondary limestone on their northern sides. Anthracite has been found in different places of this formation, and has not yet been discovered in any of the other formations in North America.

The necessity of such a class or division of rocks as the *transition*, has been doubted by some, nor is it now generally used in the south of Europe; but such rocks are found, and in very considerable quantities, in almost every country that has been examined. There are only two classes, the primitive or secondary, in which they can be placed. They are excluded from the primitive, by containing pebbles, evidently rounded by attrition when in an insulated state, and by the remains of organic substances being found, though rarely, in them; and yet many of the variety of transition rocks, such as the grey wacke slate, and quartzose aggregates, are hardly distinguishable from primitive slate and quartz when fresh:

it is only in a state of decomposition, that the grain of the transition rocks appears, and facilitates the discrimination.

If they are placed with the secondary, they would form another division in the class, already rather confusedly divided; as their hardness, the glossy, slaty, and almost chrystalline structure of the cement of a great proportion of the transition aggregates, would exclude them from any division, as yet defined, of the other secondary rocks. Besides the objections arising out of their individual structure, the nature of their stratification removes them still further from the secondary, and makes them approach still nearer to the primitive. They are found regularly stratified, generally dipping at an angle above twenty and not exceeding forty-five degrees from the horizon; whereas, the secondary rocks are either horizontal or undulating with the inequalities of the surface. A bed of grey wacke, or grey wacke slate and transition limestone, runs south-west from the Potomac to near the Yadkin river, a distance of two hundred miles, from one to five miles in breadth, having the primitive formation on each side, dipping the same as the primitive, though at a less angle, the strata running in the same direction; and from its relative situation, dip, and stratification, bearing no characters of the secondary, not having been yet found alternating with secondary rocks, it cannot be classed with them, without destroying all order and introducing confusion. To class it with the primitive, would be making the primitive include not only aggregates composed of pieces of different kinds of rocks rounded by attrition, but also limestone with a dull fracture, coloured by organic or other combustible matter, which it loses by being burnt. It would perhaps add to the precision of the classification, if this class was augmented by placing some of the porphyritic and other rocks in it, which are more of an earthy than chrystalline fracture, but which at present are considered as primitive.

It might have been as well if, when giving names to the different classes of rocks, all reference to the relative period of their origin or formation had been avoided; and in place of *primitive* and *secondary*, some other names had been adopted, taken from the most prominent feature or general property of the class of rocks intended to be designated, such as perhaps chrystalline in place of primitive—deposition or horizontal in place of secondary, &c.; but as those old names are in general use, and consecrated by time and long habit, it is more than probable that the present state of our knowledge does not authorise us to change them. The adoption of new names, on account of some new property discovered in the substance is the cause of much complication and inconvenience already; and if adopted as a precedent in future, will create a confused accumulation of terms calculated to retard the progress of the science. When we change the names given to defined substances, by those who went before us, what right have we to suppose, that posterity will respect our own nomenclature?

On the north-west side of the transition formation, along the whole range of mountains, lays the great *secondary* formation, which, for the extent of the surface it covers and the uniformity of its deposition, is equal in magnitude and importance, if not superior, to any yet known: there is no doubt of its extending to the borders of the great lakes to the north, and some hundred miles beyond the Mississippi to the west. We have indeed every reason to believe, from what is already known, that the limits of this great basin to the west, is not far distant from the foot of the Stony mountains: and to the north, that it reaches beyond Lake Superior, giving an area extending from east to west from Fort Ann, near Lake Champlain, to near the foot of the Stony mountains, of about fifteen hundred miles, and from south to north from the Natchez to the upper side of the great lakes, about twelve hundred miles.

This extensive basin is filled with most of the species of rocks, attending the secondary formation elsewhere, nor is their continuity interrupted on the east side of the Mississippi by the interposition of any other formation except the alluvial deposits on the banks of the large rivers. The foundation of most of the level countries is generally limestone, and the hills or ridges in some places consist of sandstone: a kind of dark coloured slaty clay, containing vegetable impressions, with a little mixture of carbon, frequently alternates with all the strata of this formation, the whole of which is nearly horizontal. The highest mountains are on the external borders of the basin, gradually diminishing in height towards its centre.

Two divisions of the secondary formation common in Europe have not yet been discovered in this—the chalk formation, and what Werner calls the newest floetz-trap formation. The limestone generally found in this basin is of a bluish colour, running through all the shades to a dingy black, having an even, rather earthy fracture, and sometimes a schistose structure. The flints found in the secondary limestone in America, are generally black, resembling the Lydian stone, and in all kind of irregular forms and branches intimately mixed with the limestone. The limestone, which often follows the chalk formation in countries where chalk has been found, is generally of a white, running into a drab or light-brown colour, a smooth, compact, conchoidal, almost resembling the flinty fracture; having in some parts of the stratum rounded nodules of flint, interspersed apparently without order; the flints in some places light coloured, in others dark; and some of the nodules whitish on the outer edge, and blackish towards the centre.

A very extensive and regular formation of the above mentioned kind of limestone, succeeds the chalk in Europe, and covers the transition formation on the north side of the mountains of the Crimea; holds the same relative situation along the north side of the transition on the Carpathian mountains; continuing through Silesia and Bavaria along the Bohemian mountains to Ratisbon; from thence up the Danube, to Schaffhausen on the Rhine; and follows the north-west side of the Jura, across the Rhone to the Mediterranean: the limestone during this long course, is similar, both in colour and sructure; and in some places on the banks of the Danube, is in a schistose form. It is this kind of limestone wherewith they make the plates which afford such exact impressions of writings and designs at Munich; its compact, homogenous structure, without any grain, renders it capable of receiving almost a metallic polish.

The absence of the newest floetz-trap formation (which partially and irregularly covers all other formations, thereby breaking the continuity of the other strata) with the effect of the violent convulsions and earthquakes, so frequent in the vicinity of this disputed formation, may be one cause why the prosecution of geological researches is so much more easy in North America than in Europe. A second cause producing much more universal and extensive effects, may perhaps be found in the difference of the number and magnitude of the accidents and changes that have been effected in the stratifications of the different classes of rocks on the European continent, since their original formation; by the effects of water, during the immensity of time, partially washing away the superincumbent strata, most liable to decomposition, and leaving the more hard and durable parts of the same stratification in their original positions; or by the long and continual action of rivers wearing deep beds, and exposing to view the subordinate strata, giving to the whole the present appearance of a confused and interrupted stratifications, though it might have been uniform and regular in its original state. Rivers likewise, by undermining, throw immense masses out of their places, and create a disorder and confusion, not easily unravelled.

A third cause of the facility of geological observations on this continent, may arise from the whole continent east of the Mississippi following the arrangement of our great chain of mountains. This chain commences at the St. Lawrence river, and appears to be a spur from the great mass of primitive, which occupies all the northern parts of the continent, runs a south-westerly course to the borders of Florida, is covered by the alluvial, and bounded by the sea on the east side; on the west side it is covered with a considerable transition formation, which is followed by a still more extensive secondary formation, all of which run in a regular line of continuity. Europe, on the contrary, is formed of five or six chains of mountains, all following different laws of stratification, and frequently interrupting each other; which increases the difficulty of arranging them in groups, and augments the apparent confusion.

The rivers in North America have not generally cut so deep into the different strata, either in the mountains, or during their course through the level country, as materially to derange the stratification; nor do we find those immense and inaccessible precipices, which renders the prosecution of geological researches almost impossible. Broken, detached masses of one formation, covering the tops of mountains, with their sides or foundation composed of different classes of rocks, seldom occurs; and where any irregularity or apparent confusion takes place, the vicinity generally admits of a sufficient examination of the surrounding strata, so as to account for the accident without affecting the general arrangement.

The stratification of the great chains of mountains in Europe is so cut up and deranged by the action of water, wearing deep vallies, surrounded by inaccessible precipices, that at every step some unaccountable difficulty occurs; the stratification is irregular and contradictory, the constant alternation of different formations baffles all the research which the nature of the place will permit of: if persevering industry, by accurate and minute investigation, should reduce to some order one part of the chain, another part of the chain of mountains, changed by different series of accidents, cannot be reduced to order by the same rules; and the observer may perhaps find, that he has not been acquiring the knowledge of the natural structure and arrangement of the original stratification, but only an imperfect idea of some accidental changes. It is probable in such cases, that it would be better to begin with taking general and extensive views of the whole chain, endeavouring to find out the key to the original order of stratification, which would render it more easy to account for the accidents which, when examined separately, appeared to be irreconcileable exceptions.

The difference between the ranges of mountains in Europe and North America, appears to be much greater, as respects the accidental and subsequent changes, than in the original order and arrangement of their stratification, in the relative situation whereof they frequently agree. On the edge of the secondary, not far distant from the transition, have been found the most productive salt springs, yet discovered in North America, running nearly north-east from Pigeon's river in the state of Tennessee, to Lake Onondaga; the salt works at Abingdon, and many other salt springs, though not wrought, occur; and in the same direction of the stratification, gypsum has been discovered. This situation of salt and gypsum, corresponds with the situation of the salt mines at Cracovia in Poland, which, with some others in the same country, are found on the edge of the secondary, almost touching the great transition formation, which covers the north side of the Carpathian mountains.

The country round the Baltic, bounded by a line running easterly to the Hartz, through Silesia, along the Carpathian mountains to the Crimea, and north by St. Petersburgh, including Denmark, part of Russia, Prussia, Finland, Sweden and Norway, is similar to the east side of the river Mississippi in North America, inasmuch, as it contains little or none of the basalt or newest floetz-trap formation; and very few warm springs, in proportion to the surface, have been yet found in either of the countries above mentioned; though on the south side of that line in Hungary and Bohemia, the floetz-trap formation and hot springs are frequent; and in crossing the stony mountains on the west side of North America, between the sources of the Missouri and Columbia river, two very hot springs were found by Captain Lewis: the same mountains likewise contain rocks of the newest floetz-trap formation.

The shells and other remains of organized matter, have not yet been examined with that accuracy of discrimination necessary to form just conclusions. Those found on the south-east side of the primitive are almost exclusively contained in the alluvial, in which considerable banks of shells, mostly bivalves, run parallel to the coast, imbedded frequently in a soft clay or mud resembling much that in which the living animal is now found on the sea shore, which makes the supposition probable, that they are of the same species. The shells found north-west of the primitive range, in the great secondary formation, are in great abundance, and consist of various species of Terebratulæ, Encrinites, Madripores, Caryophillites, Ammonites, Retipores, Nummulites, &c. most of which being washed out of the banks by the agitation of the water, are to be found in high preservation on the south side of Lake Erie.

SECTION II.

Observations on the Geology of the United States of America, in Explanation of the geological Map.

Necessity dictates the adoption of some system, so far as respects the classification and arrangement of names. The Wernerian seems to be the most suitable, first, because it is the most perfect and extensive in its general outlines—and secondly, the nature and relative situation of the minerals in the United States, whilst they are certainly the most extensive of any field yet examined, may perhaps be found the most correct elucidation of the general accuracy of that theory, so far as respects the relative position of the different series of rocks.

Without entering into any investigation of the origin, or first formation of the various substances, the following nomenclature will be used.

CLASS I.—Primitive Rocks.

SIENA BROWN.

1. Granite,
2. Gneiss,
3. Mica Slate,
4. Clay Slate,
5. Primitive Limestone,
6. Primitive Trap,
7. Serpentine,
8. Porphyry,
9. Sienite,
10. Topaz-rock,
11. Quartz-rock,
12. Primitive Flinty-slate,
13. Primitive Gypsum,
14. White-stone.

CLASS II.—Transition Rocks.

CARMINE.

1. Transition Limestone,
2. Transition Trap,
3. Grey Wacke,
4. Transition Flinty-slate,
5. Transition Gypsum.

CLASS III.—Flœtz or Secondary Rocks.

LIGHT BLUE.

(*dark blue*) 1. Old Red Sandstone, or 1st Sandstone Formation,
2. First or Oldest Flœtz-limestone,
3. First or Oldest Flœtz-gypsum,
4. 2d or Variegated Sandstone,
5. 2d Flœtz-gypsum,
6. 2d Flœtz-limestone,
7. 3d Flœtz-sandstone,
8. Rock-salt Formation,
9. Chalk Formation,
10. Flœtz-trap Formation,
11. Independent Coal Formation,
12. Newest Flœtz-trap Formation.

CLASS IV.—Alluvial Rocks.

YELLOW.

1. Peat,
2. Sand and Gravel,
3. Loam,
4. Bog Iron-ore,
5. Nagel-fluh,
6. Calc-tuff,
7. Calc-sinter.

GREEN.

All the rock salt and gypsum hitherto found in the United States, has been traced westward of this line.

To the east of Hudson's river, the primitive class prevails, both in the mountains and in the low lands, decreasing gradually as it proceeds south; it is bounded on the side of the ocean by the vast tracts of alluvial formation which skirt the great granite ridge, while it serves as a foundation to that immense superstructure of transition and secondary rocks forming the great chain of mountains that occupy the interior of the continent to the westward.

The primitive, to the eastward of Hudson's river, constitutes the highest mountains, while the little transition and secondary that is found, occupy the low grounds. To the south of the Delaware, the primitive is the first rock after the alluvial formation of the ocean—the lowest step of the stair which gradually rises through the different formations to the top of the Alleghany.

To the eastward of the state of New York, the stratification runs nearly north and south, and generally dips to the east, looking up to the White Hills, the most elevated ground. In New York state, and to the southward and westward, the stratification runs nearly north-east and south-west, and still dips to the east. All the rivers east of the Delaware run nearly north and south, following the stratification, while the southern rivers incline to the south-east and north-west directions.

Throughout the greatest part of the eastern and northern states, the sea washes the foot of the primitive rock; the deposition of that extensive alluvial formation commences at Long island, increasing in breadth to the south, forming a great part of both the Carolinas and Georgia, and almost the whole of the two Floridas and lower Louisiana. The coincidence of the gulf stream, with all its attendant eddies, depositions, &c. rolling along this whole extent, from the gulf of Mexico to Nantucket, may create speculative ideas on the origin of this vast alluvial formation, while the constant supply of caloric brought by that sweeping current from the tropics, may perhaps account for the sudden and great change in the temperature of the climate within the reach of the Atlantic.

The great distance occupied by the same or similar substances in the direction of the stratification, must strike the observer; as in the primitive rocks, the beds of primitive limestone and dolomite, containing in some places chrystallized feldspar and tremolite, which are found alternating with gneiss, for ten miles between Dover, state of New York, and Kent, state of Connecticut, appear forty miles north at Stockbridge, Connecticut, and eighty miles south, between Singsing and Kingsbridge, New York; where, after crossing the Hudson river, and dipping under the trap and sandstone formation in New Jersey, they most probably reappear in the marble quarries distant from twelve to fourteen miles north-west of Philadelphia—a range of nearly three hundred miles.

There is a bed of magnetic iron ore, from eight to twelve feet thick, wrought in Franconia, near the White Hills, New Hampshire; a similar bed in the direction of the stratification six miles north-east of Phillipstown on the Hudson river, and still following the direction of the stratification, the same ore occupies a bed nearly of the same thickness at Ringwood, Mount Pleasant and Suckasunny in New Jersey, losing itself as it approaches the end of the primitive ridge near Blackwater: a range of nearly three hundred miles.

Instances of the same, occur in the transition and secondary rocks; as the Blue Ridge, from the Hudson river to the Dan river, consists of rocks of much the same nature and included in the same formation.

That no volcanic productions have yet been found east of the Mississippi, is not the least of the many prominent features of distinction between the geology of this country and that of Europe; and may perhaps be the reason why the Wernerian system so nearly accords with the general structure and stratification of *this* continent.

It is scarcely necessary to observe, that the country must be considered of the nature of the first rock that is found in place, even should that rock be covered with thirty or forty feet of sand or gravel, on the banks of rivers or in vallies; for example, the city of Philadelphia stands on primitive rock, though at the Centre Square, thirty or forty feet of sand and gravel must be penetrated, before the gneiss rock, which ascertains the formation, is found.

ALLUVIAL CLASS.

At the east end of Long island the alluvial begins, occupying almost the whole of that island. Its north-western boundary is marked by a line passing near Amboy, Trenton, Philadelphia, Baltimore, Washington, Fredericksburg, Richmond, and Petersburg in Virginia, a little to the westward of Halifax, Smithfield, Aversboro', and Parkersford on Pedee river, in North Carolina, west of Cambden, near Columbia, Augusta on the Savannah river, Rocky Landing on the Oconee river, Fort Hawkins on the Ockmulgee river, Hawkinstown on Flint river, and running west a little southerly across the Chatahouchee, Alabama and Tombigbee rivers, it joins the great alluvial basin below the Natchez.

The ocean marks the eastern and southern limits of this extensive alluvial formation; above the level of which it rises considerably in the southern states, and falls to near the level of the sea, as it approaches the north.

Tide water in all the rivers from the Mississippi to the Roanoke, ends at a distance from thirty to one hundred and twenty miles of the western limits of the alluvial: from the Roanoke to the Delaware, the tide penetrates through the alluvial, and is only stopped by the primitive ridge. The Hudson is the only river in the United States, where the tide passes through the alluvial, primitive transition, and into the secondary; in all the northern and eastern rivers the tide runs a small distance into the primitive formation: here, as in the northern coasts of Europe, little or no alluvial is found on the primitive coast.

Through the whole of this alluvial formation considerable deposits of shell sare found; also a bank of shell limestone beginning in North Carolina, parallel to, and within the distance of from twenty to thirty miles of the edge of the primitive, through South Carolina, Georgia. and part of the Mississippi territory. In some places this bank is soft, with a large proportion of clay, in others hard, with a sufficiency of the calcareous matter to be burnt for lime: large fields of the same formation are found near cape Florida, and extending some distance along the coast of the bay of Mexico; in some situations the calcareous matter of the shells has been washed away, and a deposit of siliceous flint, in which they were imbedded, is left; forming a porous flinty rock, which is used with advantage for millstones.

In the alluvial of the New Jersey, about ten to twenty feet under the surface, there is a kind of greenish blue marle, which they use as manure, in which they find shells, as the Ammonite, Belemnite, Ovulite. Cama, Ostrea, Terebratula. &c. Most of these shells, are similar to those found in the limestone and grey wacke of the transition, and equally resemble those found in such abundance in the secondary horizontal limestone and sandstone; from which it would follow, that the different classes of rocks on the continent cannot be distinguished by their shells, though the different strata of the same class may be discovered and known by the arrangement of the shells found in them.

Considerable deposits of bog iron-ore occupy the lower situations, and many of the more elevated and dividing ridges between the rivers are crowned with a sandstone and puddingstone, the cement of which is bog iron-ore.

Quantities of ochre, from bright yellow to dark brown, are found in abundance in this formation, in flat horizontal beds, alternating with other earths in some places, in others in kidney-form masses, from the size of an egg to that of a man's head; in form, resembling much the flint found frequently in chalk formations.

So great an extent of alluvial, formed at periods of time so distant, though at present and from all the examinations yet bestowed, it appears to be the same formation, may at some future period and by future observations, be found to contain rocks similar to those of the secondary class; for instance, the whole or part of the greenish blue marl with shells, found in Jersey, both the Carolinas, and Georgia, may in process of time become solid and compact, and would then under the denomination of shell limestone, enter into the secondary, as well as many of the sandstones and puddings; for a bank of sand or gravel, united by a filtration of water, which deposes either clay or limestone as a cement, cannot be different from a like formation in the secondary. Even the early depositions of lime by the evaporation of lime water, such as at Tivoli, near Rome, cannot in hand specimens be distinguished from compact limestone of the secondary class. It is probable, that those immense masses of trees, accumulated on the banks of the Mississippi and other large rivers, may be covered by alluvial beds of sand and clay, which in process of time will consolidate into the coal measures of slate and sandstone, while the mass of wood will decompose into beds of coal, and become, under the denomination of the coal formation, secondary rocks.

PRIMITIVE CLASS.

The south-east limits of the great primitive formation are covered by the north-west boundary of the alluvial formation from near the Alabama river, in the Mississippi territory, to Long island, with two small exceptions; the first near Augusta on the Savannah river, and near Cambden in South Carolina, where a stratum of transition clay slate, (shist argileux) intervenes; and from Trenton to Amboy, where the oldest red sandstone formation covers the primitive along the edge of the alluvial. From Rhode Island along the coast by cape Cod, to the bay of Penobscot, the eastern edge of the primitive is bounded by the ocean.

The north-western boundary of this extensive range, is marked by a line running fifteen to twenty miles east of Lake Champlain, twelve miles east of Middlebury, state of Vermont, west of Bennington, twelve to fifteen miles east of Hudson, along the westward of Stockbridge, twelve miles south-east of Poughkeepsie, skirting the high lands; it crosses the Hudson river, at Philipstown, by Sparta, about ten or fifteen miles east of Easton on the Delaware, and terminates in a point a few miles north of Bethlehem, recovering fifteen miles west of Trenton; on the south side of the river it passes about the same distance west of Philadelphia, eight miles east of Downingstown, ten miles east of York by Petersburg, crosses the Susquehannah, twenty-two miles west of Washington, and joins the Blue Ridge, along the top of which is the dividing line between the primitive and transition to Magotty Gap, from thence to four miles east of the lead mines at Austinville, and following a south-western direction, by the Stony and Iron mountains, six miles south-east of the warm springs in Buncomb county, in North Carolina, to the eastward of Hightown on the Cousee river; and a little to the westward of the Talapoosee river, it meets the alluvial near to the Alabama, which runs into the bay of Mexico.

Besides this range, there is a great mass of primitive on the west side of Lake Champlain, having that lake and Lake George for a boundary on the east, joining the primitive in Canada to the north and north-west, and following a line from the Thousand islands in St. Lawrence, running nearly parallel to the Mohawk, until it meets Lake George as a south-west limit. This primitive runs across the Mohawk at the Little Falls, and near to Johnstown on the Mohawk, where it is covered by limestone; it occupies all the mountainous country, between Lake Champlain, the St. Lawrence, and Lake Ontario.

In general, the strata of this primitive rock runs from a north and south to a north-east and south-west direction, and dips generally to the south-east at an angle of more than 45 degrees from the horizon; the highest elevation is towards the north-western limits, which gradually descends to the south-east, where it is covered by the alluvial; and the greatest mass as well as the highest mountains, are found towards the northern and southern extremities of the north-western boundaries.

The outline of the mountains of this formation, generally consists of circular, waving, detached masses, with rounded flat tops, as the White Hills to the north; or conically waving in small pyramidical tops, as the peaks of Otter, and the ranges of hills to the south. Has the climate any agency in the forms of the summits of the northern and southern mountains? Their height does not appear to exceed six thousand feet above the level of the sea, except perhaps the White Hills; it is even probable that those mountains are not much higher.

Within the limits prescribed to this primitive formation there is found the following exception, viz. Covering part of this primitive there is a transition formation, which occupies all Rhode Island (except a small part south of Newport) and runs from Rhode Island to Boston from ten to fifteen miles broad, and by the rounded transition pebbles, which cover part of the primitive, as well as the small patches left at Pembroke township, and ten miles south-west of Newburyport, on the new turnpike, it is probable that at some former period this transition has covered the primitive considerably east of Boston, perhaps as far as cape Cod. There is also a range of secondary, extending with some intervals, from the Connecticut to the Rappahannock rivers, in width generally from fifteen to twenty-five miles; bounded on the north-east, at New Haven, by the sea, where it ends to recommence on the south side of Hudson river. From Elizabethtown to Trenton it touches the alluvial: from a little above Morrisville, on the Delaware, to Norristown, Maytown on the Susquehannah, passing three miles west of York, Hanover, and one mile west of Frederickstown: it is bounded, or rather appears to cover a tongue of transition, which occupies a progressively diminishing width, as far south as the Yadkin river, at Pelot's Mount.

This secondary formation is intercepted after it passes Frederickstown, but begins again between Monocasy and Seneca creeks, the north-eastern boundaries crossing the Potomac by the west of Cartersville, touches the primitive near the Rappahannock, where it finishes. On the north-west side, it is bounded by the primitive, from some distance to the westward of Hartford, passing near Woodbury, and recommencing south of the Hudson, passing by Morristown and Germantown, &c. to the Delaware; after which it continues along the transition, by the east side of Reading, Grub's mines, Middletown, Fairfield, to near the Potomac, and recommencing at Noland's ferry, runs along the edge of the transition to the westward of Leesburg, Haymarket, and the vicinity of the Rappahannock.

All this secondary, appears to belong to the oldest red sandstone formation;* though in some places about Leesburg,

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* The oldest red sandstone family or formation in most places in Europe where I have seen it, such as on the south side of the Vosges, the south of the Alps, Tyrolian and Bohemian mountains, the south side of the Pyrenees, &c. consists of compact red sandstone, schistose red sandstone, and schistose blackish sandstone, coloured by carbon; a bluish schistose sandstone, running into wacke, compact wacke, schistose wacke, blue compact conchoidal limestone, seldom thicker than from six inches to a foot, small strata of two or three inches thick of jet, a pudding with the red sandstone for cement, greenstone and hornblende trap in ridges, and salt and gypsum. It has thus been found in Europe as above stated. All the members of this family have been found alternating with each other in the United States, except the gypsum; and there appears little reason to doubt but that more accurate research will find this likewise.

Reading, &c. the red sandstone only serves as cement to a pudding formed of transition limestone, and other transition pebbles, with some quartz pebbles, large beds of greenstone trap and wacke of different kinds, which covers in many places this sandstone formation, and forms the small hills, or long ridges, that occur so frequently in it.

The stratification in most places runs from an east and west to a north-east and south-west course, and dips generally to the north-west, at an angle most frequently under twenty-five degrees from the horizon, covering both the primitive and transition formation, at every place where their junction could be examined; and in some places, such as on the east side of the Hudson (where the action of the water had worn away the sandstone) the smooth water-worn primitive, was covered with large rolled masses of greenstone trap, to a considerable distance; the hardness and solidity of which, had most probably survived the destruction of the sandstone formation. May not similar derangements be one of the causes of the broken and unconnected state of this formation?

Prehnite and Zeolite are found in the trap of this formation; and considerable deposits of magnetic iron ore at Grub's mines, are enveloped, and have their circular layers intersected by greenstone trap; on a ridge of which, this extensive cluster of iron ore seems to be placed.

Grey copper ore has been found in the red sandstone formation, near Hartford and Washington in Connecticut; there are likewise mines in New Jersey, where copper pyrites and native copper have been found. The metallic veins at Perkiomen creek, containing copper, pyrites, blend and galena, are in the same formation, running nearly north and south across the east and west direction of the red sandstone, and a small bed from a half to three inches thick, of brown or red copper ore is interspersed, and follows the circular form of the iron beds at Grub's mines.

Besides this red sandstone formation, there is included within the described limits of the primitive, a bed of transition rocks, running nearly south-west from the Delaware to the

Yadkin river, dipping generally to the south-east, twenty-five or more degrees from the horizon; its width is from two to fifteen miles, and it runs from the west of Morrisville to the east of Norristown, passes Lancaster, York, Hanover, Fredericktown, Bull-run mountain, Milton, foot of Pig river, Marlinsville, and finishes near Mount Pilot, on the Yadkin river. Between the Delaware and Rappahannock it is partially covered by the red sandstone formation, and is in the form of a long wedge, the thick end touching the Delaware and the sharp end terminating at the Yadkin river.

This range consists of beds of blue, grey, red, and white small grained transition limestone, alternating with beds of grey wacke and grey wacke slate, quartzy granular rocks, and a great variety of transition rocks. Much of this limestone is intimately mixed with grey wacke slate, others containing so great a quantity of small grained sand as to resemble the dolomite, and in many places considerable beds of fine grained white marble, fit for the statuary, occur.

Limespar runs in veins and detached masses through the whole of this limestone formation; and both it and the grey wacke slate contain quantities of the cubic pyrites. Galena has likewise been found near Lancaster, and many veins of the sulphat of barytes traverse this formation, which runs about twenty-five to thirty miles south-east, and nearly parallel to the great transition formation.

A similar formation about fifteen miles long, and two to three miles wide, occurs on the north fork of Catawba river, running along Linnville and John's mountain near to the Blue Ridge; and a bed of transition rock, commencing on Greenpond mountain, New Jersey, runs through Suckusanny plains, increasing in width as the primitive range decreases, joining the great transition formation between Easton and Reading.

On the west side of this partial transition formation, from the Potomac to the Catawba, between it and the great western transition range, a series of primitive rocks intervenes, something different from the common primitive, having the structure of gneiss, with little mica, the scales detached and not contiguous, or much feldspar, rather granular than chrystallized; mica slate, with small quantities of scaly mica; clay slate, rather soft and without lustre, the whole having a dull earthy fracture and gritty texture, partaking of transition and primitive, but not properly belonging to either. This rock is always found on the edge of the primitive, before you come upon the transition, but no where in such quantities as in this range. There is great variety in the appearance of this rock, an imitation of almost every species of the common primitive rocks, but differing from them by having a dull earthy fracture, gritty texture, and little or no chrystallization.*

About ten or twelve miles west of Richmond, Virginia, there is an independent coal formation, twenty to twenty-five miles long, and about ten miles wide; it would not be far distant from the range of the red sandstone formation had it continued so far south; it is situated in an oblong basin, having the whitish freestone, slaty clay, &c. with vegetable impressions, as well as most of the other attendants of that formation. This basin lays upon and is surrounded by primitive rocks. It is more than probable, that within the limits of so large a mass of primitive, other partial formations of secondary rocks may be found.

Granite in large masses forms but a small part of this formation, and is found indifferently on the tops of mountains and in the plains; it is both large and small grained, is mixed occasionally with hornblende and talc, and contains, as in Europe, rounded masses of a rock consisting of hornblende and feldspar in small grains, disseminated through it; it generally

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* This class of rocks differs from the primitive, in having a less brilliant and chrystalline fracture, but corresponds with it in the direction and almost vertical position of the stratification: it differs from the transition in not containing any of those aggregates, the component parts whereof have been evidently rounded by attrition, and in the circumstance of affording no remains of organic matter, though many of the species of schist, taken separately, have a great resemblance to some of the schistose rocks, included in the transition formation. In conformity to the Wernerian nomenclature, they are here classed with the primitive, as not coming properly under any description of rocks described as transition in that system.

divides vertically into rhomboids, and, except in some very small grained, there is no appearance of stratification, when found in low situations, as in the interior of South Carolina and Georgia. It is frequently so far decomposed as to have lost the adhesion of its particles, to the depth of thirty or forty feet below the surface; each chrystal is in its place, and looks like solid granite, while you may take it up in handfuls like sand and gravel.

Gneiss extends perhaps over a half of this formation, and includes in a great many places beds from three to three hundred feet thick, of a very large grained granite, which run in the same direction, and dip as the gneiss does; it is in those beds generally where the emeralds, phosphate of lime, tourmaline, garnet, cymophane, octahedral iron ore, graphic granite, &c. &c. are found. These beds are mixed, and alternate occasionally in the same gneiss, with the primitive limestone, the beds of hornblende and hornblende slate, serpentine, magnetic iron ore, and feldspar rocks. In some places this gneiss contains so much mica, as to run into mica slate; in others, large nodules of quartz or feldspar; in others, hornblende takes the place of the mica; in short, I scarcely know any of the primitive rocks that may not occasionally be found included in the gneiss formation.

It is therefore probable that geology must rest, more upon relative positions, than upon the constituent parts of rocks. For instance; the hornblende rocks which cover the red sandstone, are in many places so chrystalline, as scarcely to be distinguished in hand specimens from some of the hornblende rocks which alternate with the gneiss; it is the same with much of those small grained rocks of trappose forms, found in the primitive, compared with the transition trap or hornblende rocks found in the transition; though the latter alternate with transition slate, or what is called roofing-slate, in which the remains of organic matter have been found.

The rounded globules of feldspar and hornblende found in the great masses of granite of the Alps, in Cornwall, and in this country, could not be distinguished, in hand specimens, from the sienite of Werner, though the one is placed in the Wernerian system as the oldest, and the other among the newest, of the primitive rocks, all which proves the difficulty of establishing a line in the gradations of nature to place our artificial boundaries on; and indicates the necessity of first ascertaining the limits of the great divisions, before we attempt the specific and more minute, which would seem to require more accurate and extensive observations, than have as yet been made.

There is a compact, rather dull fractured hornblende rock, generally found on the edge of the primitive, before meeting with the transition, which is in many places mixed with epidote, both compact and chrystalline; as on the south side of Rhode Island, and along the Blue Ridge, in Virginia, &c. &c. This rock resembles the rock found in the harbour of Penzance in Cornwall, and not unlike the rock of the Lizard in England. From its appearing here always on the edge of the primitive, it is probably one of the last members of that class.

No gypsum has yet been found in the primitive of this country; nor do I think it will be ascertained to have been in place, when alternating with the primitive in Europe, having examined the gypsum near Mont St. Gothard, Mont Cenis, Coll de Tende, &c. &c. In the Alps I found it always in transition, though in one or two places that transition had slid down from the top of a neighbouring mountain into a valley of primitive rocks.

Great varieties of mineral substances are found in the primitive formation, such as garnets in the granite and mica slate, from the size of a pin's head to the head of a child, staurotide, andalusite, epidote in vast varieties and abundance, tremolite, all the varities of magnesian rocks, emerald, touching graphic granite, and disseminated in the granite of a large extent of country, adularia, tourmaline, hornblende, sulphat of barytes, arragonites, &c. &c.

From the number already found in proportion to the little research that has yet been employed, there is every reason to suppose, that in so great an extent of chrystalline formation.

almost every mineral discovered in similar situations on the ancient continent of Europe will be found on this.

Metallic substances in the primitive, are generally extensive, like the formation itself. Iron pyrites runs through vast fields, principally of gneiss and mica slate; magnetic iron ore, in powerful beds from ten to twelve feet thick, generally in a hornblende rock, occupies the highest elevations, as in Franconia, the Highlands of New York, the Jerseys, Yellow and Iron mountains in the west of North Carolina. A black brown bed of hematitic iron ore in Connecticut and New York states. Chrystals of octahedral iron ore, (some of which have polarity) disseminated in granites, as at Brunswick, district of Maine, and in many varieties of the magnesian genus; black lead in beds, from six to twelve feet wide, traversing the states of New York, Jersey, Virginia, Carolina, &c.; native and grey copper ore, near Stanardsville, and Nicholson's Gap, Virginia, disseminated in a hornblende and epidote rock, bordering on the transition; molybdena at Brunswick (Maine), Chester (Pennsylvania), Virginia, North Carolina, &c.; arsenical pyrites in large quantities in the district of Maine; red oxyd of zinc and magnetic iron ore in a powerful bed on the edge of the primitive, near Sparta in New Jersey, having a large grained marble, with nigrin or silico-calcareous titanium imbedded in it on one side, and hornblende rock on the other. This bed contains likewise large quantities of blende. Detached pieces of gold have been found in the beds of some small streams in Cabarro county, North Carolina, and other places, apparently in a quartz rock. Manganese has been found in New York, North Carolina, &c. &c. Near the confines of the red sandstone and primitive formation, a white ore of cobalt has been wrought above Middletown on the Connecticut river, and found also, as is said, near Morristown in New Jersey.

The general nature of metallic repositories in this formation, appears to be in beds, disseminated, or in laying masses; when in beds (as the magnetic iron ore and black lead) or disseminated (as the iron pyrites, octahedral iron ore, molybdena, &c. &c.) they occur at intervals through the whole range of the formation. Veins to any great extent have not yet been discovered in this formation.

TRANSITION CLASS.

This extensive field of transition rocks is limited on the south-east side from a little to the eastward of Lake Champlain to near the river Alabama, by the north-west boundary prescribed to the primitive rocks. On the north-west side it touches the south-east edge of the great secondary formation, in a line that passes considerably to the westward of the ridge which divides the eastern and western waters in Georgia, North Carolina, and part of Virginia, and runs near it in the northern part of that state and in the states of Pennsylvania and New Jersey.

This line of demarcation runs between the Alabama and Tombigbee river, to the westward of the north fork of the Holstein, till it joins the Alleghany mountains, near the sulphur spring along that dividing ridge to Bedford county in Pennsylvania, and from thence north-east to Fort Ann, near Lake Champlain, and follows the east side of that lake to Canada: the separation of the transition and secondary is not so regularly and distinctly traced as in the other formation; many large vallies are formed of horizontal secondary limestone, full of shells, while the ridges on each side consist of transition rocks. The two formations interlock and are mixed in many places, so as to require much time and attention to reduce them to the regular and proper limits. It is however probable, that to the north-west of the line here described, little or no transition will be found, although to the south-east of it, partial formations of secondary may occur.

The transition formation is generally broadest where the primitive is narrowest, and vice versa; and runs from twenty to one hundred miles broad: the stratification runs from a north and south to a north-east and south-west direction, dipping generally to the north-west, at an angle in most places under forty-five degrees from the horizon. On the edge of the primitive it deviates in some places from this general rule, and dips for a short distance to the south-east: the most elevated ground is on the confines of North Carolina and Georgia, along the south-east limits to Magotty Gap, descending towards the north-west until it meets the secondary; from Magotty Gap, north-easterly, the highest ground is on the north-west side, sloping gradually towards the primitive, which ranges along its south-eastern boundary.

The outline of the mountains of this formation is almost a straight line, with few interruptions, bounding long parallel ridges of nearly the same height, declining gently towards the side, where the stratification dips from the horizon, and more precipitous on the opposite side, where the edge of the stratum breaks out to the day.

This formation is composed of the following rocks; viz. a small grained transition limestone, of all the shades of colour from a white to a dark blue, and in some places intimately mixed with strata of grey wacke slate; limespar in veins and disseminated; in many places an intermixture of small grained particles, so as to put on the appearance of a sandstone, with excess of lime cement. This occurs in beds from fifty to five thousand feet in width, alternating with grey wacke and grey wacke slate. Near the borders of the primitive is found a siliceous aggregate, having particles of a light blue colour, from the size of a pin's head to an egg, disseminated in some places in a cement of a slaty texture, and in others in a quartzose cement; a fine sandstone cemented with quartz in large masses, often of a slaty structure, with small detached scales of mica intervening; a rock not far from the borders of the primitive, partaking both of the porphyry and the grey wacke, having both feldspar chrystals and rounded pebbles in it, with a cement of a kind of dull chlorite slate in excess; another, though rarer, with pebbles and feldspar chyrstals in a compact petrosiliceous cement, and a great variety of other rocks, which, from their composition and situation, cannot be classed but with the transition.

The limestone, grey wacke, and grey wacke slate, generally occupy the vallies, and the quartzy aggregates the ridges; amongst which is what is called the country burr stone or mill stone gritt, which must not be confounded with another rock, likewise denominated mill stone gritt, which is a small grained granite, with much quartz, found in the primitive formation. There are many and extensive caves in the limestone of this formation, where the bones of various animals are found.

Beds of coalblende, or anthracite, accompanied by alum slate and black chalk, have been discovered in this formation, on Rhode Island, the Lehigh and Susquehannah rivers; and a large body of alum slate on Jackson's river, Virginia; many powerful veins of the sulphate of barytes cross it in different places; granular, as that near Fincastle, or slaty, as that in Buncomb county, North Carolina.

Iron and lead have as yet been the principal metals found in this formation; the lead in the form of galena, in clusters, or what the Germans call Stockwerk, as at the lead mines on New river, Wyeth county, Virginia; the iron disseminated in pyrites, hematitic and magnetic iron; or in beds; and considerable quantities of the sparry iron ore in beds, and disseminated in the limestone.

This class of rocks, occupying the space between the primitive and secondary, is perhaps the first that ought to be studied and the limits fixed; as a knowledge once acquired of what rocks are transition, there can be no difficulty in distinguishing the secondary at one end and the primitive touching the other.

As nature in her imperceptible gradations from one species of rock to another, has not left any marked or distinct limits, on which to place the artifical boundaries of the different classes, it is not easy to fix with certainty the kind of rocks, at which the one class ought to begin, and the other finish; and it is probable that a long series of exact observations will be necessary to determine with accuracy that line of separation.

It is probable, that between the secondary and transition class, the *horizontal stratification* of the secondary will constitute the strongest and best defined line of separation; every stratum of rocks that is horizontal, or nearly so in its original situation, will be secondary; and those which are found near it, not chrystalline or primitive, having a regular dip or declination from the horizon, will naturally fall into the transition class. It is under this idea that the dark blue colour on the map has been used for the oldest red sandstone, while the light blue has been the mark of the secondary, because I have generally found the oldest red sandstone dipping or declining from the horizon at a regular angle though small; and at same time having few organic remains; which agrees with the general characters of the transition: whilst in relative position on the sides of many of the range of mountains it assumes the place of the transition.

The line between the primitive and transition may perhaps be marked by the presence or absence of organic remains—or of aggregates of rounded particles, the result of former decomposition—in part, by the more or less chrystalline texture—and its approach towards deposition.

SECONDARY CLASS.

The south-east limit of this extensive formation is bounded by the irregular border of the transition, from between the Alabama and Tombighee rivers to Fort Ann near Lake Champlain. On the north-west side it follows the shores of the great lakes, and loses itself in the alluvial of the great basin of the Mississippi; occupying a surface from two hundred to five hundred miles in breadth, and extending probably on the west side of the Mississippi to the foot of the Stony mountains.

This horizontal limestone and slate, skirt Lake Champlain about Ticonderoga and Crown Point, and for some considerable distance down the east side of the lake; seldom extending above half a mile from the edge of the water; containing some shells and flints, as on Lake Erie, and appears to be the same formation as on Lake Erie. Its greatest elevation is on the south-east boundary, from which it falls down almost imperceptibly to the north-west, and mingles with the alluvial of the Mississippi, having an outline of mountains, straight and regular. A boundary of long and parallel ranges of a gradually diminishing height as they approach to the north-west limits; a stratification almost perfectly horizontal, waving with the inequalities of the surface, distinguishes this from the two preceding formations.

Immense beds of secondary limestone, of all the shades from a light blue to a black, intercepted in some places by extensive tracts of sandstone and other secondary aggregates, appears to constitute the foundation of this formation, on which reposes the great and valuable coal formation, which extends from the head waters of the Ohio in Pennsylvania, with some interruption, all the way to the waters of the Tombigbee, accompanied by the usual attendants, slaty clay and freestone, with vegetable impressions, &c.; but in no instance that I have seen or heard of, covered by, or alternating with any rock, resembling basalt; or indeed any of those called the newest floetz trap formation.

The limestone of this formation contains irregular pieces in nodules and bands, of a kind of black flint (like what is called chert in England) scattered in all forms and directions, often resembling in colour the limestone, in which case it is with difficulty they can be distinguished; they abound on the banks of Lake Erie, on the banks of St. Lawrence, where it runs from Lake Erie, and generally through the whole stratification of limestone.

Along the south-east boundaries not far from the transition, a rock salt and gypsum formation has been found. On the north fork of Holstein, not far from Abingdon, Virginia, and on the same line south-west from that, in Greene county and Pigeon river, state of Tennessee, it is said quantities of gypsum have been discovered; from which, and the quantities of salt licks and salt springs found in the same range, so far north as Lake Oneida, there is some probability that this formation is upon the same great scale that almost all the other formations have been found on this continent; at least rational analogy supports the supposition; and we may hope one day to find an abundance of those two most useful substances, which are generally found mixed or near each other in all countries that have hitherto been carefully examined.

At Lewistown, ten miles below the falls of Niagara, the old red sandstone appears from under the limestone and other strata over which the falls roll; the same makes its appearance near the Salines in the Genesee country, which would give some probability to the conjecture, that the old red sandstone is the foundation of all this horizontal formation, and may perhaps be attached to some series of rocks laying on the primitive, on the north side of the lake.

Metallic substances, hitherto found in this formation, are iron pyrites, disseminated both in the coal and limestone; iron ores, consisting principally of brown, sparry and clay iron stone in beds; galena, but whether in beds or veins is not ascertained. The large deposits of galena at St. Louis on the Mississippi, have been described as detached pieces, found covered by the alluvial of the rivers, and of course, not in place. All the large specimens I have seen were rolled masses, which rather confirms the opinion, that they were not found in their original situation.

On the Great Kanhawa, near the mouth of Elk river, there is a large mass of black (I suppose vegetable) earth, so soft as to be penetrated by a pole ten or twelve feet deep; out of the hole so made, frequently issues a steam of hydrogen gas, which will burn for some time; and in the vicinity of this place there are constant streams of that gas, which, it is said, when once lighted will burn for several weeks. Query, if a careful examination of this place would not throw some light on the formation of coal and other combustible substances found in such abundance in this formation?

Large detached masses of granite are found laying on this formation from Harmony to Erie, and from thence by the Genesee country to Fort Ann; though in many places no granite of this kind is found in place nearer than two hundred miles at the falls of the Mohawk, or perhaps on the north side of the lakes.

From near Kingston on Lake Ontario to some distance below Quebec, the country is principally primitive, and from all the information I could collect, that great mass of continent laying to the north of the 46th degree of latitude for a considerable distance to the west consists mostly of the same formation: from which it is probable, that on this continent, as well as in Europe and Asia, the northern regions are principally occupied by the primitive formation.

The foregoing observations are the results of many former excursions in the United States, and the knowledge lately acquired, by crossing the dividing line of the principal formations in twenty-five or thirty different places, from the Hudson to Flint river; as well as from intelligent men, whose situation and experience made the nature of the place, near which they lived, familiar to them; nor has the information that could be acquired from specimens where the locality was accurately marked, or the remarks of judicious travellers, been neglected.

Notwithstanding the various sources of information, much of the accuracy of the outlines of separation between the formations must depend on rational analogy; for instance, between Magotty and Rock-fish Gaps, a distance of upwards of sixty miles, I found in six different places that were examined that the summit of the Blue Ridge divided the primitive and the transition formation. I concluded of course, that in places where I had not examined (or which from their nature could not be examined) that the Blue Ridge, from Magotty to Rock-fish Gap, was the boundary of the two formations.

In adopting the nomenclature of Werner, I do not mean to enter into the origin or first formation of the different substances, nor into the nature and properties of the agents that may have subsequently modified and changed the appearance and form of those substances. I am equally ignorant of the relative periods of time, in which those modifications and changes may have taken place. These speculations are beyond my range, and pass the limits of my inquiries. All that I mean by a *formation*, is, a mass of substances (whether adhesive, as rocks, or separated as sand and gravel) uniform and similar in their structure and relative position, occupying extensive ranges with few or no interruptions of the rocks belonging to another series, class, or formation; and when such partial mixture apparently takes place, a careful examination will seldom fail to explain the phenomenon, without injuring the general principle, or making it a serious exception to the rule.

In the account of the metals and minerals, it is not intended to give a list of the number, extent, and riches of the metallic and mineral repositories; the nature of the ore or mineral, with a description of its relative position in regard to the surrounding substances, is the principal object of geology, which cannot be understood by microscopic investigations or the minute analysis of insulated rocks and detached masses; it would be like the portrait painter dwelling on the accidental pimple of a fine face; the geologist must endeavour to note the great and permanent outlines of nature, and get acquainted with her general laws, rather than study her accidental deviations, or magnify the number and extent of the supposed exceptions which must frequently cease to be such when accurately examined.

SECTION III.

Hints on the Decomposition of Rocks, with an Inquiry into the probable Effects they may produce on the Nature and Fertility of Soils.

Rocks in their natural hard and compact state afford little or no nourishment to vegetables; it is only in their state of decomposition and dissolution, that they become useful or necessary to the growth of plants.

The greatest part of the substances which constitute most soils, proceeding immediately from the decomposition of the rocks surrounding or laying under them, it follows of course that those soils must be materially affected by the nature and quality of those rocks: first, by the peculiar mode of their decomposition and dissolution into earth or liquids, and secondly by the nature and qualities of those earths and liquids in the formation of soils, and as food for vegetables. We shall now consider their mode of decomposition.

1st.—The mode of decomposition by dissolution in water, as limestone and gypsum.

2dly.—Rocks, which though not soluble in water, yet contain something which facilitates the solution of earths, as alkalies, &c. such as feldspar, mica, volcanic rocks, &c.

3dly.—Rocks which decompose into small, minute particles, such as argillaceous slate, hornblende, talc, and serpentine.

4thly.—Rocks which decompose only by trituration, such as flints, quartz, &c. and those which contain siliceous matter as a component part of their aggregates, such as granite, gneiss, &c.

It has been generally supposed that vegetables cannot absorb any earth in a solid state, and that solution was necessary to render any substance fit for the food of plants. Those earths, therefore, that remain in a solid state, and are indissoluble by the common fluids, most probably act only as a medium through which the plant may receive the proper proportion of the two great causes of vegetable growth, heat and moisture; two fluids, positively necessary for the support of vegetable as well as animal life, neither of which could exist without a certain quantity of heat and moisture. This is proved by the total sterility of the polar regions and the tops of high mountains from the deficiency of heat, and of the deserts of Arabia, Africa, &c. from the absence of moisture.

Earths, as a medium through which the plants may be supplied with their necessary quantity of fluids, may act in various ways; first, as a soil easily reduced by tillage into a moveable mass offering the least possible resistance to the roots of plants, when in search of their food, and at the same time facilitating the circulation of such fluids as are indispensible to their growth, as absorbents of heat and moisture. Earths as well as rocks, differ greatly in their capability of receiving more or less of those necessary fluids, because they vary in their property of retaining one or both of them, for a longer or shorter time.

Earths as well as rocks may injure materially the fertility of the soil, by allowing one or both those fluids to filter through them, thereby depriving the plant of its necessary portion. In the same manner, rocks as a sub-stratum may be useful or beneficial to the plants which grow on the surface, by their greater or less capacity of retaining the necessary fluids, as Fabroni has shewn.

It may be proper to mention here, that the effect either of rocks in their compact state as rocks, or in their decomposed state as earths, forming the soil, is the only subject of these hints or observations; and that all artificial or accidental additions of animal or vegetable matter in a decomposed state, must be considered as exceptions of the general results. Whether these decompositions of vegetable or animal matter have been scattered over the surface by the annual fall of the leaves of the forest, and decay of animal or vegetable matter—or whether the floods of rivers have covered the lower ground with their fertilizing vegetable mud—or whether the industry and ingenuity of man has strewed it over the soil as manure

—the results of all such additions must be considered as foreign to the present subject, excepting inasmuch as the properties of the original soil may conduce to retain and prolong the advantages of this adventitious cause of fertility.

When a farmer clears the land of the United States under the trees, he finds a stratum of black vegetable mould, more or less thick in proportion to the original properties of the soil, the time that the trees have been dropping their manure upon it, and the declivity which obstructs or facilitates its washing away; for this mould is lighter than water, and runs off rapidly from the sides of hills, and seldom or ever lays long on the steep descents of mountains.

While this bed of vegetable mould remains, the labour of the farmer is rewarded by rich and abundant crops; for when he sows and reaps from such a soil, four or five years before he exhausts it, he not only expends as many years' natural productions, but he consumes as many hundred or perhaps thousand years' accumulation of natural manure, which would require a very long time for the common operations of production and decomposition to replace.

It is therefore the peculiar interest of all farmers in America, to be sparing of this natural manure, and to make it last as long as they can, which may perhaps be best effected by preventing as much as possible its washing away with the rain,* a much greater proportion running off with the water than is consumed by the production of the vegetables raised on it.

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* The quantum of vegetable mould in a soil has been considered as a criterion of its richness. To ascertain it, a chemist dries perfectly a given quantity and weighs it; after which he exposes it to a red heat, and weighs the residue; the difference between the two weights is considered as the quantity of vegetable matter lost by combustion, and of course the measure in a great degree of its fertility.

Where this vegetable mould is not more than three to four inches thick, perhaps ploughing it in like stable manure, by ploughing a little deeper might be one means of keeping it from washing; as this process would cover it with a part of the soil, which from its weight would not be so easily washed away.

While this vegetable mould is in sufficient quantities on the surface, the lands are more or less fertile, independent of the nature of the earth on which it lays; it is when that coat of manure is gone, and the land worn out by constant cropping,* that the soil shews its fertility, as depending on the nature of the rock of the country, and species of earth or loam, resulting from their decomposition. It is at that time that the difference between a granite and limestone soil appears, and where any one can see the effects, though few ever think of inquiring into the cause; yet it is evident that the washing and decomposition of a granite soil, can only afford sand mixed with a small proportion of sand or clay, from the mode in which the rocks divide in their process of decomposition; and even this small quantity is liable to filter through the interstices left in the aggregates of gravel, by the form of their chrystalline particles.

The limestone, on the contrary, by its easy solution and facility of decomposition, furnishes to the exhausted soil, with every rain, a quantity of food, fitted by solution for vegetable absorption, as well as a great quantity of mould divided and triturated into impalpable powder, which forms an excellent pabulum through which the vegetable can receive the other fluids necessary for its growth. Meantime this mould forms a retentive base or soil, which prevents the filtration of the smaller particles, and even retains the water in its pores, so as to give it out by regular evaporation to the surface, when necessary for the increase and support of the plants that may be sown on the land.

Beside the division of rocks into those which dissolve in and easily mix with water, as their mode of decomposing, and those which are insoluble in water, this last species of rocks

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* A great deal of the soil east of the Alleghany mountains does not produce now much more than one half it did when first cleared, which is probably one of the causes why the surplus produce of the United States for exportation is not now greater, if so great, as it was twenty years ago, though the quantity of land under culture, as well as the population that tills it, is almost double.

are divided by their mode of decomposition into chrystalline, and deposition rocks; because when changing from the solid rock into earth or soil, they follow a different process which produces different effects.

First, the chrystalline rocks are composed of an aggregation of chrystals of various substances interwoven and adhering together by the laws of attraction. Such rocks generally begin to decompose by a disunion of the different chrystals, and a destruction of their adhesion; then they fall into a mass of angular particles like a bed of gravel, and form a filter, through which all fluids pass more or less rapidly in proportion to the size of the chrystals; after which, each chrystal, according to its nature, begins its decomposition by throwing off an exceeding thin pellicle from its surface, and this continues scaling off until it is totally reduced; all those thin scales falling into the banks of angular particles, are generally washed by the water and filter through it; so that the residue consists of a mass of such substances as do not decompose easily but by trituration, and forms a granular bed of sand or gravel according to the size of the particles.

Rocks of deposition, consisting of particles more or less minute, arising from the decomposition of other rocks, when aggregated into a mass and fixed either by a cement or by juxtaposition, are subjected to laws of decomposition different from other rocks ; for when the adhesion of their particles is destroyed, they fall immediately into a state of earth more or less pervious to fluids, according to the nature of the particles; which being the result of a former decomposition are minute, and when pressed together by their own weight, form a mass which does not permit the fluids to pass in such quantities as to carry along with them the finest particles, and of course are not subject to wash away by filtration, like the remains of chrystalline rocks, though perhaps more easily carried off by the water from the steep sides of the hills.

All rocks which divide in the trappose form into parallelopipeds, not by chrystallization, but by shrinking or retraction from the loss of heat or moisture, fall into considerable square masses, and decompose by first losing their corners and approaching the round form, constituting a part of the rounded pebbles found in our fields; which are not rounded by attrition of water or any other cause of movement, but by the general mode of decomposition of homogeneous rocks.

It may perhaps be considered as a general principle that the farther the agents of decomposition can penetrate into rocks, insoluble in water, the greater will be the quantity that they will decompose in a given time; and the quicker that decomposition into minute particles is effected, the smaller will be the quantity washed away by the rains, and of course the necessary thickness of the soil for the production of vegetables will accumulate more rapidly; this must depend on the hardness and compactness of the rock, and all rocks of the slaty or the schistose form must be more easily reduced into soil, that those in a solid mass.

Rocks of easy decomposition into minute particles, accumulate a thickness of soil sufficient to prevent the filtration of any small particles that may be added to it, and form a bottom capable of holding what it obtains; on the contrary, rocks which in the first stage of decomposition fall into granular pieces of an angular form, leaving spaces through which all minute particles (produced by the slow decomposition of hard or chrystalline rocks) can filter along with the water, form no bottom or foundation for the accumulation of soil fit for vegetable production, but remain dry and steril; it is only on the lower ground of such countries that soil can accumulate.

To the foregoing general principles of the decomposition of rocks, there will be many exceptions when compared with actual results, arising from local observation and experience; and those exceptions will be in proportion to our deficiency in the knowledge of the various modes of working which nature employs, and our ignorance of the variety and nature of the new mixtures and compounds formed by all changes resulting from a natural process.

Great allowance must likewise be made for the action of water; for example, a river rises in a secondary country, and after traversing through limestone and other secondary rocks some hundreds of miles, it flows through a primitive country, carrying with it all the gravel and mud it has collected; it follows of course, that soils, formed of such depositions, though in a primitive country, must partake of the properties and fertility of a secondary soil, as the decomposition of limestone gravel, giving off a coat of decomposed limestone every year, will keep up the soil; on the contrary, rivers running through secondary countries, after having long flowed over primitive, will carry along with them primitive sand and gravel that will partake of the properties of primitive soils, though formed in secondary countries.

After examining some of the effects that would most probably be produced on the soil, by the decomposition of the different classes of rocks, we shall endeavour to apply the principles to the soils of the United States, in reference to the accompanying map.

The primitive, or chrystalline class, is not favourable to the forming of soil fit for vegetation.

1st. It has no remains either of vegetable or animal matter.

2dly. It is slow to decompose, and easily washed away.

3dly. It is generally situated on higher elevations, owing in some degree to its difficult and slow decomposition.

4thly. There is little or no calcareous earth in the primitive; the strata found occasionally in the gneiss, mica slate, &c. are seldom more than from twenty to one hundred feet in thickness, and do not affect much the surrounding soils.

5thly. The particles of chrystals are so minute and so compactly placed by the laws of affinity, that they absorb little or no moisture.

6thly. For the same reason they are perhaps bad absorbers and still worse retainers of heat; which may be one cause why primitive soils are so cold.

7thly. They have no gypsum in them, and very little of any other rock, soluble in water.

8thly. They have no carbon or any species of coal in their stratification, though coals are often found in the secondary basins they enclose.

The first primitive rock is the granite, which is a granular aggregate of chrystals, decomposing into a gravelly mass: this rock proceeding slowly through the other stages of decomposition, is liable to run off through the filter, or wash down the declivity.

Gneiss, from its fissile structure and additional quantity of mica, is of easier decomposition, not quite so easily washed, and forms a soil a little more argillaceous.

Mica slate has still more argil in it, and decomposes more rapidly.

Clay slate in general forms a tough strong soil, and retains the little it receives.

The accidental beds of limestone, hornblende, and serpentine, found in the three last mentioned rocks, are so small and partial, as not to affect the general nature of the soil, though their almost perpendicular position brings the edges of all the stratifications of the above mentioned rocks to the surface, and thereby renders a mixture of their component parts almost a certain consequenee of their decomposition. This is one advantage the primitive has in common with the transitions, as it is more than probable that such a mixture would form a better soil than the decomposition of any one of the different strata, if isolated by being in a horizontal position; for this would confine the formation of soil to the decomposition of the uppermost stratum.

The hornblende rocks, either compact or slaty, often have small particles of pyrites scattered through them, which hastens decomposition into fine red mould, perhaps the best soil of all the primitive rocks.

Serpentine, as well as the greatest part of the magnesian genus, though decomposing easily with a stiff clay, is nevertheless unfriendly to vegetation; perhaps from the soil being so strong and adhesive as to prevent the vegetable roots from penetrating; in that case, sand might be a good manure.

Whether it is from the elevation in height, rigour of climate, or from the various other defects before mentioned, it may be safely laid down as a general position, that the primitive is covered with a soil less productive than the other classes of rocks, and serves as a foundation for much of the steril regions of the north, as well as the burning sands of the deserts.

The rivers of this class roll over precipices and rocky beds full of obstructions, scarcely admitting any continued navigation. So, when the primitive touches the ocean, it forms what is called a bold shore with perpendicular precipices, deep water, and harbours free from banks, or any other obstructions from the alluvial class.

Abundance of fine springs of clear good water, more free from all the impurities of foreign substances than in any other of the classes, are found in this class of rocks; which at the same time are generally healthy and favourable to human existence.

Quartz in small chyrstalline particles being a constituent part of this class, it is of course from the decomposition and minute trituration of this quartz by the action of currents of water or wind, that we obtain the greatest part of our siliceous sand. Great masses of rocks, in rolling, form an impalpable powder, but do not form sand. It is this class that may be supposed to furnish the materials for the formation of all the aggregates of the three following classes, except perhaps the limestone, and the remains of vegetable and animal matter.

TRANSITION CLASS.

The greatest part of the rocks of this class decompose into soils favourable to vegetation.

1st. They are composed of particles, previously the result of the decomposition of other rocks; and are more easily and rapidly turned into soil.

2dly. They contain some remains of vegetable and animal matter.

3dly. With a few exceptions of those that are near the primitive, they consist either of limestone, or of rocks that have some quantity of lime in their composition.

4thly. They contain large beds of gypsum.

5thly. Being aggregates of minute rounded particles, they permit the absorption of heat; and not being good conductors, are useful in retaining it.

6thly. They absorb moisture and retain it.

7thly. They are subject, though in a less degree, to one disadvantage attending the primitive, that is, they occupy high and broken countries.

8thly. This class holds considerable masses of anthracite, and other rocks containing carbon.

The sandstone of the transition class, is difficult to decompose, and consisting for the most part of silex, makes a light gravelly soil; the greatest part of the rolled pebbles in the alluvion of this class, are sandstone.

Two kinds of aggregates are found in this class, one having a base of a greenish slate, with chrystals of feldspar and rolled pebbles, and another consisting of rounded masses of a light blue quartz, in a fibrous cement; both of these are near the primitive, and partake of its qualities, that is, decompose slowly into a sand or gravel.

Grey wacke decomposes likewise into a sand or gravel; but the cement, consisting of clay and lime, forms a considerable part, and makes a tolerable soil.

Grey wacke slate of all kinds, consisting of small rounded particles, imbedded in a considerable quantity of clay mixed with lime, and generally alternating with strata of limestone, from one inch to one hundred feet thick, decomposes into a fine loam, favourable for vegetation.

Limestone, which is found in large and extensive fields in the transition class, is likewise favourable to the formation of a good soil; but is subject to the inconvenience of forming caves, and allowing much of the water which falls on the surface, to filter through, and form little streams under the surface, which deprives the soil of its necessary moisture. This is sometimes prevented by the alternation of the grey wacke slate, which stops the circulation and throws the water out to the surface. Hence it is probable, that the alternation of the grey wacke slate with the limestone, will form a more productive soil, than when the limestone is in great masses and extensive fields.

This class generally covers the primitive, and is often found on the flanks of steep mountains, of course liable to wash, and leave the rocks bare of soil; but when it is found in low and level situations, it decomposes into a mould easily wrought and favourable to vegetation.

Being in the vicinity of mountainous and broken countries, the rivers run through it rapidly; it is therefore unfavourable to navigation.

The water is tolerable, but not so pure as that of the primitive class, holding often a small quantity of lime or salt in solution; but it is much purer than the limestone water of the secondary class, the limestone of which dissolves in water more easily and in much greater quantities.

This class, placed between the primitive and secondary, partakes of the properties of both. It has the advantage of consisting of rocks formed by the aggregation of particles the result of former decompositions, like the secondary; and resembles a little the primitive in its situation and constant declination from the horizon. This regular dip or declination from the horizon, throws the edges of all the strata on the surface, which gives to the soil formed by their decomposition the benefit of a mixture, which horizontal strata cannot produce; for example, a country composed of transition slate, limestone and sandstone, alternating in strata of from one foot to one hundred feet thick, in a state of decomposition, forms a soil, which consists of a mixture of the component parts of all the three species of rocks. This will most probably be superior for vegetation to any soil formed entirely of the decomposed particles of any one of the rocks, as would be the case, if they were in a horizontal position; it is therefore probable, that the nature of the soil is more varied, and does not continue for any great distance exactly similar, as is found in the extent of barren sand, found both in the secondary and alluvial, owing perhaps to their horizontal position.

SECONDARY, OR HORIZONTAL CLASS.

This class has many properties favourable to the growth of vegetables.

1st. It is horizontal, or nearly so; forms large level plains; and drops down by plates or embankments, seldom or never precipitous, like the two last classes.

2dly. It consists of aggregations of particles, the result of former decompositions; soft and easily reduced into mould.

3dly. It contains the remains of vegetable and animal matter in abundance.

4thly. It has much limestone strata, and rocks containing a considerable proportion of lime.

5thly. It contains large beds of gypsum and salt.

6thly. Coals are principally found in this class, as well as many compound rocks containing carbon.

7thly. Being aggregates of minute rounded particles, not so compact as the transition, they have more interstices for the reception and retention of heat.

8thly. For the same reason, they absorb and retain moisture.

The oldest red sandstone is one of the principal members of this class, and partakes a little of the properties of the transition, in having a much greater proportion of cement, consisting of fine clay mixed with the oxyd of iron, and forms a good soil; the other sandstones, united by the infiltration of water with a small proportion of cement, decompose into sand, and form a dry barren soil.

Limestone, alternating with a slaty clay mixed with carbon, forms an excellent loam and good soil. Limestone by itself, in large fields, is likewise favourable to a good soil, when it does not run into caves and under-ground drainings, which deprives the surface of its necessary moisture.

Chalk decomposes into good soil, when level; but is apt to wash, and leave only a thin soil, when in hills or steep declivities.

Sand and salt are perhaps the least favourable to vegetation of all the substances of this class; and when joined together in a warm climate, form barren deserts. Where the salt water runs under the sand, and is stopped by some stratum from going further, it has a constant tendency to mount to the surface, either by capillary or some other attraction. Arrived at the surface, the water is evaporated, and the salt left on the sand, frequently preventing all vegetation, and at best producing coarse and bad grass.

Gypsum has as yet only been found in the United States in this class, though in time it is possible that great quantities will be found, as in Europe, in the transition.

The properties of gypsum as a manure, are too well known to the farmers of the United States, by an extensive and profitable application, to require any elucidation. Why so small a quantity, as a bushel to the acre, should produce such astonishing fertility, has been a matter of controversy. Some are of opinion that it acts as a stimulant, others that it attracts the moisture of the atmosphere, &c.; but I should be rather inclined to think, that it owes its fertilizing power to its solubility in water, the same quantity of water dissolving more of this rock than any other.

Vegetables cannot absorb any substance, unless it be in a state of complete solution; but the quantity of earthy matter found in vegetables is exceedingly small; it would therefore follow, that should that small quantity of earthy matter be presented to the mouths of the vegetable absorbents in a complete state of solution, they would take up as much as was necessary for the future developement of the plant, and would only require afterwards the free access of the fluids of heat and moisture, which contribute so much to vegetable growth and production. Now this quantity of earthy substances, is furnished by the small quantity of the powdered gypsum thrown over the plant, which dissolving by the first rain or even dew, carries what is necessary to the mouths of the absorbents, and in this manner supplies the plant with all the earthy particles necessary for its future growth.

There are two negative proofs in favour of this supposition; first, that gypsum when burnt, loses the greatest part of its fertilizing powers, and at the same time is deprived of its property of easy solution; whereas limestone, when burnt, is of easy solution in water, and forms good manure, but in its natural state is not so easily dissolved in water, nor is it nearly so good for vegetable production; in both cases their utility as a manure appears in the direct ratio of their solubility in water.

The same theory is confirmed by the limestone land, being more favourable to the growth of vegetables, than soils produced by the decomposition of siliceous clay rocks; and perhaps for the same reason, that is, the solubility of limestone, which, though a better manure when burned, because more soluble in water than in its natural state, yet even in its state of limestone rock, it is more soluble in water than those rocks composed of siliceous or argillaceous earths.

It may perhaps be found that artificial composts, used as manure, derive part of their fertilizing qualities from the salt and alkalies they contain, having the properties of facilitating the dissolution of the different earths, and reducing them to a state of liquidity, capable of being absorbed by the vegetable as food, and of course accelerating its future growth.

The doctrine of stimulants may perhaps be applied to vegetable as well as animal life; but even in animals their common food is the principal stimulant they take, and it is probable that stimulant without nourishment is only applied in a diseased state, and when often applied to a healthy subject, will create a state of disease that will require a continuance of their irritating effects.

The supposition, that the gypsum acts as the healthy stimulant of the food of animals, both as a stimulant and nourishment to the vegetable, is perhaps carrying the analogy of animal and vegetable life as far as our present knowledge of the nature of both will admit.

As all substances used as manure for land, are bulky, and cannot bear the expense of land carriage any distance, the advantage of an easy river navigation is inappreciable to agricultural pursuits; this advantage is one of the most valuable attached to the secondary class of rocks, which from their horizontal position and small elevation, permit the rivers to run slowly over deep and unobstructed beds nearly from their sources to the ocean; so that all the small ramifications of the inferior streams can transport limestone, coal, gypsum, &c. to the door of every farm house, and carry away his surplus produce to market on easy terms.

This horizontal position, by allowing only one of the strata to appear, is the cause of large tracts of country being covered with the same kind of soil, the result of the decomposition of the same kind of rocks. Nothing but lowering or raising the level to the full thickness of the strata can change it; which is unfortunate where a sandstone is at the surface, decomposing into vast regions of sand; which, if it had been mixed with the strata of slaty clay, that might perhaps be found under it, would form good soil. This class of rocks falls or rises by plateaus, with large fields of table land, in general having a soil very different from each other, because they are formed from the decomposition of rocks of a very different nature.

Springs of water are of very different qualities in this class of rocks, depending on the nature of the strata through which they filter. Those which pass through sandstone, have the best chance of being purest; slaty clay, and all those argillaceous rocks that accompany coals, are often saturated with the neutral salts of copperas or alum, the result of the decomposition of pyrites which they often contain, or of common salt. The limestone of this class is so easily dissolved in water, that the greatest part of the water that traverses the limestone of it, is fully impregnated with lime, and deranges materially the bowels of strangers for the first day or two that they drink it. This is so frequent a quality attending the limestone in a horizontal position, or secondary limestone, that it may perhaps be considered as one of the characteristic properties, by which to distinguish it from the limestone of the primitive or transition class.

ALLUVIAL CLASS.

This class consists of every thing that is washed from all the other classes and deposited in beds, either from the waves of the sea, or of lakes, the currents of rivers, of winds, &c.

It possesses the advantage of being nearly level, and not subject to wash.

When deposed by the action of rapid running rivers, it is generally sand and gravel and poor soil; but where slow running rivers overflow their banks, they for the most part leave a rich vegetable mould, making a fertile soil.

The sea most usually agitated, leaves sand or gravel on its shores, which is likewise the case with the great lakes; this seldom forms a good soil.

In this class we find the greatest quantity of marshy soil, rich in vegetable production, but difficult to drain, on account of its low and unhealthy situation.

Marle is one the best depositions for making good soil, and is generally found in alluvial situations by the sediment of rivers that have run through limestone countries. The gravel deposited by rivers, which run through a limestone country, decomposes into good soil, and may be called a limestone soil; but the depositions of sand and gravel, from rivers running through primitive countries, partake of the qualities of primitive rocks, and form but a dry, light soil.

Extensive plains of sand are often found in the alluvial formed by the sea; these frequently change place by the wind, and form a series of small hills, covering in many places large tracts of low country, which it renders barren and unfit for production.

Inland navigation in this class is extensive and commodious, the rivers running slowly and smoothly over deep beds, renders them navigable to near their sources. The navigation from the Caspian sea to the Baltic, by the Wolga and the Neva, carries boats upwards of one hundred tons burthen, with only one canal of about a mile long to join the two rivers, there being only four feet difference of level between them; all which long navigation, is through alluvial for the greatest part of the distance. That junction of the waters of the Black sea and the Baltic, by river navigation across Poland, is likewise through an alluvial country. The internal navigation of alluvial countries is generally good; but where the alluvial forms a sea coast, the harbours and bays are difficult and dangerous, obstructed with sand banks and shoals.

From the nature of the aggregation of alluvial materials, they generally consist of a considerable mixture of different substances, yet from its horizontality, it sometimes contains extensive tracts, covered with soil of the same or similar depositions, being the result of the same causes, such as the sand thrown up by the action of the waves of the sea, &c.

The alluvial of small vallies, situated in broken and mountainous countries, has a much better chance of being rich and fertile than of large vallies in level countries; because in proportion to the extent of the surface, they receive the washings of a much greater extent of soil, than those large vallies in level countries can possibly receive from surfaces whose horizontal position prevents their washing. It is from this cause, that the few small vallies, found in primitive countries, are so rich, and form so great a contrast with the soil of the mountains.

TRAP CLASS.

This class, though exceedingly limited in extent, generally lays over all the others, and occupies the tops of hills.

1st. It is of difficult decomposition, being hard and adhesive, but falling easily into trappose pieces.

2d. It is capable of absorbing and retaining moisture, resembling in a small degree lava, being full of very small interstices.

3d. It is equally capable of absorbing and retaining heat.

4th. Being a partial and scattered class, it is mixed, and covers all the rocks of the other classes, and of course, in the formation of soil, partakes of their quality.

The basalt of this class decomposes slowly, but forms a good soil, where it does not wash. The wacke and porphyries decompose into strong clay soil, capable of retaining the manure put into it, and in low situations form a tolerable soil.

Tuffa, and other loose aggregates of this class, partake of the nature of volcanic rocks when decomposed, and form excellent soils.

VOLCANIC CLASS.

This is a partial, irregular, and variegated class, and has many properties highly favourable to vegetation in its decomposed state.

1st. From its origin it generally occupies elevated situations.

2d. It contains from one-twentieth to one-tenth of alkali, which favours its decomposition, and perhaps its dissolution.

3d. Though hard, and often chrystalline, yet it is in some places full of pores, and in general has innumerable small interstices, which both absorb and retain moisture.

4th. For the above reason it both absorbs and retains heat.

Lava, when compact and approaching the vitrified slate, is exceedingly slow of decomposition; but when decomposed in low places, it forms a rich soil; the fuller it is of pores, the more easily it decomposes, and of course makes the soil deeper and more productive.

All kinds of volcanic ashes, with all kinds of tuffas, form fine rich mould, and in a short time equal in thickness the bed of ashes or tuffa; the fertility of such a soil is inexhaustible.

From the foregoing investigation it may perhaps be concluded, as a general result, that the oftener rocks have undergone decomposition and trituration into minute particles, the more fit they are to produce and support vegetables; and the more frequently they have been moved from one place to another, by the agents of decomposition, the more plain and level is the situation they are left in: after every change, this may be traced from the primitive through the transition and secondary to the alluvial; the surface of the decomposition, after such change, becoming less steep and precipitous, approaching nearer and nearer to a level, fit for the reception and retention of all matter, both fluid and solid, capable of assisting vegetable growth.*

To the above general result, the trap and volcanic, or what some would call the old and new volcanic formations, are exceptions as to situation; being thrown from an opening in the surface, the matter ejected must accumulate round the mouth of the crater and its vicinity; and the oftener it is remitted and ejected, the higher will most probably be the mountains it forms, and of course less fit for the production of soil and situation favourable to the growth of plants; this is one of the striking contrasts between the Neptunian operations and the volcanic, that are daily going on under our eyes; rains and rivers wash down the mountains into the plains, while fire heaps up the plains into high and precipitous mountains.

Considering that the action of fire is but partial, and the action of water constant and general, the prospect into futurity is consoling and cheerful; that the earth is every day moulding down into a form more capable of producing and

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* In aid of nature's operations to reduce the particles of earth to a state more fit for vegetable production, comes the industry and ingenuity of man, by digging, ploughing, harrowing, and manuring; they much accelerate the progress of ameliorating the earth's surface, and thus accomplish in a few years of labour judiciously applied, what nature would require many centuries to effect by operations of her general laws.

The perfection of all the arts, therefore, only prepares the means of a more rapid and certain progress towards perfection, and who can fix the limits where it shall stop?

increasing vegetable matter, the food of animals, and consequently progressing towards a state of amelioration and accumulation of those materials, of which the moderate and rational enjoyment constitutes great part of our comfort and happiness. On the surface of such an extensive and perpetual progression, let us hope that mankind will not, nay cannot, remain stationary.

On looking back to the probable past, without going so far as to interfere with any of the present general laws of nature, it may occur, that before all this alluvial, secondary or transition had been rolled about, pounded up and mixed by the rains and rivers, united with the various operations of vegetable and animal production, the state of this earth most probably was different, when the first lichen began to accelerate the progress of decomposition on the surface of the first rock.

SECTION IV.

The probable Effects, which the Decomposition of the various Classes of Rocks may have on the Nature and Fertility of the Soils of the different States of North America, in reference to the accompanying geological Map.

It may be necessary again to say, that these observations are only adapted to the earthy part of soils, and are not applicable to soils where the operations of nature in covering the surface with the decomposition of vegetable and animal matter, or the industry of man in putting manure, has mixed the soil with a considerable quantity of vegetable mould. Such soils are productive so long as the vegetable mould remains. The earth formed by the decomposition of the rocks, or the rocks in their original state, are only accessory to the production of this mould, in proportion to their quality of producing a more or less quantity of vegetables, and their property of retaining the vegetable mould a greater or less period of time.

Over the extended surfaces which one class of rocks covers, some considerable exceptions to general rules must be expected; such as remains, or partial patches of a different class of rocks, overlaying the general stratification, and producing effects on the soil, conformable to the properties of the class they belong to. An example of this on a large scale is to be found in the Redlands, which crosses Virginia in the direction of the Green mountains, and penetrates considerably into North Carolina. These lands, though resting in many places upon a primitive formation, differ from the generality of primitive soils; they contain little or no sand, fall into impalpable powder, and I believe hold a small portion of lime; if there should be an extensive mass of hornblende rocks intimately mixed with pyrites, the decomposition of such a mixture might perhaps produce a similar soil, but such a circumstance rarely happens. It is therefore more probable, that this extensive bed is the remains of a transition formation, part of which still runs near it and under it, from the Delaware to the Yadkin. Although at present this formation is by no means so broad and extensive as the red soil, yet it might formerly have been competent to produce an alluvial of that extent. The red soil, and this narrow bed of transition, running in the same direction and always together, though the red soil covers a much greater surface at present, renders the supposition the most probable that it is the decomposition of a bed of transition limestone and grey wacke, that formerly covered a much greater surface than it may now do; or it may be perhaps a continuation of the red sandstone, which begins at Connecticut river, and finishes near the Rappahannock, with some few interruptions; or it may be a bed of alluvial, transported from a great distance by the movement of waters that have long since ceased to act. As the transition strata accompany it through its whole course, the most rational conjecture is, that it is the decomposition of a transition bed formerly more extensive than at present. In this manner many partial beds of a different class form patches over a general formation, producing soils that to a superficial observer might become a great exception to the general principle, though when accurately examined, only tend to confirm and support the general rule.

By reference to the accompanying geological map it will be seen, that the four New England states consist mostly of the primitive class of rocks, except in two places; the one from the boundary line between Vermont and Massachusetts, on the Connecticut river, south of Middletown, and from thence to New Haven, in breadth from fifteen to twenty-five miles, composed of the oldest red sandstone formation.

The second exception is the greatest part of Rhode Island, and from thence to Boston, where about fifteen miles broad of the primitive is covered by the transition class or formation, and from the remains of a few patches of transition to the east and north-east of Boston, with the beds of transition pebbles found on the primitive. In that direction it is more than probable that the transition has extended, at some former period, much farther to the north-east.

To the west the New England states, including the district of Maine, are bounded by a range of high and rugged mountains, where the vallies are very narrow, and surrounded by steep and rocky banks. Many of those vallies are fertile, being the repositories of the washings of a great surface of mountain; but the sides of the hills and mountains are bare, and retain little or no soil. Where the mica slate, clay slate, hornblende and primitive limestone prevail, the soil will most probably be more adhesive, accumulate quicker, and form a thicker bed. Where granite, gneiss, quartz, and other siliceous rocks prevail, the soil will most probably be light and thin.

From the mountains to the westward the country declines gradually to the sea coast, where there are but few hills; yet the surface is rugged and broken, obstructed in many places by large blocks of rocks, chiefly granite, heaped on the surface of a soil, rather sandy and light, which is tolerable the first four or five years after it is cleared of wood, but would require manure afterwards to make it productive.

A proper proportion of heat and moisture is requisite for the production of all plants, but the grasses require more especially moisture. It would appear that the New England states are best fitted for a grazing country, and moisture becomes more necessary for such a country, than for a wheat or Indian corn country. The clearing away the woods, favours the accumulation of heat in the earth, but decreases the quantity of vapour, that in passing would be condensed into rain. It would therefore seem to be prudent in such countries, not to clear more land than is positively necessary, and on no account to cut down the trees that crown the tops of the hills and mountains; for by baring their tops, the summer temperature will be so much increased, that the clouds will pass over them without condensing, and the effects which are produced in the islands of the West Indies, by cutting away the woods, will take place on this continent, though not in so great a degree.

Between Rhode Island and Boston, the transition will most probably be covered with a soil rather fertile, where the grey wacke schist and limestone prevail; and only tolerable, where the grey wacke with large pebbles is found, but on the whole, better than the upland of any primitive soil.

The oldest red sandstone on the Connecticut river, when level, which it generally is, ought to produce a good soil where it is covered with ridges of greenstone trap; but a gradually thin soil, where the irregular declivities and trappose division of the rock, prevents the accumulation of earth sufficiently quick to form a permanent soil.

The sea coast, is, agreeably to the general character of the primitive class, little obstructed by banks or shoals, and the harbours are open, large and commodious, of easy access, with plenty of water, and safe; but the internal navigation by the rivers is exceedingly bad, full of rocks and rapids, difficult to remove; while the hard and adhesive nature of the rock, is a great hindrance to the cutting of canals.

Where the oldest red sandstone occupies the banks of the Connecticut river, from the frontiers of Vermont to below Middletown, the navigation is tolerable, approaching a little to the advantages generally attending that class of rocks; but further up the river, in Vermont or New Hampshire, where the river runs over primitive rocks, the falls and rapids are both greater, and occur more frequently.

Vermont lays to the westward of the New England states, and occupies part of that range of mountains, running north and south in the direction of the stratification, nearly twenty to thirty miles from Lake Champlain, and parallel to it. Two classes of rocks occupy the whole state; the transition which extends along Lake Champlain, and is about twenty-five miles broad, where the primitive begins, and continues till it joins the frontiers of New England.

In the transition, the soil will most probably be good, where the land is level and composed of grey wacke schist and limestone; the siliceous members of the transition class occupying in general the mountains, will most probably be thin and sandy, though in level places the soil may be tolerable, owing to the declination from the horizon mixing the alternating strata.

The primitive, which forms the east side of the state, is principally composed of mica and clay slate, which may form a compact and strong soil in the valleys; the sides of the mountains will most probably be thin and light soil, not sufficiently thick to produce much vegetation.

Through the whole of this state, as well as the New England states, the range of the mountains runs from north to south, and of course all the vallies of any consequence follow the same direction; open to the north and north-west winds, they are equally exposed to the south and south-west, taking immediately the temperature of those two contrary currents of air. Vallies thus situated, are subject to have a very hot summer and cold winter, and also to the great evil of a vacillating spring and autumn, where heat and cold alternate so quickly, as to injure materially all vegetables, but more particularly those of foreign origin, which is the case with most of the plants that are cultivated in the United States.

To the south-west of the Hudson river this inequality of climate is moderated a little by the chain of mountains, as well as the principal vallies, running south-east,* and consequently in some measure sheltered from the sudden changes produced by the north and north-west winds in spring and fall.

All circulation of heavy and cumbersome articles, such as are used for manure, is exceedingly difficult in the interior of this state, as the rivers are full of falls and rapids; but Lake Champlain facilitates considerably the exportation of their surplus produce; they also have the advantage of the tide navigation of the Hudson, for taking their produce to market.

The state of New York consists partly of alluvial, and partly of primitive, transition, and secondary rocks, and enjoys a tide navigation on the Hudson river, which penetrates through the whole classes.

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* The same difference of climate is observable between Italy and Spain. In Italy the chain of the Apennines runs nearly north and south, leaving a free passage to the northerly winds to carry their temperature into all the great vallies; but in Spain the Sierra Novada, and many of the ranges of mountains, like the Pyrenees, run from east to west, and protect all to the south of them, from the sudden variations of climate, which frequently occurs in Italy during the winter. Nice, for the same reason, is considered to have the mildest winter of any place in the south of France, being under shelter of the Alps, which run towards the east on the north side, and screen the town from the northerly winds. Tokay produces what is called the finest wines in Europe, and is only a degree south of Poland, where there is no species of wine; it owes this to the chain of the Carpathian mountains, running east and west, and protecting Hungary from the rigour of the north winds. Even the polar climate of the great plain of Tartary, may perhaps be owing to the ranges of mountains running towards the Frozen ocean, while the great valleys, through which the rivers Obi, Lena, Tenisey, &c. run their long rapid courses, may serve as conductors of the temperature of the poles to their sources, and the same chains of mountains, which by running east and west, protect Indostan from the northern blast, may equally prevent Tartary and Siberia from enjoying the vivifying influence of the southern breezes. It is probable, that much of the climate of all countries depends on the currents of air and water, and their direction is perhaps regulated by the mountains on shore, and the banks, and other obstructions at sea, as well as by periodical winds.

Long island forms the alluvial part of the state, and has all the advantages of being a low level country, which is generally attached to this class. The west end of this island is partly made up of the alluvial, washed down by the Hudson from a transition and secondary country, and may be considered as forming a soil favourable to vegetable production, where the action of the waves has not washed away the lightest and most productive part of it.

The east end of the island, formed principally by the alluvial of the sea, joined to a proportion of alluvial furnished by rivers, such as the Connecticut, that run through the primitive, is most probably light and sandy, with extensive beds of gravel, too poor to produce a sufficient growth of trees or plants to enrich the soil; but enjoying the advantages of an even surface, not liable to wash; and likewise the moderate and equal climate of a low island, surrounded by the sea; hence it is capable of being made productive in pasture lands, like all the islands on this coast, which are favourable to the breeding of sheep bearing fine wool.

York island, and the Highlands, as far as Newbury and Philiptown, on Hudson river to the north, and the boundaries of Connecticut to the east, is primitive. From the town to the commencement of the Highlands we find principally gneiss and granite, and of course it inclines towards a gravelly and thin soil; the Highlands as well as the primitive which skirts the Connecticut border, contains much clay and mica slate, and will most probably form a stronger soil in the vallies.

That mass of country north of the Mohawk, bounded by Lake Champlain to the east, and the river St. Lawrence to the north, is likewise primitive; and from all appearance is a rough mountainous country, with some vallies of tolerable soil; but the mountains are most probably thin and poor, subject to the northern winds, and the rigorous changes of climate, which are the natural consequences.

From Philiptown on the Hudson, to near Lake Champlain, is a strip of transition from fifteen to twenty-five miles wide on the east side of the Hudson, and extending on the west side perhaps further; though in many places west of the Hudson, on the tops of mountains and rising grounds, it is covered by secondary, forming a constant alternation between transition and secondary, which would require much accurate examination to designate; we have therefore coloured the whole as transition, which we consider the foundation.

This valley, divided by the Hudson, ought to have a good soil, where it is level, consisting principally of grey wacke slate and limestone; but is subject to the inconvenience of the Vermont vallies, in being open to the north, and liable to sudden and great changes in the temperature. The advantage of a tide navigation, running almost the whole length, is all important to the progress of agriculture, by transporting, at an easy expense, the bulky articles necessary to improve the soil.

The secondary of this state, runs along the Mohawk to Lake Ontario, and follows the borders of the lakes to the frontiers of Pennsylvania, skirting the transition to the south-east; it is generally tolerable soil, the alluvial of the rivers being composed of depositions from the decomposed secondary; is in most places rich and fertile, as on the Mohawk, &c. The alluvial of the lakes, in many places washed by the movement of the waters, is but thin and inclined to be sandy. How far the alluvial of the lakes extends to the south depends on how far the lakes themselves have covered those countries formerly; which is uncertain.

This secondary makes rather a small exception to the general rule of that class, possessing the properties of easy and safe navigation in the interior, owing to its small rivers running principally into Lake Ontario, which is so considerably below the general level of the country, that the streams are rapid and often obstructed by the falls. The communication with the sea, either by the lake and the St. Lawrence, or by the Mohawk and Hudson rivers, is but slightly obstructed with rapids and rocks. From the western part it is probable that the communication through French creek, the Ohio, and down the Mississippi to the gulf of Mexico, is perhaps the most easy and convenient passage to the sea.

A canal from Lake Erie to the Mohawk has been projected. So great a distance, across all the vallies made by all the streams, which run into the Lake Ontario, would make it an expensive undertaking; so much so, that it is probable the whole surplus produce that would pass through it would not pay one per cent. on the sum expended, in making it. The quantity of surplus produce to feed the idle, or to export to foreign countries, depends on the quantity consumed by the farmers and labourers at home. In this country, where they eat animal food, and every thing of the best kind, three times a day, the surplus produced by three or four labourers is not equal to the surplus produced by one labourer in countries where they eat nothing but brown bread and potatoes; where the labourers are slaves; where consumption is restricted to a few quarts of corn a week. In such places, the surplus produce destined to feed their masters and for exportation, is considerable. If all the produce made by the slave states, and exported by them, or through the medium of the other states, could be deducted from the whole exports of the United States, the balance exported by the free labour states, would be much smaller than most people are aware of.

While the labourer lives so well, and consumes such a great proportion of the produce of his labour, those statesmen and others who judge of the capability of this community to pay taxes, and feed the unproductive classes, from what takes place in Europe, will be much mistaken. No produce can possibly supply more to the non-productive class, than the surplus that remains to the farmer, after furnishing every thing his habits make necessary to feed himself and family; where those habits are like those of the labourers in most parts of Europe, they can furnish four times more surplus, out of the same produce, than the labourer can here with his present habits.

Jersey consists of alluvial along the sea coast, which runs along the east bank of the Delaware from Cape May to Trenton; and from thence to Elizabethtown it is bounded by the red sandstone. It is of course partly formed by the sea and partly by the depositions of the Hudson and Delaware rivers, which touch two sides of it; the part of this alluvial, formed by the above mentioned rivers, consisting of depositions washed off the transition and secondary formations, is most probably good soil; but the part of it thrown up by the waves of the sea, will be thin and sandy.

Considerable depositions of bog-iron ore, are found in this alluvial, which may perhaps be owing to the vicinity of the old red sandstone, the iron oxyd of its cement furnishing the materials. So, the bog-iron ore is more abundant in the alluvial of Maryland and the Jerseys, where the red sandstone is found in the neighbourhood, than in other states to the south.

The oldest red sandstone extends from the edge of the alluvial to the foot of the primitive mountains, and from the Hudson to the Delaware. Where the country is level, and consists of the red sandstone only, the soil is good; where it is covered with the greenstone trap, it is generally thin soil and stony.

To the north-west the primitive range occupies the frontier of the state, diminishing in breadth as it progresses to the south-west, and finishes in a point south of Bethlehem. This primitive is rugged and steril, where the mountains are steep and precipitous, or where the quartz and siliceous rocks predominate. The slates, hornblende, and primitive limestone, where level, form a tolerable soil; it is likewise rich in fine magnetic iron ore, which has been wrought to advantage; but is deprived, like the greatest part of primitive ranges, of river navigation; a great hindrance to the progress of agriculture as well as manufactories, from which disadvantage the secondary and alluvial of this state, is in some measure free.

Pennsylvania consists principally of transition and secondary, having the smallest quantity of the primitive class of any state east of the mountains, and most probably the greatest quantity of good land, in proportion to its surface, of any of the Atlantic states.

From the south-east boundary, to about twenty or twenty-five miles north-west, is included all the primitive of the state, which is light and indifferent, where the gneiss, granite or serpentine prevails; the limestone or hornblende rocks may form a tolerable soil, as the country, though broken, is not hilly, and has nothing that can be called a mountain. The rivers Susquehannah, Schuylkill, Delaware, or any other inferior streams, where alluvial is formed, being the depositions from transition and secondary formations, will most probably produce a rich soil.

An extensive transition formation succeeds to the primitive and occupies nearly seventy miles in breadth to the top of the dividing ridge, between the western and the eastern waters, which forms the summit of the Alleghany mountains. In this place the transition is wider than in any other part of our range of mountains, and is only interrupted for about twenty or thirty miles, between Norristown and Reading, by being covered by the oldest red sandstone formation.

The soil, through the whole of this tract, when level, is tolerably good; where formed by the alluvial of the rivers, it is generally rich and fertile, but the quartzy and siliceous aggregates, which most frequently occupy the mountains, decompose into a light sandy soil, though the vallies between those mountains are rich and productive.

The river navigation of the primitive and transition of this state is, agreeable to the general character of those classes, very indifferent, obstructed by a great many rapids and falls, liable to the freshets of mountain torrents, breaking through narrow and rocky passages, with all the extremes and inconvenience of too much or too little water, to remove which would require much labour and expense, which perhaps could only be repaid by the transportation of some very bulky articles, such as coal, gypsum, or limestone. It is a query whether an expensive canal navigation can be repaid by the mere transportation of the surplus produce of the soil, or even of manufactories, except bulky coal. Limestone, iron and manures, it is probable, support the greatest part of the expense of canals, even in England.

From the top of the Alleghany mountains to Lake Erie, is part of the great secondary formation of the basin of the Mississippi, and extends from the frontier of the state of New York to the limits of Ohio and state of Virginia; this secondary formation may incline to be sandy on the hills, where the sandstone prevails; but the valley and river alluvial is rich and fertile. It loses little of the vegetable mould by washing, owing to its general horizontal position; and the accumulation of such vegetable manure is in proportion to the time the trees have been growing on the soil. It is probable that the alluvial made by the washing of the lake, may be thin and sandy, as well as the part that may have been at no very distant period the bottom of the lake; and for that reason the trees may not have been long enough on the surface to accumulate a bed of vegetable decomposition of any great thickness; in that case, though the earthy part of the soil may be good, the natural manure, dropped from the trees, may be thin and soon worn away.

Both coal and limestone have been found in great abundance on the west side of the Alleghany mountains; the coal they use with advantage as manure; the slaty clay, which alternates so often with the limestone in this formation, contains carbon, which augments its productive quality when decomposed into soil.

Though nearly fifteen hundred miles from the sea, it enjoys a river navigation, without any siliceous obstructions, the whole distance; as the secondary extends to the bay of Mexico, and affords all the advantages of deep and slow running rivers (which is generally the character of this class of rocks) facilitating every kind of internal navigation.

From the ease with which they navigate the small creeks and streams, every farmer may have a landing place near his plantation, and receive at small expense the limestone, plaister, or coals, necessary to agriculture and the other arts. Even where a canal is necessary in this class, the level situation and nature of the rocks, makes the accomplishment of it easier than in most of the other classes.

There is no ridge of mountains on this side Lake Erie that can shelter the country from the north and north-west winds; it is therefore probable that this part of the great basin is exposed to the sudden and great changes of temperature, produced by the rapid currents of air from north to south, or from south to north; it is equally in the nature of such a situation for the changes to be more rapid and more severe, in proportion as the land is cleared of wood. Prudence might perhaps dictate the leaving strips of wood from east to west, on purpose to protect as much as possible the useful plants from the effects of the rapid changes in the spring and fall.

The state of Pennsylvania is perhaps the best cultivated of all the states in the union; that is, more of the farmers have dropped the ancient practice of wearing out one field, and going to clear away the trees of another, without adopting any system of manuring by plaister, or rotation of crops, so as to keep the lands once cleared continually in heart. Most of the Pennsylvania farmers, like the farmers in Europe, make their fields better and richer in proportion to the time they have been in culture; it is therefore partly to art and industry, and partly to nature, that we are indebted for the prosperous state of agriculture in this commonwealth.

Delaware, the smallest state of the union, consists almost entirely of alluvial; the part formed by the depositions of the Delaware, will most probably be good soil, while that made by the washings of the sea will be light and sandy. That small strip of primitive, which touches the Pennsylvania frontier, being low and level, is more or less covered with alluvial, and is likely to be tolerable soil.

The tide water of the Delaware, and small rivers and creeks in the alluvial, furnishes this state with good internal navigation.

Almost surrounded by tide water, this state has access to the sea at all points, and enjoys, from its being placed between the Delaware, the sea, and the Chesapeak, almost the mildness of an insular situation, not so subject to extremes of heat and cold.

Maryland has a great deal of alluvial, some primitive and transition, and very little secondary. The Chesapeak is the large inland bay, formed most probably by the ocean throwing up a bank of sand and gravel on the eastern shore; on the inside of which the great rivers, that now run into the bay, have been constantly heaping their depositions, consisting of the washings of a great transition and secondary country, which descend with the waters of the Susquehannah and Potomac, and the sediment of the Rappahannock and James rivers, consisting of transition and primitive deposition.

It is therefore probable, that the alluvial of both sides of the Chesapeak, protected by the neck of land on the eastern shore from the washing of the waves of the sea, will be good soil generally, and approach nearer to the quality of river bottoms, than any alluvial open to the movements of the sea, and liable to be washed by it. The situation in which we now find it, after so long a practice of so ruinous a system of culture, constant cropping, and no manure, is a strong proof of the original good quality of the soil.

Such is the nature of the alluvial in Maryland, occupying all the state south-east of a line drawn from Havre de Grace on the Susquehannah, passing through Baltimore to Washington on the Potomac. For navigation, both internal and external, the alluvial of Maryland enjoys all the advantages attached to that class of rocks, in an easy and safe access to the sea by the Potomac and Chesapeak bay, and a free circulation of craft in the interior by means of all the small rivers and creeks, through which the tide mounts to the foot of the granite ridge, that is, to the entrance upon the primitive.

This primitive begins at the line where the alluvial ends, and continues towards the north-west, from twenty to twenty-five miles; the country rugged but level; in some places thin and poor, in others tolerable, as it approaches the old red sandstone; a band of which, eight or ten miles wide, lays upon the outer edge before we come upon the transition; this band of red sandstone makes good soil, where the sandstone prevails, but rather thin and light soil, where the greenstone trap covers it.

The west part of the state is a strip along the banks of the Potomac, of transition, which is most probably good soil. So great a proportion of this state laying upon tide water, intersected by the Chesapeak, and so many bays and creeks, will probably diminish the rigour of the winter, and modify the extremes of heat and cold in the spring and fall.

Virginia contains all the classes of rocks, and like Pennsylvania stretches considerably into the secondary basin of the Mississippi. The alluvial occupies all that part of the state situated on the south east side of a line drawn from Washington through Fredericksburg, Richmond, and Petersburg, to the Roanoke, having the sea for its south-east boundary. On the northern part it is good soil, like the alluvial of Maryland, but towards the south it is partly made up of the alluvial of the ocean, and partly of the deposits brought down by the Rappahannock and James rivers, collected principally from primitive countries, mostly of sand and gravel; of course, the probability is, that the soil towards North Carolina will be sandy and thin.

Both the internal and external navigation is excellent; for the tide flows up all the small rivers and creeks to the limits of the alluvial or commencement of the primitive; and the vast influx and reflux of the tide into the Chesapeak, sweeps the channels between the capes so clear of banks, as to afford water of sufficient depth for any ship; which is rather contrary to the general effects produced on alluvial coasts.

The primitive succeeds to the alluvial, and runs north-west to the Blue Ridge, which it keeps as a boundary to Magotty Gap; from thence it proceeds south-west, and passes to the eastward of the lead mines at Austinville, and from thence towards the warm springs in North Carolina. The vallies in this, like all other primitive, are narrow, but generally rich and fertile. The upland, as far west as the South or Green mountains, is rather level, but broken; the soil thin and light near to the Green mountains; ranging in the same direction, is the red soil, which crosses the state, seldom extending twenty miles in width, or much less than six to seven miles broad; frequently irregular and in patches, and is perhaps the best upland soil, independent of river bottoms, that is in the Atlantic states.

This bed of red soil follows a narrow stratum of grey wacke slate and transition limestone, and in many places it covers the primitive at some distance from the limestone, yet it is more than probable, that it is the remains of a transition formation, which may have formerly covered the primitive to a greater extent.

Westward of the red soil, the soil is thin as long as the Blue Ridge is the boundary, to Magotty Gap; but after the ridge is primitive, to the south of Magotty Gap, there is a considerable extent of gravel, covering the foot of the ridge, called the gravel ridges, which being composed of rolled quartz, apparently the remains of a great field of clay slate, mixed with a great quantity of transition sandstone pebbles, the soil is barren and thin, producing no growth of wood sufficient to manure it. Those gravel ridges continue along the foot of the primitive mountains, through both North Carolina and Georgia.

The navigation is indifferent, though below the ridge, from the level situation of the country, boats run upon James river.

On the limits of the primitive begins the transition, which continues west of the top of the Alleghany, near the Sulphur springs; from thence south-west to the eastward of Abingdon, passing about twenty-two miles west of the Painted rock on the frontiers of North Carolina and Tennessee. This is rather a broken, mountainous country, with extensive vallies of limestone and slate, which produces good fertile soil, while the mountains, consisting principally of sandstone and quartzy aggregates, make a thin, poor soil; the navigation being bad, owing to the want of water near the sources of the rivers, and the obstructions of falls and rapids hinders equally internal circulation and external communication with a market; resembling in this, the whole country which occupies the dividing range between the eastern and western waters; that is, to be further from a market than those lands situated either east or west on a navigable river.

Between the limits of the transition and the river Ohio, is the secondary of this state, which enjoys the soil and advantages of the secondary of Pennsylvania, except as to the rivers that water it. The Great Kanhawa and other streams rise in a mountainous transition country, and may probably carry down and deposit masses of gravel, formed by the quartzy aggregates and sandstone, which frequently occupies the high lands in transition countries; whereas all the rivers in the Pennsylvania secondary, rise and run their whole course in the secondary, and are therefore more likely to make deposits, that are richer and more adapted to vegetable production.

North Carolina consists principally of alluvial and primitive, divided by a line running to the west of Halifax and the east of Raleigh, passing by Aversboro' and Rockingham. To the east of this line, extending to the sea, runs the alluvial formation. From the circumstance of this alluvial being made by the washing of the waves of the sea, or accumulated by the depositions from rivers which have run their whole course through a primitive country, the probability is, that it will in many places be sandy and thin soil.

That part of the coast bordering on Pimlico and Albemarle sounds, being protected by the sand banks and bars from the washing of the waves of the sea, may deposit a tolerable alluvial, approaching in quality to that of the Chesapeak; if the same bars and banks did not obstruct the draining of the low lands that surround those inlets, and render them too watery for the purpose of agriculture: though from the heat of the climate it is probable, when united to a sufficient moisture, the accumulation of vegetable productions will be rapid.

From this increasing heat, as we go south, a considerable increase of vegetable production must accumulate in the low lands, where there is moisture; and on the contrary, where there is sand and no moisture, the sterility must be augmented, which will have the effect of rendering the poor lands, that are dry, less productive, and the low lands that have moisture, more rich and fertile; producing a much greater contrast between the rich and the poor soils, than takes place in the northern latitudes.

Internal navigation is good, and all kinds of manures and bulky articles can circulate through the creeks and rivers at small expense; but the communication with the sea is obstructed by sand banks and bars, which makes the export of their surplus to foreign countries, difficult and expensive.

From the limits of the alluvial to within ten miles of the frontiers of the Tennessee, all is primitive. For some distance westward, it is rather level, and covered with a coat of alluvial, which in some places forms a tolerable soil; the country afterwards becomes broken, with much granite and gneiss, forming a thin soil to the foot of the mountains, where the gravel ridges begin; being steril and unproductive. The mountains are high and rugged, rather bare of soil; the vallies, as in all primitive, narrow, but fertile. It is in this state, that the whole mass of mountains begins to be primitive, as in New England; they are therefore more steep and rocky, and the vallies fewer and narrower; they constitute the dividing ridge, and the rivers which run to the westward pass through a considerable extent of primitive country, as well as those which drain the water off to the eastward.

Navigation, both internal and external, is bad; the rivers are incumbered with falls and rapids. The strip of transition of about ten miles broad, which touches the frontiers of Tennessee, is a rough, mountainous country, consisting of the quartzy aggregates in the high lands, and of course their soils; but the vallies, though confined and narrow, are fertile and productive.

South Carolina is entirely formed of alluvial and primitive, divided by a line, running by Columbia to Savannah; the alluvial extending east from that line to the sea. This alluvial is formed by the washing of the sea and by the sediment of rivers, which have their sources and run the greatest part of their course through primitive; it is therefore probable, that the dry part of the alluvial will incline to be sandy and light soil. The river bottoms and low situations, where there is water, will be rich and fertile, from the heat and moisture accumulating so rapidly the vegetable matter. It is likewise probable, that the remains of the madrepore rocks, which are equal to powdered limestone, may be brought by the currents from the south, and mixed with the sand on the sea islands, by which the nature of the soil would be materially changed for the better. The quantity of coral and madrepore rocks, that are forming on both sides of the gulf stream, where it passes the coast of Florida, gives probability to this conjecture.

The bed of blue marl, with shells, which crosses this state and Georgia, and extends even through the Floridas, will be likely to form a soil equal to limestone land; it is deposited by the sea, most probably in places protected by sand banks from the washing of the waves, and approaching to the alluvial made by the rivers.

Though the tide of the rivers ceases to flow twenty or thirty miles below the primitive, yet the navigation for craft is good to the edge of the primitive rocks, and the communication with the sea is tolerable by the means of bar harbours.

The primitive in this state, as North Carolina, is flat for some distance from the edge of the alluvial, and covered with a coat of earth, apparently the decomposition of hornblende and slate rocks, which makes a good soil, and becomes more rugged and broken as you proceed towards the mountains, which are high and steep, composed principally of gneiss and granite, and forming a thin soil, disposed to be gravelly; but the vallies or river bottoms, though narrow, are rich and fertile, diminishing in extent and number, as you proceed higher up the mountains, where the rapidity of the rivers gives little lime or still water to form the deposition of any other but heavy substances, such as rolled rocks or gravel.

The navigation in this, like the other primitive countries, is bad; the rivers, obstructed with falls and shoals, are too rapid and uncertain.

That part of the primitive which touches the alluvial, or the eastern and lowest edge, becomes flatter and more inclined to decomposition, as you proceed south on this and the two bordering states, at the junction of the primitive and alluvial; the former is decomposed to a considerable thickness below the surface, though covered with a considerable depth of alluvial; and above the junction where the primitive rocks appear in all the rivers and water courses, the surface is flat, and overlaid by a considerable mass of earth, for many miles to the westward. It is therefore probable, that heat facilitates the decomposition of primitive rocks more than water, and that the result of the decomposition, that is, the soil it makes, is more favourable to the production of vegetable matter, inasmuch as it decomposes more rapidly, and is not so liable to be washed during the operation.

Georgia, like South Carolina, consists almost entirely of alluvial and primitive; divided by a line running from Augusta by Milledgeville, Fort Hawkins, and the agency on Flint river, to the south. East of that line, to the sea and frontiers of Florida, the soil is alluvial, formed by the rivers and the sea. Some of the rivers, such as the Savannah, run through primitive country, and form sandy, light soil. The Altamaha holds the greatest part of its course through alluvial country, and will most probably form richer and more productive depositions.

The sea may form alluvial of a superior quality, by being mixed with the broken remains of the madrepore rocks in the vicinity; it is even probable, that the islands on the coast may have madrepore and coral rocks for their foundation, which in warm climates decomposes rapidly into very good soil.

Wherever there is the command of water in this climate, vegetable matter will accumulate, which makes all the low lands on the rivers rich and fertile, though the dry land may be poor and sandy. It is however probable, that the alluvial above tide water, being level and not much washed, may be tolerable good soil. River navigation is good, and boats run up to the edge of the primitive, and coasters to the head of tide water, which is, in some of the rivers, nearly fifty miles below the primitive ridge; the communication with the sea by bar harbours is not difficult.

To the north, a little westerly of the limits of the alluvial, is the primitive formation, level, and covered with earth of tolerable quality; for some distance towards the mountains, this plateau of level country, decreases in width the further you go west, finishing in a rough, broken country. To the north it consists principally of gneiss and granite; as you approach the mountains, which are high, the soil is rather thin and poor, but the vallies between them are rich and fertile, though narrow.

A small angle of this state crosses the mountains, and touches at a point the river Tennessee; this is in part transition, and the rest secondary, which corresponds in quality with the same classes of rocks in North Carolina, and the state of Tennessee.

The part of this state, which lays upon the declivity of the Alleghany mountains, sheltered to the south from the northerly winds, and open to the mild temperature of the south and south-west breezes, ought to be, and indeed is, one of the most moderate climates of the United States; in a great measure free from the sudden and violent changes of heat and cold, produced by the free circulation of those two opposite currents of air from the north and south, bringing along with them the temperature of the opposite climates, from whence they come. It may likewise be considered as a climate more congenial to the growth of plants from the south of Europe, such as the vine and the olive, than any situation north of it in the United States.

From the circumstance of the range of mountains approaching nearer and parallel to the sea, the rivers are shorter, and run their whole course in nearly the same latitude, which renders the floods less dangerous and more under the command of dykes and barriers, than they are in the western country, where the whole basin of the Mississippi is drained by one river, and the melting of the snows in the north inundates and ravages the plains in the south, with a force and weight of water, difficult to be controlled by the limited exertions of man, and perhaps not to be accomplished by a thin and scattered population.

The foregoing short description includes the whole Atlantic states; that is, all the states which consist of a variety of all the different classes of rocks in a geological point of view; the application of the properties whereof to agriculture, in modifying the nature and fertility of soils, is rather mixed and complicated. The rest of the United States, round by the lakes, and we have reason to believe, even as far west as the foot of the Stony mountains, consist of two classes of rocks, the secondary, and the alluvial made up of the washings of the secondary; these two classes possess properties the most favourable to the production of vegetables, first, in situation; tending always towards the level and even surface, and secondly, in component parts; being made up of particles ground and worn by repeated friction into minute powder, mixed and triturated so as to produce earths and soils best calculated for the growth of plants.

In this vast extent of country therefore, the different nature and fertility of soils does not depend as much on any difference in the quality of the rocks whereof the soils are formed in a geological point of view, for they are nearly the same, but chiefly on the difference of climate, and relative situations as to height, the regular or irregular supply of heat and moisture depending on the constancy or uncertainty of the agents that furnish them, including the various effects produced by the freshets and inundations of the rivers, with the nature of the rocks at their sources, and through which they may have run for some distance.

The division, called the Mississippi territory, extends from the confines of Georgia to the limits of Louisiana and the river Mississippi; and from north to south from the frontiers of Tennessee to Florida, and the gulf of Mexico. This division is composed of secondary, and the alluvial made up of the decomposition of secondary rocks; both classes of rocks contain the materials necessary to the formation of good loam, and will most probably make good soils.

That part of this district, which lays on the declivity of the hills towards the south, protected from the north wind and open to the south, will most probably enjoy an equal and moderate climate; and like the part of Georgia in a similar situation, it will be favourable to the production of the vine and the olive. Where it touches the river Mississippi, it will partake of the river alluvial, and the inconveniences of its floods and marshes; and that part bordering on Tennessee, will most probably be similar in soil, produce and climate, to the coast of the great basin which it joins.

Bounded on the west, north, and east side by navigable rivers, and drained by three other rivers that communicate immediately with the gulf of Mexico, this district ought to enjoy a good navigation, both internal and external, while it is in some measure free from the inundations and uncertainty of the rivers of long course; those rivers which have run through it, are of a size capable of being controlled by the industry of man, and at no season subject to the inconvenience of great periodical floods, or the obstruction of ice towards their sources, which is more or less the case with those rivers that rise in northern latitudes.

From the gradual declivity of the ground, and from the rivers which run through the country, rising in a rather elevated situation at no great distance, the springs of water will most probably be abundant, and the water tolerable; the east part of the territory, with the western part of the state of Georgia, are the only body of lands in the United States, which lays on a southern coast, open to the influence of the southern breezes, and sheltered from the sudden changes which accompany the northerly winds on this continent. It may therefore be reasonably inferred, that the climate is one of the most moderate in the United States, or at least that part which has been as yet settled; and that the range of the thermometer is not so extensive, nor the extremes of heat and cold so great as in those places exposed to the influence of the northerly winds. It is equally probable, that the portion immediately south of the highest part of the termination of the Alleghany mountains will be the best protected from the influence of the north wind, and of course the most temperate climate, though the soil may be less productive from its proximity to the primitive.

The head waters of the Tennessee river, rising in a mountainous country, consisting of primitive and transition rocks, and running a considerable distance through them, will be apt to bring down considerable quantities of sand and gravel, composed of quartz, and sandstone of transition pebbles; of course, the state of Tennessee may contain a greater quantity of gravel ridges or sand beds, than the other states in this great basin; but the state of Kentucky, made up of the alluvial that descends the Ohio, collected from a coal, grey wacke, and limestone country, will most probably be rich and fertile; the same causes will produce the same effects, with a little allowance for difference of climate, in the states of Ohio, Indiana, and Illinois. The Michigan and North Western territory, being still further north, and having more of their alluvial originating from the washing of the lakes, will require still a greater deduction from their fertility and productiveness. The whole basin consists of secondary, or alluvial resulting from secondary decompositions: and therefore has the best chance of a good natural soil, while its level situation, not liable to be washed, insures it all the benefits of an accumulation of vegetable mould, from the fall of the leaves, decayed grass, and other vegetable decompositions.

There are a great many detached masses of granite and sienite, scattered over the surface of that part of the basin, which lays to the north of the Ohio river, but runs to the south; from which it is probable, that they have come from the north, perhaps from the primitive mountains, north of the great lakes; if so, the movement of waters must have been at some former periods different from what they are now; and those waters (in place of depositing the decomposition of secondary, as all the rivers rising near the lakes do now) most probably brought with them, along with those masses of primitive rocks, the remains of primitive mountains, and may have left more sand and gravel on the northern parts than is to be found in the south.

West of the Mississippi, the whole passes under the name of the Missouri territory, and near the sea it is called Louisiana. The whole of this territory, to near the foot of the Stony mountains, appears to be secondary; but what is the nature of the Stony mountains, or how much of the alluvial brought down from them by the large rivers (which have been the principal agents in filling up the west side of the basin) may be the washings of primitive mountains, is uncertain. The tops of the Stony mountains are covered to a considerable extent with perpetual snows and pendent glaciers; a proof that they are vastly higher than the Alleghany mountains; of course, the numberless streams and torrents, which descend their flanks, roll with much more violence and rapidity a far greater quantity of water from the melting of the snows, than can be expected to descend from mountains of the height of the Alleghany. It is therefore reasonable to suppose, that they will deposit at the foot of the Stony mountains, and for some considerable distance, a much greater quantity of sand and gravel than the streams from the west side of the Alleghany.

This sand and gravel, when dried up by a southern sun, may form extensive basins, deprived of water: they will become deserts, while the banks of rivers or moist places may make tolerable soil. These causes may render the soil of the western part of this extensive basin unequal, and vibrating between very poor and tolerably rich.

Rivers, which rise on the mountains and run over such a vast extent of country, carrying all their waters and deposits towards one common centre, and all joining the sea by one common outlet, are generally liable to periodical inundations, and bring down with them a great body of water accompanied with a great deal of sediment or alluvial. This alluvial is generally first deposited on the bed and banks of those rivers, raising them very much above the level of the surrounding country, and giving the rivers the appearance of running upon a ridge, which is the cause why the surrounding country is liable to be flooded to a great distance by the first inundation; the draining of which, after the rivers subside, is very much impeded by the circumstance of the bed and banks of the rivers being on a higher level, and preventing the water from running off, forming large lakes and marshes, until the heat dries them up, to experience again the same drowning as at the first periodical inundation. When the weight of waters that roll down in such rivers is so great as to be out of the controul of the labour of man, it is attended with great inconvenience and uncertainty to the farmer, and by rendering property precarious, becomes one of the greatest hindrances that can be put in the way of improvement; but this is fortunately limited in the basin of the Mississippi, to the lower part of the largest rivers, and even they, like the Nile, may perhaps be brought hereafter under the controul of persevering industry.

Though this basin is highest on the west, north, and east side, and declines gradually to the south side of the great northern lakes, there is no range of mountains or any basin sufficiently elevated to protect it against the northerly winds, which range through the whole without obstruction, and carry with them the sudden changes of temperature, common to the north winds on this continent. It is not improbable, that the frequency of those north winds may be limited by the south wind being forced up the basin by the constant effects of the trade wind, filling the bay of Mexico, and the range of mountains at the bottom of the bay turning the current to the north; still, there is a change of the opposite winds, and a sudden transition from cold to heat.

This transition of temperature may certainly become every day less injurious, both to men and vegetables, in proportion as they become habituated to the climate, and acquire new habits better fitted for their situation; for it is probable, that we have not been struggling long enough with the inequalities of the climate, to have lost our European habits; which being forced on us by an order of things quite different, does not suit this country. Most of the vegetables, fruit, &c. which we cultivate, have likewise their European habits, which they have not yet had time enough to change.

On examining both the geographical and geological maps of the United States, it will appear, that they are divided into two distinct and separate parts, differing materially from each other in their relative situation and means of communication with the rest of the globe, as well as in their interior circulation and communication within their own territory. The national line of separation between those two great territories, is that range of mountains, called the Alleghany; which from the poorness of the soil, and the difficulty of getting to market, will most probably be the last part of the continent thickly inhabited.

On the west side of this ridge is the vast basin of the Mississippi; geologically composed of similar substances, enjoying the advantage of all climates from the 29th to the 45th degree of latitude, having the command of the tropical productions as well as those of the north, circulated through its most distant extremities by the immense ramifications of one great navigable river, communicating with the ocean only at one point; navigable with some danger and difficulty by merchant ships, but inaccessible to large ships of war.

On the Atlantic side of the ridge, they enjoy nearly the same variety of climate and production; but for the medium of communication, from north to south, they depend on the sea, which is accessible at all points, both to merchant ships and ships of war.

The inhabitant west of the mountains is forced by situation to consider the internal navigation as the cause of his riches, independence and happiness; but having only one leading sea port, the foreign commerce will most propably be considered of secondary moment, and be given up to those who can do it cheapest. At the same time, confident of his strength, and having only one point to defend, it is difficult for his rulers to persuade him of the necessity either for a fleet or an army; so that both his situation and interest force him to be at peace with all the world.

It is not the same with the inhabitant on the shore of the Atlantic. Placed on an extensive coast, accessible at all points to the depredations of a superior fleet, he is easily persuaded by his rulers to keep up a fleet and an army to protect commerce, &c. tending doubtless to involve us in all the wars of Europe, at the enormous expense it must always cost a government such as this. Taxes follow in proportion. The inhabitants of the west pay their proportion of these taxes without the same feeling or interest. The breach widens by the natural gravitation of interest arising out of situation; and nothing can long keep them together but the utmost prudence and economy in the federal rulers, by avoiding war and every cause of expense.

On this earth, or in the page of history, it is probable no place can be found of the same extent, so well calculated to perpetuate a free and equal representative government, as the basin of the Mississippi, both from its physical advantages and the political constitutions on which the state of society is bottomed.

By enjoying the different productions of a variety of climates through a rapid and easy circulation to the extremities of the country, by means of rivers, secured against the depredations of any foreign enemy, they set out with advantages, which thousands of years of labour have not been able to obtain for other nations.

That territory, being inclosed within a chain of mountains, or lakes, together with the comparative weakness of their neighbours, guarantees the inhabitants against the least apprehension of invasion, while their having only one bad harbour, unfit for ships of war, takes away the ability of invading by sea the property of others—removes in a great measure the temptation of war—and deprives the rulers even of an excuse of keeping either a fleet or army establishment, which hitherto have always produced the ruin of free and equal representative governments.

Bottomed on a free and equal representation of men, they will most probably be governed by the majority; not like the greatest part of the Atlantic states, which are founded on a representation of property, and liable to be governed by the few or the minority. Monopoly of property ensures monopoly of power, and the means of perpetuating it, as is proven by the experience of all other nations. They will most probably be divided into twenty or thirty free and independent representative governments, which will guarantee them against any sudden usurpation. But as all the nations in the old world who possessed any share of equal representation, have been deprived of it by the intrigues of their rulers, experience forbids the placing great confidence in the continuance of equal representation, even on this favourite spot, though we may be allowed to indulge in the hope, that it will long be governed by the positive majority, and remain a place of refuge to oppressed humanity.

EXPLANATION OF PLATE II.

[ON THE GEOLOGY OF THE U. STATES.]

THIS Plate contains five sections of the United States, from the sea shore to the great secondary basin of the Mississippi, with the comparative elevation of the range of mountains called in general the Alleghany. The scale of height on the margin is divided into ten parts; the first five is two hundred feet each, to give some apparent height to the small hills and low country; the upper half of the scale is equally divided into five, and is one thousand feet, each division; making the whole scale six thousand feet. It is not meant that the highest part of the ridge shall be found exactly where the line passes, but that the highest part of the ridge in the vicinity of that line, shall most probably be found of the height marked by the scale in the section.

The colours correspond with those on the map; that is, the Siena for the rock, red for the transition, the blue for the secondary, and the yellow for the alluvial, &c.

The Catskill mountains are here represented as transition, though in many places west of the Hudson the transition is found only on the lower

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No. II.

Astronomical Observations, &c. communicated by Andrew Ellicott, Esq.—Read Nov. 16th, 1810.

Lancaster, Nov. 14th, 1810.

I BELIEVE none of the following observations have as yet been communicated to the Philosophical Society.

Observations on the Eclipse of the Moon, Jan. 4th, 1806.

The beginning of the eclipse could not be observed, the Moon being covered by clouds. The end was observed as follows:

Moon's limb visible through the penumbra at	8h	15′	0″	Apparent time.
Moon's limb clear of the penumbra at -	8	17	12	

Observations on the Eclipses of Jupiter's Satellites.

1806	July 5th	Emersion of the	3d Satellite	observed at	7h	53′	17″	Mean time.
	Do.	do.	2d	do.	10	44	7	
	Aug. 5th	do.	1st	do.	11	21	15	
	6th	do.	2d	do.	10	20	18	
	21st	do.	1st	do.	9	40	42	
	Sept. 6th	do.	1st	do.	8	0	44	
	13th	do.	1st	do.	9	56	21	

1807 July 31st at 9h 53′ 18″ the 2d Satellite of Jupiter was observed emerging from behind the body of the planet, but was not completely emerged till 9h 57′ 37″. Jupiter was so near the opposition, that neither the immersion into, nor emersion out of, the shadow could be observed.

	Sept. 15th	Immersion of the	3d Satellite	observed at	8h	33′	13″	Mean time.
		Emersion	do.	do.	12	7	12	
	Oct. 11th	do.	1st	do.	7	48	59	
1810	Oct. 30th	Immersion	2d	do.	10	57	22	
	Nov. 6th	do.	1st	do.	8	40	16	

Observations made at Lancaster on the Comet of 1807.

The first sight I had of this Comet, was on the evening of the 22d of September; but being severely indisposed, I was not able to make any observations on it till the 5th of October.

The observations were all made with a small sextant of six inches radius, graduated by Ramsden, and are communicated more as a curiosity, to show what degree of confidence may be placed in an instrument of that size and construction, than from their positive accuracy and utility.

October 5th—6h 55′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		228°	10′	26″
	N. polar dist.		83	22	31
	Long.	7s	13	42	8
	Lat. N.		23	36	40
October 6th—6h 42′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		229°	11′	14″
	N. polar dist.		82	26	47
	Long.	7s	14	27	51
	Lat. N.		24	47	26
October 7th—6h 39′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		230°	11′	33″
	N. polar dist.		81	30	57
	Long.	7s	15	13	36
	Lat. N.		25	57	59
October 8th—6h 49′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		231°	14′	25″
	N. polar dist.		80	37	42
	Long.	7s	16	3	27
	Lat. N.		27	6	34
October 10th—6h 44′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		233°	17′	29″
	N. polar dist.		78	52	39
	Long.	7s	17	42	34
	Lat. N.		29	21	1
October 11th—6h 51′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		234°	17′	15′
	N. polar dist.		77	58	38
	Long.	7s	18	30	41
	Lat. N.		30	29	6
October 13th—6h 38′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		236°	16′	22″
	N. polar dist.		76	17	54
	Long.	7s	20	10	35
	Lat. N.		32	36	54
October 14th—6h 29′, by the distance of the Comet from *Arcturus*, and *α Lyræ*.	A. R. of the Comet		237°	16′	44″
	N. polar dist.		75	30	15
	Long.	7s	21	3	16
	Lat. N.		33	38	9

Same day, at 6h 42′, by the distance of the Comet from *α Lyræ*, and *α Coro. Borealis.*	A R. of the Comet		237°	17′	24″
	N polar dist.		75	30	22
	Long.	7s	21	4	1
	Lat. N.		33	38	12

The above two observations, being on different stars, agree as nearly as could reasonably be expected, considering the size of the sextant.

October 24th—6h 41′, by the distance of the Comet from *α Lyræ*, and *α Coro. Borealis.*	A. R. of the Comet		247°	2′	35″
	N. polar dist.		67	53	30
	Long.	8s	0	6	45
	Lat. N.		43	31	0

October 26th—6h 37′, by the distance of the Comet from *α Lyræ*, and *α Coro. Borealis.*	A. R. of the Comet		248°	56′	31″
	N. polar dist.		66	35	32
	Long.	8s	2	16	34
	Lat. N.		44	52	43

October 31st—7h 2′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R of the Comet		253°	59′	9″
	N. polar dist.		63	20	49
	Long.	8s	7	58	23
	Lat. N.		48	53	47

This observation is marked "*doubtful*" in my journal.

November 1st—6h 28′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R. of the Comet		254°	57′	47″
	N polar dist.		62	42	32
	Long.	8s	9	7	49
	Lat. N.		49	40	16

November 7th—6h 33′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R. of the Comet		261°	6′	26″
	N. polar dist.		59	11	22
	Long.	8s	16	59	9
	Lat. N.		53	52	12

November 13th—6h 23′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R of the Comet		267°	25′	58″
	N. polar dist.		56	2	59
	Long.	8s	26	2	44
	Lat. N.		57	24	0

November 18th—6h 15′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R. of the Comet		272°	54′	38″
	N. polar dist.		53	42	49
	Long.	9s	4	38	52
	Lat. N.		59	37	51

November 19th—6h 3′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R. of the Comet		273°	57′	1″
	N. polar dist.		53	17	29
	Long.	9s	6	20	36
	Lat. N.		60	0	38

November 21st—6h 28′, by the distance of the Comet from *α Lyræ*, and *α Aquilæ.*	A. R. of the Comet		276°	10′	37″
	N. polar dist.		52	26	52
	Long.	9s	10	4	11
	Lat. N.		60	47	54

Same day, and same time, by the distance of the Comet from α *Lyræ*, and α *Cygni.*	A. R. of the Comet		276°	9′	41″
	N. polar dist.		52	26	6
	Long.	9s	10	3	47
	Lat N.		60	48	44

Same day, and same time, by the distance of the Comet from α *Aquilæ*, and α *Cygni.*	A. R. of the Comet		276°	10′	22″
	N polar dist.		52	27	0
	Long.	9s	10	3	45
	Lat. N.		60	47	47

These three observations of the 21st of November, made on different stars, are reduced to the same time: the distances were all taken between 6h 18′ and 6h 36′: the greatest difference is in the latitude, which amounts to but 57″.

November 22d—6h 15′, by the distance of the Comet from α *Lyræ*, and α *Cygni.*	A. R. of the Comet		277°	16′	58′
	N. polar dist.		52	4	0
	Long.	9s	11	56	51
	Lat. N.		61	5	34

Same day, same time, by the distance of the Comet from α *Lyræ*, and α *Aquilæ.*	A. R. of the Comet		277°	16′	40″
	N. polar dist.		52	3	34
	Long.	9s	11	55	51
	Lat. N.		61	6	3

Same day, same time, by the distance of the Comet from α *Aquilæ*, and α *Cygni.*	A. R of the Comet		277°	16′	32″
	N. polar dist.		52	3	12
	Long.	9s	11	55	42
	Lat. N.		61	6	20

These three observations of the 22d, on different stars, are reduced to the same time, as in the foregoing case: the distances were all taken between 6h 1′ and 6h 29′: the greatest difference is in the longitude, which amounts to 1′ 9″.

November 24th—6h 11′, by the distance of the Comet from α *Lyræ*, and α *Aquilæ.*	A. R. of the Comet		279°	30′	6″
	N polar dist.		51	16	48
	Long.	9s	15	44	58
	Lat. N.		61	39	47

Same day, same time, by the distance of the Comet from α *Lyræ*, and α *Cygni.*	A. R. of the Comet		279°	30′	0″
	N. polar dist.		51	15	57
	Long.	9s	15	44	44
	Lat. N.		61	40	37

Same day, same time, by the distance of the Comet from α *Cygni*, and α *Aquilæ.*	A. R. of the Comet		279°	30′	24″
	N. polar dist.		51	16	38
	Long.	9s	15	45	12
	Lat. N.		61	39	55

These three observations on different stars, are reduced to the same time, as in the preceding cases: the distances were all taken between 5^h 58′ and 6^h 24′: the greatest difference is in the N. polar dist. which is but 51″.

November 30th—6h 44′, by the distance of the Comet from α *Aquilæ*, and α *Cygni.*	A. R. of the Comet		286°	23′	27″
	N. polar dist.		49	9	10
	Long.	9s	27	46	27
	Lat. N.		62	44	10

Same day, same time, by the distance of the Comet from α *Lyræ*, and α *Aquilæ*.	A. R of the Comet		286°	22′	31″
	N. polar dist.		49	9	24
	Long.	9s	27	45	48
	Lat. N.		62	44	7

The greatest difference between these two observations of the 30th, is in the right ascensions, and amounts to 56″.

December 3d—6h 13′, by the distance of the Comet from α *Aquilæ*, and α *Cygni.*	A. R. of the Comet		289°	48′	16″
	N polar dist.		48	12	15
	Long.	10s	3	44	46
	Lat. N.		62	57	16

Same day, same time, by the distance of the Comet from α *Lyræ*, and α *Aquilæ*.	A. R of the Comet		289°	47′	46″
	N. polar dist.		48	12	16
	Long.	10s	3	43	58
	Lat. N.		62	57	58

The greatest difference between the results of the observations of this day, on different stars, is in the longitudes, and amounts to 48″.

The observations on the comet were continued till the evening of the 10th of December; but the meeting of the legislature about that time occasioned so much hurry in the public offices, that the last observations, which were entered on loose papers, were mislaid, and probably lost, for want of time to record them.

Without feeling much partiality in favour of my own observations, I am induced to believe the foregoing may generally be depended upon, as coming within one minute of the truth; which is as near as could be reasonably expected from the size of the instrument I was under the necessity of using.

Various opinions have been suggested respecting the tails of comets; some of them are too absurd to merit attention, and others, though not reasonable, it might be difficult to refute for want of the necessary data. It is a subject on which we are confined to conjecture; but were I to venture an opinion, it would be, that comets are surrounded by a very rare, and luminous atmosphere, and that the tails are produced by the progressive motion of the light, emitted from the sun, propelling this luminous and rare atmosphere, (if it may be so called,) in a direction nearly opposite to the sun. When the comet is very distant from the sun, the effect of his light becomes less, and the attraction of the nucleus diminishes the length of the tail, which probably disappears entirely in the higher parts of the orbit, when the nucleus will be equally surrounded by this luminous and rare matter, as our earth is by its atmosphere; the higher and more rare parts of which I suspect are affected in the same manner, though in an infinitely less degree. Again, if the comets depended wholly on the sun for light, the nucleus of some of them, from their situation with respect to the sun and earth, ought to have appeared almost dichotomized; which I believe has never been observed. The nucleus of the comet of 1807, in the whole progress of my observations, appeared perfectly round.

Note.—All the calculations respecting the right ascension and north polar distance of the comet, were gone over twice, at different times; those of the latitude and longitude, but once, as they are deduced from the others, and may be examined at any time by those who have inclination and leisure.

Lancaster, Nov. 25th, 1810.

[*Read Nov. 28th*, 1810.]

I HERE inclose the formula, which I have used for many years, for calculating the parallax in latitude, and longitude. It is that of Dr. Maskelyne, somewhat abridged, by which the writing of three logs., with a little addition, is dispensed with. I do not think this important problem can be reduced to a shorter or more simple form. I have likewise inclosed an example, with some remarks, being one of the operations for calculating the beginning of the eclipse of the Sun on the 17th of next September: the operation was gone through in 22 minutes with Taylor's logarithms: the example includes all the work and all the figures. The figures 1, 2, 3, 4, in the margin, shew the logs. which are repeated, by which means they may be more readily compared to prevent mistakes: moreover, when the figures are entered in the margin of the operation, there will be no occasion to write down a number, or angle which is repeated, but merely the log. In my practice, I never write down a recurring number, or angle, but merely designate it by a marginal figure. So that in the original work of the inclosed example, nothing appeared on the left side of the logs. but the marginal figures 1, 2, 3, 4, and the signs +, there being no signs —, in the formula. I am sorry to trouble you with trifles, but have at present nothing else to send.

My observations on the Comet of 1807, I have had inclosed and sealed up for some time, but have been disappointed in forwarding them till the present opportunity.

Formula for calculating the Parallax in Latitude and Longitude.

Call the Moon's horizontal parallax, h; the altitude of the nonagesimal degree, H; the Moon's true latitude, L; the Moon's distance from the nonagesimal degree, n; the parallax in longitude, P; the parallax in latitude, Q; and the Moon's apparent latitude, l.

(1) + log. h
(2) + s. H reserve c. s. of H (3)
+ co. ar. c. s. L

Sum call A
+ s. n

= P nearly.

+ sum A
+ s. n+P

= P sufficiently correct

(1) + h
(3) + c. s. H

= Q nearly.
+ c. s. l reserve the s. of l (4)

= 1st part of Q.

(1) + h
(2) + s. H
(4) + s. l
+ c. s. n + ½ P

= 2d part of Q.

Note.—The 2d part of Q must be added to the 1st part, when the Moon's distance from the north pole of the ecliptic, and from the nonagesimal degree are of a different affection, and taken from it when of the same affection. In eclipses of the Sun it will be too small to need attention.

Moon's horizontal parallax from the Sun corrected 3236″ (h), altitude of the nonagesimal degree 53° 45′ 51″ (H), Moon's true latitude 32′ 54″ N. (L), Moon's distance from the nonagesimal degree 11° 8′ 41″ (n), Moon's apparent latitude (l). Then,

(1)	+ h 3236″ -	log. 3 5100085	
(2)	+ s. H 53° 45′ 51″ -	9 9066533	reserve c. s. H 9.7716685 (3)
	+ co. ar. c. s. L 0 32′ 54″	0 0000199	
	Sum call A -	3.4166817	
	+ s. n 11° 8′ 41″ -	9 2862046	
	= 504″.5 = 8′ 24″.5 -	2.7028863	= P nearly.
	Sum A - -	3.4166817	
	+ s. n + P 11° 17′ 5″.5	9 2915620	
	= P 510″ 7 = 8′ 30″.7	2 7082437	= P sufficiently correct.
(1)	+ h 3236″ -	3 5100085	
(3)	+ c. s. H 53° 45′ 51″ -	9 7716685	
	= 1912″ 8 + 31′ 52″.7	3 2816770	= Q nearly.
	+ c. s l 1′ 1″.3 -	10 0000000	reserve the s. l. 6.4770907 (4)
	= 1912″ 8 = 31′ 52″.7	3.2816770	= 1st part of Q.
(1)	+ h 3236″ -	3.5100085	
(2)	+ s. H 53° 45′ 51″	9 9066533	
(4)	+ s. l 0 1′ 1″ 3 -	6.4770907	
	+ s. n + ½ P 11° 12′ 59″.3	9.2889562	
	= 0″.15 -	9.1827087	= 2d part of Q.

n =	11° 8′ 41″
P nearly =	8 24.5
Moon's ap. dist. from nonag. deg.	11 17 5.5

Moon's true lat. N.	0° 32′ 54″
— P nearly -	31 52.7
Moon's ap. lat. (l)	1 1 3

n =	11° 8′ 41″
½ P =	4 15.3
n + ½ P	11 12 59.3

1st part of Q	31′ 52″.7
1d part of Q	.15
= Q.	31 52.55

Parallax in long.	8′ 30″.7
Do. in lat.	31 52.5

Note 1.—When the apparent latitude of the Moon is small, the subsequent part of the operation will have but little effect on *Q nearly*, or the first value of Q, as may be seen by this example; because the c. s. of the apparent latitude of the Moon being nearly equal to radius, does not sensibly change the value of *Q nearly*. The 2d part of Q may always be omitted in eclipses of the Sun. When the sum of the four logs. of the 2d part of Q fall short of 30.0000000, the 2d part will be the decimal of a second, as in the above example.

Note 2.—*P nearly*, and *Q nearly*, differing a little from P Q, the first are to be considered as approximations.

No. III.

Abstracts of Calculations to ascertain the Longitude of the Capitol, in the City of Washington, from Greenwich Observatory, in England. By William Lambert.—Read July 18th, 1817.

January 21st, 1793.

Occultation of α *Tauri* (Aldebaran) observed by Andrew Ellicott, Esq. supposed to have been at the Capitol, in the city of Washington. Latitude of the place of observation stated at 38° 52′ 40″ North.

Latitude of the place, reduced (320 to 319)	38° 42′ 9″.51 N.
Longitude assumed for the calculation	76 46 0 0 W.

Immersion, at	7h 55′ 49″.50	P. M. apparent time.
Emersion, at	9 25 21.50	

By De La Lande's Tables.

Star's *mean* right ascension	66° 0′ 57″.64	*Mean* declination N.	16° 4′ 47″.47
Nutation	— 0 2.87	Nutation	— 0 9.10
Aberration	+ 0 11.84	Aberration	+ 0 0.27
Right ascension	66 1 6 61	Declination N.	16 4 38.64

Obliquity of the ecliptic, January 21st, 1793	23° 27′ 48″.32
Star's longitude, by computation	66 53 59.50
latitude, south	5 28 54. 0

Moon's Longitude at Greenwich (Naut. Alm.).

1793. Jan. 20.	Midnight	53° 46′ 59″	A				
				+ 6° 12′ 35″ *a* 1			
21.	Noon	59 59 34	B		— 3′ 14″ *a* 2		
				+ 6 9 21 *b* 1		+ 24″ *a* 3	
	Midnight	66 8 56	C		— 2 50 *b* 2		. 0″ *a* 4
				+ 6 6 31 *c* 1		+ 24 *b* 3	
22.	Noon	72 15 26	D		— 2 26 *c* 2		
				+ 6 4 5 *d* 1			
	Midnight	78 19 31	E				

Moon's Latitude, South.

1793. Jan. 20.	Midnight	4° 46′ 3″ A				
			+ 10′ 56″ *a* 1			
21.	Noon	4 56 59 B		− 3′ 31″ *a* 2		
			+ 7 25 *b* 1		− 0′ 2″ *a* 3	
	Midnight	5 4 24 C		− 3 33 *b* 2		+ 5″ *a* 4
			+ 3 52 *c* 1		+ 0 3 *b* 3	
22.	Noon	5 8 16 D		− 3 30 *c* 2		
			+ 0 22 *d* 1			
	Midnight	5 8 38 E				

By the Immersion.

Apparent time of the immersion	7h 55′ 49″.50		118° 57′ 22″.50
Estimated longitude, West,	5 7 4.		
Corresponding time at Greenwich	13 2 53.50	Sun's R. A.	304 52 19 03
Right ascension of the meridian, from beginning of ♈ -			63 49 41 53
Do. do. from beginning of ♑ -			153 49 41 53
Altitude of the nonagesimal - -			72 51 36 14
Longitude of the nonagesimal, from beginning of ♈ -			68 53 14.05
Moon's *true* longitude (Naut. Alm.) - -			66 41 2.33
true latitude, South, - -			5 4 52.75
true distance from the nonagesimal (West) - -			2 12 11.72
equatorial horizontal parallax - - -			0 55 7.78
horizontal parallax reduced (320 to 319) -			0 55 3.71
parallax in longitude - -			0 2 3.74
apparent distance from the nonagesimal (West) -			2 14 15.46
parallax in latitude - -			0 21 7 91
apparent latitude, South, - -			5 26 0 66
augmented semidiameter, arising from apparent altitude			0 15 15.26
inflexion of light - -			— 0 2.98
semidiameter, corrected - -			0 15 12.28
Difference of apparent latitude, * south of ☽'s center -			0 2 53.34

To find the Difference of Longitude between the Moon's Limb, at the Point of Occultation, and the Moon's Center.

Moon's semidiameter, corrected -		912″.28		
Difference of apparent latitude -		173.34		
	Sum,	1085.62 -	log.	3.0356778
	Diff.	738.94 -	log.	2.8686092
				2)5.9042870
				2 9521435
Arith. comp. cosine Moon's apparent latitude - -				0.0019558
Diff. ☽'s longitude - -	14′ 59″.70	= 899″.70	log.	2 9540993

Star's longitude,	66°	53′	59″.50
Parallax in longitude,	+	2	3 .74
True longitude ☽'s limb, at the point of occultation,	66	56	3 24
Difference of longitude,	—	14	59 70
True longitude of ☽'s center, by calculation,	66	41	3 .54
Apparent time at Greenwich, when the Moon had that longitude,	13h	2′	55″.86
Apparent time of the immersion at Washington,	7	55	49 50
Longitude, in time, found by the immersion,	5	7	6 36
Equal to	76°	46	35 .40

By the Emersion.

Apparent time of emersion	9h	25′	21″.50		141°	20′	22″.50
Estimated longitude, West,	5	7	4 .—				
Corresponding time at Greenwich	14	32	25 .50	Sun's R. A.	304	56	14 .29
Right ascension of the meridian, from beginning of ♈					86	16	36 .79
Do. do. from beginning of ♑					176	16	36 .79
Altitude of the nonagesimal					74	43	18 .57
Longitude of the nonagesimal, from beginning of ♈					86	59	19 .53
Moon's *true* longitude (Naut. Alm.)					67	26	43 .90
true latitude, South,					5	5	30 .86
true distance from the nonagesimal (West)					19	32	35 .63
equatorial horizontal parallax					0	55	6 .04
horizontal parallax reduced (320 to 319)					0	55	1 .97
parallax in longitude					0	18	5 .56
apparent distance from the nonagesimal (West)					19	50	41 .19
parallax in latitude					0	19	8 .96
apparent latitude, South,					5	24	39 .82
augmented semidiameter, arising from apparent altitude					0	15	14 .09
inflexion of light					—	0	2 .98
semidiameter, corrected					0	15	11 .11
Difference of apparent latitude, ✱ south of ☽'s center					0	4	14 .18

Moon's semidiameter, corrected		911″ 11	
Difference of apparent latitude		254 18	
	Sum,	1165 .29	log. 3.0664340
	Diff.	656 .93	log. 2.8175191
			2)5.8839531
			2.9419765 5
Arith. comp. cosine Moon's apparent latitude			0.0019406.6
Diff. ☽'s longitude	14′ 38″.85	= 878″.85	log. 2.9439172

Star's longitude,	66° 53′ 59″.50
Parallax in longitude,	+ 18 5 56
True longitude of ☽'s limb, at the point of occultation	67 12 5 06
Difference of Moon's longitude,	+ 14 38 85
True longitude, Moon's center, by calculation,	67 26 43 91
Apparent time at Greenwich, when the Moon had that longitude,	14h 32′ 25″ 52
Apparent time of emersion at Washington,	9 25 21 50
Longitude, in time, found by the emersion,	5 7 4 .02
Equal to	76° 46 0 .30
By the immersion,	76 46 35 .40
Mean result—Longitude found by occultation of January 21st, 1793,	76 46 17 .85

October 20th, 1804.

Occultation of η Pleiadum (Alcyone,) by the Moon, observed by Messrs. Abraham Bradley and Seth Pease, North 75° W. one mile 7-10ths (estimated) from the Capitol. Difference of longitude, — 1′ 49″.75.

Latitude of the place of observation, estimated,	38° 53′ 30″.00 N.
Do. do. reduced (320 to 319)	38 42 59 .44
Longitude assumed for the calculation	76 56 51 —W.

Time of immersing by watch,	9h 30′ 2″ —
Watch too fast,	— 7 32 8
Apparent time of immersion,	9 22 29 .2
Time of emersion, by watch,	10h 24′ 40″
Watch too fast,	— 7 32 .8
Apparent time of emersion,	10 17 7 .2

By De La Lande's Tables.

Star's *mean* right ascension	53° 58′ 33″.80	Declination N.	23° 29′ 35″.20
Nutation	+ 0 14 .96	Nutation	+ 0 8 .10
Aberration	+ 0 18 .77	Aberration	+ 0 3 .48
Right ascension	53 59 7 .53	Declination N.	23 29 46 .78

Obliquity of the ecliptic, October 20th, 1804,	23° 27′ 54″.25
Star's longitude, by computation	57 16 37 44
latitude, north. do.	4 2 1 .16

Moon's Longitude at Greenwich (Naut. Alm.).

1804. Oct. 19.	Midnight	39°	44′	37″	A				
						+ 7° 34′ 6″ *a* 1			
20	Noon	47	18	43	B		− 0′ 57″ *a* 2		
						+ 7 33 9 *b* 1		− 1′ 11″ *a* 3	
	Midnight	54	51	52	C		− 2 8 *b* 2		+ 6.″ *a* 4
						+ 7 31 1 *c* 1		− 1 5 *b* 3	
21.	Noon	62	22	53	D		− 3 13 *c* 2		
						+ 7 27 48 *d* 1			
	Midnight	69	50	41	E				

Moon's Latitude, North.

1804. Oct. 19.	Midnight	4°	56′	34″	A				
						− 8′ 49″ *a* 1			
20.	Noon	4	47	45	B		− 5′ 1 *a* 2		
						− 13 50 *b* 1		+ 0′ 18″ *a* 3	
	Midnight	4	33	55	C		− 4 43 *b* 2		+ 9″ *a* 4
						− 18 33 *c* 1		+ 0 27 *b* 3	
21.	Noon	4	15	22	D		− 4 16 *c* 2		
						− 22 49 *d* 1			
	Midnight	3	52	33	E				

By the Immersion.

Apparent time of immersion,	9h	22′	29″	.2	=	140°	37′	18″	.00
Estimated longitude, West,	5	7	47	.4					
Corresponding time at Greenwich,	14	30	16	.6	Sun's R. A.	205	31	17	.37
Right ascension of the meridian, from beginning of ♈,						346	8	35	.37
Do. do. from beginning of ♑,						76	8	35	.37
Altitude of the nonagesimal,						49	35	51	.28
Longitude of the nonagesimal, from beginning of ♈,						5	51	6	.63
Moon's *true* longitude, (Naut. Alm.),						56	26	12	.93
true latitude, North, do.						4	30	25	.30
true distrnce from the nonagesimal, (East,)						50	35	6	.30
equatorial horizontal parallax,						1	1	3	.33
horizontal parallax, reduced (320 to 319),						1	0	58	.82
parallax in longitude						0	36	17	.78
apparent distance from nonagesimal, (East),						51	11	24	.08
parallax in latitude,						0	37	26	.94
apparent latitude, North,						3	52	58	.36
augmented semidiameter arising from apparent altitude,						0	16	47	.78
inflexion of light,						—	0	2	98
semidiameter, corrected,						0	16	44	.80
Difference of apparent latitude, ✱ north of ☽'s center,						0	9	2	.80

Moon's semidiameter corrected,		1004″.80			
Difference of apparent latitude,		542 80			
	Sum,	1547 60		log.	3.1896587
	Diff.	462 —		log.	2.6646420
					2)5 8543007
					2.9271503 5
Arith. comp. cosine Moon's apparent latitude,					0.0009981.5
Difference ☽'s longitude,		14′ 7″.57	= 847″.57	log.	2.9281484

Star's longitude,	57°	16′	37″	.44
Parallax in longitude,	—	36	17	78
True longitude ☽'s limb, at the point of occultation,	56	40	19	65
Difference ☽'s longitude,	—	14	7	57
True longitude Moon's center, by calculation,	56	26	12	09
Apparent time at Greenwich, when the Moon had that longitude,	14h	30′	15″	.26
Apparent time of immersion at Washington,	9	22	29	20
Longitude, in time, by the immersion,	5	7	46	06
Equal to	76	56	30	90

By the Emersion.

Apparent time of emersion,	10h 17′ 7″.2	=	154°	16′	48″	.00
Estimated longitude, West,	5 7 47 4					
Corresponding time at Greenwich,	15 24 54 6	Sun's R. A.	205	33	26	53
Right ascension of the meridian, from beginning of ♈,			359	50	14	53
Do. do. from beginning of ♑,			89	50	14	53
Altitude of the nonagesimal,			54	55	35	78
Longitude of the nonagesimal, from beginning of ♈,			17	34	3	38
Moon's *true* longitude, (Naut. Alm.),			57	0	29	46
true latitude, North,			4	29	6	04
true distance from nonagesimal, (East),			29	26	26	08
equatorial horizontal parallax,			1	1	2	72
horizontal parallax, reduced, (320 to 319)			1	0	58	21
parallax in longitude,			0	32	9	36
apparent distance from nonagesimal, (East),			39	50	35	44
parallax in latitude,			0	32	18	54
apparent latitude, North,			3	56	47	50
augmented semidiameter, arising from apparent altitude,			0	16	50	15
inflexion of light,			—	0	2	98
semidiameter, corrected,			0	16	47	17
Difference of apparent latitude, ✱ north of ☽'s center,			0	5	13	66

Moon's semidiameter corrected,	1007″.17	
Difference of apparent latitude,	313 66	
	1320 83	log. 3 1208469
	693 51	log. 2 8410527
		2)5.9618996
		2.9809498
Arith. comp. cosine ☽'s apparent latitude,		0 0010311
Difference ☽'s longitude,	15′ 59″.36 = 959″.36	log. 2.9819809

Star's longitude,	57°	16′	37″	.44
Parallax in longitude,	—	32	9	36
True longitude ☽'s limb, at the point of occultation,	56	44	28	08
Difference of ☽'s longitude,	+	15	59	36
True longitude ☽'s center, by calculation,	57	0	27	44
Apparent time at Greenwich, when the Moon had that longitude,	15h	24′	51″	.37
Apparent time of the emersion at Washington,	10	17	7	20
Longitude, in time, found by the emersion,	5	7	44	17
Equal to	76°	56′	2	55
By the immersion,	76	56	30	90
Mean result—Longitude of the place of observation,	76	56	16	72
Difference of longitude to the Capitol,	—	1	49	75
Longitude of the Capitol, by occultation of Oct. 20th, 1804,	76	54	26	97

Annular Eclipse of the Sun, on the 17th September, 1811, observed by Seth Pease, Esq. and others. North 71° W. one mile 3-8ths from the Capitol. Difference of longitude, — 1′ 26″.89.

Latitude of the place of observation, (estimated)	38°	53′	25″.00	N.
Do. do. reduced, (320 to 319)	38	42	54	43
Longitude assumed for calculation of the external contacts,	77	0	0	0

Beginning of the eclipse, at	0h	22′	9″	P M. Apparent time.
Annulus formed, at	2	2	6	
broken, at	2	6	53	
End of the Eclipse, at	3	36	53	

Obliquity of the ecliptic, September 17th, 1811, 23° 27′ 42″.70

Moon's Longitude at Greenwich (Naut. Alm.).

1811. Sept. 16.	Noon	158°	44′	5″	A				
						+ 5° 53′ 27″ a 1			
	Midnight	164	37	32	B		+ 0′ 22″ a 2		
						+ 5 53 49 b 1		+0′ 17′ a 3	
17.	Noon	170	31	21	C		+ 0 39 b 2		—1″ a4
						+ 5 54 28 c 1		+0 16 b 3	
	Midnight	176	25	49	D		+ 0 55 c 2		
						+ 5 55 23 d 1			
18	Noon	182	21	12	E				

Moon's Distance from the North Pole of the Ecliptic.

1811. Sept. 16	Noon	90°	47′	30″	A				
						— 32′ 36″ a 1			
	Midnight	90	14	54	B		— 0′ 11″ a 2		
						— 32 47 b 1		+ 0′ 19″ a 3	
17	Noon	89	42	7	C		+ 0 8 b 2		+ 1″ a 4
						— 32 39 c 1		+ 0 20 b 3	
	Midnight	89	9	28	D		+ 0 28 c 2		
						— 32 11 d 1			
18.	Noon	88	37	17	E				

Difference of Sun and Moon's Longitudes.

1811. Sept. 16.	Noon	346° 3′ 0 A	+ 5° 24′ 9 *a* 1	+ 0′ 22 *a* 2	+ 0′ 16″ *a* 3	+ 1″ *a* 4
	Midnight	351 27 9 B	+ 5 24 31 *b* 1	+ 0 38 *b* 2	+ 0 17 *b* 3	
17.	Noon	356 51 40 C	+ 5 25 9 *c* 1	+ 0 55 *c* 2		
	Midnight	2 16 49 D	+ 5 26 4 *d* 1			
18.	Noon	7 42 53 E				

By the external Contacts.

Apparent time of beginning of the eclipse,	0h 22′ 9″	=	5°	32′	15″.00	
Estimated longitude, West,	5 8 0					
Corresponding time at Greenwich,	5 30 9	Sun's R. A.	174	23	15	12
Right ascension of the meridian, from the beginning of ♈,			179	55	30	12
Do. do. from beginning of ♑,			90	4	29	88
Sun's longitude,			173	53	7	47
horizontal parallax,			0	0	8	70
semidiameter,			0	15	57	23
irradiation of light,			—	0	1	62
Altitude of the nonagesimal			55	1	1	16
Longitude of the nonagesimal, from beginning of ♈,			162	14	15	29
Moon's *true* longitude, (Naut. Alm.),			173	13	47	43
true latitude, north ascending,			0	32	53	39
true distance from the nonagesimal, (East)			10	59	32	14
horizontal parallax, reduced, (320 to 319)			0	54	5	38
horizontal parallax from the Sun,			0	53	56	68
parallax in longitude,			0	8	32	13
apparent longitude,			173	22	19	56
apparent distance from nonagesimal, (East)			11	8	4	27
parallax in latitude,			0	30	54	16
apparent latitude, North,			0	1	59	23
augmented semidiameter, arising from apparent altitude,			0	14	56	84
inflexion of light,			—	0	2	98
semidiameter, corrected,			0	14	53	86

Sun's semidiameter,		957″.23			
irradiation of light,		— 1 62			
semidiameter corrected,		955 61			
Moon's do. do.		893 86			
	Sum,	1849 47			
Moon's apparent latitude,		119 23			
	Sum,	1968 70		log.	3 2941795
	Diff.	1730 24		log.	3 2381065
					2)6 5822858
					3.2911429
Arith. comp. cosine Moon's apparent latitude,					0 0000001
Difference of apparent longitude,		30′ 45″.62	= 1845″ 62	log.	3 2661430

Sun's longitude, at beginning of the eclipse,	173°	53′	7″	.47
Parallax in longitude,	—	8	32	13
True longitude ☽'s limb, at the point of contact,	173	44	35	34
Difference of apparent longitude,	—	30	45	62
True longitude ☽'s center, by calculation,	173	13	49	72
Apparent time at Greenwich, when the Moon had that longitude,	5h	30′	13″	.35
Apparent time of beginning of eclipse at Washington,	0	22	9	—
Longitude, in time, by 1st external contact,	5	8	4	35
Equal to	77°	1′	5″	.25

Second external Contact.

Apparent time of the end of the eclipe,	3h	36′	53″		54°	13′	15″	.00
Estimated longitude, West,	5	8	0					
Corresponding time at Greenwich,	8	44	53	Sun's R. A.	174	30	32	25
Right ascension of the meridian, from the beginning of ♈,					228	43	47	25
Do. do. from the beginning of ♑,					41	16	12	75
Sun's longitude,					174	15	57	26
semidiameter,					0	15	57	26
horizontal parallax,					0	0	8	70
irradiation of light.					—	0	1	62
Altitude of the nonagesimal,					36	10	25	85
Longitude of the nonagesimal, from beginning of ♈,					209	18	40	65
Moon's *true* longitude, (Naut. Alm.)					174	49	40	69
true latitude, north ascending,					0	41	43	03
true distance from the nonagesimal, (West)					34	28	59	76
horizontal parallax, reduced, (320 to 319)					0	54	6	19
horizontal parallax from the Sun,					0	53	57	49
parallax in longitude,					0	18	10	25
apparent distance from the nonagesimal, (West)					34	47	10	01
apparent longitude,					174	31	30	44
parallax in latitude,					0	43	34	22
apparent latitude, South,					0	1	51	19
augmented semidiameter, arising from apparent altitude,					0	14	52	62
inflexion of light,					—	0	2	98
semidiameter, corrected,					0	14	49	64

Sun's semidiameter,	957″.26		
irradiation of light,	— 1 62		
semidiameter, corrected,	955 64		
Moon's do. do.	889 64		
Sum of semidiameters,	1845 28		
Moon's apparent latitude,	111 19		
Sum,	1956 47	log.	3.2914710
Diff.	1734 09	log.	3.2390716
			2)6.5305426
			3.2652713
Arith. comp. cosine Moon's apparent latitude,			0.0000001
Difference Moon's longitude,	30′ 41″.92 = 1841″ 92	log.	3.2652714

Sun's longitude at end of the eclipse,	174°	1′	3″	.24
Parallax in longitude,	+	18	10	25
True longitude ☽'s limb at the point of contact,	174	19	13	49
Difference ☽'s longitude,	+	30	41	92
True longitude ☽'s center, by calculation,	174	49	55	41
Apparent time at Greenwich, when the Moon had that longitude,	8h	45′	22″	.89
Apparent time of the end of the eclipse at Washington,	3	36	53	—
Longitude, in time, by end of the eclipse,	5	8	29	89
Equal to	77°	7′	28″	35

By the internal Contacts.

Annulus formed at,	2h	2′	6″	.00		30°	31′	30″	.00
Estimated longitude, West,	5	8	18	79					
Corresponding time at Greenwich,	7	10	24	79	Sun's R. A.	174	27	0	19
Right ascension of the meridian, from beginning of ♈,						204	58	30	19
Do. do. from beginning of ♑,						65	1	29	81
Sun's longitude,						173	57	12	42
semidiameter,						0	15	57	25
horizontal parallax,						0	0	8	70
Altitude of the nonagesimal,						45	10	41	21
Longitude of the nonagesimal, from beginning of ♈,						184	18	3	45
Moon's *true* longitude,						174	3	9	19
true latitude, north ascending,						3	37	26	30
true distance from the nonagesimal, (West)						10	14	54	26
horizontal parallax, reduced (320 to 319)						0	54	5	79
horizontal parallax from the Sun,						0	53	57	09
parallax in longitude,						0	6	53	04
apparent distance from the nonagesimal, (West)						10	21	47	30
apparent longitude,						173	56	16	15
parallax in latitude,						0	38	2	19
apparent latitude, South,						0	0	35	89
augmented semidiameter, arising from apparent altitude,						0	14	55	49

No allowance is made in the calculation by the internal contacts, for irradiation of the Sun's, or inflexion of the Moon's, light.

Sun's semidiameter,	975″.25		
Moon's augmented do.	895 49		
Diff.	61 76		
Moon's apparent latitude,	35 89		
Sum,	97 65	log.	1.9896722
Diff.	25 87	log.	1.4127964
			2)3.4024686
			1.7012343
Arith. comp. cosine Moon's apparent latitude,			0.0000000
Difference Moon's longitude,	= 0′ 50″.26	log.	1.7012343

Sun's longitude,		173°	57′	12″.	42
Parallax in longitude,	+		6	53	04
Difference ☽'s longitude,	—		0	50	26
True longitude ☽'s center, by calculation,		174	3	15	20
Apparent time at Greenwich, when the Moon had that longitude,		7h	10′	36″.	91
Apparent time of formation of annulus at Washington,		2	2	6	—
Longitude, in time, by first internal contact,		5	8	30	91
Equal to		77°	7′	43″	65

Second internal Contact.

Annulus broken at,	2h	6′	53″.	00		31°	43′	15″.	00
Estimated longitude, West,	5	8	18	79					
Corresponding time at Greenwich,	7	15	11	79	Sun's R. A.	174	27	10	92
Right ascension of the meridian, from beginning of ♈,						206	10	25	92
Do. do. from beginning of ♑,						63	49	34	08
Sun's longitude,						173	57	24	11
semidiameter,						0	15	57	25
horizontal parallax,						0	0	8	70
Altitude of the nonagesimal,						44	42	9	15
Longitude of the nonagesimal, from beginning of ♈,						185	26	28	61
Moon's *true* longitude,						174	5	30	51
true latitude, north ascending,						0	37	39	31
true distance from the nonagesimal, (West)						11	20	58	10
horizontal parallax, reduced (320 to 319)						0	54	5	81
horizontal parallax from the Sun,						0	53	57	11
parallax in longitude,						0	7	33	02
apparent distance from the nonagesimal, (West)						11	28	31	12
apparent longitude,						173	57	57	49
parallax in latitude,						0	38	21	24
apparent latitude, South,						0	0	41	93
augmented semidiameter, arising from apparent altitude,						0	14	55	17

Sun's semidiameter,		957″.25		
Moon's augmented do.		895 17		
	Diff.	62 08		
Moon's apparent latitude,		41 93		
	Sum,	104 01	log.	2.0170751
	Diff.	20 15	log.	1.3042751
				2)3.3213502
				1.6606751
Arith. comp. cosine Moon's apparent latitude,				0.0000000
Difference ☽'s longitude,		0′ 45″.78	log.	1 6606751

Sun's longitude,	173°	57′	24″	.11
Parallax in longitude,	+	7	33	02
Difference ☽'s longitude,	+	0	45	.78
True longitude ☽'s center, by calculation,	174	5	42	91
Apparent time at Greenwich, when the Moon had that longitude,	7h	15′	37″	.39
Apparent time of breaking annulus at Washington,	2	6	53	—
Longitude, in time, by 2d internal contact,	5	8	44	39
Equal to	77°	11′	5″	.85
By 1st internal contact,	77	7	43	65
1st external do.	77	1	5	25
2d external do.	77	7	28	35
Mean result—Longitude of the place of observation,	77	6	50	77
Difference of longitude to the Capitol,	—	1	26	89
Longitude of the Capitol, by solar eclipse,	77	5	23	88

JANUARY 12th, 1813.

Occultation of ρ *Taurus*, by the Moon. Immersion *only*, observed with sufficient accuracy, by Messrs. Abraham Bradley and Seth Pease. North 75° W. one mile 7-10ths (estimated) from the Capitol—difference of longitude — 1′ 49″.75.

Latitude of the place of observation, estimated,	38° 53′ 30″.00 N.
Do. do. reduced (320 to 319)	38 42 59 .44
Longitude assumed for the calculation	76 57 30 —W.

By De La Lande's Tables.

Star's *mean* right ascension	62°	17′	24″.14	*Mean* Declination N.	15°	10′	5″.82
Nutation -	—	0	10 .34	Nutation -	—	0	8 .62
Aberration - -	+	0	13 .56	Aberration	+	0	0 .93
Right ascension -	62	17	27 .36	Declination N.	15	9	58 .13

Obliquity of the ecliptic, January 12th, 1813, -	23°	27′	43″.50
Star's longitude, by computation - -	63	11	18 .25
latitude, south, do. - - -	5	45	6 .07

Moon's Longitude at Greenwich (Naut. Alm.).

1813. Jan. 11.	Noon	41° 38′ 21″	A				
				+ 7° 10′ 4″ *a* 1			
	Midnight	48 48 25	B		+ 55″ *a* 2		
				+ 7 10 59 *b* 1		— 30″ *a* 3	
12.	Noon	55 59 24	C		+ 25 *b* 2		— 6″. *a*4
				+ 7 11 24 *c* 1		— 36 *b* 3	
	Midnight	63 10 48	D		— 11 *c* 2		
				+ 7 11 13 *d* 1			
13.	Noon	70 22 01	E				

Moon's Latitude, South.

1813. Jan. 11.	Noon	5° 9′ 49″	A				
				+ 3′ 16″ *a* 1			
	Midnight	5 13 5	B		— 4′ 54″ *a* 2		
				— 1 38 *b* 1		+ 0″ *a* 3	
12.	Noon	5 11 27	C		— 4 54 *b* 2		+ 7″ *a* 4
				— 6 32 *c* 1		+ 7 *b* 3	
	Midnight	5 4 55	D		— 4 47 *c* 2		
				— 11 19 *d* 1			
13.	Noon	4 53 36	E				

Time of immersion by watch,	5h	55′	28″					
Watch too fast, -	—	8	39					
Apparent time of immersion, -	5	46	49		86°	42′	15″.00	
Estimated longitude, West, -	5	7	50					
Corresponding time at Greenwich,	10	54	39	Sun's R. A.	294	15	30	95

Right ascension of the meridian, from the beginning of ♈, -	20	57	45	95
Do. do. from beginning of ♑, -	110	57	45	95
Altitude of the nonagesimal - - -	62	26	37	89
Longitude of the nonagesimal, from beginning of ♈, -	34	43	50	50
Moon's *true* longitude, (Naut. Alm.), - - -	62	31	38	54
true latitude, south, - - -	5	5	42	58
true distance from the nonagesimal, (East) - -	27	47	48	04
equatorial horizontal parallax, - -	0	59	28	91
horizontal parallax, reduced, (320 to 319) - -	0	59	24	51
parallax in longitude, - - -	0	24	59	84
apparent distance from nonagesimal, (East) - -	28	12	47	88
parallax in latitude, - - -	0	31	54	57
apparent latitude, South, - - -	5	37	37	15
augmented semidiameter, arising from apparent altitude, -	0	16	26	55
inflexion of light, - - -	0	0	2	98
semidiameter, corrected, - - -	0	16	23	57
Difference of apparent latitude, ✱ south of ☽'s center, -	0	7	28	92

Moon's semidiameter, corrected	983″ 57		
Difference of apparent latitude	448 92		
Sum,	1432 49	log.	3.1560916
Diff.	534 65	log.	2.7280696
			2)5.8841612
			2.9420806
Arith. comp. cosine Moon's apparent latitude			0.0020978
Diff. ☽'s longitude 14′ 39″ 38 =	879″.38	log.	2.9441784

Star's longitude,	63°	11′	18″.25	
Parallax in longitude,	—	24	59	84
True longitude ☽'s limb, at the point of occultation,	62	46	18	41
Difference of longitude,	—	14	39	38
True longitude of ☽'s center, by calculation,	62	31	39	03
Apparent time at Greenwich, when the Moon had that longitude,	10h	54′	39″.82	
Apparent time of the immersion at Washington,	5	46	49	—
Longitude, in time, found by the immersion,	5	7	50	82
Equal to	76°	57′	42″	30
Difference of longitude from the place of observation to the Capitol,	—	1	49	75
Longitude of the Capitol,	76	55	52	55

Results.

By the occultation of January 21st, 1793,	76°	46′	17″.85	
of October 20th, 1804,	76	54	26	97
Solar eclipse, Sept. 17th, 1811,	77	5	23	88
occultation of January 12th, 1813,	76	55	52	55
Mean result,	76	55	30	31

Equal to 5h 7′ 42″.02, in time.

City of Washington, July 4th, 1817.

SIR,

IT was my intention to have sent you the above abstracts of astronomical calculations, some time ago, for the use of the American Philosophical Society. Relying on your candour, and knowledge of the subject, I flatter myself, that the work submitted to your inspection, will be estimated according to its *real* value. The ratio of 320 to 319, of the equatorial to the polar diameter of the earth, has been used, as a proportion supposed (if not actually found) to be more accurate than that of 334 to 333, or 230 to 229. The Moon's positions, at noon and midnight, in longitude and latitude, as given in the British Nautical Almanacs, have been considered as *strictly correct*, as well as the apparent times of the phenomena: and as no corresponding observations at Greenwich could be resorted to, the errors in the lunar tables are not known. It will be recollected, that M. Burg's improved tables were not used at Greenwich, until the year 1813, so that, in the preceding years, the errors of the tables might considerably affect the latitude of a place as far distant as the city of Washington. Whether these, or any arising from the apparent times, have produced a variance of 19 minutes of longitude between the results of the first and third observations, I am at a loss to discover; but if a mean of both be taken, it will be found not to deviate much from the results of the others, as shewn by the following statement:

Result, January 21st, 1793 -	76° 46′ 17″.85
Do. September 17th, 1811	77 5 23 .86
Mean result -	76 55 50. 86

agreeing very nearly with the last, and differing 1′ 23″½ of longitude from the third observation.

I need not remark to you that occultations and solar eclipses afford the best means to ascertain the longitude of a place with precision; and although that of the Capitol in Washington, from Greenwich, may not yet have been correctly determined, for want of a greater number of observations, it is believed, that the *mean* result herewith furnished, is a near approximation to the truth.

I am, very respectfully,
Your most obedient servant,
WILLIAM LAMBERT.

Robert Patterson, Esq.
A Vice President of the Am. Phil. Soc. Philadelphia.

No. IV.

Investigation of the Figure of the Earth, and of the Gravity in different Latitudes. By Robert Adrain.—Read October 7th, 1817.

Having in the year 1808 discovered a general method of resolving several useful problems, by ascertaining the highest degree of probability where certainty cannot be found; I shall here apply that method to the determination of the earth's ellipticity, and of the gravity on its surface; by means of the observed lengths of pendulums vibrating seconds in different latitudes.

The lengths adopted in this investigation are those made use of by La Place in the third book of his incomparable work, the *Mecanique Celeste:* they are disposed in the following table with the corresponding latitudes in French degrees, the length of the pendulum at Paris being denoted by unity.

TABLE

Of the Observed Lengths of Pendulums vibrating Seconds in different Latitudes.

LATITUDES.		LENGTHS.
0°	00′	0.99669
10	61	0.99689
13	25	0.99710
20	00	0.99745
20	50	0.99728
37	69	0.99877
48	44	0.99950
53	57	0.99987
54	26	1.00000
56	63	1.00006
57	22	1.00018
64	72	1.00074
66	60	1.00101
74	22	1.00137
74	53	1.00148

The first two of these measures were determined by Bouguer, the one on the equator in Peru, the other at Portobello; the third was determined by Gentil at Pondicherry; the fourth was determined from that of London, by a comparison of the oscillations of an invariable pendulum, transported from London to Jamaica by Campbell; the fifth was determined by Bouguer at Little Guave in the West Indies; the sixth by La Caille at the Cape of Good Hope; the seventh by Durquier at Toulouse; the eighth by Liesganig at Vienna in Austria; the ninth at Paris, by Bouguer; the tenth at Gotha, by Zach; the eleventh was deduced from that of Paris by the difference of the oscillations of an invariable pendulum transported from London to Paris; the twelfth and fourteenth were deduced in the same manner from that of Paris by the observations of Mallet, at Petersburg and Ponoi; the thirteenth was in like manner deduced from that of Paris, by Griscow, at Arensburg; finally, the fifteenth was determined according to the same process by the French Academicians who measured a degree of the meridian in Lapland.

Now it has been demonstrated, on the principles of hydrostatics, by several eminent mathematicians, and particularly by Clairaut in his treatise on the figure of the earth, and by La Place in his Mecanique Celeste, that the augmentation of gravity in proceeding from the equator to the pole is as the square of the sine of the latitude; supposing the centrifugal force arising from the rotation of the earth on its axis to be very small in comparison to the gravity, that the several elliptical strata of the earth vary in density and ellipticity according to any function of the distance from the centre, and that the superficial parts of the earth are fluid, so as to obey the compound gravity, or the joint action of the attraction, and the centrifugal force. And, as the length of the simple pendulum vibrating in a second, or in any given time, is directly as the gravity, therefore the length of the pendulum follows the same law with the gravity, in passing from the equator to the pole, and the preceding table may be considered as a table of the observed gravities in different latitudes.

Let x be the unknown length of the pendulum vibrating seconds at the equator, y an unknown but fixed co-efficient, λ any latitude, and r the length of the pendulum in latitude λ; then agreeably to the law of gravity just stated, we have the following equation,

$$r = x + y \sin^2 \lambda,$$

in which when x and y are found we shall have the value of r, or the measure of gravity, in every latitude. But it is certain that whatever constant numbers we substitute for x and y, we cannot deduce such values for r as are exactly coincident with those given in the foregoing table according to observation: though the discrepancies are not considerable, and may justly be ascribed to the inevitable errors of experiment, in conjunction perhaps with a small deviation, in the constitution of the earth, from the conditions that have been specified as the basis of the forementioned physical investigations of Clairaut and La Place.

Since therefore it is impossible to reconcile completely the physical theory with the observations; all that can be done is to determine such values for x and y as will cause the formula $x+y \sin^2 \lambda$ to *accord best* with the numbers in the table. This is effected by a rule published by the writer of this article in the *Analyst*, in 1808; and which applied to the present research requires us to discover such values for x and y as will render the sum of the squares of the differences between the several numbers of the table and the corresponding values of $x+y \sin^2 \lambda$ the least possible.

Now r, r', r'', &c. be the lengths of the pendulums, as given in the table, corresponding to the several latitudes $\lambda, \lambda', \lambda''$, &c. then will the several differences between the function

$$x \times y \sin^2 \lambda$$

and the value r, r', r'', &c. be

$$x+y \sin^2 \lambda - r, \quad x+y \sin^2 \lambda' - r', \text{ \&c.}$$

and the squares of those differences will be

$$(x+y \sin^2 \lambda - r)^2, \qquad (x+y \sin^2 \lambda' - r')^2, \text{ \&c.}$$

of which squares the sum is

$$\Sigma.(x+y \sin^2 \lambda)^2,$$

where Σ is the characteristic of integrals to finite differences, so that the last expression denotes the sum of the squares of all the differences as far as the table extends which contains the values of λ, λ', &c. and r, r', r'', &c. which in the present case is to 15 terms; and therefore, according to the rule prescribed, we are to make

$$\Sigma.(x+y \sin^2 \lambda - r)^2 = \text{min.}$$

To obtain the minimum, we must, as usual, make the fluxion of the expression $= 0$, which produces the equation

$$\Sigma.\left\{ 2(\dot{x}+\dot{y} \sin^2 \lambda) \times (x+y \sin^2 \lambda - r) \right\} = 0.$$

This equation may be written in the following manner,

$$\Sigma.\, 2\dot{x}(x+y\sin^2\lambda - r) + \Sigma.2\,\dot{y}\sin^2\lambda\,(x+y\sin^2\lambda - r);$$

and since x and y are independent, the co-efficients of $\dot{x}$ and $\dot{y}$ must be separately $= 0$, therefore,

$$\Sigma\,(z+y\sin^2\lambda - r) = 0;\ \text{and}\ \Sigma\,(x\sin^2\lambda + y\sin^4\lambda - r\sin^2\lambda) = 0.$$

Let $n = 15 =$ the number of observations, and the last two equations manifestly become

$$nx+y.\,\Sigma\sin^2\lambda - \Sigma r = 0$$
$$x.\Sigma\sin\lambda + y.\,\Sigma\sin^4\lambda - \Sigma\, r\sin^2\lambda = 0.$$

The former of these shows us that the sum of all the errors is equal to nothing; and the latter that when each error is multiplied by the square of the sine of the corresponding latitude, the sum of the products is equal to nothing. It remains to compute the values of the four series $\Sigma\, r$, $\Sigma\sin^2\lambda$, $\Sigma\sin^4\lambda$, and $\Sigma\sin^2\lambda.r$, and then x and y will be found by the usual rules for simple equations.

TABLE I. Values of r, r', &c.	TABLE II. Log. sines of λ, λ', &c.	TABLE III. Log. (sin $^2\lambda$), &c.
.99669	— infinity.	— infinity.
.99689	9.2198229	8.4396458
.99710	9.3151957	8.6303914
.99745	9.4899824	8.9799648
.99728	9.5003421	9.0006842
.99877	9.7466726	9.4033452
.99950	9.8385777	9.6771554
.99987	9.8725218	9.7450436
1.00000	9.8766829	9.7533658
1.00006	9.8902999	9.7805998
1.00018	9.8935323	9.7870646
1.00074	9.9295895	9.8591790
1.00101	9.9372677	9.8745354
1.00137	9.9633730	9.9267460
1.00148	9.9642734	9.9285468
Σr=14.98839		

TABLE IV.	TABLE V.	TABLE VI.
Log. $\sin.^4 \lambda$, &c.	Log. r, r', &c.	Log. $r \sin^2 \lambda$, &c.
— infinity.	— 1.9985601	— infinity.
6.8792916	— 1.9986472	.4382930
7.2607828	— 1.9987387	.6291301
7.9599296	— 1.9988911	.9788559
8.0013684	— 1.9988171	.9995013
8.9866904	— 1.9994655	.4928107
9.3543108	— 1.9997828	.6769382
9.4900872	— 1.9999435	.7449871
9.5067316	0.0000000	.7533658
9.5611996	0.0000261	.7806259
9.5741292	0.0000782	.7871428
9.7183580	0.0003213	.8595003
9.7490708	0.0004384	.8749738
9.8534920	0.0005946	.9273406
9.8570936	0.0006423	.9291891

TABLE VII.	TABLE VIII.	TABLE IX.
Values of $\sin^2 \lambda$, &c.	Values of $\sin.^4 \lambda$, &c.	Values of $r \sin.^2 \lambda$, &c.
.0000000	.0000000	.0000000
.0275198	.0007573	.0274342
.0426964	.0018229	.0425726
.0954915	.0091186	.0952480
.1001577	.0100316	.0998852
.3114191	.0969818	.3110361
.4755053	.2261053	.4752675
.5559601	.3090916	.5558878
.5667164	.3211675	.5667164
.6033924	.3640823	.6034286
.6124415	.3750846	.6125518
.7230678	.5228270	.7236028
.7490924	.5611395	.7498490
.8447846	.7136610	.8459420
.8482948	.7196040	.8495504
6.5565398	4.2314750	6.5589724

Table I. contains merely the lengths of the pendulums vibrating seconds according to observation in fifteen different latitudes; Table II. gives the logarithmic sines of those latitudes according to Callet's Tables of centesimal degrees; Table III. is formed by doubling the numbers in Table II.; Table IV. is formed by doubling the numbers of Table III.; Table V. contains the common logarithms of the numbers in Table I.; Table VI. is formed by adding the corresponding numbers in Tables III. and V.; and Tables VII. VIII. and IX. are the natural numbers belonging to the logarithms in Tables III. IV. and VI.

The values of $\Sigma\, r$, $\Sigma \sin^2 \lambda$, $\Sigma \sin^4 \lambda$, $\Sigma\, r \sin^2 \lambda$, are the sums of the numbers in Tables I. VII. VIII. and IX. and are set down at the bottom of those Tables; we have therefore

$$\Sigma\, r = 14.98839; \qquad \Sigma \sin^2 \lambda = 6.5565398;$$

$$\Sigma \sin^4 \lambda = 4.2314750; \qquad \Sigma\, r \sin^2 \lambda = 6.5589724.$$

Our two equations

$$nx + y\Sigma \sin^2 \lambda - \Sigma.r = 0,$$

$$x\Sigma \sin^2 \lambda + y\Sigma \sin^4 \lambda - \Sigma.r \sin^2 \lambda = 0,$$

will now become

$$15x + 6.5565398\, y - 14.98839 = 0,$$

$$6.5565398\, x + 4.2314750\, y - 6.5589724 = 0;$$

which, divided by the co-efficients of x, produce

$$x + .43710265\, y - .9992260 = 0,$$

$$x + .64538234\, y - 1.0003710 = 0;$$

whence by subtraction

$$.20827969\, y - .0011450 = 0,$$

consequently $y = .00549741,$

and $x = .96582307.$

Thus the expression for the length of the pendulum in the lat. λ is

$$.99682307 + .00549741 \sin^2 \lambda.$$

Or we may divide by the first term, and the length just stated will become

$$.99682307(1 + .00551493 \sin^2 \lambda);$$

and therefore, if the length of the pendulum vibrating seconds at the equator, be denoted by unity, the length of a pendulum vibrating seconds in the latitude λ will be expressed by

$$1 + .005515 \sin^2 \lambda :$$

And thus the comparative gravity is known for every latitude.

We may also express the gravity without the squares of sines as follows. Since, by trigonometry, $\sin^2 \lambda = \frac{1}{2} - \frac{1}{2} \cos. 2\lambda$, therefore by substitution we have

$$1 + .005515 \sin^2 \lambda = 1.002757465 - .002757465 \cos. 2\lambda ;$$

and the latter number of this equation may be reduced to the form

$$1.002757465.(1 - .00275 \cos 2\lambda).$$

If therefore we denote the gravity at the equator by g, and the gravity in latitude λ by γ, we shall have the two following expressions for γ;

$$\gamma = g . (1 + .005515 \sin^2 \lambda),$$

$$\gamma = g \times 1.002757(1 - 00275 \cos 2\lambda).$$

Or if the gravity in latitude 45° be denoted by G, we shall have the gravity γ in latitude λ expressed by

$$\gamma = G\,(1 - 00275 \cos. 2\lambda).$$

In fact, the whole investigation and computation were conducted by the method of double ares, and the result was found precisely the same with that just exhibited: and though the calculation by double arcs is equally easy with the method given above, I shall not detain the reader with it, but proceed to compare the gravities expressed by the function

$$.99682307 + .00549741 \sin^2 \lambda,$$

with the gravities as given by the numbers in Table I. For this purpose we must add the logarithm of .00549741, which is 7.7401581 to each of the numbers in Table III. and the sums will be the logarithms of all the values of $.00549741 \sin^2 \lambda$. These logarithms are set down in Table X. following. Table XI. contains the natural numbers belonging to the logarithms in Table X.; and Table XII. shows the values of $x + y \sin^2 \lambda$, being formed by adding .9968231 to each of the numbers in Table XI.

TABLE X.	TABLE XI.	TABLE XII.	TABLE XIII.
Log. of .00549. &c. $\sin^2\lambda$.	Values of .00549741 $\sin^2 \lambda$.	Values of $x+y \sin^2 \lambda$.	Errors.
— infinity.	.0000000	.99682	— 13
6.1798039	.0001513	.99697	— 8
6.3705495	.0002347	.99706	+ 4
6.7201229	.0005249	.99735	+ 10
6.7408423	.0015506	.99737	— 9
7.2335033	.0016120	.99853	+ 24
7.4173135	.0026640	.99944	+ 6
7.4852017	.0030563	.99988	— 1
7.4935239	.0031155	.99994	+ 6
7.5207579	.0033171	1.00014	— 8
7.5272227	.0033668	1.00019	— 1
7.5993371	.0039750	1.00080	— 6
7.6146935	.0041181	1.00094	+ 7
7.6669041	.0046441	1.00147	— 10
7.6687049	.0046634	1.00149	— 1

Table XIII. is formed by subtracting the numbers in Table XII. from those corresponding in Table I.; and shows the error of each observation with its proper sign; those errors marked with the sign *plus* indicate that the observed lengths of r, r', &c. are too great, and those with the sign *minus* the contrary. The greater error + 24 belongs to the observation made by La Caille at the Cape of Good Hope.

The equation $\gamma = g\ (1 + .005515 \sin^2 \lambda)$ is applicable only to places at the level of the sea. When the place of observation is elevated above the level of the sea, the gravity will be different according to the altitude, and may be investigated as follows.

Let $R =$ the mean radius of the earth in feet, $h =$ the height of the place of observation above the level of the sea in feet, and $\gamma' =$ the gravity at the height h: then, by the general law of gravitation, we have

$$(R+h)^2 : R^2 : : \gamma : \gamma',$$

whence $\gamma' = \gamma \times \frac{R^2}{(R+h)^2} = \gamma \times \frac{1}{(1+\frac{h}{R})^2}$,

and by division $\gamma' = \gamma \times (1 - \frac{2h}{R}$ &c.) in which we have retained only two terms as all that are necessary. The mean diameter of the earth taken as a sphere is very nearly 7920 English miles; let us therefore assume $R = 3960$ miles $= 20908800$ feet, and we have $\frac{2}{R} = .000000957$, and therefore

$$\gamma' = \gamma \times (1 - .0000000957h);$$

but $\gamma = g \times (1 + .005515 \sin^2 \lambda)$,

therefore, by the multiplication of the two equations, and division by γ, we have

$$\gamma' = g.\ (1 + .005515 \sin^2 \lambda - .0000000957h),$$

which equation shows the gravity γ' in any latitude, and at any altitude, in terms of the altitude, and gravity at the equator. If we place the standard of gravity in latitude 45° of the nonagesimal division, we shall have

$$\gamma' = G.\ (1 - .00275 \cos 2\lambda - .0000000957h).$$

Now put $p =$ the length of the pendulum to seconds at the equator, P in latitude 45°, $\pi =$ that in latitude λ, all at the level of the sea, and π' at the altitude h; then we have

$$\pi' = p.(1 + .005515 \sin^2 \lambda - .0000000957h),$$

and $\pi' = P.(1 - .00275 \cos 2\lambda - .0500000957h)$.

In these equations p and P are constant quantities, and may be found from the observed value of π', that is, from the observed length of the pendulum vibrating seconds in any latitude λ, and at any height h; for when π', λ and h are given, we have by division

$$p = \pi'.\ (1 - .005515 \sin^2 \lambda + .0000000957h)$$

$$P = \pi'.(1 + .00275 \cos 2\lambda + .0000000957h):$$

and thus we obtain an universal standard of measure p or P. If, however, the observation with the pendulum be made in one temperature, and its length be used as a measure in another temperature, it will be necessary to make another correction.

Let the length π' be observed at the temperature t in degrees of any thermometer, and let π'' be the length of the same pendulum when applied as a measure in the temperature t'; also let $m =$ the measure of the change in the length unity of the pendulum for one degree of the thermometer, according to observation. Then will $m(t' - t)$ be the augmentation of the length unity, for the augmentation $t' - t$ of temperature, and therefore

$$\{ \pi'' = \pi'.\{1 + m(t' - t)\};$$

which equation being multiplied by each of the two preceding equations exhibiting the value of π', we have

$$\pi'' = p.\{1 + .005515 \sin^2 \lambda - .0000000957h + m(t' - t)\}$$

and $\pi'' = P.\{1 - .00275 \cos 2\lambda - .0000000957h + m(t' - t)\}$.

From these two equations we obtain by division

$$p = \pi''.\{1 - .005515 \sin^2 \lambda + .0000000957h - m(t' - t)\}.$$

and $P = \pi''.\{1 + .00275 \cos 2\lambda + .0000000957h - m(t' - t)\}$.

It is easy to understand in what manner a universal standard of measure may be obtained by help of the preceding calculations: for the length π' is given directly by experiment, and this length π' becomes π'' by the change of temperature $t - t'$; and having the length π'' we derive p or P from it by the last two equations, which lengths p and P are invariable, and will therefore serve as universal standards of linear measure.

If the pendulum be of iron and t, t', be taken from Fahrenheit's scale, we shall have the multiplier $m = .0000064$ nearly, and in this case the two preceding equations became

$$p = \pi''.\{1 + .005515 \sin^2\lambda + .0000000957h - 0000064(t' - t)\},$$

$$P = \pi''.\{1 + .00275 \cos 2\lambda + .0000000957h - 0000064(t' - t)\}.$$

From the equation $\gamma = g(1 + .005515 \sin^2\lambda)$, we may also deduce the figure of the earth by help of the following theorem, derived from the principles of hydrostatic equilibrium. If from 5 halves of the ratio of the centrifugal force at the equator to the attraction at the same place, we subtract the co-efficient of $\sin^2 \lambda$, the remainder will be the ellipticity of the earth, or the excess of the equatorial semidiameter above the semiaxis taken as unity.

When the attraction of the earth at the equator is denoted by unity, the centrifugal force at the same place is known to be $\frac{1}{289}$, and therefore we have $\frac{5}{2} \times \frac{1}{289} = .00865$,
from which subtracting $.005515$
we have the ellipticity $= .003135$,

which is equal to $\frac{1}{319}$; and therefore the greatest and least radii of the earth are in the ratio of 320 to 319. This ratio is very different from that belonging to a fluid spheroid of uniform density; and can be accounted for on physical principles, only by admitting an increase of density, in proceeding from the surface of the earth to its centre.

In the preceding investigation, I have used the same data with La Place, who solves this problem of the figure of the earth, and the variation of gravity, by a very different method in the third book of his Mecanique Celeste. His method is exceedingly ingenious, and is built on principles which appear to me to be reasonable and satisfactory:* but notwithstanding all this, it is certain that his results are inconsistent with those assigned above.

By my calculation $\gamma = g. (1 + .005515 \sin^2 \lambda)$,
By La Place, $\gamma = g. (1 + .00569 \sin^2 \lambda)$.

The ellipticity by my rule is $\frac{1}{319}$, and he finds $\frac{1}{336}$. This difference in the results of the two calculations is not owing to any great discordancy in the principles of the two methods; for they give results nearly coincident, when properly conducted; but to two errors committed by La Place in the calculation of the problem. The first of these errors consists in assigning a wrong number for the square of the sine of the latitude of Gotha where one of the observations was made.

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* The principles adopted by La Place are the same with those given before by Boscovich in his notes on the celebrated poem of Stay, viz. 1. the sum of all the errors with their proper signs must be equal to nothing: 2. and their sum with the same sign must be a minimum.

The latitude of Gotha as given by La Place is 56° 63′; and for the square of the sine of this latitude he has taken 0.57624 instead of the correct number 0.60339. This error, had he not committed another, would have led him to the ellipticity $\frac{1}{338}$; but by the omission of the divisor z, answering to x in the preceding investigation, he subtracts from the quantity ,00865 a number doubly wrong, and finds the ellipticity to be $\frac{1}{336}$, or, as he has it $\frac{1}{335.78}$. As his results are thus rendered of no value, I shall therefore exhibit an accurate calculation of the earth's ellipticity, and of the gravity at its surface, in different latitudes, according to this method of La Place.

The data used by La Place being the same with those given in the beginning of this Essay, as well as in Tables I. and II. need not be repeated: we commence therefore with the assumption of the formula $z+y \sin^2 \psi$, which, in the notation of La Place, expresses the length of the pendulum to seconds in latitude ψ, according to the physical theory: and z, y, are the unknown but fixed quantities which are to be determined. Then, having previously calculated the numerical values of $\sin^2 \psi$, that is, of the squares of the sines of all the latitudes, we are to subtract from the several numbers in Table I. the corresponding values of the formula $z + y \sin^2 \psi$; and calling the remainders $x^{(1)}$, $x^{(2)}$, $x^{(3)}$, &c. we have the following

TABLE.

$$
\begin{gathered}
0.29669 - z - y.0{,}00000 = x^{(1)} \\
0.99639 - z - y.0{,}02752 = x^{(2)} \\
0.99710 - z - y.0{,}04270 = x^{(3)} \\
0.99745 - z - y.0{,}09549 = x^{(4)} \\
0.99728 - z - y.0.10016 = x^{(5)} \\
0.99877 - z - y.0.31142 = x^{(6)} \\
0.99950 - z - y.0{,}47551 = x^{(7)} \\
0.99987 - z - y.0{,}55596 = x^{(8)} \\
1.00000 - z - y.0{,}56672 = x^{(9)} \\
1.00006 - z - y.0.60339 = x^{(10)} \\
1.00018 - z - y.0{,}61244 = x^{(11)} \\
1.00074 - z - y.0.72307 = x^{(12)} \\
1.00101 - z - y.0{,}74909 = x^{(13)} \\
1.00137 - z - y.0{,}84478 = x^{(14)} \\
1.00148 - z - y.0{,}84829 = x^{(15)}
\end{gathered}
$$

Now add together the absolute terms of all these equations, which terms are merely the numbers in Table I. and the sum is 14.98839 which divided by 15, the number of observations gives .99923. Again, adding together all the co-efficients of y in the same equations, the sum is 6.55654, which divided by 15, gives us the quotient = .43710; and therefore, according to the rule prescribed by La Place, the relation of z and y is determined by the equation

$$.99923 - z - y.0.43710 = 0.$$

Now let this last equation be taken from each in the preceding table, and we shall have the following

TABLE.

$-,00254 + y.0,43710 = x^{(1)}$
$-,00234 + y.0,40958 = x^{(2)}$
$-,00213 + y.0,39440 = x^{(3)}$
$-,00178 + y.0,34161 = x^{(4)}$
$-,00195 + y.0,33694 = x^{(5)}$
$-,00046 + y.0,12568 = x^{(6)}$
$+,00027 - y.0,03841 = x^{(7)}$
$+,00064 - y.0,11886 = x^{(8)}$
$+,00077 - y.0,12962 = x^{(9)}$
$+,00083 - y.0,16629 = x^{(10)}$
$+,00095 - y.0,17534 = x^{(11)}$
$+,00151 - y.0,28597 = x^{(12)}$
$+,00178 - y.0,31199 = x^{(13)}$
$+,00214 - y.0,40768 = x^{(14)}$
$+,00225 - y.0,41119 = x^{(15)}$

The next operation consists in dividing the first term of each of these equations by the corresponding co-efficient of y; and the several quotients being set down according to their magnitude, will form the following

TABLE.

,0070294
,0059404
,0058110
,0057874
,0057132
,0057053
,0054719
,0054185
,0054006
,0053845
,0052803
,0052494
,0052106
,0049913
,0036601

Of this table the sum is ,0820537,

And the half sum = ,0410268.

But the sum of the first six numbers = ,0359867,

And the sum of the first seven = ,0414586.

Since therefore the 7th term in this table, viz. 0054719 is that which changes the aggregate from being less than the half sum to being greater, we are, according to the rule of La Place, to take this term .0054719 as the value of y, therefore

$$y = .0054719.$$

Again, since we found before that

$$.99923 - z - y.0{,}43710 = 0,$$

therefore by substituting the known value of y, we find $z = .99684$; and thus the formula expressing the length of the pendulum in latitude ψ is

$$.99684 + .0054719 \sin^2\psi.$$

If we divide by the first term, we have the following expression for the length of the pendulum,

$$.99684\ (1 + .00549 \sin^2 \psi):$$

but if we denote the length at the equator by p, and that in latitude ψ by π, we shall have

$$\pi = p.\ (1 + .00549 \sin^2 \psi).$$

But $\pi = p.\ (1 + .00551\tfrac{1}{2} \sin^2 \lambda)$,

according to the former investigation, and therefore in this case the rules are nearly equivalent. We may also determine the ellipticity from the equation $\pi = p.(1 + .00549 \sin^2 \psi)$, as was done in the former investigation.

Thus, from $\frac{5}{2} \times \frac{1}{289} = .00865$

Subtract .00549,

and the remainder .00316 is the ellipticity $= \frac{1}{316\frac{1}{2}}$: so that the two rules give $\frac{1}{319}$ and $\frac{1}{316\frac{1}{2}}$ for the ellipticities, and therefore approach very near to each other, in determining the figure of the earth.

No. V.

Memoir on Leaden Cartridges. By William Jones.—Read March 15, 1811.

THE awful catalogue of disasters, produced by the accidental explosion of gun powder, particularly on board ships of war, has been the subject of serious contemplation, and of earnest solicitude, for the discovery of an adequate remedy.

Naval and military history is replete with instances of the destruction of ships of war, and of military magazines, by accidents arising from the exposed and defective manner in which gun powder is kept; and particularly from the loose and combustible nature of *the common paper cartridge:* also of men killed and maimed in the act of reloading cannon, in consequence of the burning remnant of the paper cartridge, remaining in the chamber of the gun after the discharge.

Naval expeditions of the utmost importance are said to have failed, from the defective quality of the powder; damaged either by accident, or impaired by long exposure to the saline atmosphere, in the confined apartments on shipboard; and it is equally susceptible of injury from the humidity of a military magazine; as, in both cases, it is kept in casks, accessible to the action of the air.

The magazine of a ship of war, is a place that can be approached but with the greatest caution; and even under the highest state of discipline and vigilance, frequent and fatal accidents occur.

Impressed with the importance of the subject, I conceived the idea of *substituting lead for paper*; and in the year 1805, when at Canton in China, I caused to be made one hundred cartridges of thin sheet lead, with a portion of tin, to give it more tenacity.—One half were of six, and the other of four, pounder calibre; I have yet remaining between 80 and 90.—The whole cost five dollars; but if the order had been for a considerable quantity, the price would doubtless have been much reduced.

On my passage that year in the ship Ploughboy, from Canton to Philadelphia, I took an opportunity to make a fair experiment, and fired six rounds from a four pounder in quick succession, by instantly inserting the charge without spunging; and then upon cleaning out the gun, I found only a small portion of lead, nearly of the size and form of mustard seed shot, and in quantity only sufficient to cover a surface of an inch square.

The lead cartridge may be perforated with as much ease as paper; and as it is not necessary to ram home the charge, or prime the gun, until intended to be used, it may remain at all times in the gun, ready for service, without injury from wet or damp.

When ships of war take fire by any casualty, unless it can be instantly subdued, it becomes absolutely necessary to deluge the magazine; for which purpose there is usually a stopcock through the bottom of the ship: thus the whole of the powder on board may be rendered totally unfit for service, and of course the ship utterly defenceless. Whereas, if enclosed in lead, the powder would not sustain the least injury from the inundation.

The whole of the powder for a ship of war, may be filled in a perfect state, in the laboratory on shore; and the aperture in the end of the cartridge, being closed with a cap of lead, secured by a cement of white lead, or other proper substance, will be impervious to moisture; and thus the powder may be preserved unimpaired in the state in which it was filled, for *any length of time*—an advantage of the utmost importance to the success of an enterprise.

The cartridges should be packed in cases, with cylindrical compartments fitted to the size of the several calibres; or with some soft substance to preserve them from injury or deformity; hence the necessity and the danger of filling the cartridges on board, in time of action, will be superseded.

If it shall be deemed necessary to have some larger packages of powder for ordinary or casual uses, the casks containing it, should be lined with thin lead, in *the manner of a tea chest*, and closed, like the cartridges, until required for use.

I think *cases* preferable to *casks:* their cubical form will occupy less space in proportion to their contents than casks; and about 50 pounds weight in each case, can be handled by one man with convenience.

As leaden cartridges will preserve their form better when full than empty, and will occupy only the same space, the whole of the ammunition should be filled in the laboratory, and the contents of each case distinctly marked with the number, calibre, and nature of the charges, whether full or reduced.

The increase of expense in substituting lead for paper cartridges, will be comparatively trifling, and will be amply remunerated, by the preservation of the quality, and saving in quantity, of the powder. For I believe when ships of war return from a cruize, their powder is generally sent to be remanufactured.

The preceding remarks are applied principally to naval service; but I conceive them to be equally applicable to many military purposes, particularly magazines, and even to field service, when rapid firing is necessary; for the charge may be instantly inserted without danger, as there is no necessity to spunge the gun, except when it may be necessary to cleanse or cool it.

We often hear of partizan detachments being frustrated in the object of their enterprise, by long exposure to heavy rains, or by fording deep streams, and thus damaging their powder. Why may not the cartridges of the infantry as well as the artillery, be formed of lead, *for particular objects?*[*]

The musket cartridge may be made as thin as paper, so that neither weight nor expense, can form an objection; and, when to be used, the end can be opened with the teeth, with as much facility as a paper cartridge.

The two cartridges now exhibited, contain a charge for a four pounder; and although they are of the size of a cylindrical powder measure for one pound weight, they are each made to contain nearly a pound and a quarter of powder, by gently striking the bottom on a table when filling, which serves the better to distend and support the sides of the cartridge.

One of them had a small neck about one-fifth of an inch high, and is closely corked and sealed with a cement of resin gum-mastic, and red lead; the other had merely a circular aperture closed with a cork, and over that a cap of lead, cemented with white lead—they have both *been completely immersed in water during the preceding forty-eight hours.* It is practicable to solder the cap; but, on trying the experiment, I found the degree of heat necessary to fuse solder, to approach so near to the ignition of gunpowder, that I think it would be found too hazardous in common practice.

It was my intention to have made this communication long since; but it has been delayed by the pressure of other pursuits, and partly by neglect. In the interval, I have occasionally conversed with several philosophical, naval, and military gentlemen, on this subject, who have all corroborated my views of the utility and importance of the object, and have

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[*] Observe the difficulties that Pike and other travellers have experienced, from the effect of humidity upon their powder.

urged the communication which is now submitted with deference and respect to the American Philosophical Society, by

WM. JONES.

Philadelphia, March 15th, 1811.

This Memoir being referred to Messrs. Robert Patterson, T. Matlack and Joseph Cloud, to report thereon to the society: the author made a further communication on the subject to the committee, which, together with their report, was directed to be printed.

Philadelphia, March 22, 1811.

Dear Sir,

As the only legitimate end of philosophical investigation is the discovery of truth, and as the truth can only be ascertained by a careful examination of facts, as they are developed in the progress of experiment, I deem it necessary to state to you, that after the exhibition of my leaden cartridges, (which had been immersed in water 48 hours) one of which was opened, and a part of the gun powder poured out perfectly dry, in the presence of the society at its last meeting—I emptied both the cartridges, and, contrary to my expectation, a part of the powder appeared in lumps *slightly adhesive*, but apparently dry. My first impressions were that a small degree of humidity must have penetrated through some imperceptible crevice, or that the low temperature of the water in which they had been immersed, had condensed the air within, and produced a slight degree of deliquescence, and consequent adhesion of the grains of powder: but, upon a more strict examination, I found the powder perfectly dry, and the interior of the cartridge equally so ; not a grain of powder adhering to the corners, or the appearance of the least humidity—then recollecting that I had packed the powder very hard, in order to distend and support the sides of the cartridge, it occurred to me that this must have been the cause of the adhesion. In order to satisfy myself on this head, I returned the powder into the cartridge, and packed it hard as before. Two days afterwards, I emptied it again, and found the powder in lumps slightly adhesive, exactly in the state first described; so that I am entirely satisfied that not the least moisture had passed through the cartridge, but that the powder and the interior of the cartridge were as perfectly dry after the immersion as before.

When the cartridges are filled and the caps cemented and dry, I would recommend a good coat of paint, in order to prevent oxidation, as well as to fill up any imperceptible crevice or defect in the cartridge. It is easy, however, to prove the soundness of the cartridge, by blowing in it to ascertain whether or not it is air tight.

I am of opinion, that very thin tin plate cartridges may be made to answer the same purpose, (in the absence of lead, which I think much preferable) provided they were well protected by a coat or two of paint, as tin will oxidate much sooner than lead.

Thin tin plate may readily be perforated by a slight stroke with a steel-pointed pricker.

I am very respectfully,
Yours,
WM. JONES.

Messrs. Patterson, Cloud and Matlack.
Committee on Leaden Cartridges.

The Committee to whom was referred the Memoir on Cannon Cartridges,

REPORT,

That the Committee have attentively considered *the Memoir on Cannon Cartridges*, presented to the society by Captain William Jones of this city, and are of opinion, that the experiments made by him fully demonstrate the utility of sheet-lead cartridges.

The security they will afford, against the danger from latent fire, so frequently retained by the cartridges now in use, and the time saved in scooping and spunging the cannon, which will be altogether unnecessary, are evidently of very great importance in the land service; and, in addition to those advantages, that of securing gun powder at sea, from the destructive effects of moisture, extending even to the case of inundation of the powder-room, sometimes indispensibly necessary for the preservation of the ship; they consider as being in the sea-service *inestimable*. Your Committee are therefore of opinion, that the communication is well worthy of a place in the transactions of the society.

And as practical improvements of this kind belong to the nation: your Committee therefore recommend, That the secretary of the society be directed to transmit to the secretary of the navy and the secretary at war of the United States, a copy of Captain Jones's Memoir. This, they conceive, ought not to be delayed, as sheet-lead of a size suitable for cannon cartridges not being in common use, time will be required for the necessary preparations for rolling it of that size. For a supply of an article of such importance in national defence, we ought not to depend on foreign nations; and the readiness with which this can be manufactured within ourselves, at an expense, it is believed, that will not exceed the cost of flannel, or even paper cartridges, renders that dependence altogether unnecessary. How far the use of sheet lead cartridges may, in some cases, be applied to musquetry, will of course present itself for consideration to the board of war of the United States;—and possibly that board may take into consideration the utility of preserving the whole stock of powder in their magazines in sheet-lead; either in cases or boxes lined with it.

R. PATTERSON,
T. MATLACK, } Committee.
JOS. CLOUD,

Copies of the Memoir and of the Report were transmitted as directed to the Secretary of War, from whom the following letter was received.

War Department, April 27th, 1811.

John Vaughan, Esq.
Librarian Am. Phil. Society.

Your letter of the 11th inst. inclosing a memoir on the advantages of using sheet-lead for cartridges instead of paper or flannel, has been received. The attention of the American Philosophical Society, to a subject so interesting as that of the preservation of powder, is equally honourable to them, and promising of usefulness to the public; and is observed (with suitable acknowledgments) by this department, to which it is peculiarly important.

Boxes or casks for keeping powder, lined with lead, are unquestionably applicable to all magazines constructed within or under walls of earth or masonry, or others, exposed to dampness or moisture; the introduction and use of leaden cartridges, however, must depend on further experience.

On the suggestion of an officer, a common tea-chest made of wood, and lined as usual with lead, was filled with powder.

The top, or mouth of the chest, was covered with pieces of board. It was buried in the earth in the month of November, 1809, where it remained until the month of May, 1810, when it was taken up. The powder was perfectly dry, excepting round the edges of the mouth, where it had been covered with the boards.

Respectfully, Sir,
Your obdt. servant,
W. EUSTIS.

No. VI.

Tables of the Altitudes of Mountains in the States of New York, New Hampshire, and Vermont, calculated from Barometritrical and Thermometrical Observations, by A. Partridge, Captain of the Corps of Engineers of the United States. Communicated by Col. Jonathan Williams.—Read February, 1812.

TABLE I.

	Feet.
Altitude of the Roundtop above high water of Hudson's River,	3566
of the High Peak,	3486
of the Highest of the Turnpike,	2273
of the Roundtop of the base of the range of Mountains,	2911
of the High Peak above the same,	2831
of the highest part of the Turnpike above the same,	1630
Base of the Mountains above the River,	655
of the Roundtop above its base,	1550
of the High Peak above its base,	1470
Whole Altitude of the High Falls,	310
Altitude of the first Fall,	190
of the second Fall,	120

TABLE II.

Altitudes of the highest Mountains at and near West Point, State of New York.

Names of the Mountains and Elevations.	*Altitudes in Feet above Hudson's River.*
Anthony's Nose,	877
Sugar Loaf,	812
Fort Putnam,	561
West Point Plane,	176
Bull Hill,	1391
Breakneck Hill,	
First Peak next the River,	939
Second Peak,	1113
Crow's Nest,	1330
Butter Hill,	1432
Old Beacon,	1379
New Beacon,	1486

TABLE III.

Altitudes of the most elevated parts of the White Hills, in the State of New Hampshire.

Names of the Peaks.	*Altitude in Feet.*	
	Above the Sea.	*Above their Bases.*
Mount Washington,	6234	4464
First Peak South of do. (Adams)	5328	3558
Second do. do. (Jefferson)	5058	3288
Third do. do. (Madison)	4866	3096
Fourth do. do. (Franklin)	4711	2941
Fifth do. do.	4356	2586
Base of the Mountains,	1770	

Note.—"The great distance at which these mountains are visible, and "the apparent length of their ascent, have led to estimates of their height "considerably exceeding the probable truth. The Rev. Dr. Cutler, who "twice visited them, and took barometrical observations, computes the height "in round numbers, at 10,000 feet above the level of the sea." "Mr. Bowditch has published in the transactions of the American Academy, (Vol. "iii. p. 326). a logarithmic calculation founded on the barometer, as observed by Dr. Cutler and Professor Peck, in 1804, which gives them an elevation of 7055." See Account of the White Mountains of New Hampshire, published in the New England Journal of Med. and Surg. for Oct. 1816.

TABLE IV.

Altitude of Killington Peak, said to be the highest part of the Green Mountains, in the State of Vermont.

	Feet.
Altitude above the Sea, -	3679
above its base, -	2807
of the base above the Sea,	872

No. VII.

On the Population and Tumuli of the Aborigines of North America. In a Letter from H. H. Brackenridge, Esq. to Thomas Jefferson.—Read Oct. 1, 1813.

Baton Rouge, July 25, 1813.

Sir,

From a knowledge that research into the history of the primitive inhabitants of America, is one of your favourite amusements, I take the liberty of making this communication. My attention to the subject, was first awakened on reading, when a boy, the observations contained in the "Notes on Virginia," and it has become, with me, a favourite theme of speculation. I often visited the mound, and other remains of Indian antiquity in the neighbourhood of Pittsburgh, my native town, attracted by a pleasing interest, of which I scarcely knew the cause, and afterwards read, and heard with delight, whatever related to these monuments of the first, or rather earlier, inhabitants of my native country. Since the year 1810 (without previously intending it) I have visited almost every thing of this kind, worthy of note on the Ohio and Mississippi; and from examination and reflection, something like hypothesis, has taken the place of the vague wanderings of fancy. The following is a sketch of the result of those observations.

I. Throughout, what is denominated by Volney, the valley of the Mississippi, there exist the traces of a population far beyond what this extensive and fertile portion of the continent, is supposed to have possessed: greater, perhaps, than could be supported of the present white inhabitants, even with the careful agriculture practised in the most populous parts of Europe. The reason of this, is to be found in the peculiar manners of the inhabitants by whom it was formerly occupied; like those of Mexico, their agriculture had for its only object their own sustenance; no surplus was demanded for commerce with foreign nations, and no part of the soil, susceptible of culture, was devoted to pasturage; yet, extensive forests filled with wild animals would still remain. The aggregate population of the country might be less, but that of particular districts much greater. We must, in this way, account for the astonishing population of the vale of Mexico, when first known to the Spaniards; perhaps equal to any district of the same extent of climate.* The astonishing population of Owyhee, and Otaheite, must be accounted for in the same way. There are certainly many districts on the Ohio and Mississippi equally favourable to a numerous population. When I contemplated the beauty and fertility of those spots, I could scarcely believe it possible, that they should never have supported a numerous population; such a fact would form an exception to what has usually occurred, in every other part of the globe.

II. In the valley of the Mississippi, there are discovered the traces of two distinct races of people, or periods of population, one much more ancient than the other. The traces of the last are the most numerous, but mark a population less advanced in civilization; in fact, they belong to the same race that existed in the country when the French and English effected their settlements on this part of the continent: but since the intercourse of these people with the whites, and their astonishing diminution in numbers, many of their customs have fallen into disuse. It is not more than a hundred and twenty years, since the character of the population, which left the traces of the second period, underwent a change. The ap-

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* See Humboldt, Vol. II. page 127.

pearances of fortifications, of which so much has been said, and which have been attributed to a colony of Welch, are nothing more than the traces of pallisadoed towns or villages. The first travellers mention this custom of surrounding their towns with pallisades; the earth was thrown up a few feet, and pickets placed on the top. I have seen old volumes in which they are represented in the engravings.* The Arikara and Mandan villages are still fortified in this way. The traces of these are astonishingly numerous in the western country; I should not exaggerate if I were to say that *five thousand* might be found. Some of them inclose more than an hundred acres. From some cause or other (and we know that there are enough which might suffice to effect it) the population had been astonishingly diminished immediately before we became acquainted with them; and yet Charlevoix mentions a town of the Mascutin tribe (at present incorporated with the Kickapoos) containing a thousand families! The barrows, or general receptacles of the dead, such as examined by yourself, may be classed with the pallisadoed towns, though they are much more numerous; they are, in fact, to be found in almost every cornfield in the western country. The tumuli or mounds, are often met with, where there is no appearance of pallisadoed villages or fortifications, or of barrows.

III. The first and more ancient period, is marked by those extraordinary tumuli or mounds. I have reason to believe that their antiquity is very great. The oldest Indians have no tradition as to their authors, or the purposes for which they were originally intended; yet they were formerly, I might almost say instinctively, in the habit of using them for one of the purposes for which they were at first designed, to wit, as places of defence. The old chief Du Coin, told Mr. Rice Jones that the mounds in the American bottom had been fortified by the Kaskaskias in their wars with the Iroquois. An old

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* These are to be seen in many old volumes in the present library of Congress, which contains the most valuable collection of Books on America to be found in any part of the world.

work by Lafitau, a jesuit, which I met with at New Orleans, contains a curious plate in which one of these mounds fortified by pallisades on the top, and large beams extending to the bottom, is assaulted by enemies. These tumuli as well as the fortifications, are to be found at the junction of all the considerable rivers, in the most eligible positions for towns, and in the most extensive bodies of fertile land. Their number exceeds perhaps *three thousand;* the smallest not less than twenty feet in height, and one hundred in diameter at the base. Their great number, and the astonishing size of some of them, may be regarded as furnishing, with other circumstances, evidence of their antiquity. I have been sometimes induced to think that at the period when those mounds were constructed, there existed on the Mississippi, a population as numerous as that which once animated the borders of the Nile, or of the Euphrates, or of Mexico and Peru.

IV. The most numerous, as well as the most considerable of these remains, are found precisely in the part of the country where the traces of a numerous population might be looked for, to wit, from the mouth of the Ohio (on the east side of the Mississippi) to the Illinois river, and on the west side from the St. Francis to the Missouri. I am perfectly satisfied that cities similar to those of *ancient Mexico*, of several hundred thousand souls, have existed in this part of the country. Nearly opposite St. Louis there are the traces of two such cities, in the distance of five miles, on the bank of the Cohokia, which crosses the American bottom at this place.* There are not less than one hundred mounds, in two different groups; one of the mounds falls little short of the Egyptian pyramid Mycerius. When I examined it in 1811, I was astonished that this stupendous monument of antiquity should have been unnoticed by any traveller: I afterwards published an account in the newspapers at St. Louis, detailing its dimensions, describing its form, position, &c. but this, which I thought might

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* See the Chapter on the Antiquities of the Valley of the Mississippi, in the "Views of Louisiana," by the author of this Memoir, p. 181. Pittsburg edition, 1814.

almost be considered a discovery, attracted no notice: and yet I stated it to be eight hundred paces in circumference (the exact size of the pyramid of Asychis) and one hundred feet in height. The mounds at Grave Creek and Marietta are of the second or third class. The mounds at St. Louis, at New Madrid, and at the commencement of Black River, are all larger than those of Marietta. The following is an enumeration of the most considerable mounds on the Mississippi and on the Ohio; the greater part I examined myself with such attention as the short time I had to spare would permit.

1. At Great Creek, below Wheeling.
2. At Pittsburgh. .
3. At Marietta.
4. At Cincinnati.
5. At New Madrid—one of them 350 feet diameter at the base.
6. Bois Brulie bottom, fifteen miles below St. Genevieve.
7. At St. Genevieve.
8. Mouth of the Marameck.
9. St. Louis—one with two stages, another with three.
10. Mouth of the Missouri.
11. On the Cohokia river—in two groups.
12. Twenty miles below—two groups also, but the mounds of a smaller size—on the back of a lake, formerly the bed of the river.
13. Near Washington (M. T.) 146 feet in height.
14. At Baton Rouge, and on the bayou Manchac—one of the mounds near the lake is chiefly composed of shells—the inhabitants have taken away great quantities of these for the purpose of making lime.
15. The mound on Black River, of two stages, with a group around it.

At each of these places there are groups of mounds; and at each there probably once existed a city. On the other considerable rivers which are tributary to the Ohio and Mississippi, in Kentucky, Tennessee, state of Ohio, Indiana Territory, &c. they are equally numerous. But the principal city and center of population was between the Ohio, Mississippi, Missouri, and Illinois. I have been informed that in the plains between the Arkansa and St. Francis, they are numerous and some very large. They resemble the Teocalli, in these important features, 1. In their positions the cardinal points are observed with considerable accuracy. 2. The larger mounds have several stages. 3. In every group there are two mounds much larger than the others. 4. The smaller mounds are placed around symmetrically. A closer examination would show a resemblance in other particulars. It is doubted by Humboldt whether advantage had not been taken of some natural rise, in the formation of the pyramid of Cholula; with respect to the mound of Cohokia, there can be no doubt, for it stands in the midst of alluvium, and there is no natural hill nearer than two miles.*

Such are the appearances of antiquity in the western country, which I consider as furnishing proof of an ancient and numerous population. The resemblance to those of New Spain would render probable the existence of the same arts and customs; perhaps of an intercourse. The distance from the large mound on Red River, to the nearest in New Spain, is not so great but that they might be considered as existing in the same country.

From the description of the *Adoratorios*, as they are called, it appears highly probable that the mounds on the Mississippi were destined for the same purposes. Solis tells us, that every considerable place had a number of them, upon which a kind of tower was erected, and which gave rise to the belief of those who first visited the coast of New Spain, that they had seen cities with numerous steeples;† from which circumstance they bestowed upon it the name of their native country. The four

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* See the account of the Teocalli of New Spain, by Humboldt, pages 16, 41, 44, 123, 170, &c. vol. II. New York edition, 1811.

† Mr. Robertson, who is disposed to lessen every thing American, and to treat with contempt unworthy of a philosopher, all their acts and advancement in civilization, attributes this to the imaginations of the Spaniards, inflamed with the spirit of Quixotic adventure.

great cities to which the general name of Mexico was given, contained two thousand of these *Adoratorios* or Teocalli; at the first glance, this vast population, equal perhaps to London or Paris, appeared to be crowned with innumerable towers and steeples. Architecture was perhaps too much in its infancy to enable them to build to any great height, a mound was therefore raised, and a building erected on the top. It was in this way the temple of Belus at Babylon was erected, and the Egyptian pyramids of the second class, which are solid, and probably the most ancient. Besides being places of adoration, the Teocalli also served as fortresses; they were usually the last places, to which the inhabitants of the cities conquered by Cortez, resorted, after having been driven from every other quarter. They were enabled from the position, form, and the tower on the top, to defend themselves in these situations to great advantage. Placed from the bottom to the top of the mount, by gradations above each other, they appeared (as Solis in his animated style expresses it) to constitute "a living hill;" and at first, judging only from the experience of their own wars, they fancied themselves unassailable.

From the oldest book extant, the bible, we see exemplified in numerous instances, the natural predilection for resorting to *high-places*, for the purpose of worship; this prevailed amongst all nations, and probably the first edifice dedicated to the Deity was an elevation of earth, the next step was the placing a temple on it, and finally churches and mosques were built with steeples. This having prevailed in all countries, may be considered as the dictate of nature. The most ancient temples of the Greeks were erected on artificial, or natural elevations of earth; at the present day, almost every part of Europe and Asia, exhibits these remains of tumuli, the rudest, though perhaps the most lasting of human works.* The mausoleum generally holds the next place to the temple; and, what is remarkable, all nations in their wars have made the last

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* See Appendix to Volney's View of America, Clark's Travels in America, &c.

stand in the edifices consecrated to their gods, and near to the tombs of their ancestors. The *Adoratorios* of New Spain, like all works of the kind, answered the three purposes, of the temple, the fortress, and the mausoleum. Can we entertain a doubt but that this was also the case with those of the Mississippi?

The antiquity of these mounds is certainly very great; this is not inferred from the growth of trees, which prove an antiquity of a few centuries, but from this simple reflection; a people capable of works requiring so much labour, must be numerous, and if numerous, somewhat advanced in the arts; we might therefore look for works of stone or brick, the traces of which would remain for at least eight or ten centuries. The great mound of Cohokia, is evidently constructed with as much regularity as any of the Teocalli of New Spain, and was doubtless chased with brick or stone, and crowned with buildings; but of these no traces remain. Near the mound at St. Louis, there are a few decaying stones, but which may have been casually brought there. The pyramid of Papantla, in the northern part of the Intendency of Vera Cruz, unknown to the first conquerors, and discovered a few years ago, was still partly cased with bricks. We might be warranted in considering the mounds of the Mississippi more ancient than the Teocalli: a fact worthy of notice, although the stages are still plain in some of them, the gradations or steps have disappeared, in the course of time the rains having washed them off. The pieces of obsidian or flint, are found in great quantities near them, as is the case with the Teocalli. Some might be startled if I should say that the mound of Cohokia is as ancient as those of Egypt! The Mexicans possessed but imperfect traditions of the construction of their Teocalli; their traditions attribute them to the Toultecs, or to the Olmecs, who probably migrated from the Mississippi.

Who will pretend to speak with certainty as to the antiquity of America—the races of men who have flourished and disappeared—of the thousand revolutions, which, like other parts of the globe, it has undergone? The philosophers of Europe, with a narrowness and selfishness of mind, have endeavoured to depreciate every thing which relates to it. They have called it the *New World*, as though its formation was posterior to the rest of the habitable globe. A few facts suffice to repel this idea:—the antiquity of her mountains, the remains of volcanoes, the alluvial tracts, the wearing away of cataracts, &c. and the number of primitive languages, greater perhaps than in all the rest of the world besides.

The use of letters, and the discovery of the mariner's compass, the invention of gunpowder and of printing, have produced incalculable changes in the old world. I question much whether before those periods, comparatively recent, there existed, or could exist, nations more civilised than the Mexicans, or Peruvians. In morals, the Greeks and Romans, in their most enlightened days, were not superior to the Mexicans. We are told that these people sacrificed human beings to their gods! did not the Romans sacrifice their unfortunate prisoners to their depraved and wicked pleasures, compelling them to kill each other? Was the sacrifice of Ephigenia, to obtain a favorable wind, an act of less barbarity than the sacrifices by the Mexicans of their prisoners on the altar of their gods? The Peruvians were exempt from these crimes —perhaps the mildest and most innocent people that ever lived, and in the arts as much advanced as were the ancient Persians or Egyptians; and not only in the arts, but even in the sciences. Was ever any work of the old world superior to the two roads from Quito to Cusco?

Pardon me, sir, for troubling you with this long, and perhaps tiresome letter, dictated probably by the vanity of personally communicating my crude theories to one who holds so distinguished a place in that temple of science which belongs to every age and every country.

With sentiments of the highest respect,
I am, Sir,
Your most obedient,
Humble servant,
H. M. BRACKENRIDGE.

No. VIII.

An Account of some Experiments made on Crude Platinum, and a New Process for separating Palladium and Rhodium from that Metal. By Joseph Cloud.—Read November 3d, 1809.

NATIVE Platinum, as we receive it from South America, is a heterogeneous compound, generally mixed with a considerable quantity of ferruginous sand, very sensibly attracted by the magnet; such, at least, was the specimen,—the subject of my experiments. In order, therefore, to free it as much as possible from the ferruginous mixture, I used the magnet as long as any thing could be separated by that means. Having thus far freed it from extraneous matter, it was submitted to the following treatment.

Process 1st. The crude Platinum was subjected to the action of boiling in nitro-muriatic acid (composed of an equal quantity, by measure, of the nitric and muriatic acids) until no further action took place. The acid, now holding Platinum, Palladium, Rhodium, Iron, and perhaps some other metals in solution, was decanted from the undissolved residue; which, according to Mr. Tenant, contains iridium and osmium.

Process 2d. To the solution from process 1st, I added a saturated solution of muriate of ammonia in boiling water, until no further precipitation of platinum took place; taking care to separate the fluid from the precipitate as soon as possible, to prevent the precipitates of palladium and rhodium from mixing with the platinum; these metals being also precipitated by muriate of ammonia, although not with so much facility as the platinum. The precipitate was well washed with pure water, and the washings added to the decanted fluid.

Process 3d. The last precipitate, being an ammoniaco-muriate of platinum, was heated to ignition, for the purpose of separating the muriate of ammonia, and was again dissolved in the nitro-muriatic acid, and precipitated in the same way, and with the same precaution observed in the last process. I now had a beautiful orange-coloured precipitate; which, on being heated to a white heat in a crucible, adhered together, was perfectly metallic, and very brilliant; and when fused by united streams of oxygen and hydrogen gas, it was very malleable and ductile; so that by means of rollers it was reduced into extremely thin plates: its specific gravity, in distilled water at 62° Fahrenheit, by a balance sensible to $\frac{1}{1000}$ part of a grain, was 23.543.

Process 4th. The acids and washings from process 2d and 3d, still holding a portion of platinum, and all the metals that were combined with it (except the osmium and iridium) in solution, were mixed together; and the platinum, palladium, rhodium, and perhaps small portions of other metals, were precipitated in a metallic form, by plates of zinc.—The precipitate was washed and dried.

Process 5th. The precipitate from the last process was combined with four times its weight of fine silver, and coupelled with a sufficient quantity of lead, for the purpose of destroying any of the base metals that were thrown down by the zinc. I had now a compound of silver, platinum, palladium, rhodium, and perhaps a small portion of gold.

Process 6th. The metals from process 5th, were reduced to thin plates, and submitted to the action of boiling nitric acid, until the silver and palladium were dissolved, and the acid ceased to operate: the solution was decanted, and the remaining metals were well washed, to free them from the solution of silver.—This is a necessary precaution, for if any of it were suffered to remain, it would form a muriate of silver in the subsequent process, and impede its operations.

Process 7th. To the solutions and washings from the last process, I added pure muriatic acid to excess, and the silver was thrown down in form of muriate of silver. The acid, holding now nothing but palladium in solution, was decanted; the precipitate washed, and the washings added to the decanted fluid. From this the palladium may be precipitated, either by pure pot-ash, or prussiate of mercury, and the precipitate fused with borax. By the above processes, pure ductile palladium was obtained; its specific gravity in river water at 64° Fahrenheit, was $11.\frac{4}{99}$.

Process 8th. The undissolved metals from process 6th, being platinum, rhodium, and perhaps gold, were subjected to the action of nitro-muriatic acid, assisted by heat, until no further solution could be obtained. The platinum, and gold if any was present, were dissolved; and the rhodium remained in the form of a black powder. The solution was decanted, and the powder washed; which, on being heated to a white heat, assumed a metallic brilliancy, and was completely fused by the hydro-pneumatic blow pipe, at about 160° of Wedgewood. Its specific gravity 11.2.

The rhodium thus obtained, very much resembles cast iron in colour; and, like it, is rigid and friable under the hammer. it is not acted on, either by the nitric or nitro-muriatic acids. As the principal object of this memoir is to communicate a new method of obtaining rhodium from its native combination, for a fuller account of the characters and properties of this metal, the reader is referred to the Transactions of the Royal Philosophical Society of London for 1804, page 428.

Process 9th. The platinum and gold may be obtained from the last solution, through the agency of muriate of ammonia, and sulphate of iron.

It is an extraordinary fact, first discovered by Dr. Wollaston, and fully confirmed by my experiments, that rhodium in an uncombined state, and in some of its combinations with other metals, is insoluble in the nitric and nitro-muriatic acids. It is particularly remarkable, that it should be soluble in its native combination with crude platinum, and become insoluble in the artificial compound produced by process 5th. These phenomena may probably be accounted for by supposing that the platinum, palladium and rhodium, in a state of nature, were in *perfect* chemical combination; the effect of reciprocal attraction. That is, the different metals were united together so intimately by chemical affinity, that each integral particle consisted of the same principles, combined in the same relative proportions, as in the general mass, united by the force of aggregation: the platinum and palladium being dissolved by the nitro-muriatic acid in process 1st, the force of aggregation, and the chemical attraction of the integrals are both destroyed; and the rhodium, which perhaps did not form more than $\frac{1}{100}$ part of each integral; becomes so extremely divided, that it is rendered susceptible of being oxidated, and dissolved by that agent.

There are numerous examples in chemistry, in which aggregation in bodies is so powerful that they are not sensibly acted on by others, even in the fluid state; though the combinations of them are affected when the aggregation of the solid is destroyed: the native oxide of tin resists the action of any acid. This apparent insolubility is owing to its strong aggregation; when this is overcome by mechanical operations, it becomes soluble. The ruby, the sapphire, and the adamantine spar, from the strength of aggregation, are scarcely affected by any chemical agent; but if their cohesion be destroyed, they are then acted on. Hence the mechanical operations of trituration, levigation, and granulation, are of importance in facilitating chemical action; partly by diminishing aggregation, and partly by increasing the surface on which action is exerted.

In the artificial compound of process 5th, the metals were in the state of *imperfect* chemical combination; the integrant and constituent particles of the compound were substances differing in their nature from each other, and from the general mass; which was composed by their being united by the force of aggregation, and presenting distinct surfaces to the action of their respective solvents. This appears evidently to be the case in a combination of gold and silver, and platinum and silver; for all compounds of these metals are soluble by alternate treatment with the nitric and nitro-muriatic acids.—If two parts of silver, intimately mixed with one part of gold, and reduced to a thin plate, be subjected to the action of dilute nitric acid, the silver will be dissolved without altering the form of the plate, other than rendering it extremely porous; cavities having been formed in the plate corresponding to each integral of the silver that was in the compound: Consequently, the silver and palladium would be taken up by the nitric acid in process 6th, and the platinum and gold by the nitro-muriatic in process 8th, without a solution of the rhodium taking place; its integral aggregation being superior to the chemical action of the acids.

How nature forms the immense varity of compounds which we are unable to imitate by art, and how far I have succeeded in illustrating these phenomena, I must leave for others to decide: as a humble labourer in the science of Analytical Chemistry, I have with much diffidence submitted these theories to the public eye, from a hope that they will draw forth a better explanation from some abler hand.

No. IX.

An Attempt to ascertain the Fusing Temperature of Metals.

By Joseph Cloud.—Read May 20th, 1814.

THE fusing or melting temperature of the different metals has long excited the attention of philosophers, and many unsuccessful attempts had been made to ascertain that point, when, at length, the ingenious Mr. Wedgewood invented a pyrometer, which appeared to be sufficiently accurate to indicate the comparative fusibility of such metals as came within its range. To this instrument, however, there are several objections. 1st. As to the accuracy of its *zero* stated to be equal to 1077½° of Fahrenheit, and that each degree of the former is equal to 130° of the latter. 2d. Mr. Wedgewood found, from experience, that the pyrometrical pieces were liable to suffer variable contractions, at the same temperature, from circumstances in their preparation, apparently minute. And another source of error, not easily avoided, is, that natural clays, taken from the same bed or stratum, and apparently of similar qualities, differ considerably in the contractions they suffer. 3d. Experiments with the pyrometer pieces seem to lead to the inference, that their contraction is, in some degree, proportioned to the quantity or duration, and not simply to the intenacity of the heat applied. Having noticed the present state of our knowledge on this branch of science, I shall endeavour to point out a method for ascertaining the fusing temperatures of the metals in a way less liable to error.

The dilatation observable in the fusion of metals is a proof that the particles are separated, and kept at a distance from each other, by the interposition of caloric between their integrants, sufficient to overcome their attraction of cohesion, and their *vis inertiæ*. And when certain degrees of temperature are excited, they lose their solidity and become fluid. From these general laws of fusion, it necesssary follows, that the melting heat of a metal will be governed both by its attraction of cohesion, and *vis inertiæ;* and that the comparative fusibility of the metals will be in the compound ratio of their comparative attraction of cohesion, and specific gravity.* In order to illustrate this position, I have availed myself of Mr. Guyton Marveau's experiments on the attraction of cohesion of the metals, by which he found that wires of 0.787 of a line in diameter required the following forces to tear them asunder. Iron, 549,250lbs. copper, 302.278lbs. platinum, 274.320 lbs. silver, 187.137lbs. gold, 150.753lbs. zinc, 109,540lbs. tin, 34.630lbs. lead, 27.621lbs. I shall also make use of the specific gravities as stated by chemical authors.—Iron, 7.788, copper, 8,667; platinum, 23.543; silver, 10.510; gold, 19.361; zinc, 6.861; tin, 7.299; lead, 11.352. Now, as it has been ascertained that, in the fusion of tin, 442° of Fahrenheit's scale are required to overcome the combined powers of 34.630 attraction of cohesion, and 7.299 of *vis inertiæ* (spec. grav.) I have taken them as a standard to find the melting temperature of the other metals, by the following proportions. If 34.630 multiplied by 7.299 require 442°, what will 150.735 multiplied by 19.361 (the attraction of cohesion and specific gravity of gold) require? The answer will be 5103° degrees of Fahrenheit, the fusing point of gold.

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* As the tendency in bodies to be at rest, and consequently the force required to put them into motion, depends upon their weight, their specific gravity furnishes us with an easy and correct method of ascertaining their comparative *vis inertiæ*.

By proceeding, as in the above example, with the other metals, we shall obtain the following results as their fusing temperature—platinum, 11293°—iron, 7480°—copper, 4581°—silver, 3439°—zinc, 1314°—lead, 548°.3. This last turns out to be the precise temperature at which Sir Isaac Newton found lead to melt.—If the above results are reduced to Wedgewood's scale, they will be found to differ but little from the fusibility given by chemists, of such metals as come within the lower range of that scale. The only two in which there is much difference are platinum and iron, this may probably arise from the circumstance of the contraction of Wedgewood's pyrometer pieces being governed by the quantity and not merely by the intensity of the heat applied; these refractory metals necessarily requiring a longer continuation of it, before a sufficient degree can be excited to effect their fusion.—Chemical writers state platinum to melt at 170° of Wedgewood, equal to 23177½° of Fahrenheit; and iron at 158° of Wedgewood, equal to 21617½° degrees of Fahrenheit; from which it would appear, that the difference in their fusibility is but 1560° of Fahrenheit. This trifling disparity can hardly be accounted for, when we consider that the fusion of iron is completely within the range of a common melting furnace, and that platinum can only be fused, even in small quantities, by means of a powerful lens, a combination of oxygen and hydrogen gases, or by combustion urged by a stream of pure oxygen gas.—Again, gold is stated to fuse at 32° of Wedgewood, equal to 5237½° of Fahrenheit, which is 16380° of Fahrenheit below the fusing temperature of iron; now, here is a difference that cannot be correct; and the most common observer, at all acquainted with the fusion of metals, must be convinced of the error.—Palladium is stated to fuse at 160° of Wedgewood, equal to 21877½° of Fahrenheit; which is 260° of Fahrenheit above the fusing point of iron; to this error I can testify, from frequently fusing that metal in a common air-furnace; but as I have not had an opportunity of ascertaining its attraction of cohesion, I am unable to calculate its precise fusing temperature; which, however, appears to be greater than that of gold, but far less than that of iron.

No. X.

An Inquiry into the Causes why the Metals in a Solid State appear to be Specifically lighter than they are in the State of Fusion. By Joseph Cloud.—Read July 15th, 1814.

AN opinion has universally prevailed among chemists and metallurgists, that cast iron, in the state of fusion, occupies less volume, and is consequently denser, than it is in the solid state. This inference has arisen out of what has been considered an anomalous circumstance, that unfused iron will float on the surface of that metal in the fluid state. This, however, is not peculiar to iron; for, although it may have escaped the notice of others, experience authorises me to assert, that the same law appears to govern the other metals, under the same circumstances. This singular fact would naturally lead to such a conclusion; for, what better evidence can be looked for, in the laws of gravity, to establish the superior density of a fluid, than that of supporting the solid on its surface? but this paradoxical phenomenon appears to be irreconcileable with the laws of expansion and fusion.—Caloric, whose particles mutually repel each other, and the attraction of cohesion, are antagonist forces; the action of one always opposing resistance to, and diminishing that of the other. Expansion arises from the excess of energy, in the repulsive power of the caloric, over the force of cohesion, inherent in the ultimate integrals of the metal; and thereby increasing the distance, and diminishing the attraction of cohesion between them, until they are in a situation to move independently of each other; and thus constitute fusion. At this period, however, the attraction of cohesion is not completely destroyed; as an increased temperature and expansion are required to produce evaporation. To prove that the energy of attraction is not destroyed:—1st. If we place a small quantity of metal, in the state of fusion, on a plane surface, it will assume the spherical form; and, if two of these globules are made to approach, they will attract each other, and form one sphere. 2d. If a glass plate be laid on a globule of mercury, the globule, notwithstanding the pressure applied to it, endeavours to preserve its spherical form; if we gradually charge the plate with weights, the globule will be depressed and become thinner and thinner; but if we again remove the weights from the plate, the mercury will instantly recover its former figure, and push up the glass before it. From these facts it appears, 1st. That the metals, in a state of fusion, are not mere inert fluids, as they could not assume the globular form unless a real reciprocal attraction among their particles existed. The 2d proves that the attraction is not only superior to gravitation, but that it also overcomes an external force.

It is a practical fact, well known to every iron founder, that, in order to procure a casting of certain dimensions, it is necessary to have patterns and moulds, from 1-8th to 3-16ths of an inch to the foot, larger than the casting is intended to be; and that spherical castings, such as cannon balls, will be 1-66th of their diameter less than the moulds in which they were cast. The reverse of this would take place if it were true that iron, in the state of fluidity, occupied less space than the solid metal: for the fluid, when first cast into the mould, must necessarily fill its whole cavity; and its expansion in cooling would produce a casting of larger size than the pattern and mould.

The sharpness of iron castings has also been advanced as an evidence in support of the superior density of the fused metal. This circumstance, however, appears more probably to depend upon the fusibility of the metals; iron being the most infusible of the metals used for that purpose, it will necessarily produce the sharpest castings. For, when melted iron is poured into a mould, it runs like other fluids into all the interstices of the mould, which being at a lower temperature than that of the metal, the heat is conducted off from the external particles of the metal, by the first impression, and the surface is reduced to a state of solidity under the pressure of the superincumbent fluid before any change of temperature or contraction takes place in the centre;* in this way a shell of solid metal will be formed corresponding to the most minute impressions or figures of the mould, and although a subsequent contraction of the whole mass takes place, and the figures on the casting are diminished in size, they lose nothing of their sharpness and perfection.

Having briefly noticed the laws of expansion and fusion, and a few practical facts connected with iron founding, in which I flatter myself that I have satisfactorily shown the prevailing opinion respecting the superior density of the fused metal to be, if not erroneous, at least very doubtful, I shall now endeavour to account for the buoyancy of the unfused metals, from the laws governing the metals in the state of fusion. 1st. The attraction of cohesion existing among the particles of the fused metals. 2d. The radiant caloric escaping in a strong ascending current from all parts of the melted mass, its levity naturally giving it that tendency, and from its meeting least resistance in that direction. These co-operating powers will oppose the gravitation of the unfused metal, with a force sufficient to overcome its superior density, and support it on the surface of the fluid till it has nearly acquired the same temperature. This effect will necessarily be the most remarkably produced in the case of iron, in consequence of the intense degree of heat required to fuse it. The truth of this

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* As the cooling process continues to go on from the surface to the centre, and the loss of temperature increases the attraction of cohesion, the particles of the metal will be drawn from the centre toward the surface; hence we find the centre to be hollow, or honeycomb, unless this effect is prevented by what the founders call a *sinking head*.

hypothesis is rendered more probable by the remarkable circumstance (noticed by Mr. Mushet) that the solid metal, notwithstanding its expansion by the increased temperature, sinks in the fluid when it arrives nearly at the fusing point, and previous to its passing into that state. This singular fact, however inconsistent it may appear, is, nevertheless, reconcileable with the laws of cohesion, repulsion, and gravity. The metals, in a state of fusion, do not operate as mere conductors of heat, but their particles, being considerably separated, like all other fluids, permit the caloric to pass in an uninterrupted current between them, without being subjected to the tardy and progressive conducting powers of the solid metal. The heat thus passing through the fluid metal, with increased facility, and striking the under surface of the unfused metal, will become subjected to the conducting powers thereof, and consequently be retarded in its progress: a strong current of ascending caloric will then continue to oppose the superior gravity of the unfused metal, and keep it buoyant until it arrives nearly at the melting heat, when it becomes so much expanded that the caloric is not entirely subjected to the conducting power of the metal; for, in proportion to the increased expansion, so will the passage of the caloric be facilitated, and its action on the unfused metal diminished until it ceases to oppose a sufficient force, co-operating with the attraction of cohesion, to prevent the unfused metal from sinking by its superior density.*

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* Or, assuming what is no doubt generally the case, that the bottom part of a melting-pot is hotter than the upper part, and especially when a piece of solid, and comparatively cold, metal, is placed on the surface, a current in the particles of the melted metal will, on hydrostatic principles, take place, from the bottom upwards; and thus, from their mechanical impetus, will contribute to prevent the unfused metal from sinking. From a similar cause, if in a vessel of boiling water, a solid body of somewhat superior specific gravity, be laid on the surface, it will not sink, but remain buoyant, as long as the water boils.

No. XI.

Observations and Conjectures on the Formation and Nature of the Soil of Kentucky. By J. Correa de Serra.—Read, April 21, 1815.

THE surprising fertility of that part of the state of Kentucky commonly called the *Elkhorn Tract*, and of many of the adjoining tracts in several directions, particularly to the south west, is so generally known in America, that I may, without inconvenience, forego the details of the extraordinary luxuriance of vegetation, and richness of crops that take place in it. The following observations and conjectures are only directed to attempt an explanation of the causes of the wonderful fertility of that soil, and I leave to books of travels and to statistical writers the care of mentioning the instances or appreciating the amount of its uncommon productiveness.

It is well known that the country to the west of the Alleghanies, is of a different and more recent formation than that of the countries situated to the east of this long ridge of mountains. Granitic or amphibolic rocks, primitive limestone, disposed in broken strata with an obliquity from 40 to 50 degrees from the horizon, are the chief components of the country on the east of the Alleghanies. Their disposition and combinations abundantly show that this part of the world, is among those which have claims to a formation of very ancient date, and that they have been worked and shaped by one or more posterior revolutions, into their present appearance.

The country to the west of the Alleghanies, is, on the contrary, all formed of horizontal strata; whether the stones that form its several parts be siliceous, argillaceous or calcareous. Certainly the formation of that country, is posterior to the revolutions that have overturned every where the strata of the materials which form the country to the east of the Alleghanies. If this western country had been coeval, nothing could have saved its strata from partaking of the same catastrophes, and being dislocated in the same manner. These western strata contain imbedded in them an immense quantity of marine shells, and other organised bodies belonging both to the animal and vegetable kingdom. The vegetable remains in particular, are in such astonishing abundance, that they form thick strata of coals extending in some parts to hundreds of miles, keeping always nearly the same level, as it is particularly ascertained of that stratum of excellent coals which is now worked at *Coal Hill*, opposite to Pittsburgh, on the other side of the Monongahela.

It is clear from these phenomena, that the soil of all this basin contained between the foot of the Andes, the highlands to the north of the lakes, and the Alleghanies, has not only been formed after these last mountains, but also at an epoch when the organised bodies were already in existence; and moreover, that the precipitation and deposition of the materials which have filled this space, have been calmly and quietly worked by nature as in a sheltered harbour, where the turmoils of the primitive ocean had little effect.

But though all this region is in the same predicament as to its original formation, still there are strong appearances of a part of it having been left by the ocean after the other, and of its being comparatively of a more recent epoch. The materials that form it, are very probably the last, and, in some respects, incomplete operation of the sea before its total retreat, as the following considerations seem to indicate.

Almost every part of the country to the north of the Ohio, the western parts of Pennsylvania and Virginia, the eastern part of Kentucky, and as far as my information goes, all the

East Tennessee, are formed, it is true, of horizontal strata, but compact enough, mixed in many parts with argillaceous slate, and the strata of limestone are sometimes interrupted with other strata of siliceous stones. The calcareous themselves are almost always but sparingly provided with fossil remains of shells. These stony strata are generally covered by many others of argillas, sand, and of gravel and rolled pebbles. Above these, is the vegetable soil commonly of a good quality, but in the same proportions as it is found in other fertile countries, and nearly of the same nature as in the good parts of Pennsylvania.

All this region is high, composed of hills commonly steep, with narrow tops, intermixed with valleys of different breadth, but generally flat, wide, and filled with alluvial soil, which the currents of water have taken from higher grounds and deposited there; consequently of a superior fertility to the upland. The horizontal position of the strata, has in some places undergone a partial and slight alteration, and over all the surface of this region, particularly in the state of Ohio, are not unfrequently found considerable insulated fragments of stones, of more primitive formations, such as siliceous, puddingstones, &c. and if I am not mistaken, granitellos, and porphyritic stones, carried from their original distant situations by the currents of the ocean, when covering these spaces.

Far different from this is the nature and aspect of the country, the extraordinary fertility of which is the subject of this paper. The whole of this tract is of a lower level than the preceding, a great presumption this, of its more modern formation, because the lowest parts of the terrestrial surface have naturally been the latest relinquished by the sea. No diversity of stones is found here, but every where a pure, soft, carbonate of lime, which is generally about the surface of a tender texture, disposed in very thin horizontal strata, not commonly thicker than the sheets of argillaceous schists. It does not acquire compactness but at a certain depth, and even then it appears of the most fine homogeneous texture, as may be observed in all the blocks of Kentucky marble. In all its states this calcareous stone is filled with marine shells, amongst which the genus *terebratula* seems the more predominant. The horizontality of the strata is most striking. Above this carbonate of lime, scarce any earth, sand or gravel appears; but a thick bed of soft black saponaceous, but not adherent, loam, from three to sixteen feet in depth, which is the seat of the most amazing vegetation.

The aspect of the country, is very different from that of the preceding region. It is not a flat plain, but one strongly undulated, the tops of the high lands are wide extended, the furrows of the water courses very narrow, nowhere accompanied by any thing like flat vallies or bottoms. Contrary to what happens almost any where else, the wide extended tops of the hills are endowed with an unbounded fertility, and this diminishes on their sides in proportion as you descend to the water courses. This simplicity of structure, this homogenity of composition, together with the lower level of this region, afford strong presumption that all this tract has undergone still less revolutions than the rest of the western lands, and that the deposition of the materials that form it, was one of the last operations of the power of the ocean before it left this western continent wholly uncovered.

The almost immediate superposition of this very thick body of fine vegetable soil on the tender layers of carbonate of lime, is a phenomenon not easily explained in the ordinary ways. We must remember that the productive soil of every country is composed of the friable detritus of the stony materials of which the country is formed; almost always covered by a light stratum of mould, proceeding from the rotten remains of vegetables, which, in the process of ages had covered its surface. This detritus of the stony materials of each country, partakes of the nature of the rocks from which it is taken, and contains the chemical principles of the earths which entered into the composition of these stones. Hence the different nature and fertility of soils. A constant observation has shewn that argillaceous and calcareous earths, but chiefly the last, were the most propitious to vegetable production, and mixed with the decomposed materials of organised bodies, constituted by their several proportions the basis of strong vegetation.

The superior stratum of vegetable mould, is in all countries generally thin, and if we reflect on the nature of vegetables, and of their nutrition and decomposition, it is easily perceived that it cannot be otherwise. Gases and water constitute by far the greatest part of the aliments of plants, and into the same principles they are easily dissolved. If we find this vegetable mould apparently plentiful in a decayed or rottening tree, successive evaporation of moisture and developement of gases daily reduce its bulk, and the remains of a gigantic tree left to the decomposing process, must in a series of years be reduced to a few ounces of perceptible matter, still liable to further gaseous decomposition. The quantity of organic decomposed matters remaining in the soil is small indeed, and on examination almost every where this superior layer of mould is not simply vegetable matter, but the result of the decomposition of vegetables incorporated and combined with the earth of the stratum immediately under it.

One exception only exists to this universal rule. The bottom of rivers where the annual inundations quietly deposit a sediment of the more soluble parts of earth, which, in their course they have detached from their original stations, in the long lapse of ages treasure a thick mass of fat loam, washed from a wide extended surface of soil. But the country, of which we speak, has nothing common with these river bottoms, the highest parts of it are the most fertile, and thickness of loam and fertility both diminish in proportion as the surface is lower.

Let us now remember the unbounded deposits of fossil vegetables which are found in this western region, the coal stratum of Pittsburgh for instance, extending for hundreds of miles. Let us also reflect on the difference of the alterations which vegetable bodies undergo when decomposing, if imbedded between stony strata of a ponderous solid nature, or only covered by light permeable strata of earth, or under a column of water. How different are these operations from their decomposition in the atmosphere! In the first case the pressure of a solid stratum, the heat of a fermentation which cannot work but on itself, where no principle is lost, but all of them form new combinations, reduce the decomposed vegetables to the state of coals. In the second case, when decomposed under water, or under light materials, strata are formed of fossil half rotten wood, imbedded in rotten leaves, and when this mass is exposed to the action of the atmosphere, it is soon converted into a black, soft, saponaceous matter, not unlike the loam of Kentucky. Such subterraneous and submarine forests of vast extension are more common than is generally supposed. The Atlantic states of America, in their alluvial parts, offer in the digging of wells abundant reasons to believe that like deposits are contained under their soil. In Europe they have been observed in several parts. I have had the pleasure myself of making known, in the Philosophical Transactions, that the eastern part of England contained, at the depth of sixteen feet, a subterraneous and submarine forest, the remains of which could be traced from near the mouth of the Humber to Peterborough, a distance of about an hundred miles.

If such a deposit is not covered by any other substance, it is clear that if left dry by the retreat of the water, it must become such another soil as that of the *Elkhorn Tract*, to a depth proportionate to the quantity of rotten vegetables.

In resuming these facts, great reasons I believe exist, for more than suspecting that the soil of this part of Kentucky is but a bed of vegetables, the deposit of which has been the last operation of the waters before their final recess, and which not being covered by any other heavy material, have been left to rot and dissolve themselves into mould of a depth proportionate to their vast quantity. Only thus can we explain the depth of the Kentucky mould, because no forests growing on the spot could ever have produced it, as they do not produce it in other countries where they have vegetated from the creation. The soft fossil shells, and tender carbonate of lime. on which this mould lies, and with which, no doubt, it is mixed in some proportion, afford the happiest combination that nature presents to improve fertility. The calcareous earth is the only one that water can nearly perfectly dissolve, and with it the animal principles which the fossil shells contain. The theory and practice of manures offers nothing superior to such combination.

From all the preceding considerations, I am disposed to conclude that the soil of the millions of acres which constitute the Elkhorn Tract, and its ramifications, is the produce of the decomposition of an immense *deposit* of vegetables, which the ocean had left uncovered by any other deposition. Such naturally, would have been the soil of all that large portion of country, where the coals are found at a constant depth in West Pennsylvania, West Virginia, and Ohio, if the vegetable *depot* had not been covered by the heavy materials which form the few superincumbent strata.

No. XII.

An easy Solution of a useful Problem in Arithmetic. By James Austin.—Read November 3, 1815.

THE committee to whom were referred the papers from Mr. James Austin, of Lycoming County, Pennsylvania, relative to an easy solution of a useful problem in arithmetic, recommend that the following abstract of the same be published in the transactions of the society.—[*Adopted.*]

IN casting up the contents of a survey or inclosure of land, from the course and distance of its several boundary lines, as well as in many other parts of practical mathematics, it becomes a necessary problem—"To find the sum or difference of the products of any number of given factors."

The following process, it is presumed, exhibits a very easy and expeditious solution of this problem, by simple addition:—

1. You rule out nine columns, or vertical spaces, which you number, at the head, 1, 2, 3, &c.

2. In those columns, you write down, in succession, the several multipliers, each under the digits of its multiplicand at the top of the columns; observing to set the units figure of each multiplier in such place of the column, as the figure at the top occupies in its multiplicand.

3. You add up the numbers in column 9, and set down the sum: to this sum you add the numbers in column 8, and set down the sum, under the former: to this last sum you add the numbers in column 7, and so on, with all the other columns.

4. You add together the nine sums before found, and their sum will be *that* of the products required.

This process will be better understood from the following examples.

EXAMPLE I.

Let it be required to find the Sum of the Products of the following Factor, viz.

342 × 756
301 × 127
89 × 1634
120 × 97
551 × 27.4
6.8 × 16.9

1	2	3	4	5	6	7	8	9
30100	3010	890	89	3420	342	34200		1200
89000	5310		55.1		8900	301		.68
68					6.8	120		1200.68
						551		1200.68
								36372.68
								45621.48
								49041.48
								49185.58
								50075.58
								58595.58
								177763.58

Sum of products = 469057.32

EXAMPLE II.

Let it be required to find the Difference of the Products of the following Factors, viz.

42 × 72
35 × 19
73 × 81
122 × 25

—

34 × 14
56 × 18
13 × 14.3

1	2	3	4	5	6	7	8	9
350 73	42 1220			122		420	730	35
340 560 130		1.3	34 13				56	35 709 1129 1129 1251 1204 1202.7 2464.7 1857.7

Diff. of products = 10982.1

EXAMPLE III.

(Taken from Gibson's Surveying.)

Let it be required to find the Area of an Enclosure, of which the Meridian Distances (or Multipliers) and Differences of Latitude are as follows, viz.

235.3 × 14.2 N.
302.6 × 38.6 N.
368.7 × 117.7 S.
228.7 × 15.5 S.
166.6 × 36.0 N.
120.5 × 4.9 S.
37.2 × 27.8 N.
46. × 61.5 N.
113.4 × 51.7 N.
181.5 × 11.0 S.
217.0 × 41.6 S.
194.1 × 38.8 S.

1	2	3	4	5	6	7	8	9
490	155	11770	38.8	.49	1177	11.77	117.7	388
11	1550	1.42	615	1.1	3.68	1.55	15.5	388
1100	49	142	5.17	14.2	3.6	41.6	110	631.2
416	4160	3860			36	27.8		586.12
3.88	1420	278			360	492.76		1863.12
3880	38.6	51.7			61.5	506.96		1864.71
3600	2.78					1127.13		1903.51
517						5460.25		13663.51
5170						6921.63		19587.51
						16208.63		25488.39
						30745.16		66086.07
								30745.16
								2)35340.95
							Area in per. =	17670.45

EXPLANATORY REMARKS.

1. In Example I. the first multiplier, 342, is set down in the columns, three times; viz. under 6, 5, and 7, the digits of its multiplicand; the units figure, 2, in the units' place of column 6, in the tens' place of column 5, and in the hundreds' place of column 7; and so of all the other multipliers, respectively.

2. The sum of the multipliers in column 9 amounts to 1200.68. This sum added to the multipliers in column 8, (0) gives the same number; and this again added to the multipliers in column 7, amounts to 36372.68; and in the same manner the remaining sums are found, as in the example.

3. From the above process it is evident, that the sum of the numbers in column 9 is taken 9 times; [multiplied by 9] that in column 8, 8 times; that in column 7, 7 times, &c. and the aggregate of those sums is evidently the sum of the products required.

4. In Example II. where the *difference* of the products of given factors is to be found, the multipliers of the products to be subtracted, are placed under a line separating them from the other multipliers; and in adding up the numbers in the respective columns, the *co-arithmetical* (as it may be called) of the subtrahends are taken; i. e. what the right hand significant figures want of 10, and what all the others, respectively, want of 9; subtracting 1 from the next vertical line of figures on the left of each subtrahend. This mode of adding and subtracting at the same time, is frequently practised in trigonometry, and readily demonstrated.

5. In Example III. instead of taking the co-ar. of the subtrahends, which, in some cases, is a little embarrassing, the respective sums of the north and of the south products are found separately, and then their difference taken. This operation, though a few more figures are employed, is, however, much more simple, and requires no more time, but perhaps less, than when the co-ar. is used.

6. Almost in all cases, especially where the number of products is considerable, the above method, by simple addition, has greatly the advantage over the common method by multiplication, both in respect to facility and expedition; as will be evident to any one who will make the comparison.

R. PATTERSON.
F. R. HASSLER.
S. COLHOUN.

No. XIII.

On the Geological Formation of the Natural Bridge of Virginia. By Francis William Gilmer.—Read February 16, 1816.

IT is chiefly to Mr. Jefferson that naturalists are indebted for their knowledge of this beautiful and uncommon accident in the structure of mountains. The description which our distinguished philosopher has given of it in his Notes on Virginia, not only excited the curiosity of the learned, but induced the French general Marquis of Chatelux, to have an exact draught of it made by one of his engineers; from which both Europe and America were supplied with plates, which have justified the admiration excited by the description of Mr. Jefferson.

This object is not only singular in its structure, but, in a high degree, picturesque and romantic. And though Mr. Jefferson, with whom I had the pleasure of visiting it in the autumn of 1815, thinks it has lost some of its embellishments in 50 years of invasion upon the trees which crowned its borders, and overhung its sides, it still retains enough of its beauty and grandeur to vindicate all the pretensions which such fortunate patronage could give it.

The bridge is situated on Cedar Creek, a small stream in the county of Rockbridge. The channel of this creek is, for some distance both above and below the bridge, a deep, narrow ravine, with almost perpendicular sides of rock, disposed in unequal, horizontal strata. The fissures between these strata are sometimes so large as to give growth to Kalmia, Thuia, Abies, and many mosses and lichens, whose perpetual verdure is agreeably contrasted with the blue limestone. The hills about the bridge are covered with the ordinary forest trees of this part of Virginia. Tilia, Cercis, Thuia, Abies, Liriodendron, Fagus, and many species of Quercus. In the aspect of the country there is nothing peculiarly beautiful or striking. You follow the road which lies on a transverse ridge of hills, crossing the ravine by the bridge, until you are near the object of your philosophical pilgrimage, without observing any indication of its approach. It is not until you are very near, that you perceive a deep cleft in the earth;—you rush to its side, impatient to examine so unexpected a phenomenon. The curiosity of most persons, however, is overcome by fear, before they reach the margin of the precipice; they either abandon the enterprise, or timidly accomplish it by resting on a tree or rock, while they peep into the chasm which yawns beneath. While standing on the brink of this awful object, I had an opportunity of taking its height with a chord, more accurately than some others, who have made it much beyond what it really is, from the principles of a fallacious calculation.

	Feet.
The height of the lower surface of the arch above the water is about	160
The thickness of the arch varies from a much greater extent to	35
The height of the upper surface or top of the arch,	*200

Such is the effect of the great elevation of the arch, that though more than 30 feet thick, it possesses all the lightness and elegance of Ionic proportions. It only wants a curvature

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* It has been said to be as much as 270 feet. Mr. Jefferson found its latitude to be north, 37°, 42′, 44″.

rather more regular, to give it the graceful symmetry of the most beautiful works of art. After the curiosity is satisfied, the mind passes from the contemplation of an object, so wonderful in its structure, and vast in its dimensions, to consider the operations of nature which could produce so extraordinary a phenomenon.

Theories have already been attempted for explaining the formation of the Natural Bridge. As they were generally formed in the age of the mechanical philosophy, before geology or even chemistry had become sciences, we need not wonder to find the solutions they offered, very insufficient. Mr. Jefferson's hypothesis rested entirely upon the supposition, that some sudden and violent convulsion of nature, tore away one part of the hill from the other, and left the bridge remaining over the chasm. This, however, is referring to an agent whose existence even is unknown, and in explaining one phenomenon, involves us in greater difficulties by requiring an explanation of a still greater one ;—unless this sudden convulsion be supposed to have been an earthquake, in which case the indications of its existence would have been numerous, and not a few solitary ones. Besides, there are no corresponding *salliant* and receding angles, which would have been a circumstance necessarily attending this violent emotion and severance of one part of the hill from the other. And why should the bridge remain, more than any other part of the surface, across the ravine? This hypothesis then, however ingenious it be, when we consider the age of science in which it appeared, must be rejected as contradicting a rule which is necessary to impart to fiction some degree of veri-similitude:

> " Nec Deus intersit nisi dignus vindice nodus."

It contradicts, also, that beautiful and valuable rule laid down by Newton, " that it is unphilosophical to assign more causes for the natural appearance of things than are both true, and sufficient to account for the phenomena." The certainty of the existence of a cause is an inquiry which must always precede the admission of any effect from it.

In the present state of geology, the phenomenon does not require us to resort to the operation of unknown, or even of doubtful agents. And instead of its being the effect of a sudden convulsion, or an extraordinary deviation from the ordinary laws of nature, it will be found to have been produced by the very slow operation of causes which have always, and must ever continue, to act in the same manner.

To make this manifest, let us consider the situation of the bridge. That the place at which it stands is the highest point of a transverse ridge of hills, with a narrow base, which crosses the ravine at that spot. The country about the bridge, like all that which is west of the mountains, from the Atlantic to the Pacific ocean, is calcareous.* The strata of rock, which at different places make different angles with the horizon, are here parallel to it. This rock is soluble in water to such a degree, as to be found in solution with all the waters of the country, and is so soft as to yield not only to its chemical agency, but also to its mechanical attrition. Here, as in calcareous countries generally, there are frequent and large fissures in the earth, which are sometimes conduits for subterraneous streams, called 'sinking rivers,' 'sinking creeks,' &c. of which there are several in the western parts of Virginia, Kentucky, and Tennessee. It is probable, then, that the water of Cedar Creek originally found a subterraneous passage beneath the arch of the present bridge, then only the continuation of the transverse ridge of hills. The stream has gradually widened, and deepened this ravine to its present situation. Fragments of its sides also yielding to the expansion and contraction of heat and cold, tumbled down even above the height of the water. Or, if there was no subterra-

* There have also been found near the sea similar arches, formed by the chemical and mechanical action of its waters. There is both the figure and description of one in Capt. Cooke's Voyages, which was found in New Zealand, and there is something of the same kind in the Island of Jersey, as we learn from the Memoirs of the English Geological Society.

neous outlet, the waters opposed by the hill flowed back, and formed a lake, whose contact dissolved the resistance where it was least, wore away the channel through which it now flows, and left the earth standing above its surface. I incline, however, rather to the first hypothesis, because the ravine has the appearance, from its narrow banks, of having been the channel of a stream in all time, and had it been the bed of a lake, the continued action of the water would have widened it into a basin. The stone and earth composing the arch of the bridge, remained there and no where else; because, the hill being of rock, the depth of rock was greatest above the surface of the water where the hill was highest, and this part being very thick, and the strata horizontal, the arch was strong enough to rest on such a base.

The same circumstances having concurred, the same phenomenon has been produced in Scott county, lately a part of Washington county, in Virginia. There is, over Stock Creek, a branch of Clinch River, a bridge, whose height is estimated at 300 feet, with a thicker arch; whose formation, in every material respect, resembles that of its more celebrated rival of Rockbridge. Indeed, the numerous subterraneous caverns which are found in this range of country, and which were formed in the original crystallization of the rock, only require a section of their ends to be taken away to become natural bridges, and these ends remain, only because their arches are thick enough to support the superincumbent weight. This, however, may, in the endless flow of time, cease to be the case, and caves may become bridges, and bridges cease to exist.

If it be difficult to carry our minds so far forward as to embrace such great changes, produced by causes operating so slowly, we may assist their operation by recollecting a still more prodigious effect of the same agent. At Reizi in Switzerland, a few years since, an entire mountain was excavated by a stream, part of it fell down, and inundated the neighbouring country by obstructing the waters of the river.

Indeed, the very process by which the natural bridge was formed, is still visibly going on; the water, which is accidentally thrown entirely on the western side, is excavating the rock, and widening the channel, which, after a long lapse of time, may become too wide to support the arch, and this wonder of our country will disappear—indicating, in all its mutations, the uniformity of the operations of nature, showing as well by its decay as by its present situation, an effect, different only in degree, of the same undeviating power.

No. XIV.

Analysis of the Blue Iron Earth of New Jersey. By Thomas Cooper, M. D.—Read May 3, 1816.

THIS earth is found in many places of New Jersey, not usually of a blue colour when dug up, but acquiring that colour after being exposed to the air. I do not enter into any geological details, because I have reason to believe this part of the subject will occupy the attention of a member of this society, better qualified, from local knowledge, to treat it than I am. I offer to the Society the following experiments, because I think the nature of the substance has been mistaken.

External Characters.

1st. It has a moderately deep smalt-blue colour, neither verging toward copper-red, like indigo and Prussian blue; nor toward green, like mountain blue, and blue fluor.

2d. Its appearance to the eye is earthy.

3d. When breathed upon, it gives out a slight earthy odour.

4th. It is moderately hard: when scratched by the point or edge of a common penknife, the streak is bluish and dusty, from the knife penetrating the substance of the stone; but when scratched by the back of the knife, or by the nail, the streak is greyish-white and shining.

5th. It breaks with a fracture somewhat conchoidal.

6th. It adheres to the tongue with some force.

7th. When a drop of oil is poured on it, the colour becomes black, or of a deep blue, approaching to black: so that it promises to be useful as a pigment.

8th. Its specific gravity is 2,5338.

9th. It absorbs 35 per cent. of water on immersion in that fluid.

Its Habitudes when exposed to Heat.

10th. Before the blow-pipe, whether supported by charcoal, or on the bottom of a crucible, it becomes of a brown colour, and then melts into a shining greyish globule, not attractable by the magnet, unless this treatment with charcoal be continued.

11th. When this stone in powder is distilled at a low red heat for an hour in close vessels, with a pneumatic apparatus, no gas is collected, except the common air expelled by rarefaction from the containing vessel; moisture arises, which by means of a cold atmosphere, is condensed into pure water, exhibiting no chemical qualities on dropping a drop of it into muriate of baryta, or diluted tincture of galls. The powder thus distilled, loses from 23 to 24 per cent. when the distillation has been urged.

12th. On calcining 100 grains in a full red heat for an hour, 80 to 81 grains of a bright brown powder are procured, consisting (as will be seen) partly of the brown-red oxyde of iron, and partly of alumina.

13th. This calcined brown powder, when treated in a crucible with charcoal, or when made into a paste with wax, and burnt three several times, yielded 48 grains of iron, by means of a magnet; and there were left behind, six and a half grains of a powder not acted upon by the magnet. This last, being dissolved in sulphuric acid, diluted, and precipitated by carbonate of ammonia, possessed the common characters of alumina.

14th. When fused in small proportion with potash, for the purpose of discovering the presence of manganese, the trace of green colour was too slight to indicate any appreciable quantity of that substance.

Its Habitudes with Solvents.

15th. This stone does not dissolve perceptibly in pure rain water at the common temperature of the atmosphere; nor does the water in which it has been infused, exhibit any colour when tested by galls, or triple prussiate of potass: nor does it afford any precipitate by carbonat of potass.

16th. The sulphuric, the nitric, and the muriatic acids, dropt on this stone, excite no effervescence, they are diffused on it, and sink into it.

17th. It is not easily dissolved in *sulphuric* acid, without the aid of moderate heat. I used the top of the common tenplate stove, of about 150° of Fahrenheit; but with heat, and after some hours digestion, it becomes a white mass with this acid; which mass is soluble entirely in boiling water, producing a clear solution; there is no effervescence during the solution.

18th. Having dissolved 50 grains of the stone in sulphuric acid, and diluted the solution with hot water, I added a filtered solution of triple prussiat of potass, made in the common way, by digesting carbonat of potass on Prussian blue, till the latter no longer became discoloured. On continuing to add this while any precipitate appeared, I obtained a quantity of the most intense and beautiful Prussian blue, which, when calcined in a full red heat for an hour, yielded forty grains of red oxyd. The remaining liquor, after filtration, and precipitation by carbonat of ammonia, afforded a precipitate which, when carefully filtered, and moderately dried, weighed about 4 1-2 grains: it was alumina. It weighed less in proportion than the alumina of experiment 13, in consequence of not being so much dried. The quantity thus obtained, of iron and alumina, is probably not quite accurate, owing to the iron contained in the triple prussiat: but very near the truth.

19th. This stone when powdered, dissolves in *nitric* acid in the warm atmosphere of a summer's day, after 10 or 12 hours digestion, without residuum.

20th. This nitric solution, was evaporated to perfect dryness; the powdered residuum was digested in fresh nitric acid, which was again evaporated to dryness. A third portion of the same acid was now poured on the brown-red powder, and digested on it: about 1-10th was dissolved, as appeared on drying and weighing the residuum. The solution moderately diluted and filtered, exhibited but very slight shades of colour with tincture of galls and solution of triple prussiat of potass, so that but a trace of iron was taken up, as was originally presumed and intended. The digestion in nitric acid, and driving it off by heat, being meant for the purpose of oxyding the iron beyond the point of solubility in that acid. The last portion of nitric acid therefore, took up nothing but the earths. These being precipitated by carbonat of ammonia, afforded about nine per cent. of earth, when dried at the heat of 150 Fahrenheit, and consisted entirely of alumina.

21st. *Muriatic* acid dissolves this stone by heat. The solution is of a brownish-yellow colour. It leaves no residuum.

22d. *Oxalic acid* and oxalat of ammonia, occasion no precipitate from any of these solutions: hence there is no trace of any of the alkaline earths.

Experiments to discover the Presence of Puissic Acid in this Stone.

23d. Carbonat of potass digested on the powdered stone, takes away the colour, but does not dissolve the substance. The solution of carbonat of potass so digested on the stone in fine powder, being filtered, produced no blue precipitate when poured into a solution of sulphat of iron.

24th. A piece of this stone suspended for many hours in a solution of sulphat of iron, diffused no trace of blue colour.

either when immersed dry, or moistened with an alkaline solution.

25th. The following experiment was suggested and made for me by Mr. Cloud, who appears to have investigated the properties of palladium more fully than any other chemist. The nitro-muriat of palladium, and the nitro-muriat of gold, are not precipitated by the chromat of potass, but they are precipitated by the prussiats. When the red oxyd of mercury is triturated with Prussian blue, and boiled with water for half an hour, a prussiat of mercury is formed, which occasions a fawn-coloured precipitate, when added even in a very minute portion to the nitro-muriat of palladium: this precipitate is a prussiat of palladium. Red oxyd of mercury was mixed with the blue earth in fine powder, and water being added to the mixture, was boiled in a sand-bath for more than half an hour, and constantly stirred during the time: when cool, the liquor was filtered and dropped into a nitro-muriatic solution of palladium, but no precipitate appeared.

Experiments to ascertain the Presence of Phosphoric Acid.

PRELIMINARY OBSERVATIONS.

When the native green phosphat of lead, is melted before the flame of the blow-pipe on charcoal, it chrystallizes on cooling into a polyhedral garnet-like kind of chrystallized mass; so does the artificial phosphat of lead, made by adding phosphat of soda to nitrat or acetat of lead; in which case the phosphat of lead precipitates in a dense white powder, speedily and distinctly. These remarks have been made by Klaproth, in his Analysis of the Phosphated Lead Ores.

When nitrat of lead, or acetat of lead, are added to any solution containing phosphoric acid, the solution of lead is instantly decomposed, and a phosphat of lead is formed. Thus, when phosphat of iron made either directly by solution in phosphoric acid, or by precipitation by phosphate of soda, is dissolved even in small quantity in the nitric acid, this solution is immediately precipitated by any solution of lead: these facts were previously ascertained.

Moreover, solutions of iron in phosphoric acid, were made both directly and by double decomposition, as by precipitating a solution of sulphat of iron by phosphat of soda. The phosphat of iron in both cases, when dried moderately, assumes a slight bluish tinge by exposure to the atmosphere; which may have led to the supposition of this blue stone being phosphat of iron. These previous experiments were made to ascertain the colour of artificial phosphat of iron.

With these facts in view, a solution of the blue iron earth (or stone) was made in pure nitric acid, freed from muriatic acid by nitrat of silver, and from sulphuric acid by nitrat of baryta: precautions which were afterwards found unnecessary for this particular purpose, the common nitric acid of commerce answering sufficiently well. This nitrated solution of the substance under analysis, was mixed gradually with nitrat of lead, and subsequently in a distinct experiment with acetat of lead. In neither case, was there any precipitate produced, as might have been expected to take place, had even a trace of phosphoric acid, combined or uncombined, existed in this nitric solution.

Again, a considerable quantity of the substance in powder, dried, but not discoloured, was rubbed up with about 1-10th of its weight of lamp-black: in another experiment with 1-10th of sulphur; in a third experiment with 1-10th of a a mixture of lamp-black and sulphur. The mixed powder was put into bottle-shaped crucibles, having clay stoppers. with a glass tube of about 1-16th of an inch diameter, passing through the stopper. The clay was burned to fit the aperture, and during the experiments the stoppers were also well luted and attended to.—The mixtures were exposed to a gradual heat for half an hour, to dissipate the hygrometrical moisture, if any should remain. The stoppers constantly examined: the heat was gradually increased to a full red. at the close of an hour: during this time a lighted paper was very frequently applied to the orifice of the glass tubes whence the vapours from the blue earth issued, but there was no trace of any thing inflammable to be discovered. Nor was any, the slightest phosphorescence discovered, on dropping the powdered stone on red hot charcoal. Hence I conclude,

1st. That the hard blue earth of New Jersey is probably the same substance with the blue earth of Jamison and Werner, the fer azurè of Hauy, and the fer phosphatè of Brochant and Brogniart; but it seems to differ somewhat from the smalt-blue fossil of the Vorau, analysed by Klaproth.

2d. That this blue earth of New Jersey, contains neither prussic or phosphoric acid.

3d. That it consists of sub-oxyd of iron, intimately united with about 1-10th of the earth of alum, and 24 per cent. of water, probably in chemical union.

4th. That it contains no perceptible quantity of silica, lime, magnesia, or the other earths.

5th. That its colour may be of vegetable origin, but I cannot venture any probable surmise concerning it.

The chrystallized earth of New Jersey, consisting of olive green chrystals, upon a bluish green earthy stone, is very similar in its geological and chemical characters, to the blue earth just described; but as I propose a more perfect analysis of these chrystals than I have yet made, I shall say no more about them at present.

THOMAS COOPER.

No. XV.

On Vanishing Fractions. By Jared Mansfield, Professor of the Military Academy at Washington.—Read, May 17th, 1816.

THE numerical value of an algebraic expression, is not to be estimated, in all cases, from the value of the terms which compose it, independently or separately considered; or from the coalesced value of any part of them, but from the joint effect of the whole. For sometimes one or more of the terms vanish, or become infinite; and, therefore, as these are non-entities, or inconceivable by our understanding, we may hastily conclude the whole to be impossible, or not susceptible of management: whereas, by some contrary operation implied in the general expression, the evanescence, or infinity, may be destroyed. This is more particularly the case with those functions of a variable quantity, denominated *Vanishing Fractions.* The principles necessary for a developement and right understanding of this subject, are analogous to those employed in explaining the first elements of algebra, in respect to the use of the negative sign. As the abstract consideration of negative quantities lead to absurdity and erroneous conclusion, so does that of quantities which are supposed to be nothing, infinite, or more than infinite.

In order to clear this subject of its difficulties, it may be well to observe, generally, that algebraic expressions, or functions of any quantity are a combination of ratios, either arithmetical, or geometrical. The effect of these on the function, does not depend on the absolute magnitude of the terms, but on their relative, or comparative value; for no variation of ratio arises from the variation of the magnitudes of quantities compared, under the same circumstances and considerations: thus the ratio of the diagonal of a square to its side, or of the diameter of a circle to the circumference, is the same, whatever the magnitude of those figures may be. Indeed the reasonings of mathematics consist altogether in the investigations of *relative magnitude*, or of relations generally, in which the consideration of absolute magnitude is excluded, and is only resorted to as a unit, or standard of numerical computation.

When a ratio is formed by a comparison, either arithmetical or geometrical, of two equal quantities, the function is not affected by it, whether they be supposed finite, infinite, or nothing. This inference is drawn, not from any consideration of quantities infinitely great or infinitely small, but rather from the reverse, viz. that in all possible states of their existence, there cannot, by hypothesis, be any ratio of *inequality;* there cannot, therefore, be any effect produced by such a ratio, in any state of the existence of the terms, and it is the same when they become non-entities. This argument might be stated logically, according to the *reductio ad absurdum*. Again, whatever the magnitude of the terms compared may be, if their ratio, or the relative value of one to the other, be great, or little, the function will be proportionally increased or diminished; but this, as has been already observed, must be estimated from the aggregate effect of all the ratios included in the function.

If there be some ratios of majority, and some of minority, these, like positive and negative quantities in algebra, have contrary effects, and where there is such a combination, the negative, or even impossible quantities by themselves, are not therefore to be considered as impossible in their effects on one another. A negative quantity, or an impossible expression in algebra by itself, is unmanageable, and not susceptible of ratiocination; but in composition with others of the same kind, it may be rendered possible, or made to vanish. Thus the value of $x+\sqrt{-a}$, or of $\sqrt{-a}$, in itself is imposssible, and inconceivable by our understandings, but that of $x+\overline{\sqrt{-a}\times\sqrt{-a}}$ $=x-a$, is a pure algebraic quantity, or function of x, whose effect is simple and obvious. So likewise $x\sqrt{a-b}$, when b is greater than a, is an impossible function of x, but that of $x\frac{\sqrt{a-b}}{\sqrt{a-b}}$, in the same circumstance of b, is assignable, being equal to x; or in the ratio of 1 to $\sqrt{a-b}$, the numerator, whatever its value may be, is destroyed, by an equal and contrary ratio in the denominator, or of $\sqrt{a-b}$ to 1, or $\frac{\sqrt{a-b}}{1}\times\frac{1}{\sqrt{a-b}}=1$. In order, therefore, to estimate the true value of any function, we must resolve it into all the ratios of which it is composed, and if any of them be impossible by themselves, before we conclude, that the whole is such, we must ascertain, whether, as in common algebra, the impossibles may not destroy one another, so as to produce altogether no effect in the function. This will be best illustrated by examples, and from them may be derived all those rules, which have been considered not merely as mysterious, but absurd.

It is obvious, that an arithmetical ratio of equality as in the simple function of x, $x=\pm=\overline{a-b}$, when $a=b$, produces no effect, or that its value is $x=\pm=o=x$: Let $x\frac{a}{b}$, be another function of x, involving the geometrical ratio $\frac{a}{b}$, this also, when it is a ratio of equality, or $a=b$, will produce no effect, although it be expounded by 1, unity in a geometrical, being equivalent to 0 in an arithmetical ratio; for $\frac{a}{b}$ involves two other ratios, viz. that of $1:a$ and $b:1$, which, when $a=b$, are reciprocals; or as much as unity is increased by one, it is diminished by the other, and therefore their compounded value is unity. If the ratio of 1 to a, be infinitely great in the antecedent, or a

be nothing, this is an infinite ratio of minority in the consequent, which by itself, would cause $a\times x$ to become nothing; also the other ratio, the reciprocal of the former, $(\frac{1}{b}$ or $\frac{1}{a})$ by itself, would cause x to be infinitely great, and by estimating the ratios thus separately, we find them vanishing or infinite, and of course out of the limits of our faculties. It is from such a process, that the unskilful have found difficulties, which they charge to the mysterious nature of the subject, and the unintelligible doctrine of mathematicians concerning infinities. Let now this quantity x, which has been put out of existence by bad management, be restored to its function, and remain unmolested, until the balance of powers, which is to establish its weight and consequence, be ascertained. The first ratio, viz. that of 1 to 0 is $\frac{1}{0}$, the second is its reciprocal or $\frac{0}{1}$, and these compounded make $\frac{1}{1}=1$, and, therefore, the true value of $x\frac{a}{b}$, in the circumstance of $\frac{a}{0}$ being $=\frac{0}{0}$, is $x\frac{0}{0}=x\times 1=x$.

The argument in words is this; the first ratio is an infinite ratio of minority in the consequent, the other is an infinite ratio of majority in the same. These two compounded, constitute a ratio of equality, which is numerically expressed by a unit.

From the preceding observations, one of the results of mathematics on this subject may be derived, viz. *that nothing divided by nothing is equal to unity;* or, *that unity is a mean proportional between nothing and infinity; also, that* $\frac{x\text{ infinite}}{x\text{ infinite}}=1$.

When compounded expressions are found in the numerator and denominator of the fraction, there are oftentimes ratios included in it, which do not so readily appear, and its true value, in consequence, is liable to be mistaken in the circumstance of one or more of the ratios vanishing. Functions of this kind are those, which have received the appropriate denomination of *Vanishing Fractions.*

Let $\frac{a-x}{b-y}$ be such a fraction, it is evident from what has been before observed, that if the numerator and denominator were equal, then, one being a direct and the other a reciprocal, and equal ratio, these two would destroy one another's effect, and the result would be equal to unity; but in the circumstance, when $x=a$, and $y=b$, it will be $a : b :: x : y$, and by alternation and division, $a-x : b-y :: x : y :: a : b$, whence there are found three ratios, besides the arithmeticals $a-x$ and $b-y$, in the expression $\frac{a-x}{b-y}$, viz. $1 : \overline{a-x}$, $\overline{b-y} : 1$, and and this last $b-y$ compared with the former, $\overline{a-x}$, or that of $b : a$. The two former combined are equal to 1, and all conjoined equal $1 \times \frac{a}{b}$. Hence it appears, that the ratio of $a-x$ to $b-y$ does not vanish, because the coalesced values of those quantities vanish; for that ratio is, in that case, the ratio of the terms $a : b$, or $x : y$, and it is only one of the ratios, viz. the arithmetical $a-x$, or $b-y$, which really vanishes. Again, let $\frac{a-x}{b-y} = \frac{a}{b}$ be multiplied by $a+x$, or increased by another ratio, as $1 : \overline{a+x}$, and we shall have $\frac{a^2-x^2}{b-y} = \frac{a}{b} \times a+x = \frac{a}{b} \times 2a$, the true value of the fraction when $x=a$, and $b=y$. If $a=b$, and $x=y$, the expression becomes $\frac{a^2-x^2}{a-x} = \frac{a-x}{a-x} \times \overline{a+x} = 2a$, when vanishing. Also, $\frac{a^2 x-x^3}{a-x}$, or $\frac{a^3-x^3}{a-x}$, in the same circumstance $=3a$, and if $a=1$, then $\frac{1-x^2}{1-x} = 2$, $\frac{1-x^3}{1-x} = 3$, &c.

From which, it is manifest, that the geometrical ratio of $\overline{1-x}$ to $\overline{1-x^2}$ is real and determinate, though the arithmetical ratios, or the coalesced values of the terms of those quantities vanish, or $=o$. Moreover, those quantities have a determinate ratio, when they are negative in their combined values, or in effect less than nothing: for when in the fraction $\frac{1-x^2}{1-x}=\frac{1-x}{1-x}=1\times\overline{1+x}$, the value of x is greater than 1, $\overline{1-x}$ is negative, and the value of the fraction is $1\times\overline{1+x}$, or greater than before when vanishing. Suppose $x=2$, then $1\times\overline{1+x}=3$, &c. The value, therefore, of the fraction $\frac{1-x^2}{1-x}$, increases as x increases; when $x=0$, it is equal to $\frac{1}{1}$ or 1, when $x=1$, it is equal to 2, when it exceeds 1, or the coalesced terms of numerator and denominator are negative, it exceeds 2, and increases continually as x increases. This being the case, viz. the law being established, that the value of the fraction $\frac{1-x^2}{1-x}$, increases from unity as x increases from nothing, and so continues to increase; it would be a contradiction to this law, that when $x=1$, or had a real and determinate value, the fraction should be equal to nothing, or have no assignable value.

The illusion, which has prevailed on this subject, arises from the idea of the impossibility of any geometrical ratio existing between two or more terms of an arithmetical series, which taken together are equal to nothing, and other similar terms of such a series; whereas, it can be shown that the former ratio does not depend on the aggregate of the arithmetical ratios; for the terms themselves do not vanish with their differences, and are therefore susceptible of a comparison with the other terms, and this constitutes the geometrical ratio. This will be evident from the following example. Let $\frac{2rx-x^2}{2r-x}$, be another fraction, of which the numerator is the equation of the circle, where r is radius, x the abscissa, and

$\sqrt{2rx-x^2}$ an ordinate; when $x=2r$, or the abscissa = the diameter, the aggregate or coalesced value of the numerator $\overline{2rx-x^2}=4r^2-4r^2=0$, or the ordinate vanishes, when the abscissa is equal to the diameter, which is also evident from the construction of the circle. Also the denominator $2r-x$, or the difference between the diameter and abscissa = 0. Now, though the arithmeticals $2rx-x^2$, $2r-x$, vanish, their geometrical ratio is not affected by the evanescence; for the ratio of the first terms, viz. $2r : 2rx$, is that of 1 to x, and that of the second, or $-x : -x^2$ is the same, whence by composition $2r-x : 2rx-x^2 :: 1 : x$, or $\frac{2rx-x^2}{2r-x}=\frac{2r-x}{2r-x}\times x=1\times x=2r$. If while the radius of the circle remains the same, we suppose $x=y$, then $\frac{2rx-x^2}{2r-x}=\frac{2ry-y^2}{2y-y}=2r$, and $\overline{2r-x}$ (the evanescent versed sine) : $\overline{2rx-x^2}$ the square of half the chord) :: $\overline{2y-y}$ (another evanescent versed sine) : $\overline{2ry-y^2}$ (the square of one half its corresponding chord); whence the *versed sines when vanishing are as the squares of their chords.*

It is from such considerations of the different ratios, which obtain among functions when vanishing, or when their aggregate value is nothing, that the different degrees of curvature of any curve, or the comparison of curvatures of different curves is susceptible of determination; and as on this depend the higher geometry, and the laws of centripetal forces. it may be proper to illustrate this doctrine by other examples.

Let a be to b, in any ratio of minority, or majority, then $\frac{b}{a}\times\overline{ax-x^2}=y^2$, is an equation of the ellipsis, in which the squares of the ordinates have the same value as in the circle, but, increased or diminished in the ratio of a to b, and while this is finite, the whole becomes equal to nothing in the same circumstance as before, when $\overline{ax-x^2}=y^2$ denoted a circle. But if a, which represents the diameter, becomes infinitely great $\frac{b}{a}\times\overline{ax-x^2}=\frac{bax}{a}-\frac{b}{a}x^2=bx=y^2$; because $\frac{a}{a}=1$, and $\frac{b}{a}=0$. If $a=0$.

then $\frac{a}{a}=1$, and $\frac{bax}{a}=bx$; $\frac{b}{a}x^2=x^2$ infinitely great $=y^2$; or since adding or subtracting a finite quantity to or from an infinite quantity, has no effect, $x^2=y^2$, whence x and y are equal straight lines infinitely extended. If a be finite, and x indefinitely small in comparison of a, in that circumstance, we shall have $bx=y^2$, which is the same equation as before, viz. that of a parabola, whose parameter is b: from which it appears, that an ellipsis and parabola having equal parameters, have their nascent ordinates, or nascent arcs equal, or their curvature is equal, and that this is proportional to their parameters. If $b=a$, or the parameter be made equal to the diameter, $\frac{b}{a}\times\overline{ax-x^2}=y^2$ becomes the equation of the circle, and x being indefinitely small, it will be $ax=y^2$, the same as before in the ellipsis and parabola; which shows that a circle whose diameter is equal to the parameter of either of those curves, has the same curvature, or becomes the osculatory circle. In the general expression for the ellipsis $\frac{b}{a}\overline{ax-x^2}=y^2$, when $a=$ the transverse axis, is infinite or nothing, the ordinate is finite or nothing, but when $a=b$, or the expression becomes $\overline{ax-x^2}=y^2$, which is the equation of the circle; then, when the diameter a, is infinite or nothing, the ordinate is infinite or nothing, whatever x, or the abscissa may be. Whence the ordinates corresponding with any finite abscissa in an infinite ellipsis or parabola are finite, but in an infinite circle they are infinite, or the curve becomes a straight line or nothing.

Let x, or the abscissa of the curve, from first being $=0$, become negative, or pass from affirmation to negation, which in geomety implies, that it passes to the other side, from whence it commenced its existence; the equation of the curve will then become $\frac{b}{a}ax+x^2=y^2$. This exceeds the equation of the parabola $ax=y^2$ by x^2, and that of the ellipsis falls short as much; from which it is obvious, that the curve is an hyperbola, whose ordinates fall on the other side of the diameter of the circle, with which it is compared. As the expression $ax+x^2$, is less than the square of the binomial $\frac{a}{2}+x$, by $\frac{a^2}{4}$ the locus of the latter, which is a straight line, will exceed that of the curve, always by the same quantity $\frac{a^2}{4}$; whence, if $\overline{\tfrac{1}{2}a+x}^2=z^2$, then $z^2-y^2=\frac{a^2}{4}$, or $\overline{z+y}\times\overline{z-y}=\frac{a^2}{4}$, and in the general expression, this difference becomes $z^2-y^2=\frac{b}{a}\times\frac{a^2}{4}=\frac{ba}{4}$, which, putting $c=\frac{1}{2}$ the conjugate diameter, becomes $z^2-y^2=c^2$. For $\sqrt{ba}=$ conjugate diameter, and $\frac{ba}{4}=\frac{\sqrt{ba}}{2}=c$ squared; or *square of half the conjugate equals the difference of the squares of the ordinates z and y.* As this difference is always equal to a finite quantity, the curve will always approach, but can never coincide with that right line. This, therefore, is an asymptote to the curve.

The equation of the curve being transformed from the axis to the asymptote, if instead of the difference of two variable quantities, z and y, we substitute that of one of them, and a given quantity, we shall arrive at the general equation of the hyperbola, by lines parallel to both the asymptotes; therefore, putting the ratio of $r-u:r$ equal to that of $z-y:c$, and that of $r:r+x$ equal to that of $c:z+y$, it will be $r-u:r::r:r+a$. This expression is that of a secant of an arc, of which r is the radius, and u the abscissa. If to the latter the secant of a quadrant be applied ordinately, the curve becomes *a figure of secants.*

Moreover, $\overline{r-u}$, being reciprocally as $r+x$, their rectangle will always be a given quantity $=r^2$, whereof the two sides are lines drawn parallel to the asymptotes from any points of the curve. As this distance never becomes equal to nothing, or the ratio of $\frac{r}{r-u}$ and $\frac{r+x}{r}$, never becomes infinite, the hyperbolic space, comprehended between the curve asymptote, will continue to increase *ad infinitum*, but the increase of the area will be uniform, being that of an arithmetical progression, or the reciprocals of two equal ratios; for $-u:r::r:x$, and $ru+xu=rx-ux=1$. But while these spaces are in arithmetical, $\frac{x}{r-x}$, or $\frac{r+x}{r}$, are in geometrical progression, consequently the former are the logarithms of the latter, or of the natural number $r+x$, and they are of the Napierian kind, when the comparison of x and u is made the same with the quantity r.

But the most important application of these principles, is to the metaphysics, or fundamental principles of fluxions, or the science of differentials. This, however, cannot be comprised in the compass of the present paper, but is intended for the subject of another.

No. XVI.

An Account of Pyrometric Experiments, made at Newark, New Jersey, in April, 1817. *By F. R. Hassler.—Read, June* 29*th*, 1817.

THE object of these experiments was to determine the expansion of four iron bars, each two metres in length, and the difference between their expansion and that of brass.

These iron bars are intended to be put end to end, and clamped together in this situation, so as to form one continued bar of eight metres long, fitted in a wooden box, to serve, with certain other apparatus, for the measurement of the base lines in a survey of the coast of the United States, ordered by the government.

The determination of their exact expansion is necessary, in order to reduce the different temperatures observed in the measurement of the bases, to one temperature adopted as a standard; and, in order to compare the length of these bars to the English standard, it is likewise necessary to determine the difference between their expansion and that of brass; the English standard, belonging to the collection of instruments made for the survey of the coast, being a brass scale, of 85 inches long, 2 1-2 inches broad, and half an inch thick, inlaid with silver to receive the divisions, which are tenths of inches over the whole length. It is one of the finest and most accurate pieces of workmanship of the celebrated artist, Mr. Edward Troughton, of London.*

The four iron bars used in the following experiments made together a length of 315,04 English inches, at the temperature of about 50° Fahrenheit; they are 1,1 inch broad, and 0,38 of an inch thick.

To obtain the comparison of their expansion with that of brass, under exactly equal circumstances, I procured the thickest brass wire I could obtain, which was 0,37 of an inch in diameter, and had a length of it straitened, as long as the four bars together. No piece being long enough to make the whole required length, three pieces were jointed and pinned together, overlapping about 2 1-2 inches, as shown in Fig. I., and soldered over the joint, so as to form one single piece of the required length.

The expansion of this length of metal, from the freezing to the boiling point of the thermometer, is out of the reach of any microscopic arrangement; and large enough to allow us to substitute immediate observation for the multiplying apparatus often made use of; since it would give above 1-3 of an inch in the iron, and above 1-2 an inch in the brass, which, as far as I know, is the greatest quantity of expansion as yet submitted to accurate experiment.

To obtain the extent of temperature from freezing to boiling, I chose a season when almost every night brought the temperature of the air near to freezing, so that to obtain the boiling point was the only requisite to be fulfilled by the intended pyrometric arrangement.

I had seen Mr. Troughton, in his pyrometric experiments, use the spirit level upon a lever, resting with one end on its axis, and adjusted at the other by a micrometer screw, so as to measure the increased expansion. Having several spirit

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* It may be observed here, that the French standards were always *a certain unit of length in iron*, and the English standards always *a brass scale of inches*, on which a mean result is taken, for any length desired. To say more of this belongs to the account of the comparison I have made of these two standards.

levels of eight inches long, ground and adjusted by him, and having also the late Mr. Bird's own leveltryer, with a steel micrometer screw, (which Mr. Troughton had made me a present of,) I availed myself of these means to construct a pyrometer, with the accuracy of which I could be satisfied; making use of a brass beam compass with a brass screw, to construct a similar instrument, by adding a crossbar at one end of it, and otherwise suiting it to my purpose. The first, with the steel screw, was used for the iron bars, and the second, with the brass screw, for the brass wire.

The head plate of the screw of Bird's leveltryer is divided into 240 parts, each of which indicates an angular movement of one second of a degree, in the arm of the instrument, which is about seventeen inches long.

I divided a similar plate into the same number of parts, for the brass screw of the new leveltryer.

To determine accurately the absolute value of the revolutions of both screws of these leveltryers, I made one of the pieces cut off from the bars, of near half an inch long, perfectly parallel in two opposite planes, by the same means as the bars themselves had been standarded, and measured its length under the microscope of the brass standard scale above mentioned. This piece was found to be = 0,504543 of an inch. Placing the leveltryer upon an iron plate perfectly even, and adjusting the levels, both on the plate alone, and when this piece was laid under the micrometer screw, I found its value in revolutions and seconds, (which the subdivisions are intended to represent, and which I shall call them hereafter.)

Under the steel screw of Bird's leveltryer, - - - = 26R+3″,1=6243″,1.
Under the brass screw of the new leveltryer, - - - = 23R+203.1=5723″.1.

This gives the following values for one revolution of the two screws:

For the steel screw, 1R=0.01939581 } Decimal parts of an inch.
For the brass do. 1R=0,02115815 }

From this I constructed Table I., for the reduction of the observed revolutions and seconds into parts of English inches.

To make the pyrometric experiments with this apparatus, the following arrangements were made.

On the outside of the north wall of the house, an iron bracket was driven into the wall, about five feet from the ground. Upon a cast iron plate, laid on this bracket, a box 2 1-2 inches square on the inside, and of the length of the four bars, was placed vertically, reaching along the wall up to the third story, and fastened to brackets in the wall in various places, without allowing it to touch the wall.

On the ground, and about two feet from one side of the box, a large pot was walled up, in a close oven, to serve as a boiler. The wooden cover of this pot, shutting close, had in its middle a wooden canal or chimney, by which the steam was led into the box, as seen in the lower part of Fig. II. The draught or chimney of the oven was on the opposite side.

In the bottom of the box, on the cast iron plate, was laid a flat piece of ground iron, to give the same level and smooth resting place, both to the bars and the brass wire.

The iron bars and the brass wire were set perpendicularly upon this plate, and held in that position by brass wires, *b*, *b*, &c. Fig. II. and III., driven horizontally in the side of the box opposite the cover, about four in each bar's length, and so long that they reached to the cover in *b'*, *b'*, &c. Other smaller brass wires were laid across these, in the following order:—nearest to the side of the box was one small cross wire, then came the brass wire under experiment, then again a small cross wire, then the bars, then the brass pins lightly bound together by thin copper wire.

This arrangement, as seen in Fig. VI., formed five intervals between each part, admitted free passage to the steam all round the bars and the wire, hindered the latter from bending by its own weight, prevented their rubbing against the box, or one against the other, and held both perpendicular in their place, and yet so loosely, that when lifted between the wires.

they would return again to their exact place; so that their expansion and contraction were perfectly free.

To prevent the iron bars from sliding at their joining places, and at the same time to preserve their ends from rust, which must be the consequence of their exposure to the steam, sheet tin boxes, *c*, *c*, of about five inches long, were made to fit the bars exactly, were oiled a little inside, and, when the bars were set upon one another, were slided over the joints.

Fig. II. and III. represent a section of the lower and upper part of the apparatus, through the breadth of the bars and the wire, the whole of it being too long to be represented on a proper scale, and uniform through the whole length, within the size of a common sheet of paper. Fig. V. is a horizontal section of the top, on which the measuring screws rest; and an intermediate section, through a set of supporting pins. is represented in Fig. VI.

Four thermometers were put in the box; one at the top, showing the boiling point just at the upper end of the bars, one about two feet from the bottom, and two at about equal intermediate distances, showing themselves through glasses fitted like windows, in the side *f*, *f*, as in Fig. VI.

The temperature being raised in the box by means of the steam from the boiler, which was driven up through the whole extent of the box, the upper ends of the bars and the wire were naturally raised by their expansion, and sunk again by their cooling down to the temperature of the atmosphere.

To measure this expansion by means of the levels above mentioned, they were placed as shown at the top of Fig. III.; Fig. IV. presents a horizontal view of them: *t*, *t*, are two iron brackets driven fast into the wall. to receive the resting pins or screws, *d*, *d*, *d*, *d*, at the ends of the cross bars of the level-tryers: *e*, *e*, *e*, *e*, are the supporting Y's of the levels L, L; *s*, *s*, the screws measuring the expansion on the indices, *i*, *i*, by a horizontal stroke, to count them, being made at every two revolutions, reading from the highest division downwards; the subdivisions were read on the divided top plates, *g*, *g*, by their coincidence with a vertical line on these indices.

The steel micrometer screw rested on the top of the iron bars immediately; but as the wire would not afford a secure rest for the brass screw of its level, and as its divided plate would also have interfered with that of the other screw, a clamp, *h*, was screwed on the wire, presenting a short brass plate at the distance of about one inch at the side of the wire, to rest this screw upon; the upper plane of this plate being at the height of the bars, so as to give nearly an equal length to the iron and the brass engaged in the experiment. See Fig. III. and V.

To admit a free passage to the steam, so as not to condense it in the box, the top was left open, except a covering of thin muslin round the screws, to prevent the immediate contact of the metal under experiment with the external air.

A screen was placed at *x*, *x*, to hinder the steam from reaching the levels, and to make it ascend vertically from the box.

To make the observations thus outside of the house, at the third story, I hung a scaffolding out from the two windows on each side of the apparatus, held at some distance from the wall by butting pieces so as never to touch any part of the box or apparatus, by which means I could walk easily all round it.

First Experiment.

The second of April, the arrangement being ready, fire was made under the boiler, and the water made to boil as much as practicable; but the arrangement being new, and the day cold, the thermometers could not be brought to the boiling point. All that could be obtained, was to bring them to be for some time steady at the following temperatures, reading them in order, from below, upwards.

Thermometers.				
1	2	3	4	Mean.
180°.	—	181°.	179°.	180°.0.

The second thermometer could not be read for want of a fourth assistant.

The levels being adjusted in this temperature, by means of the measuring screws, the indications of the micrometer heads were read as follows:

On the Iron.	On the Brass.
26R + 58″.	24R + 215″.

In this situation the whole apparatus was left, the boiling ceased, and the muslin on the top, and the steam chimney below, removed to let the whole cool.

The 3d of April, at half past 5 o'clock in the morning, the standing of the micrometer heads being verified, and every thing found in order, the levels were again adjusted, and the following readings made on the thermometers and the micrometer heads.

Thermometers.

1	2	3	4	Mean.
39,5	36,0	36,2	38,3	37,5.

Micrometers.

On the Iron.	On the Brass.
42R + 20.	47R + 106″.

At half past 6 o'clock, returned to the apparatus, adjusted the levels again, and made the following readings.

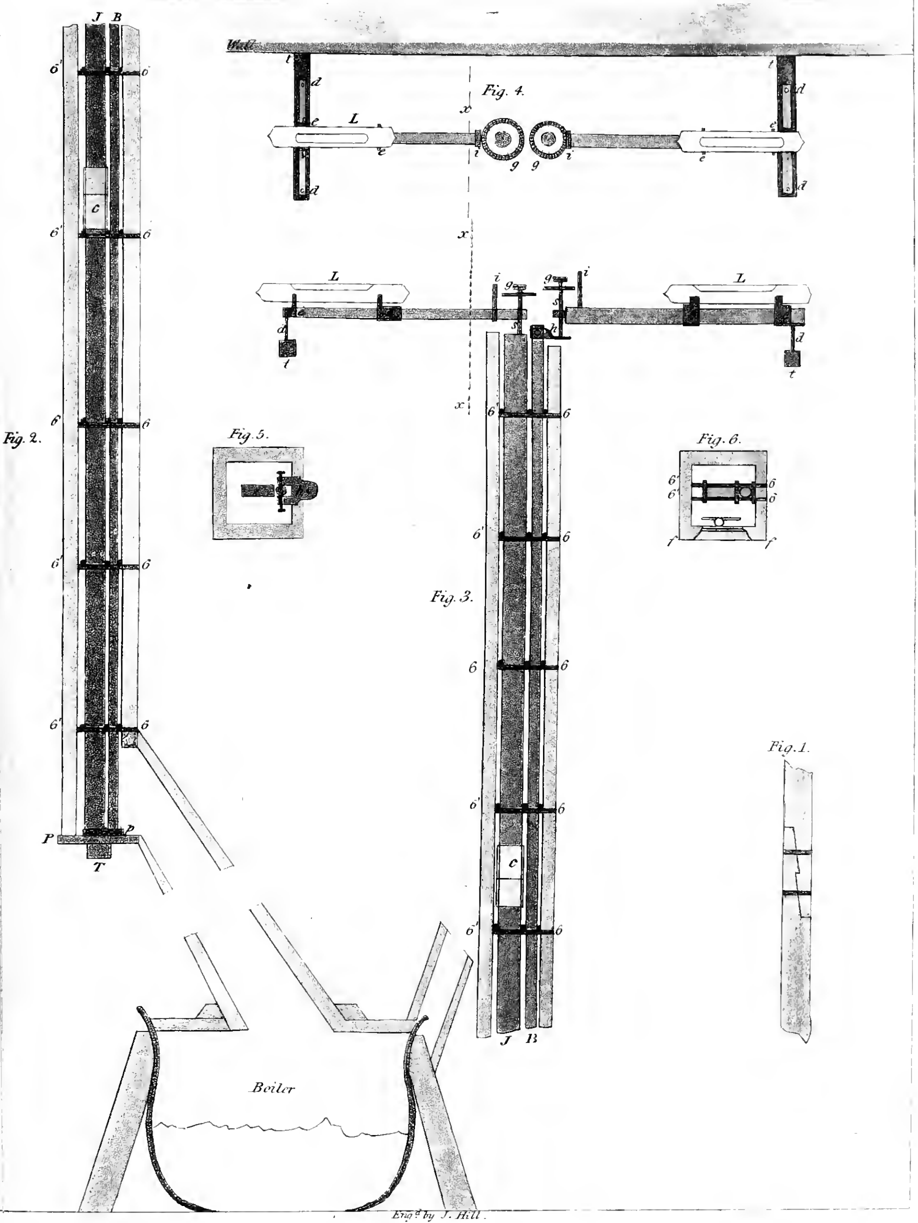
Thermometers.

1	2	3	4	Mean.
39,2	—	36,5	36,3	37,33.

Micrometers.

On the Iron.	On the Brass.
42R + 28″2.	47R + 114″.

The day being cold, I could not expect to raise the heat in the box to the temperature of boiling water. I concluded,



Engd by J. Hill.

therefore, to make only an intermediate observation, at the time I should find the thermometers the most equal.

About 7 o'clock in the evening, I made the following observations.

Thermometers.

1	2	3	4	Mean.
52°,0	52°,0	51°,7	53°,0	52,2.

Micrometers.

On the Iron.	On the Brass.
41R + 42″,5.	45R + 91″.

Though I had at the outset doubts upon the admissibility of making observations in the intermediate steps of the rising and falling of the temperature, I still tried it; but found that no coincidence of the thermometers above and below could be obtained, near enough to allow a mean to be taken, except when the temperature in the box was either at the highest degree I could bring it to, or cooled down to the temperature of the surrounding air. To procure this equality of temperature is the principal difficulty in this kind of experiments: For the sensibility of the levels to the expansion and contraction of the iron and brass, is so great, that a change of temperature was often observed in them, before it was observable on the thermometers.

A high wind rising with the night, I was obliged to take in the levels for fear of their being blown down and broken.

Second Experiment.

The 4th of April, at half past 5 in the morning, the temperature of the air being about 32°, I set the levels again in their places, adjusted them, and made the following observations.

Thermometers.

1	2	3	4	Mean.
36°,0	33°,5	32°,7	32°,	33,5.

Micrometers.

On the Iron.	On the Brass.
42R + 98″,5.	48R + 125,″0.

The sun shining on the apparatus, and the day being fair, circumstances seemed favourable for obtaining the temperature of the boiling point. About 8 o'clock, fire was made under the boiler, and the windows for the thermometers shaded from the sun; and, about half past 10, the following heights of thermometers and corresponding readings of the micrometers were obtained, at a constant temperature.

Thermometers.

1	2	3	4	Mean
212°,5	211°,	211°,	208°.	210°,6.

Micrometers.

On the Iron.	On the Brass.
22R + 83″.	20R + 179″.

The temperature now falling, the fire was raised a second time, and a second reading was made, under circumstances which I found equally trust-worthy, as follows.

Thermometers.

1	2	3	4	Mean.
212°	211°,5	212°	209°	211°,1.

Micrometers.

On the Iron.	On the Brass.
22R + 25″.	20R + 111″.

The boiling being now discontinued, the muslin removed from the top, and the apparatus otherwise left perfectly quiet to cool down to the temperature of the air, at about 8 o'clock in the evening, I adjusted the levels, and observed as follows.

Thermometers.

1	2	3	4	Mean.
45°	42°,5	44°,8	44°,3	44°,15.

Micrometers.

On the Iron.	On the Brass.
41R + 106″,5.	46R + 203″.

The apparatus was now again left in the same position, until next morning.

April 5th, at half past 5 o'clock, every thing being found in good order, I adjusted the levels, and made the following readings.

Thermometers.

1	2	3	4	Mean.
35°	32°	32°	32°	32°,75.

Micrometers.

On the Iron.	On the Brass.
42R + 118″.	48R + 112″.

Then the leveltryer on the iron was removed to clean the screw from rust, and oil it.

Third Experiment.

At 6 o'clock, the arrangement was again mounted, and the levels adjusted, to begin the third set of experiments; and the following readings were made.

Thermometers.

1	2	3	4	Mean.
34°,5	33°,0	33°,0	32°,5	33°,25.

Micrometers.

On the Iron.	On the Brass.
42R + 170″,5.	48R + 152″.

The boiler being heated, the temperature was raised to the highest about 10 o'clock, and was steady, so that the following readings were made.

Thermometers.

1	2	3	4	Mean.
213°	213°	213°	209°	212°.

Micrometers.

On the Iron.	On the Brass.
21R + 238″.	20R + 62″,5

The apparatus was again left quiet, to cool down. At 7 o'clock in the evening, the following readings were made, after adjusting the levels.

Thermometers.

1	2	3	4	Mean.
47°	—	45°	44°	45°,3.

Micrometers.

On the Iron.	On the Brass.
40R + 191″.	46R + 77″,5.

To bring the various observations of these three experiments under a comprehensive view, I have collected them together in Table II., at the end.

The first thing now to be determined, is the length of metal so engaged in these experiments as to influence the standing of the levels.

Besides the length of the bars or the brass wire, an addition is to be made for the length of the micrometer screws of each level, engaged below the bar of the leveltryer.

Then it will be necessary also to add the thickness of the supporting pieces, as they partook, in every case, of the changes of temperature, like the bars. Though these were iron, I think, on account of their smallness, they may, without any alteration, be added to the length of the brass and the iron equally. By these additions, the whole will count from the resting place in the wall, to the bar carrying the level, which also rested on the wall.

The lengths to be used in calculating the results, from the foregoing observations, will be as follows:

For the Iron.	Inches.	For the Brass.	Inches.
Four Bars	= 315,04	Brass wire	= 315,1
Screw engaged	= 1,1	Screw engaged	= 1,0
Plate and Support	= 1,4	Plate and Support	= 1,4
Sum,	= 317,54	Sum,	= 317,5

To calculate the resulting proportional expansion, for one degree of Fahrenheit's scale, from the foregoing observations, they must be combined together in each experiment, by taking the resulting expansion from the highest degree of heat to any one of the lower degrees.

The quantity of expansion observed, resulting from this comparison of the readings of the micrometer screws, and the reduction of their value by Table I., must be divided by the number of degrees of variation of the temperature, and this must again be divided by the length of the metal under experiment, expressed in the same unit of length as the expansion. The result will be the proportional expansion of the metal, for one degree of Fahrenheit, in a decimal fraction, which may be applied by simple multiplication to any length, and any degree of change of temperature.

This calculation is made by the following extremely simple formula for logarithms.

Log. P = log. E + Comp. log. D + Comp. log. L.
where P = proportional expansion.
E = expansion actually observed.
D = degrees of Fahrenheit's scale.
L = length of metal under experiment.

So that, for instance, the example of the calculation of the first observation, and result of Table III., at the end, will stand thus:

For the Iron.

Log. E = log.	0,3072620	= 9,4875088
Com. log. L = C. log.	317.54	= 7,4982016
Com. log. D = C. log.	142,5	= 7,8461851
Log. P = log. 0,00000679040		= 4,8318955

For the Brass.

Log. E = log. 0,4770212 = 9,6785441
Com. log. L = C. log. 317,5 = 7,4982563
Com. log. D = C. log. 142,5 = 7,8461851

Log. P = log. 0,0000105435 = 5,0229855

The details of these combinations of the experiments, and their results, are brought under an easy comprehensive view in Table III., which will be sufficiently explained by the heading of the columns. This table exhibits the agreement of the different results, and the general resulting mean, by taking each observation separately, through the whole of the three experiments. If the mean result of each experiment is taken as one, and the mean of these three results as the final result, the results will be as follows.

First Experiment.

	For the Iron.	For the Brass.
	0,00000679040	0,0000105435
	679554	5443
	713832	6808
Mean	0,00000690808	0,0000105895

Second Experiment.

	0,00000692024	0,0000104526
	698387	5282
	701039	4525
	693491	4101
	707357	5280
	698233	4636
Mean	0,00000698422	0,0000104725

Third Experiment.

	For the Iron.	For the Brass.
	0,00000707918	0,0000105770
	689014	4187
Mean	0,00000698466	0,00001049785

Taking a mean of these three results, will present each experiment as one individual result, and give the following general means.

For Iron = 0,00000695892
For Brass = 0,0000105199
Difference = 0,00000356098

It will be observed, that the two latter experiments give almost an identical mean, from individual results, which also agree very well; that in the first experiment the single results differ more from one another, than in the two latter, and that their mean also differs considerably more than the two others. This first experiment might therefore be rejected if desired; and this I should be inclined to do, because it was the first ever made with the apparatus, when it was new, and its use not familiar, and therefore the results not so trust-worthy. The mean of the two last, would then stand as follows, by taking each experiment for one result.

For Iron = 0,00000698444
For Brass = 0,0000104851
Difference = 0,00000350066

The single observations of the two last experiments might also be added, to take a general mean, and so a result somewhat different be obtained.

To leave it optional with any person who might wish to make use of these results, to which mean he will give the preference, I will set these different means here together. The difference between them is however only a few units in the 8th decimal, which I think within the limits of accuracy obtainable in this kind of experiments.

Mean Results of Proportional Expansion, for 1° Fahrenheit.

	For Iron.	For Brass.	Difference.
General Mean	= 0,000006963535	0,00001050903	0,000003545495
Mean of three experiments	= 0,00000695892	0,0000105199	0,00000356098
Mean of two last do.	= 0,00000698444	0,0000104851	0,00000350066
Mean of the single observation of the two last experiments	= 0,00000698433	0,0000104789	0,00000349454

I intended to pursue these experiments further, in the same manner, and to put bar-brass, glass-tubes, iron-wire, &c. under experiment; but the season calling me to the field operations for the survey of the coast, I have postponed them until next winter, when, if circumstances should be favourable, I propose to enter, with greater detail, upon more varied and multiplied results.

F. R. HASSLER.

Newark, New Jersey, June 11, 1817.

TABLE I.

For the Reduction of the Screw Values into Inches.

For the Iron.			For the Brass.		
Number.	Revolutions.	Seconds.	Number.	Revolutions.	Seconds.
1	0,01939581	0,000080816	1	0,02115815	0,000088159
2	0,03879162	0,000161632	2	0,04231630	0,000176318
3	0,05818743	0,000242448	3	0,06347445	0,000264477
4	0,07758324	0,000323264	4	0,08463260	0,000352636
5	0,09697905	0,000404080	5	0,10579075	0,000440795
6	0,11637496	0,000484896	6	0,12694890	0,000528954
7	0,13577067	0,000565712	7	0,14810705	0,000617113
8	0,15516648	0,000646528	8	0,16926520	0,000705272
9	0,17456229	0,000727344	9	0,19042335	0,000793431

TABLE II.

Experiment.	Thermometers.					Micrometers.	
Number.	1	2	3	4	Mean.	On the Iron.	On the Brass.
1st.	180	——	181	179	180	26^{R} + 58″	24^{R} + 215″
	39,5	36	36,2	38,3	37,5	42 + 20	47 + 106
	39	——	36,8	36,3	37,3	42 + 28,2	47 + 114
	52	52	51,7	53	52,2	41 + 42,5	45 + 91
2d.	36	33,5	32,7	32	33,5	42 + 98,5	48 + 125
	212	211,5	212	209	211,1	22 + 25	20 + 111
	212,5	211	211	208	210,6	22 + 83	20 + 179
	45	42,5	44,8	44,3	44,15	41 + 106,5	46 + 203
	35	32	32	32	32,75	42 + 118	48 + 112
3d.	34,5	33	33	32,5	33,25	42 + 170,5	48 + 152
	213	213	213	209	212	21 + 238	20 + 62,5
	47	——	45	44	45,3	40 + 191	46 + 77,5

TABLE III.

Results of Pyrometric Experiments.

Experiments.	Temperature.			For the Iron.			For the Brass.		
Number.	from	to	Extent.	Difference of Readings	Actual Expansion observed.	Proportional Expansion.	Difference of Readings	Actual Expansion observed.	Proportional Expansion.
1st Exp.	180	37,5	142,5	15R + 202″	0″,3072620	0,00000679040	22R + 131″	0,4770282	0,0000105435
	180	37,3	142,7	15 + 210,2	0,3079261	679554	22 + 139	0,4777334	105443
	180	52,2	127,8	14 + 224,5	0,2896845	713832	20 + 116	0,4333896	106808
2d Exp.	33,5	210,6	177,1	20 + 15,5	0,3891689	692024	27 + 187	0,5877558	104526
	33,5	211,1	177,6	20 + 73,5	0,3938561	698387	28 + 14	0,5936624	105282
	210,6	44,15	166,4	19 + 23,5	0,3704196	701039	26 + 24	0,5522277	104525
	210,6	32,75	177,85	20 + 35	0,3907448	693491	27 + 173	0,5864287	104101
	211,1	44,15	167,0	19 + 81,5	0,3751069	707357	26 + 92	0,5582225	105280
	211,1	32,75	178,35	20 + 93	0,3954320	698233	28 + 1,0	0,5925164	104636
3d Exp.	33,25	212	178,75	20 + 172,5	0,4018165	707918	28 + 89,5	0,6003184	105770
	212,0	45,3	166,7	18 + 193	0,3647221	689014	26 + 15	0,5514343	104187

General Mean of Proportional Expansion, - 0,000006963535 0,00001050903

Difference of Expansion between Iron and Brass, - - = 0,000003545495

NOTE ON THE PRECEDING ARTICLE,

By Dr. Patterson.

An excellent work on Natural Philosophy, by Biot, received in this country since the communication of the preceding paper, contains an account of a series of experiments, made on the same subject, by Lavoisier and Laplace, in 1782, and which have not before been given to the public. According to these experiments, the expansion of iron, from the freezing to the boiling point, is 0,00122045 of its length, and that of brass 0,00188971. From these data, we readily calculate the following comparative statement.

Proportional Expansion for 1° Fahrenheit.

	For Iron.	For Brass.
According to Lavoisier and Laplace,	0,00000678.	0,000010498.
According to Mr. Hassler,	0,00000696.	0,000010498.
Difference,	0,00000018.	0,000000011.

The correspondence of these results, obtained independently of each other, and by methods entirely different, must be considered as very satisfactory.

No. XVII.

English Phonology; or, An Essay towards an Analysis and Description of the component sounds of the English Language. By Peter S. Duponceau.—Read, May 24th, 1817.

BY the word *Phonology* I mean in general the knowledge of the sounds produced by the human voice. However simple and limited this knowledge may appear, it is, in my opinion, more extensive and complicated than is generally thought, so much so, that I think it never can be completely acquired. The sounds which the human voice can and does produce among the different nations of the earth, are so various, and their shades and varieties so delicate and nice, that there is probably no man on earth who has ears to comprehend and vocal organs sufficiently flexible to articulate them all.

Every body knows how difficult it is to acquire the correct pronunciation of a foreign language, but the true cause of this difficulty has never been satisfactorily explained. It has been ascribed to accent, to a tone of voice peculiar to each nation, and which foreigners, after a certain age, cannot imitate. This is certainly true, but it is true also that these national tones proceed principally from a difference in the articulation of elementary sounds, particularly vowels. Even among neighbouring nations, whose languages have been formed in a great measure from each other, there are sounds apparently similar, which, however, are not so, being produced by a different juxta-position of the organs of speech. Yet they are in general considered alike, for no other reason, in most instances, than that they are represented by the same written sign or character, and that the difference of articulation is not easily perceptible to unexperienced ears. Such, for instance, are the sounds of the vowel *a* in the words *car*, *par*, which appear the same in the French and English languages, and which, however, an Englishman and a Frenchman do not pronounce alike.* The English alphabet has no powers to express the French sound of the vowel *a* in those two words, nor can the French alphabet represent the short sound of the English *a* in *hat*, *fat*,† a sound which, however to us it may appear simple, a Frenchman cannot utter without difficulty.

If, even in the languages of neighbouring nations, in kindred languages, as the English and French are from their intermixture with each other, we find such nice yet real differences in the articulations of the human voice, we may form a tolerable idea of the variety of sounds which exists in language generally considered. Even in the idioms of the christian nations of Europe, connected as they are by constant intercourse with each other, more of those varieties are to be found than is generally imagined;—sounds which are familiar to particular nations, but which others cannot, without the greatest difficulty, imitate, and of which no idea can be conveyed by alphabetical signs through the eye, to those who have never heard them uttered. Such are the *u* of the French and Low Dutch, the *œ* and *eu* of the Germans and French, the *yerwe* of the Russians, the guttural *l* of the Poles, the θ of the Greeks, and *th* of the English, &c. &c. What shall we then say of the tones of the Chinese and the numerous sounds

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* The true French sound of the vowel *a* does not exist singly in the English language; it enters, however, into the composition of some diphthongs as will be hereafter shewn.

† This sound in French is always long, and is represented by *e*, as in terre, mer, fer, by *è*, as in père, près, or by *é*, as in bête, tête, Evêque. The short sound does not exist in the language, and therefore cannot be described to a Frenchman by mere alphabetical signs—é, or ĕ, for instance, would not represent this sound, but that of our short *e* in *wet*, *bet*.

which our ears have never heard, and yet are known to exist in the Asiatic, African, and American languages? Father Molina, in his Grammar of the Othomi language (one of the idioms of New Spain) tells us of three modes of pronouncing the Spanish *u*, (equivalent to our diphthong *oo*,) the one pure, the other nasal, and the third guttural. Although he has affixed signs to each of these, which, no doubt, are very intelligible to a Mexican missionary, it is certain that to our minds they convey no precise idea of any specific sound, except the first, which is common to them and us. And yet those sounds exist in nature, since there is at least one nation to which they are familiar. I shall also mention the *W* of our Lenni-lenape, or Delaware Indians, or rather the articulation which the German missionaries have agreed to represent by this English letter. It is a consonant, the sound of which is produced by a soft whistling; however barbarous this sound may appear to one who has never heard it, when pronounced, or rather whistled by a person to whom habit has given a facility of utterance, it has a pleasing and delicate effect on the ear, although it is frequently followed by the consonant *d* or *t*, as in *Wdanis*, daughter, *Wtehim*, Strawberries, *Wtellsin*, to do so, &c. The epithet *barbarous* is much too soon and too easily applied, when we speak of sounds and of languages that we do not know.

May I not, then, lay it down as a very probable position that there is no man on earth who has ears to discriminate, and vocal organs to execute all the varieties of sound that exist in human languages? and if there were such a man, he could not make himself understood but by those equally gifted with himself, and only by word of mouth. For how could he convey to the mental ear by means of written signs, sounds which the natural ear never heard before? This shews the great difficulty, if not impossibility, of representing in an universal alphabet, all the sounds and shades of sounds actually existing in human language: I do not mean to say, that a certain degree of approximation cannot be reached, and that by comparing together the powers of those languages which are best and most generally known, something like a general, though incomplete, alphabet of sounds might not be formed, which the learned at least, might understand, and which might be made use of to convey to the mind through the eye, a tolerable idea of the pronunciation of idioms yet unknown, and to represent the sounds of languages foreign to each other in a manner more fixed and determinate than has hitherto been done, but this is a work of much greater difficulty than will at first sight be imagined. To acquire even an imperfect knowledge of so many different sounds, to analyse and compare them with each other, class them according to their respective analogies, and graduate them by an accurate scale, and after all to communicate in an intelligible manner through the eye, the result of all these studies requires almost an Herculean labour, from which, perhaps, might result a curious and interesting science, which, until a better name can be devised, I would denominate the *Phonology of Language.*

I do not possess the requisite talents to venture upon so vast an undertaking. I leave it to those who are not aware of its difficulties, or who feel conscious of sufficient powers to overcome them. I will, however, make an attempt to apply my principles to the English language, although I am far from considering this an easy task. But it will be recollected that I present only a rude outline, indulging in the hope of seeing it filled up by an abler head and a more skilful hand than mine.

Various attempts have been made to ascertain and fix the pronunciation of the English language; none of which has yet completely succeeded. The reason of this failure is obvious. Instead of applying the process of analysis to the sounds themselves, independent of, and abstracted from, the signs which represent them, grammarians have looked to the signs in the first instance, and proceeded from them to the sounds which they are supposed to represent. Hence we are told of the sound *a*, the sound *e*, the sound *o*, when in fact there are no such sounds in nature, *a*, *e*, and *o*, being arbitrary signs, which may represent one sound as well as another, and are not always pronounced in the same manner. To avoid this inconvenience, lexicographers, among whom Sheridan and Walker are the most distinguished, have attempted to discriminate between *a* in *grace*, *a* in *bad*, *a* in *all*, and so on with the other vowels, and by means of numerical signs superadded to each character have sought to distinguish them from each other, but the result of this mode of proceeding has only been to produce still greater confusion. Sounds which are similar have been represented by different signs, and *vice versa*. Thus while the sound of *a* in the word *all*, and of *o* in the word *fortune*, are exactly alike, the former is represented in Walker's Pronouncing Dictionary by the sign $\overset{3}{a}$, and the latter by the sign $\overset{s}{o}$, and on the other hand the sound of *a* in *fame*, and that of *ai* in *fair*, though evidently dissimilar, are both represented in that book by the sign $\overset{1}{a}$. It will always be so when the alphabet of any language is taken as the basis of a system of its sounds; for an analysis which proceeds from the sign to the thing signified, can never produce a satisfactory result, unless, as in the case of the musical scale, there should be a fixed and never varying analogy established by constant and universal usage between them. But there is a very great difference between the musical notes and the alphabet, for instance, of the English language. The seven notes of the modern gamut, with their auxiliary signs will convey to the mental ear of a person skilled in the art, a clear and perfect idea of the various tones and inflexions of the human voice (as far, at least, as they are perceptible to the sense) while the English alphabet with all its accents, notes, points, and other auxiliary marks, will not give even to the best English scholar, a precise idea of the sound of any word which custom has not previously established. Let us suppose, by way of example, that the proper name *Mahomet* is now for the first time exhibited in writing to an Englishman who has never heard it pronounced, and that it is even accented thus: *Máhomet*. How will he pronounce the first vowel *a?* Will he give it a broad or an acute sound? Indeed, we know that on this point there is no generally established usage, and that the name of the Great Prophet is pronounced according to the fancy or taste of the speaker. It is so with many other words, particularly proper names,* and would not be the case if each elementary sound had a single appropriate character to represent it, and if each character represented only a single sound. But in all the languages of Europe, alphabetical writing has more or less deviated from its original plan, and there is none which can boast of a correct orthography on the true alphabetical principle.

Nor is this difficult to be accounted for. Oral language is subject to change, and the pronunciation of words does not constantly remain the same. The variations which take place are slow and gradual, at first confined to a particular class of men or district of country, and a long time elapses before they are universally established. In the meanwhile the nation is divided in opinion as well as practice, some taking to the new, others adhering to the old pronunciation; but the combination of signs, by which a particular word is represented in writing, remains the same, and by the time that the new mode of pronouncing that word has finally prevailed, the eye, accustomed to recognise it under every fluctuation of its sounds, finds no necessity for an alteration in the manner of spelling; for there is no analogy in nature between written signs and words spoken, any more than between words and ideas. Although alphabets may have been originally intended to represent mere sounds, the various combinations of their characters form at last in fact a written language, which like that of the Chinese, conveys ideas directly to the mind, without passing through the mental ear, any more than words spoken pass through the mental eye. This may be easily demonstrated. When we read the word "*thought*," notwith-

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* Among many others I may instance the English proper name *Snowden*, or *Snowdon*. One who has never heard this name pronounced, will be at a loss to decide whether the diphthong *ow* which it contains, is to be pronounced as in *blow*, or as in *now*. It would be easy to multiply examples, not only out of the English, but out of other alphabetical languages.

standing its irregular and incongruous spelling, the idea which it expresses, strikes our mind immediately, while if we saw it for the first time written *thawt*, although the sound of the spoken word would be much more accurately represented according to the idea which we entertain of the powers of our alphabetical signs, we would be at a loss to know what is meant, the ear would not help the eye, accustomed to receive and convey its impressions by itself, and independent of another organ. This accounts to us for the otherwise unintelligible phenomenon of persons born deaf and dumb having learned to read, and being able to receive ideas through combinations of alphabetical signs, though they have no conception of the sounds which the letters represent. It is true that when we read we have sometimes the consciousness of the sounds of words which are exhibited in the shape of letters to our eye, but this proceeds from the mere force of habit, and it is not at all necessary to our understanding the meaning of what we see written. It has been frequently observed, that the operation of reading proceeds much faster than that of speaking, and that the sense of what we read is taken by the eye in a much shorter time than would be required to articulate even a small part of the words it contains. Indeed there are men endowed with so rapid a glance, that they will read and understand at the same moment several lines of a printed book, so that it is impossible that in that space of time they may have the perception of the sounds of the words which their eye thus runs over. In short the eye and the ear are different senses, each of which is capable of being employed as a medium for the communication of thoughts between man and man, by means of visible or audible signs previously agreed upon. And although in general it must be acknowledged that of the two, the ear is the most convenient for practical use, yet the eye is not without its advantages as a means of communication. It certainly excels in rapidity. Without recurring even to hieroglyphical writing, how much less time does it require to convey to the mind the idea of *the fourth of July one thou-*

sand seven hundred and seventy-six, by exhibiting to the eye the letters and figures, 4th July 1776, than by speaking the words at full length? This advantage is carried to a much greater extent in the Chinese mode of writing, so much so that we are told by an eminent Sinologist, M. Remusat, that it is not unfrequent there for men to converse rapidly together, by tracing characters in the air.* The Chinese consider the mode of conveying ideas to the mind through the eye, by means of written signs, as far superior to spoken words which communicate perceptions through the ear. "The people of "*Fan*, say they, (meaning the Europeans) prefer sounds, and "what they obtain enters by the ear; the Chinese prefer beau-"tiful characters, and what they obtain enters by the eye."† "It is, indeed," says Remusat, "impossible to express in any "language, the energy of those picturesque characters, which "exhibit to the eye, instead of barren and arbitrary sounds, "the objects themselves, figured and represented by their "most characteristic traits, so that it would require several "phrases to express the signification of a single word."‡

While the written language of China has been carried to so high a degree of perfection, containing, according to M. Remusat,§ no less than eighty thousand different characters, their spoken language is the poorest and most imperfect, perhaps, of any existing, the number of its words, as is asserted by the same author, including the variations of tones, not exceeding eight hundred. It is, withal, miserably deficient in grammatical forms, and may be compared to the first attempts of children to speak, or to the jargons of the West India negroes. So that the introduction of alphabetical writing among the Chinese would be of no use to them, unless their spoken language could be new modelled, so as to make it more copious and more expressive at least, than it is at present.

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* Essai sur la Langue et la Littérature Chinoise, p. 33.

† Morrison's Chinese Dictionary—Introd. p. VII.

‡ Remusat, p. 56.

§ Id. p. 55.

The Chinese characters were originally intended to represent words, which are complex sounds, as our alphabets to represent sounds in their simple and abstract forms. But the powers of the mind are such, and such is the rapidity of its operations, that the moment any combination of known characters is exhibited to it through the eye, it immediately seizes on the ideas which the group is meant to represent, and the perception of the elementary sounds is lost in the passage. Hence the facility with which the receiving and transmitting organ accommodates itself to any mode of spelling, as it rather seeks ideas than sounds in the groups of characters that it perceives. If this theory is true, it follows, that it is of very little consequence whether the words spoken are or are not accurately represented as to sound, by the characters of the graphic language, the combinations of which, however incongruous or discrepant from their original application, never fail to impress on the mind the ideas with which habit has associated them.

I am not, therefore, one of those who wish to see any innovation introduced into the alphabet or orthography of the English language. In its present state, it is adequate to every practical object, and we do not find that children learn with more difficulty to read the French and English languages, the orthography of which is the most anomalous of any that we know, than the Spanish, Italian or German, in which the alphabetical signs in their combinations into words, preserve in a greater degree their original sounds. Nor can I perceive any good effect that would result from a similar innovation, (independent of the difficulty, not to say impossibility, of introducing it into use) for as the pronunciation of the spoken language has changed, and will still change, as years continue to roll, it would be impossible to make the changes in the orthography keep pace with those of the oral idiom, which for a long time, as I have observed, are partial and uncertain, and not seldom are rejected after having been tried for a while; so that in the course of one hundred years, perhaps, another alphabet or another mode of spelling would be required to restore the lost analogy between the written and the spoken language.

No, let our written language still retain its venerable garb, *nos anciens habits de sauvages*, as M. de Voltaire would call them, but still more decent than the masquerade dresses under which men of more fancy than reflection, would disguise the immortal thoughts of Milton and Shakespeare, so that the eye would no longer at once recognise them, and the straight and well trodden path by which they now, without difficulty, reach the mind, would be made crooked, hard of access, and overspread with brambles and thorns. Our written language, it is true, is not invariable any more than our oral mode of speech, (for what is there in this world that is not subject to change?) and the eye is sometimes inconstant as well as the ear, therefore mutations have and will again take place in our orthography; but they will be slow and gradual, and habit and practice will saction them without any extraordinary effort.

While I thus disclaim every wish to innovate upon our written language, I am not insensible of the importance of endeavouring to acquire as perfect and accurate a knowledge as possible, of the elementary sounds of which our spoken language is composed. This has been often attempted, but never, in my opinion, with any tolerable degree of success. The reason of this failure appears to me to be, that the investigation has always been carried on through the medium of the alphabetical signs, which I consider as inadequate instruments for that purpose. However, those signs may have been originally intended to represent simple sounds, they have certainly greatly deviated from their first destination. There are at present simple sounds, which cannot be represented by any one character, and can only be expressed singly by combinations of letters, such as *oo*, *ee*, *au*, *sh*. There are others, the idea of which cannot be conveyed to the mind through the eye, by any character or combination of characters in our alphabet, unless connected with others as parts of a word, of which habit has taught us to recognise the sound in a certain group of letters. Thus it is impossible to represent to the eye singly, the vowel sound which is contained in the words *mare*, *mayor*, *bear*, *hair;* the vowels which those words contain, alone and separated from their concomitant consonants, will not convey the idea of that sound to the mental ear. Write, for instance, by themselves, the vowels and combinations of vowels, *a*, *ai*, *ayo*, *ea*, and from none of them singly or together will you receive the impression produced by the vowel *a*, coupled with other letters in the word *mare.* Indeed, the impressions or ideas of sound which these characters will produce, will be vague and uncertain, because they are differently pronounced according to the words in which they are found. There is no precise idea of sound affixed to any of them. A single vowel, say *a* for instance, will probably recal to the mind the idea of the name which it bears in the list of written characters which we call *alphabet*, which is *a* pronounced as in the word *grace*, but this is the mere denomination of a letter like *alpha* or *aleph*, and not the representation of a sound. If it was called *beta* or *gamma*, it would answer the purpose equally well, and the sight of the character would affect the mind in the same manner, whatever might be its name. There are in our alphabet several letters and combinations of letters, the names of which have no affinity to the sounds which usage has affixed to them, such are *h*, *w*, *y*, *ch*, *th*, *sh*, *gh*, *ph*, *ough*, *&c.* In the word *thought*, which in our written language is formed by a group of seven characters, there is only one, (the letter *t*,) the name of which contains one of the component sounds of the word correctly pronounced. If usage had established that this group of letters should mean *the tower of Babel*, its exhibition to the visual sense would produce the idea of that celebrated edifice, as easily and as promptly as it now produces that of the metaphysical entity which we call *thought.*

This shows the futility of the attempt that has been made by some French, and I believe, by some English grammarians, to change the names of the alphabetical signs, so as to make them more simple, and more concordant with the sounds which they are supposed to represent; to say for instance, *wee*, *fee*, *hee*, instead of *double u*, *eff*, *aitsh*, or other similar alterations. This I conceive to be very unnecessary, even if each character had a certain and precise sound affixed to it, which is not the case. I should as soon think of naming men by some of the most prominent appearances in their persons, as *tall*, *short*, *fat*, *lean*, *&c.* in order to distinguish them the better from each other. Such solemn trifling is of no use whatever for the advancement of science. Let the names of things remain as they are, and let rather our studies be applied to the things themselves.

The component sounds of the English oral language, considered in the abstract, and independent of the signs which are used to represent them, are the subject of this Essay. I have attempted to subject them to the process of a severe analysis, taking the ear alone for my guide, and rejecting the delusive aid of another sense. This has been the most difficult part of my task, for in spite of all the efforts that can be made, that other sense, the sight, will ever intrude, and almost as certainly as it interferes, is sure to deceive. Such is the force of early habit, and so strong is the association in the mind between the written and the spoken language, that it is almost impossible to abstract or separate them from each other. When we have been accustomed to see the same sound represented by different characters, our ear involuntarily follows the eye, and perceives differences which do not exist in nature. Hence all the English grammarians that I am acquainted with, except Mr. Mitford, in his very interesting treatise on the harmony of language, have considered the sound of *a*, in *all*, and that of *o*, in *cottage* as differing from each other, whereas it is evident, if the ear only is attended to, that they differ in nothing but quantity, the former being pronounced long and the other short.* In

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* Quantity is so little attended to in the English language, that a foreigner judging only from our grammars and pronouncing dictionaries, would be led to believe that there is no such thing in it. Mr. Walker, in the Treatise on Pronunciation prefixed to his Dictionary, hardly deigns to bestow a few lines on this subject, "because," says he, "vowels long and

fortune, the difference of quantity vanishes, and it seems impossible for the nicest ear to discriminate between the sound of *o* in that word and that of *a* in *all*. In *hollow*, *follow*, again the quantity differs, but the sound is still the same. To try it by a sure test, let the quantity of the words be transposed, and pronounce the word *ăll*, ăll, and the word *hōllow*, hōllow, the similarity of sound cannot fail to strike every ear as it did that of Mr. Mitford, and as it certainly does mine. Here this acute and discriminating philosopher conquered the strong prejudice produced by conflicting senses, and by an early association of ideas; but he was not every where equally successful, for he distinguishes between the sound of *o* in *robe*, and that of *u*, in *but*, which he classes as different vowel sounds without considering that as in the former instance, the difference consists only in the duration. This last vowel sound he calls *u* short, and the Edinburgh Reviewer commenting on his work,* assimilates it to that of the French diphthong *eu*. With these opinions, however respectable, I cannot by any means coincide, my ear discriminates between the sounds of the English word *buff* and the French word *bœuf*, though they are both the same as to quantity. Nor can I believe with Mr. Mitford, that the sound of the short *u* as he calls it, and that of the long *o*, differ in any thing but their duration. It is astonishing how the eye in this and other like instances is apt to mislead the ear. There are few persons who will be disposed to deny that the vowel sound in the word *son* is that of the short *o*, the same which is pronounced long in the word *robe*; but change the orthography of this word and write it

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"short are always sufficiently distinguishable." He might have said as much of the sounds of letters and of every thing else that is necessary in order to a correct pronunciation. For the quantity of sounds, when abandoned to the vulgar and left without fixed rules, is not more free from fluctuation and uncertainty than the sounds themselves. The truth is that quantity has been too much neglected by grammarians, who have exclusively bestowed all their attention on accent and emphasis, without regard to duration of sound. It is not possible to ascertain with due precision the pronunciation of a language, when so material an ingredient is left out of view.

* 6 Edinburgh Rev. 360.

sun, and men will no longer feel the same impression of sound, because it is not an *o* which they have before their eyes. I have met with similar delusions at every step of this investigation, and am not certain that I have conquered them all.

There is nothing so difficult for the ear to take hold of, and correctly to discriminate, as the short sounds of the English unaccented vowels. The principal characteristics of our language are strength and rapidity. The voice does not act by pressure on accented syllables as it does in the Italian and Spanish, resting upon them a while so as to fall gently on those that are unaccented and give them their correct articulation, but strikes with sudden force on the accented vowel, and impelled by the momentum which it gives to itself, rolls on rapidly through the unaccented syllables to where it is obliged to renew its stroke. Hence our accented vowels are in general short, and those unaccented are passed over with so much quickness, that the vocal organ does not dwell upon them long enough to enable a common ear to catch their precise sound, and it perceives only an indistinct vibration, a small vacant space, as it were, between the consonants, like the *Sheva* of the Hebrews, and the French *e* feminine. This vacant space, this *Sheva*, the English Phonologists (if I may be allowed to use the name) have almost uniformly represented by *u* short, from some predilection for this character, for which I cannot, nor do I think it necessary to account. Thus *altar*, *cancer*, *honor*, *martyr*, when their pronunciation is to be explained, will be spelled, for demonstration's sake, *altur*, *cansur*, *honur*, *martur*, as if the vowel sound of the last syllable in all of them were the same. But this similarity is nothing in my opinion, but a deception produced on the ear by the rapidity of the voice passing over the unaccented vowel. If the powers of the auditory sense could be increased by some acoustic instrument, as those of the organs of vision are by a microscope, I have no doubt that the sounds of the vowels thus obscurely but correctly pronounced, would be distinctly heard; but they escape our ear as minute objects do our eyes, when the sight glances over them with rapidity. A confusion is produced, not unlike that of slurred notes by an unskilful or inattentive performer on a musical instrument. But the correct speaker as well as the skilful musician, will avoid this disagreeable confusion, and give to every passing sound as much as possible its clear and distinct utterance: in common colloquial speech, so much nicety is not required, but neither is it there that the rules of pronunciation are to be sought for, and its licenses should not be converted into principles.

This is, however, the fault which modern grammarians have committed. They have laboured, it would seem, to vulgarise our language. They have mistaken the indistinct pronunciation of unaccented vowels in colloquial speech, for their true and genuine sound. Nor are they vowels alone that have given rise to a similar error. The sound of the letter *t* when followed by the vowel *u* and rapidly uttered, appears to the sense like that of *ch*. Thus the words *nature*, *fortune*, by the operation of that delusion which I have already noticed, seem to sound like *natchure*, *fortchune*, and this has been taken for the true and genuine pronunciation of these and other similar words. But this supposed sound is mere deception, in the same manner as when we pronounce the words *don't you? can't you?* we are heard to say *don't chew*, *can't chew*. And surely it cannot be said that such is the true pronunciation of the English language, and that the sound of the letter *t* when followed by *u* is always changed into that of *ch*. It will be contended, perhaps, that there is a difference between consecutive words and consecutive syllables, a longer pause being presumed between the former than between the latter. But I assert that in point of fact there is none, that *don't you* and *can't you* in common familiar language are pronounced with as much rapidity as *nature* and *fortune*, and that the deception on the ear, of *ch* instead of *t* takes place when two words as well as two syllables follow each other. If this is true, and if this sound of *ch* is really produced by an illusion of the sense, how comes it that our grammarians have erected it into a correct and true standard of pronunciation? Such deceptions take place in every language; in French for instance, the words *Qu'est ce que c'est que cela*, in familiar speech generally sound to the ear like *Kexexa*, and this proceeds altogether from the rapidity of utterance. Yet what French grammarian has ever pretended that such is the true pronunciation of those words and recommended it to be used at the bar, on the stage or in the pulpit? But we have orators among us, who in the most solemn discourse not only do, but on the authority of Sheridan and Walker, affect to pronounce *natchure*, *fortchune*. There are even those, who following the first of these writers, pronounce *tumult*, *tumour*, like *tchumult*, *tchumor*, although the accented vowel on which the *t* falls does not so much excuse that negligence. In speaking very rapidly, it is difficult to avoid this confusion of sounds, even when the vowel is accented; but I must repeat that the true pronunciation of a language is never to be sought for in the careless habits of rapid discourse.

It is improperly, therefore, that the modern English lexicographers have substituted almost every where the dull inarticulate *sheva*, or short *u* as it is called, for the proper sounds of unaccented vowels. With equal impropriety have some of them struck out in certain words the vowel altogether, for instance, in *raven*, *maiden*, *heaven*, &c. the pronunciation of which is according to Walker, *ravn*, *maidn*, *hevvn*, thus making these words monosyllabic, as they are sometimes in poetry, when the metre requires it. For poetical licenses are not any more than those allowed to colloquial speech, the sources from which the true pronunciation of words is to be derived. The standard exists only in the language of solemn recitation, in which every sound is distinctly uttered, and no licenses are permitted. It is by adhering to this standard alone, that the purity of a language can be maintained, and that it can be saved from corruption and barbarism.

This is the important object, for which I have ventured upon this Essay. The correct pronunciation of a language cannot be preserved, unless it is precisely fixed and ascertained, and that cannot be done unless all its component sounds are accurately known and clearly distinguished from each other. This has not yet been done with respect to any language that I know of, certainly not as to the English. The various powers of the characters of its alphabet have been described, but the sounds themselves have never been analysed, nor can they be, unless they are as much as possible abstracted from the signs which represent them, for the ear alone should be listened to, nor suffer itself to be misled by the delusions of another sense, which was given us for a quite different purpose from that of conveying ideas of *sound* to the mind.

I have therefore endeavoured to analyse and distinguish by the ear only, all the various sounds which enter in the composition of the English oral language, to discriminate between those which habit and the opinions of masters, and above all the errors produced by an imperfect alphabet have taught us to consider as similar, although in fact different, and on the other hand to couple again together those which differ only from each other in point of quantity or duration of utterance, but have been hitherto supposed to differ more essentially. It was not from the rapidity of colloquial speech that I could expect to catch such a fleeting object as sound; I sought it therefore in that slow and distinct form of language in which a great number of hearers are to be addressed at the same time, and which necessitates the full articulation of every word and syllable. All deviations from this only true and correct standard I have considered as delusions of the sense proceeding from the rapidity of utterance, or as licenses allowed in familiar conversation for the greater facility of discourse, but which should never be transformed into rules or canons of language.

Although I have not found it an easy task to complete this analysis, a much greater difficulty still remained, which was to convey the result of it to the mental ear through the organs of sight. I had no other instrument but the English alphabet, which is not only inadequate but deceptive. How could I convey the idea of a particular sound, but by means of the letter or letters which have been used to represent it? And how when a particular sound (as is often the case) has no particular character or characters affixed to it? There was no possible way of getting over this difficulty but by devising a new instrument in lieu of alphabetical signs, but what instrument could I find that was not at least composed of those treacherous and insufficient elements? After much reflection and deliberation, I have at last determined upon the following mode, of the imperfection of which I am fully sensible, but it is not in my power to devise a better.

Instead of representing sounds in the first instance by alphabetical characters, I have affixed to them proper names, each of which contains the particular sound which it is intended to designate. Thus "*Aulif*" is the name of the vowel sound of its first syllable, *&c.* "*bee*" is that of the consonant with which it begins. That the application of each name may be clearly understood, I subjoin to it the various letters and combinations of letters by which each sound is expressed in the English language, exemplified by words in which they are found, and the pronunciation of which as much as possible, is also fixed and determined. And lastly I distinguish between the different modes of expressing vocal sounds, according to their quantity, shewing the various characters by which they are represented to the eye, when long and when short. Thus I have as much as possible abstracted the idea of each sound from that of any particular character or set of characters, by fixing it in the first instance upon a proper name, and explaining it afterwards by a variety of alphabetical signs, so as not necessarily to connect it with one more than with the other.

It will be said, perhaps, that I might as well, instead of proper names, have given a new table of written signs, and explained the powers of its characters by the various combinations of the English alphabet. But this would have been falling into the error which I wished to avoid, by proceeding from the sign to the thing signified; they are sounds and not letters that I wish to make known. If I succeed in my endeavour, which is to give a clear idea of the value of all the sounds existing in the English language, nothing will be so easy afterwards as to affix signs to them, and an auxiliary table of characters, to be used only as an instrument by which to compare, fix and ascertain the pronunciation of words and as a key to pronouncing dictionaries in lieu of the insufficient letters and figures that have hitherto been used. For I must repeat that I am very far from wishing to see such an alphabet introduced into common use, to the destruction of our literature, and perhaps, ultimately, the entire corruption of our language.

Having premised thus much, I proceed to my analysis.

I have not been able to discover in the English language more than twenty-nine pure elementary sounds, of which seven are vocal, twenty-one organic or consonant, and two are aspirations or spirits.

The vocal sounds are those which are represented in alphabets by the letters we call vowels. They are variously modified, all by the quantity or duration of utterance, some by a nasal pronunciation as *ong*, *ang*, *ing*. These modifications do not require separate characters to represent them, but may be distinguished in a phonological alphabet by particular signs. The signs of quantity are already known and established, nasal sounds may well be distinguished from their pure vocal, by a *cedilla* or comma under the letter as in the Polish language.

There are also diphthongal sounds composed of two vocals rapidly pronounced in succession, so as to make but one syllable. Such is *i* in *fire* and *ow* in *now*. They might with propriety be represented by simple characters, to point out to the eye their monosyllabic pronunciation; but they cannot be classed among pure elementary sounds.

The organic sounds are those which are represented in alphabets by the letters which we call consonants. I call them organic because their utterance requires the motion and various positions of the organs of speech, whereas in the pronunciation of vocals those organs are perfectly at rest. It follows from this description that there are vocal sounds which by a particular position become organic. Such are those which in our language are represented by the letters *y* and *w*. When placed immediately before other vocals, and even before their own duplicates, their pronunciation requires a certain motion of the lip or tongue, as in *ya*, *ye*, *yi*, *yo*, *yu*, *wa*, *we*, *wi*, *wo*, *wu*. Hence they are entitled to rank both among vocal and among organic sounds, and in a complete alphabet, should have particular signs to represent them in each different capacity. The French want our W in their alphabet, hence they write *Ouabache*, *Ouisconsin*, for *Wabash*, *Wisconsin*, which leaves it uncertain whether *oua* and *oui* are to be pronounced as one or two syllables, the voice being naturally inclined to rest upon every vocal sound, unless the written sign clearly indicates that two successive vocals are to be blended together as it were in one, or that the first is to be articulated as an organic sound.

Owing to this ambiguity, the French grammarians are yet in doubt whether they should pronounce *fiole* or *fi-ole ; hier* or *hi-er*. A well composed alphabet should leave no reason for such doubts.

There are organic sounds which combine so easily with each other, that when placed in a certain juxta-position, and pronounced rapidly together, they are so blended that they appear as forming but one sound. Such are the sounds of *t* and *d*, with *sh* and *zh*, as in *charm*, *joke*, *&c*. These blended sounds might well be represented by single letters in a phonological alphabet of the English language, and have separate appropriate names.

There is not so much necessity for single characters to designate the various combinations of S and Z, with other consonants preceding them, such as *ks*, *gz*, *ps*, *ts*; it would add much, however, to the beauty of an alphabet and to the facility of reading, if such letters were introduced into it, as our X.

the Greek Ψ and others, to represent analogous combinations of organic sounds. The Russian alphabet has a character to represent the compound organic sound *shtsh;* which is very proper, as it at once indicates the rapidity with which it ought to be pronounced. It formerly had the Greek Ξ, which has without reason been gradually disused, and is preserved only in church books. The name of the Emperor Alexander is now written with *KS*, instead of *X*.

In a table of alphabetical signs, the number of characters should not be too much increased, so as to make it a difficult study to acquire it; but there is no reason for restricting it to the mere representation of simple elementary sounds: on the contrary whenever double sounds, whether vocal or organic, are in a manner blended together, or are to be pronounced in succession with great rapidity, so as to form, as it were, one sound, their combination should be represented to the eye by a single letter.

In addition to the proper vocal and organic sounds, the English language has two modifications of sound, which I call aspirations or spirits. The one is soft, and in our common alphabet is represented by the letter *h*. The other is harsh and guttural, and is only found in some Scotch and Irish proper names, such as *Lough*, *Drogheda*, *&c.* It may be said, perhaps, that this last does not properly belong to the English language, but it is so common in almost every other European idiom (the French and Italian, I believe, are the only exceptions,) that it would be very useful, if added to the auxiliary table of signs which I propose. I would even suggest the propriety of adding to it, by way of appendix, a few of the best known and most familiar sounds of foreign languages, such as the French *u* and *eu*, the Spanish *ll*, the Italian *gn*, and a few others, so as to make a tolerably complete general *alphabet*, for the use of the learned, to be applied merely to the comparison and description of foreign as well as domestic sounds, and above all to the fixing of the pronunciation of our own language.

In such an alphabet the aspirations which I have above noticed, might be represented as in the Greek by commas or accents, instead of distinct letters or alphabetical characters.

But before such an alphabet can be composed on these or any other principles, and as the first preliminary step thereto, it is necessary well to ascertain what are the pure, simple, elementary sounds that are contained in our own language, so as to be able clearly to distinguish them from each other, and avoid the errors which have been produced by the confusion which has hitherto reigned respecting them; having stated their numbers and their classes, I now proceed to their description.

I make use of the words "vocal and organic sounds," instead of "consonants and vowels," which last denominations should be applied only to alphabetical characters. I do this from indispensable necessity, as in general I am no friend to innovations in nomenclature, which very seldom tend to the advancement of science.

I. VOCAL SOUNDS.

I reckon seven pure, simple, elementary vocal sounds in the English language, to which I have given the arbitrary names, *Aulif*, *Arpeth*, *Airish*, *Azim*, *Elim*, *Oreb*, *Oomin*, each name designating the vowel sound of its first syllable. I have also thought proper to distinguish the quantity, and to separate the long pronunciation of each sound from the short one. In doing this I have found great difficulty, because in many instances the quantity of the English vocal sounds is not precisely fixed, owing to the neglect in which this branch of phonology has unfortunately fallen. To determine the quantity of each word and syllable in the English language, would of itself require a long elaborate work, and perhaps after all, a great deal would remain doubtful. For instance, the word *hart* (cervus) is clearly long, while *heart* (cor) which has precisely the same sound in point of quantity, is not quite so long, and yet not absolutely short. The words " or, nor, for," and many others, appear also of the doubtful kind, being sometimes pronounced long and sometimes short, as the euphony of the phrase into which they are introduced may seem to require. I do not pretend here to solve these difficulties, as I am not writing a treatise upon quantity. I have endeavoured as much as possible in the examples that I adduce (except perhaps in very few instances) to confine myself to words and syllables, the quantity of which does not admit of doubt, but is generally admitted to be long or short, my object being merely to classify and describe the various sounds of the language, so that they may neither be confounded together when they in reality differ, nor improperly distinguished when similar.

FIRST VOCAL SOUND.

AULIF.

This sound is variously represented in the orthography of the English language, according to its quantity.

When long it is represented by the following letters and combinations of letters.

1. By *a*, in all, altar, alter.
2. By *al*, in walk, talk, chalk.
3. By *au*, in author, autumn.
4. By *augh*, in aught, naughty.
5. By *aul*, in baulk, caulk.
6. By *aw*, in raw, saw, awkward, awful.
7. By *awe*, in awe.
8. By *o*, in fortune, mortal, orchard.
9. By *ough*, in ought, thought.

When Short, it is represented

1. By *a*, in qualify, quality, equality.
2. By *au*, in authority, autumnal, austere.
3. By *o*, in God, pot, not,* olive, rosin, ostler.
4. By *oa*, in broad, groat.
5. By *ou* in cough, trough.

SECOND VOCAL SOUND.

ARPETH.†

When long is represented

1. By *a*, in art, (subst.) bard, hart, farther.
2. By *aa*, in baa, (the cry of a sheep.)
3. By *ae*, in Haerlem, Maerdyck, (proper names).
4. By *agh*, in Armagh, (proper name.)
5. By *ah*, in ah! (interj.)
6. By *au*, in aunt, jaunt.
7. By *ea*, in heart, hearth.

And when short

1. By *a*, in art, (verb,) man, carry, mortar, partition.
2. By *e*, in herd, merchant,‡ terrible.

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* Mr. Walker distinguishes between the pronunciation of the vowel *o* in *nor* and in *not;* the first he represents by $\overset{3}{o}$, and the last by $\overset{4}{o}$. I acknowledge I cannot find any difference between these two sounds; to my ear they appear exactly alike.

† This sound is not used in the French language, except in solemn recitation, at the bar, on the stage and in the pulpit, when the words having an E *ouvert*, as *fête, terre, père,* &c. are pronounced with the broad sound of *Arpeth*. In the colloquial language, they take the more acute sound of *Airish*. I have already observed that these sounds are never pronounced short in French as they are in English.

‡ According to Sheridan this word is to be pronounced *martshant,* and according to Walker *mertshant*. Neither of these writers seems to be aware that the only difference between these two modes of pronunciation is in the quantity given to the vowel *e*, and not in the sound that it receives. Those who follow Sheridan, lengthen the sound of the first vowel, and the disciples of Walker make it short. Were they all to observe the same quantity, their

3. By *ea*, in learn.
4. By *i*, in fir, sir, third, bird.*

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pronunciation of the word would not differ, whether they spelled the first syllable with *a* or with *e*, *marchant*, or *merchant*.

* The vulgar pronunciation of these words and others similarly spelt, is *fur*, *sur*, *thurd*, *burd*, but I do not think it correct. Walker and Sheridan, have adopted it in their pronouncing dictionaries, except as to the word *fir*, in which they differ, Sheridan representing it by fur, and Walker by f$\overset{2}{e}$r, by which he indicates the short sound of the letter *e* in the words *met*, *bet*. Both these Grammarians explain the pronunciation of *firkin*, by *ferkin*, and that of *firm* by *ferm*. In a number of other words in which *i* short thus precedes the consonant *r*, these two writers are thus found to differ from each other and from themselves, which shews at least that neither of them had certain ground to rest upon. If the sound of *i* in *sir*, *third*, *bird*, is that of *u* short, it must be the same in *fir*, *firkin*, *firm*, *firmament*. &c. for in all those words that vowel is sounded exactly alike, yet it is impossible not to perceive a difference between the pronunciation of *i* in *fir*, (a species of tree) and that of *u* in *fur* (the skin of a wild beast.) This obvious distinction did not escape Mr. Walker, and obliged him to drop his favourite *u* short, in all the words which begin with the syllable *fir*, although not differing in pronunciation from other words in which he employed it. Mr. Sheridan, on the other hand, ascribed the sound of *u* short to the *i* in *fir*, and that of *e* to the same vowel in *firkin*, *firm*, *firmament*. The reason of these variations is, that those writers paid no regard to quantity, while the true test of the pronunciation of a short vowel is to lengthen its sound, and see what it will produce. Had Walker and Sheridan used this method, they would have found that the pronunciation of *i* in firkin and firmament, whatever it may be, is by no means that of *e* in *met*, *bet*, as they both have explained it.

I consider the sound of *i* in these and all other similar words to be that of *arpeth*, pronounced short. To prove it, I take, for instance, the word *bird*, in which I find the sound of the *i* to be the same with that of *a* in *bard*, except that the first is short and the last is long. To bring this to a sure test, let the word *bard* be articulated, let its vowel sound *a* be prolonged, and then suddenly shortened, it will end with the sound of *i* in *bird*, thus bā-ā-ā-ĭrd. Again, in the words *thou art*, accent the word *thou*, and the *a* of the word *art*, pronounced short, will produce the sound of *i* in *bird*. It is still the sound *Arpeth*, only shortened.

This pronunciation of the short *i*, our language has derived from the German, and therefore it must be very ancient. I am told that throughout Germany the words *birn*, *hirn*, *dirne*, and others of the same kind are pronounced exactly as we would pronounce them if they were English. I have heard Saxons, men of classical education, pronounce these words in this manner. They said it was not the correct mode, but that the usage was so general, that it would appear like affectation to pronounce them otherwise. I am inclined to believe that it is the ancient pronunciation of the Germans, which was introduced into England by the Anglo-Saxons, and has been preserved to this time.

THIRD VOCAL SOUND.

*AIRISH.**

This sound when long is represented

1. By *a*, in hare, mare, care.
2. By *ai*, in hair, fair, stairs.
3. By *ay*, in Mayor.
4. By *ea*, in pear, bear.
5. By *ei*, in heir.

And when short

1. By *e*, in very, merry, where, there.
2. By *ea*, in leather, feather, measure.

FOURTH VOCAL SOUND.

AZIM.

This sound when long is represented

1. By *a*, in grace, fame, name, tame.
2. By *ae*, in Maese, (proper name of a river.)
3. By *ai*, in maid, paid, laid.
4. By *ao*, in gaol.
5. By *ay*, in pay, say, taylor.
6. By *e*, in some foreign words, as eleve, manege.

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* There is a real difference between the two sounds which I call *Arpeth* and *Airish*, though some have confounded them together as if they were the same; a Frenchman will hardly be persuaded that they are different sounds, he will call *airish* an *e* ouvert, and *arpeth*, an *e* plus ouvert. The Virginians in almost every case employ the sound of *Arpeth*, instead of *Airish*, as in *there*, *where*, *stairs*, which they pronounce as if they were written *thahr*, *whahr*, *stahrs*. This vicious pronunciation is striking to those who are not accustomed to it, and shews the essential difference which exists between the two sounds. In fact, the scale of the English vowels is truly chromatic, and requires more nice and delicate attention in order to the correct pronunciation of its various tones, than the more diatonic scales of other nations.

7. By *ea*, in great, break.
8. By *ei*, in vein, feint.
9. By *eig*, in reign, feign.
10. By *ey*, in whey.

And when short

1. By *a*, in surface, desperate, agreeable.
2. By *æ*, in Dædalus, (proper name.)
3. By *ai*, in again, captain.
4. By *e*, in bet, met, tell, sell.
5. By *ea*, in head, bread, stead.
6. By *eg*, in phlegm.
7. By *ei*, in heifer.
8. By *eig*, in foreign, foreigner.
9. By *eo*, in leopard, feoffment, jeopardy.
10. By *ie*, in friend.
11. By *u*, in bu~~s~~y, burial. / r

FIFTH VOCAL SOUND.

ELIM.

When long is represented

1. By *æ*, in Æsop, Cæsar, (proper names.)
2. By *ai*, in raisin.
3. By *e*, in scene, mere, mete.
4. By *ea*, in sea, speak, squeak, quean.
5. By *ee*, in Greece, breeze, queen.
6. By *eg*, in impregn.
7. By *ei*, in seize, deceit, conceive.
8. By *eo*, in people.
9. By *ey*, in key.
10. By *i*, in mise, (law term,) chemise, voir dire, (law term.)
11. By *œ*, in Œdipus, (proper name) œconomy.

When short

1. By *ai*, in villain.
2. By *e*, in simile, catastrophe.

3. By *ea*, in guinea.
4. By *ee*, in committee.
5. By *ei*, in surfeit.
6. By *i*, in it, bit, Italy, stingy.
7. By *oy*, in buoy, (pronounced *booey*.)
8. By *u*, in busy, business.
9. By *ui*, in build, built.
10. By *y*, in very, verily, mystery.
11. By ie, in Sieve,

SIXTH VOCAL SOUND.

OREB.

When long is represented

1. By *eau*, in beau.
2. By *eaux*, in Bordeaux (proper name.)
3. By *ew*, in sew.
4. By *eo*, in yeoman.
5. By *o*, in robe, oval.
6. By *oa*, in groan, boat.
7. By *oe*, in doe, roe.
8. By *oh*, in oh! (interj.)
9. By *ol*, in yolk.
10. By *oo*, in door, floor.
11. By *ot*, in depot, entrepot.
12. By *ou*, in mould, soul.
13. By *ow*, in flow, row, blow.
14. By *owe*, in owe, Rowe, (proper name.)
15. By *ough*, in dough.

And when short

1. By *o*, in done, son, above, love.
2. By *oo*, in flood, blood.
3. By *ou*, in rough, tough, covetous, righteous.
4. By *ow*, in narrow, fellow.
5. By *u*, in sun, dun, dull, but, mud.

SEVENTH VOCAL SOUND.

OOMIN.

When long is represented
1. By *eo*, in galleon.
2. By *ew*, in view.
3. By *w*, in new, few.
4. By *o*, in move, prove.
5. By *oe*, in shoe.
6. By *œu*, in manœuvre.
7. By *oo*, in fool, pool.
8. By *ou*, in amour, tour.
9. By *ough*, in through.
10. By *u*, in rule.
11. By *ue*, in rue, accrue.
12. By *ui*, in suit, fruit.

And when short
1. By *au*, in beauty.
2. By *o*, in wolf.
3. By *oo*, in hoof, cook, foot.
4. By *u*, in bull, pull.
5. By *ue*, in construe, construed.

II. NASAL SOUNDS.

These are modifications of pure vocal sounds which are uttered as it were through the nose, as in *ang*, *eng*, *ing*, *ank*, *ink*.

In English and French the nasal sound of a vowel is indicated by placing the consonant *n* immediately after it. The French nasal sounds are more pure than those of the English language, which being invariably followed by one or other of the hard consonants *g* and *k*, have mixed with them so as to form as it were but one sound. The pure nasal sounds are never found alone in English, as in the French words *mon, ton, son*, so that it is difficult for an Englishman to pronounce these words without the twang of the *g*, as if they were written *mong, tong, song*. Yet these pure nasal sounds are not the less component parts of the English language, and analytically speaking, should be considered apart from the consonant mixture.

The vocal sounds which in the English language take the nasal modification, are *Aulif, Arpeth, Elim* and *Oreb*. I know of no language in which *Airish* and *Azim*, receive a nasal sound; *Oomin*, however, has it in German, as in *uebung, beschreibung*, &c.

These various nasal sounds are represented to the eye in the English language, as follows:

1. The nasal sound of *Aulif*, is represented by *on*, as in *long, song*, ~~*among*,~~ along.

2. The nasal sound of *Arpeth*, is represented by *an*, as in *lank, thank, sang, mangle.*

3. The nasal sound of *Elim*, is represented by *in*, as in *ink, think, ring, thing*, or by *en*, as in the word *English.*

4. The nasal sound of *Oreb* is represented by *un*, as in *sunk, clung*, or by *on*, as in *monk*, among.

In a Phonological Alphabet, a sign or mark under each nasalised vowel, will be sufficient to represent these modifications of sound. They need no other appropriate characters.

III. DIPHTHONGAL SOUNDS.

I call diphthongal sounds, those which are composed of two vocals, rapidly pronounced in succession, so as to form but one syllable. I do not include those in which the first vocal has a consonant or organic character, as *y* and *w*.

There are four diphthongal sounds in the English language.

The first is compounded of *Aulif* and *Elim*, and is represented by *oi* or *oy*, as in *oil*, *boil*, *cloy*, *toy*, &c.

The second is compounded of *Arpeth* and *Elim*, and is represented by *i*, *ie*, *y*, *ye*, *igh*, as in *mile*, *die*, *tyrant*, *dye*, *high*.

The third is formed by *Arpeth*, compounded with *Oomin;* it is represented to the eye in our orthography by *ou*, *ow*, and *ough*, as in *foul*, *fowl*, *bough*.

When I say that *Arpeth* enters into the composition of the second and third diphthongal sounds, I am not, perhaps, perfectly correct; I rather think that it is a middle sound between *Arpeth* and *Aulif*, no other in fact than that of the French *a*, which is not, as I have said before, to be found singly in our language. But, however sensible I am of this distinction, I am obliged to reject it, as too nice in practice. I shall merely observe, that in these diphthongs, the sound of *Arpeth* should be given as full and broad as possible, without falling into *Aulif*. The people of Connecticut, and of the Eastern States generally, pronounce the third diphthongal sound by *Airish*, and are remarked for this singularity.

The fourth diphthongal sound of the English language is that which is usually represented by the vowel *u*, as in *pure*, *endure*, *usage*, &c. It is a truly national sound, which probably was introduced into the language during the Norman reigns, by an abortive imitation of the pronunciation of the French *u*.

It is not a clear and distinct succession of fully articulated sounds, as in the pronoun *you;* there is something in it more slurred, more delicate, which brings it nearer to a pure vocal sound. I am told that in some of the English provinces, it is pronounced exactly like the French *u*, and, of course, is there a pure vocal articulation. But according to its most generally received pronunciation, it is more properly a diphthong compounded of *Elim* and *Oomin*, delicately pronounced and slurred through in a particular manner, an adequate conception of which can only be conveyed through the ear.

To each of these diphthongal sounds a particular character should be affixed in order to preserve and indicate their monosyllabic character.

IV. ORGANIC SOUNDS.

The organic sounds which enter into the composition of the English language are sixteen, and are divided into classes denominated from the organs of speech that are principally employed in their utterance.

1. There are three labials, which I call *bee*, *pen*, *mem*.

BEE is represented in the English alphabet

1. By *b*, in *bed*, *bake*, *bend*.
2. By *bb*, in *robber*.
3. By *be*, in *robe*.

PEN is represented

1. By *p*, in *pain*, *pole*, *pass*.
2. By *pe*, in *pope*, *mope*.
3. By *pp*, in *happen*.

MEM is represented

1. By *m*, in *man, mild, move.*
2. By *mb*, in *comb.*
3. By *me*, in *Rome, come.*
4. By *mm*, in *summer.*
5. By *mn*, in *condemn.*

2. Two Labio-dentals, *vel* and *fesh.*

VEL is represented

1. By *v*, in *vile, vain, ever.*
2. By *ve*, in *love, move.*

FESH is represented

1. By *f*, in *fair, fine, force.*
2. By *fe*, in *strife.*
3. By *ff*, in *off, scoff.*
4. By *gh*, in *rough, tough.*

3. Two gutturals, *go* and *coss.*

GO is represented

1. By *g*, in *God.*
2. By *gg*, in *stagger, swagger.*
3. By *gh*, in *Ghent* (proper name.)
4. By *gu*, in *guile.*
5. By *gue*, in *rogue.*

COSS is represented

1. By *c*, in *call, constant, coward.*
2. By *cc*, in *occur, occasion.*
3. By *ck*, in *lick, stick.*
4. By *cke*, in *Locke* (proper name.)
5. By *ch*, in *chord.*

6. By *k*, in *sink*, *wink*.
7. By *ke*, in *make*, *take*.
8. By *que*,* in *oblique*, *risque*.

These two organics have a hard and a soft sound, the former of which takes place when they immediately precede broad or open vocals, as in *call*, *God*, and the latter when they precede acute ones as in *gain*, *king*.

4. Four linguals, *zhim*, *shal*, *zed*, and *sin*.

ZHIM is always in English represented by the letter *S*, as in *measure*, *treasure*, *occasion*, *vision*.

SHAL is generally represented by *sh*, as in *she*, *wish*, *dash*, &c. It is also represented by *c*, as in vicious; by *s*, as in *sure*, *sugar;* by *sc*, as in *conscious;* by *ss*, as in *Russian*, *Prussian*,† and by *t*, as in *mention*, *friction*, *oration*. Also by *ch*, in *chaise*, and in the proper name *Charlotte*.

ZED is represented by *z*, as in *size*, *zeal;* by *zz*, as in *dizzy*, and by *s*, as in *ease*.

SIN is represented by *c*, as in *certain*, *civil;* by *s*, as in *sore*, *sir*, *sweet;* by *sc*, as in *science;* by *sch*, as in *schism*, and by *ss*, as in *hiss*, *miss*.

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* As in the English language the *e* mute joined to *a* consonant, does not alter its sound, I do not think it necessary to instance further its combinations, which are known to take place with all organic characters, and may be added to the examples given.

† Pronounced *Rush-yan*, *Prush-yan*, and not *Rush-an*, *Prush-an*.

5. Three linguo-palatals, *lamed*, *ro*, *nim*.

LAMED is represented by *l*, as in *lamb*, *line*, *long*, or by *ll*, as in *all*, *fall*, *still*.

RO is represented by *r*, as in *ring*, *round*, *Rome*, or by *rr*, as in *horror*, *terror*. In foreign words and technical terms of foreign derivation it is sometimes represented by *rh*, as in *Rhine*, *Rhodes*, *rhomboid*, and sometimes by *rrh*, as in *catarrh*.

NIM is represented by *n*, as in *now*, *nun*, *next*, or by *nn*, as in *manner*, *banner*.

6. Four linguo-dentals, as *delta*, *tar*, *thick*, *thence*.

DELTA is represented by *d* or *dd*, as in *do*, *die*, *mode*, *add*, *addition;* and in a few instances by *th*, as in *burthen*, *murther*, better spelt according to Walker, *burden*, *murder*.

TAR is represented by *t*, or *tt*, as in *title*, *tone*, *matter*, *butter*, and in a few proper names by *th*, as in *Thomas*, *Thames*.

THICK and **THENCE** are always represented by *th*, the former as in *throne*, *thunder*, the latter as in *soothe*, *bathe*, *rather*, *further*.

7. Two vocals, *yes* and *war*.

YES is always represented by *y*, as in *yoke*, *yield*, *your*.

WAR is always represented by *w*, as in *wake*, *west*, *wind*, *wood*.

These two sounds belong alike to the class of vocals and to that of organics, as they may be employed in either way. It seems therefore proper that they should have different names and different signs to represent their vocal and organic characters. In the German language the vowel *i* when employed as a consonant is represented by *j*, and called *jod*. pronounced *yod*. Thus they write *Ja*, *Jeder*, *Jemand*, and not *Ia*, *Ieder*, *Iemand*. For the same reason we make use of *y* and not of *i* or *e*, in *yes*, *yard*, *young*.

V. ASPIRATIONS.

I have nothing to add to what I have already said on this subject.

Thus I have attempted a brief analysis of the various sounds which enter into the composition of the English language. Conceiving it necessary to distinguish them by proper names, I have given them the first that have occurred, taking care only that they should be so different as not to be easily confounded with each other. Names are of very little consequence; if this analysis should be approved of, and this plan thought worthy of being pursued, it will be easy to invent and apply to the different sounds new denominations in which a greater regard may be paid to euphony and other necessary circumstances than I have thought it worth while to do in this essay, which I present, as I have already observed, as a mere sketch.

Neither have I thought it necessary at present to affix signs or characters to the different sounds. This may easily be done when this or a better analysis shall have received the sanction of the learned. I would merely recommend that the written alphabet should neither be composed of the characters in common use nor of entire new signs. A Phonological

Alphabet ought, in my opinion, to be such as to be easily distinguished from the common one, and at the same time not difficult to be understood or retained in the memory. Therefore I would propose to take the Greek alphabet as the basis, with the addition of characters borrowed from other languages, particularly the Russian, which in the form of the letters present the greatest analogy with the Hellenic. As this alphabet would only be used for purposes of demonstration and comparison, in pronouncing dictionaries and other philological works, there would be no need of various forms of characters, such as our capital and small letters, our Roman and Italic. The small Greek alphabet with suitable additions and variations would be sufficient. This is, however, a point of minor importance; the great object to be sought after is a clear and correct analysis and description of the sounds; when that is once obtained, proper names and signs may easily be affixed to them, and will, in a manner, follow of course.

No. XVIII.

On Fossil Reliquia of unknown Vegetables in the Coal Strata.
By the Rev. Henry Steinhauer.

FOSSIL reliquia of the vegetable kingdom may be conveniently arranged under the four classes of fossil wood (Lithoxylon), fossil fruits (Lithocarpi), fossil leaves (Lithophylli), perhaps also fossil flowers, if such really occur, as has been asserted at Oeningen, and indeterminate reliquia.* The two

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* If a fossil reliquium present the form of a fructification or flower, it may be looked upon as determinate, for these parts of the plant contain a distinctive character different from similar parts in other species or at least genera; and are constant to their figure and appearance in every individual of the same species. The impressions of leaves exhibiting their organization are in like manner generally perfectly distinctive, as they determine the species in most instances, and though the genus is not ascertained from them in the Linnean system, yet there is reason to believe that if our knowledge were sufficiently extensive, detailed and precise, we should find the characteristics of every natural genus, or at any rate of every natural family in the leaf as well as in the parts of fructification. The texture of wood, where this is perfectly discernible in a specimen, satisfactorily establishes identity of species, as we are well able to distinguish between the different kinds of wood in general use, and would, were our observations properly applied, be equally able to discover a difference between that of any two trees in the vegetable kingdom. But this does not seem to be the case where we have only external form, for then is the vegetable itself no longer impregnated, bitumenized, or petrified, but a mere representation in which distinctive characteristics may be altogether wanting. We are therefore left to grope our way among a multitude of specimens, classing together such as are simi-

latter of these divisions belong almost exclusively to the carboniferous strata, though a solitary instance of a fossil fern in the white Lias, one of the lower floetz strata has come to our knowledge, while the two former are sufficiently abundant in many other strata, but very rarely occur in these. Mr. Martin figures some pericarpial remains, which appear to place the matter beyond doubt, that they are found in the coal Sandstone, but we have never been fortunate enough to meet with any, though often deceived by accounts of such, which upon examination proved to be mere fortuitous configurations of argillaceous iron ore. Fossil wood, that is, such as preserves the appearance of its original texture, and not merely the external shape, is also certainly of very rare occurrence in the coal strata, though carbon evidently originating from vegetable matter is extremely frequent. The fossil leaves which have been found in the class of strata or formation just mentioned, are well known to be closely analogous to the family, though different from the recent species of filices, with some few species of verticillate plants, which have been perhaps too precipitately referred to the genera Rubia and Galium. Their variety and extreme elegance early attracted the attention of naturalists. Scheuchzer paid considerable attention to them as appears from his Herbarium Diluvianum, which also serves as an index to his predecessors, and the subject is judiciously resumed by Mr. Parkinson in the first volume of his Organic Remains. Woodward, in his catalogue enumerates several specimens belonging to this division. Luid has a chapter on the subject and figures a few, and from him we learn that Dr. Richardson, of Bierly Hall, in Yorkshire, took considerable pains to investigate these reliquia, so abundant in the immediate neighbourhood of his residence. It is to be

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lar, tracing gradations, seeking for analogues and at last often separating what belongs together, and joining incongruities. In such a labyrinth, to err is excusable, for rare indeed is that combination of talent for observation to see every thing, ingenuity of reason to see nothing in vain, and candour of mind to advance no hypothesis but what is supported by arguments founded on observation, which alone can afford a clue to extrioate the wanderer.

regretted that we are not in possession of his entire observations, it appearing from the little which is before the public, that he was possessed of considerable ability; there is however reason to apprehend that neither his collection nor his manuscripts are any longer in existence. The most recent work on the subject that has come to our knowledge is "Von Schlottheim ueber die Pflanzen abdruecke."

Such as choose to pursue the subject farther, will probably be interested in knowing that though the nodules of iron-stone generally represent only a fragment of a leaf, yet specimens of argillaceous iron ore are found, but generally thrown into the heap as undeserving notice, exhibiting very perfect indications of the stems of these plants, which are the more valuable as in the impressions on coal Slate, *&c.* this part is much defaced by pressure. It is also worth observing, that filicites do sometimes occur on the coarse grained grit below the coal beds, in which case, at least in the specimens which we have seen, the substituted matter has been a yellow oxyd of iron, displaying the texture of the leaf very perfectly, whereas, in the nodules of iron-stone, the impression is generally tinged with carbon, attended by pyrites, and not unfrequently by Bitumen and minute crystals of cubic sulphuret of lead.

It is much to be wished that this interesting part of oryctology and botany, for which a considerable quantity of crude materials have already been collected, might soon be treated by some naturalist of competent abilities with the scientific precision of which it is both capable and deserving.

The class of reliquia to which this paper is devoted, may be defined to consist of such impressions, casts or petrefactions in the coal strata, as do not belong to the animal kingdom, yet discover no traces of organisation analogous to that of wood, fruits or leaves now known to exist. They are in fact the paradoxes of mineral botany; the hope to unriddle them seems still at a considerable distance, yet every additional observation draws the circle within which the solution lies, closer, and may thus in some degree facilitate the disclosure of the mysterious secret by the hand of future genius. To attempt a classification farther than by arranging them under the vegetable kingdom. would at present be more liable to lead to error than likely to answer any beneficial purpose. The discrimination of the different species and a correct detail of the peculiarities belonging to each, as far as they have met the eye of the writer, is all that is here aimed at.

Sp. I. PHYTOLITHUS *verrucosus.*

Plate IV. fig. 1, 2, 3, 4, 5, 6. *Martin, Petrificata Derbiensia, Plate* 11, 12 *and* 13*.—*Parkinson, Organic Remains, Vol. I. Plate III. fig.* 1.

The fossil which has received this name from the ingenious author of the Petrificata Derbiensia, is by far the most common, and perhaps the most remarkable of this class. Woodward seems already to have collected numerous specimens, notwithstanding their bulk and comparative unsightliness; (Catalogue of English Fossils, Vol. I. part 2, p. 104. Vol. II. p. 59, &c.) and Mr. Parkinson has exercised considerable though fruitless ingenuity, in elucidating them. It might appear presumptuous, after the labours of men of such distinguished abilities, to obtrude to public notice, any further remarks, had not these authors left abundant room for observation, which place of abode and inclination have enabled the writer to pursue during a series of several years. Within this period we have collected several hundred specimens, worked many from the bed of clay in which they were imbedded, and examined in quarries, on coalpit hills, among heaps of stone by the road side, and in various other situations, several thousand. The geological situation of this fossil is well known to be the coal strata, in almost all which, as far as the writer is enabled to judge, it is found. Its geographical habitats in these strata may be partly collected from the works already quoted, the specimens more immediately examined were found in the neighbourhood of Fulneck near

Leeds, or in the space included by the towns of Leeds, Otley. Bradford, Halifax, Huddersfield and Wakefield;* but have

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* This district is in fact the northern termination of the great continuous coal field of Yorkshire and Derbyshire, and through its whole extent is thickly beset with coalpits and quarries. I regret my inability to give a precise account of the various beds which occur, but those between Leeds and Bradford appear to be such as are immediately incumbent upon the grit; they consist of an alternation of yellow clay shale in various degrees of induration; argillaceous sandstone; the pale blue shale, or slate clay, accompanying the iron-stone and coal, which falls away on exposure to the air into stiff clay; the true black coal shale which on exposure shivers without becoming plastick; and coal, both the conchoidal and the brittle rhomboidal burning with flame. The argillaceous sandstone is very generally worked for building and mending the roads; a great number of the subsequent observations were made in these quarries, particularly in a very extensive one in the township of Pudsey which has been worked for above half a century, and furnishes many thousand tons of building stone, paving stone, and sandstone slate, annually. The bed of stone is of considerable thickness, probably above 40 feet. The upper stratum is a soft scaly sandstone which crumbles to fine sand on exposure to the air, and is frequently tinged yellow in various gradations by an impregnation of iron, it contains numerous indistinct impressions of vegetables in coaly matter, and has nodules which become apparent on the decay of the softer substances, consisting of a sandstone strongly impregnated with calcareous matter, so that the fracture in some directions appears sparry, and the mass effervesces with acids. I never saw traces of fossils in these nodules, which are a foot and upwards in diameter.

Beneath this stratum lies what is called by the workmen the rag, a grey sandstone possessing the properties of a freestone in cleaving, but of no great value on account of its softness, the numerous clayey blotches and black coaly spots which occur in it, and want of durability when exposed to the atmospheric influence. It contains numerous, and at times, very perfect fossil remains, also round bubbles sometimes empty, sometimes filled with ferrugineous sand. Under this the layers of wall stone, here called stone (which separates into laminae of two and a half or three inches and upwards, but not readily into thinner) the paving stone or flags, and the slate, differing in being more or less perfectly stratified, succeed. Mica is very abundant in small particles, particularly on the surfaces of the laminae. The stone is not got by blasting, but by clearing away the upper surface of a bed, and then applying wedges, and by taking advantage of the cracks which part the strata vertically into huge masses called *posts* by the workmen. In these parts of the stratum, fossils are seldom if ever found, it seeming as if the process of nature, which occasioned the laminated texture and rendered the mass so much more homogeneous and hard than the upper beds, entirely destroyed every trace of organised matter. It sometimes, but rarely happens, that the sides of the posts are united by calcareous spar, also found it on the top of Ingleborough, in the coal strata of Northumberland; abundantly in Derbyshire; at Dudley, in

and in one quarry the fissures were filled up by a fibrous deposition resembling sattin spar which had evidently exuded from the opposite sides, crystalised in spiculæ, and by accumulating, at last filled up the cavity.

In these beds of stone, the state of the siliceous and argillaceous matter, of which they principally consist is singularly different from what obtains in the grits and some of the fine sandstone. In the grit it is well known that the quartz appears in various sized rounded pebbles, cemented together by what is generally esteemed an argillaceous cement; in some of the fine sandstones it seems to be in the crystallised form, and to cohere by mere approximation of the particles. The grit wears down to round sand and gravel, and the sandstone mentioned to sharp sand. But the argillaceous sandstone of the coal strata, turns to a dust in which we believe it is impossible to distinguish the argil and silica. Is it not therefore probable that they exist in these beds in a state of chemical combination, and not mechanical mixture, as seems to have been hitherto supposed, and that the apparent sandy texture is owing to the crystalline formation of the particles? If this be admissible, the cement of the grindstones will also probably be found to consist of this micargillite substance, for which at all events, we stand in need of a distinct name, sandstone being highly improper, as it neither looks like sand, nor can be reduced to sand by any known process. Siliceous clay seems more suited to its nature, but we venture on no innovations.

The principal quarries of this species of stone, and which have furnished us with specimens are, besides Pudsey quarries, those at Stanningly producing a fine grained real sandstone; at Bramley, near Farnley, and several other places.

The iron stone in these strata, consists in general of a combination of argil and the oxyd of iron, in various proportions. It is generally found in nodules imbedded in shale, differing in size, form, colour and attendant fossils. The colour indeed changes very obviously on exposure to the oxygen of the air. Besides the fossils mentioned below, these nodules produce a considerable number of filicites, and some verticillate fossils, and two or three species of fossil Mytili and Myæ.

Within the cavities of these shells, sulphuret of zinc, and crystals of quarz tolerably regular and transparent are occasionally found. The ironstone has been dug, particularly on Wibsey Low, and Upper Moor, and north westward towards Bradford, in which places there is a great succession of beds.

Sometimes, particularly in the neighbourhood of coal seams, the iron is combined with sulphur in the form of pyrites, (the *brasses* of the colliers) which occasionally forms the substance of organic remains.

Among the number of coal shales there is one which distinguishes itself by many peculiarities, and particularly by the fossils which it contains, on which account we shall endeavour to describe it, though it has not furnished any vegetable reliquia as far as we have been able to discover. The

Shropshire, and in the neighbourhood of Bristol. With respect to mineralogical constituent matter, it seems always to coincide with that of the stratum in which it is imbedded, with a slight modification of density. It is most abundant in the fine grained siliceous stone, provincially called *Calliard* and *Gannister*, and in some of the coal *Binds*, or *Crowstones*, which have probably received this appellation from spots of bitumen or coal attached to these petrifactions. It is rather less frequent in the beds of scaly clay, or clay mixed with siliceous sand and mica; very common but completely compressed in the coal shales or bituminous slate clay; of occasional occurrence in the argillaceous iron stone; not rare in the common grit, and upper thick beds of argillaceo-micaceous sandstone or *rag*, and sometimes, though rarely, discoverable in the coal itself. Mr. White Watson, of Bakewell, had also in his collection which we examined, a specimen in the Derbyshire Toadstone or Trap, and we have also noticed it in the limestone behind the Bristol hot wells, at its junction with the sandstone. So immense, however, is the number of relics, that when the eye has been accustomed to catch their appearance, it is scarcely possible to walk a furlong in the districts where they are at home, without meeting them in one shape or ano-

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places where it has been met with in seeking coal are about two miles north of Halifax on the Bradford road, and I believe to a considerable distance to the east of this spot; at Idle, north of Bradford, and thence in an easterly direction to Coalhill near Stanningly, on the river Air. When first dug it is very similar to the common black coalshale, but on being exposed to the air, swells, the laminae being forced asunder by small crystals of selenite, which seem to be formed during the process of decomposition, by an union of the sulphuric acid and the calcareous earth with which it abounds. At Idle the bed contains a thin layer of long narrow crystals of selenite, which have an elegant appearance on the black ground. This bed of shale contains besides, nodules resembling those of ironstone, of hard black limestone, sufficiently abundant in some places to be used for lime, but generally attended by pyrites, and instead of the usual fresh water shells, we here meet with the Anomia Pecten, the Nautilus Listeri, an Orthoceratite, and probably some other marine productions in considerable abundance, indeed so much so, that the shale is sometimes quite covered with their impressions. The importance of the fact of a marine stratum interposed amidst a succession which is only attributable to fresh water, must immediately strike the geologist.

ther. The most perfect form in which this fossil occurs, is that of a cylinder more or less compressed, and generally flatter on one side than the other, (Plate IV. fig. 1 and 2.) Not unfrequently the flattened side turns in so as to form a groove. The surface is marked in quincuncial order with pustules, or rather depressed areolæ, with a rising in the middle, in the centre of which rising, a minute speck is often observable.* From different modes and degrees of compression, and probably from different states of the original vegetable, these areolæ assume very different appearances, sometimes running into indistinct rimae, like the bark of an aged willow, sometimes as in the shale impressions, exhibiting little more than a neat sketch of the concentric circles. (Fig. 4, 5, 6.) Mr. Martin suspected that these pustules were the marks of the attachment of the peduncules of leaves, and Tab. XII.* represents a specimen in which he thought that he had discovered the reliquia of the leaves themselves. We have examined the specimen whence the drawing, which is extremely correct, was made, but are convinced that Mr. Martin was misled by an accidental compression, in describing these leaves as being flat. Numerous specimens in gannister, in which the lateral compression of the trunk is generally trifling, place the assertion beyond a doubt, that the fibrous processes, acini, spines, or whatever else they may be called, are cylindrical, and small fragments of these cylinders shew distinctly a central line (pith?) coinciding with the point in the centre of the pustule. Convinced of the existence of these fibres, we were soon able to detect their remains, forming considerable masses of stone, particularly of coal Bind on Wibsey Slack, and at Lower Wyke, where their contorted figure imitates the figures of Serpulæ, but it excited much surprise on examining the projecting ends of some trunks which lay horizontally in a bed of clay, extending along the southern bank of the rivulet which separates the townships

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* Mr. Martin terms these spots verrucæ, but whether they will strictly admit of the appellation seems doubtful.

of Pudsey and Tong, and which is exposed by slips in several places, to find traces of these fibres proceeding from the central cylinder, in rays through the stratum in every direction to the distance of above twenty feet. Repeated observations, and the concurrent conviction of unprejudiced persons made attentive to the phenomenon, compelled the belief that they originally belonged to the trunks in question, and consequently that the vegetable grew in its present horizontal position, at a time that the stratum was in a state capable of supporting its vegetation, and shot out its fibres in every direction through the then yielding mud. For if it grew erect, even admitting the fibres to have been as rigid as the firmest spines with which we are acquainted, it would be difficult to devise means gentle enough to bring it into a recumbent posture without deranging their position. This supposition gains strength from the circumstance that they are found lying in all directions across one another, and not directed towards any particular point of the compass.

The flattened and sometimes grooved form of one side of the cylinder has already been noticed. Woodward already observed, that along this side there generally, or at least frequently, ran an included cylinder, which at one extremity of the specimen would approach the outside so as almost to leave the trunk, while at the other it seemed nearly central. A reference to his Catalogue, Vol. I. part 2, p. 104, to Mr. Parkinson's Organic Remains, Vol. I. p. 427, and to Martin's Petrificata Derbiensia, l. c. will show how much this included cylinder has embarrassed those who have considered it with a view to the vegetable organ to which it owes its origin. In the specimens in Calliard which have suffered little compression, but which are seldom above a few inches in length, this body is generally nearly central; perhaps in no instance perfectly lateral. In the specimens in clay, from one of which we were able to detach upwards of six feet, the flattened or grooved side is invariably downward, and consequently the included cylinder in the position which it would assume if it had subsided at one end, while the other was supported, or which would be the result of its sinking through a medium of nearly the same specific gravity with itself, provided it was at one end rather denser than at the other. It must be observed, that this included body appears to have suffered various degrees of compression, being sometimes cylindrical, which was evidently its original form, and sometimes almost entirely flattened; in the coal shale we were never able to detect a trace of its existence.

Besides these indications of organisation, we have met with several specimens which, on being longitudinally split, discovered marks of perforations or fibres, more or less parallel with the axis of the cylinder, and in some degree resembling the perforations of Terebellae in the fossil wood of Highgate and some other places. Whether these configurations be owing to the organisation of the original vegetable, or to some process which it underwent during its decay, seems impossible to determine; the specimens examined afforded no opportunity of discovering a connexion between these tubes and either the internal cylinders, or the external surface.

Among the vast number of specimens examined, only one was detected, which appeared to terminate, closing from a thickness of three inches to an obtuse point. We have given a figure of it, Plate IV. fig. 3. Two instances also came to our knowledge, of branched specimens, in which the trunk divided into two nearly equal branches. So rare an occurrence of this circumstance would however, rather induce the supposition that the original was properly simple, and that these were only exceptions or monstrosities. The size of different specimens varies greatly, but we have seen none under two inches in diameter; the general size is three or four, and some occur, but with very indistinct traces of the pustules, even 12 inches across.

From the above it appears rational to suppose, that the original was a cylindrical trunk or root growing in a direction nearly horizontal, in the soft mud at the bottom of fresh water lakes or seas, without branches, but sending out fibres from all sides. That it was furnished in the centre with a pith of a structure different from the surrounding wood or cellular substance, more dense and distinct at the older end of the plant, and more similar to the external substance towards the termination which continued to shoot. And perhaps, that besides this central pith, there were longitudinal fibres proceeding through the plant like those in the roots of Pteris aquilina. With respect to any stem arising from it, if a root, or foliage belonging to it, if a creeping trunk, we have hardly ground for a supposition.

If these points be assumed as ascertained, the manner in which the reliquia were formed is easily accounted for. Annual decay, or an accumulation of incumbent mud having deprived the trunk of the vegetating principle, the clay would be condensed by superior pressure around the dead plant so as to form a species of matrix; if this took place so rapidly that the mould had obtained a considerable degree of consistency before the texture of the vegetable was destroyed by putrefaction, the reliquium was cylindrical; if, on the contrary, the new formed stratum continued to subside, while the decomposition was going on, it became flattened, and the inferior part might even be raised up towards the yielding substance in the inside, so as to produce the groove or creest, as Woodward calls it, on the under side, in the same manner as the floor in coal works is apt to rise where the measures are soft, and the roof and sides have been secured. While the principal mass of the plant was reduced to a soft state, and gradually carried away or assimilated with mineral infiltrated matter, the central pith being unsupported, would sink towards the under side, and this the more sensibly where its texture was most distinct, while its anterior extremity would probably go into putrefaction with, and be lost in the more tender part of the plant. The mineral matter introduced would now form an envelope round the pith, where this resisted decomposition for a sufficient length of time, and when it was ultimately removed, if the surrounding mass was still sufficiently pervious, be also filled with argillaceous matter, or, if it was too much indurated, be left empty, which is the case occasionally. The epidermis or external integument of the vegetable, appears to have resisted decomposition the longest, as in many cases it has been preserved from putrefaction in the manner necessary to change it into coal; its place more frequently, however, is occupied by a ferruginous micaceous film. It therefore appears, that the original plants must have undergone a destruction by putrefaction, and the vacuities thus occasioned been very rapidly filled with mineral matter. This is evident from the reliquium in its present state exhibiting no minute traces of organisation, nor any signs of bitumenized vegetable matter so frequent in siliceous and opaline wood, except in the epidermis, and from the close similarity which this substance bears with that of the surrounding stratum; whereas in shells, &c. which have evidently undergone a very gradual lapidifying process, there is generally a very perceptible difference between the matter substituted and the surrounding mass.

Several conclusions interesting to the science of geology, will readily be drawn. The formation of these strata from the deposit of water is clearly ascertained, also that the argillaceous strata in question must have been when originally deposited of nearly the same thickness as they now are, as appears from the undisturbed position of the vegetables of which they were once the bed, and are now the tomb. On the other hand, the shale of coal or slate clay appears to have originated from a great number of successive depositions, which must have been of a very diluted consistence, when vegetation became extinct in the plants of which they now bear the impressions. All these strata must be supposed to have been successively at no great depth from the surface of the water resting upon them, that these plants might be supplied with air; and the situation in which they are found precludes the possibility of any motion of that sea sufficiently violent to disturb the bottom. The general diffusion of this and several of the following species, strongly suggests the belief that all the coal strata through which they are dispersed. owe their existence to a similar origin.

Sp. II. PHYLOLITHUS *sulcatus*, Plate V. Fig. 1 & 2.

Martin Petrif. Derb. Plates 8. 25. 26.—*Parkinson, Organic Remains, Vol. I. Plate III. Fig.* 3.—*Luid, Lithophyllacion Brit. Tab. V. Fig.* 184. 6.—*Scheuchzer, Herb. Diluv. Tab. IV. Fig.* 1.—*Volkammer, Siles. subterr. Tab. VII. Fig.* 7. *Tab. VIII. Fig.* 6.

Mr. Martin has described and figured this species under the names of Phytolithus sulciculmis and striaticulmis. The characters distinguishing these two varieties appear too vague, and too many intermediate gradations exist, to permit us to constitute two distinct species, and we are induced to depart from his names, as it is by no means ascertained that the original was, strictly speaking, a culmus. Mr. Parkinson, Mr. Luid and Scheuchzer's specimens were very imperfect. Its geographical habitat corresponds with that of the former species, but its geological situation appears rather to vary. We have found it in sandstone (argillaceous, the thick laminated upper bed of the quarry, called *rag*) and in ironstone abundantly, also not unfrequently in the coal shale, but have never been able to detect it in the coal, nor in the argillaceous beds which produce the former species so abundantly. Indeed, if it had existed in the latter, it is hardly possible that it could have escaped our notice; it seems also to be wholly absent from the Calliard. It must certainly be ranked among the fossils of more frequent occurrence, but as with the whole class, so with this species, fragments and traces are far more abundant than perfect specimens. On account of the peculiarity of its structure, very minute portions are recognised among the numerous specks of coaly impressions abounding in the rag, the greater part of which can be referred to no particular species, but it is more usual to find tolerably perfect specimens in iron stone.

The most perfect form in which we have met with it, is that of a gently tapering cone, ending in a somewhat obtuse point, divided into joints, and longitudinally striated, each stria having at the joint a protuberance indicating a fibre or leaf in the original. In a single specimen in standstone, represented in Plate V. fig. 2, traces of the whorls of leaves or fibres were very distinct, but only towards the termination of the plant. Da Costa mentions a specimen with a large bulbous root, but we have never been fortunate enough to meet with any thing to which that name was applicable.

The size, joints and striæ of this vegetable, to judge by its reliquia, must have been liable to the greatest variety, if we do not suppose that under a single name we in fact comprise a whole family of plants. The cylindrical or nearly cylindrical part of the trunk varies from one quarter of an inch in diameter to six or more inches, besides the accidental varieties from compression; the joints are sometimes at the distance of less than half a diameter, at others two or three diameters asunder; sometimes, they grow gradually closer and closer towards the end, at others a short joint is placed between two long ones. Some specimens are finely striated, others widely ribbed, and a few occur in which the projecting part between each sulcus has a finer line impressed along its course, so as to divide it in two. We have not met with more than about a dozen terminations, almost every one of which differs considerably from the other, but three in iron stone had the remarkable coincidence of being curved as if the original had withered, and the end been bent down by the weight of the leaves attached to it. If this was the case, we must suppose the prototype to have been of a very succulent nature. We have no grounds to imagine, that we ever detected this plant in the situation in which it originally grew, as was the case with the former, nor have we been able to discover any traces of internal organisation.

The original seems to have vegetated in an upright position, with a reeded, jointed trunk, surrounded at every joint towards the top with a whorl of leaves; from the manner in which its fragments are found, it appears either to have been hollow or to have had a brittle and probably elastic outer coat, which in many instances is converted into coal. The traces of the insertion of the peduncules of the leaves into the joints, is most visible in the ironstone specimens, (Plate V. fig. 1.) though we never could find any marks of the leaves themselves in that matrix. Frequently single joints are found, and called by the ironstone diggers, *cork stones;* often, however, several occur united, which break not across the joints, but in a sloping direction, owing to the texture of the stone. It is remarkable that cubic crystals of Galena (sulphuret of lead) are often discernible upon the ironstone in these reliquia, but never to our knowledge pyrites or sulphuret of zinc, which occasionally present themselves in the cavities of shells in the same strata.

We may safely assert that this species was not subaquatic, as, if this had been the case, we could hardly have failed to find it along with the former, whose reliquia are in so undisturbed a state.

Persons acquainted with the appearances of tropical vegetation have informed us, that some of the thicker specimens resemble the young shoots of the Surinam bamboo, when first appearing above ground.

Sp. III. **Phytolithus** *cancellatus.* Plate VI. Fig. 2, 3, 4, 5, 6.

Martin, Petrif. Derb. Plates 13. 50.—*Sowerby, British Mineralogy, Plates* 39, 40, 385.—*Da Costa, in Phil. Trans.*—*Parkinson, Organic Remains, Vol. I. Plate I. Fig.* 6. *Plate II. Fig.* 4.—*Volkmann, Silesia Subterr. Tab. VIII. Fig.* 10, 11, 12, 13.

This remarkable fossil appears to have been very generally confounded with others, some of which will be mentioned below, and which resemble it in exhibiting a cancellated appearance.

Mr. Parkinson united with it a fossil of a very distinct nature, Org. Rem. Vol. I. Plate IX, fig. 1. and Mr. Martin, though he points out Mr. P.'s error, is himself led into a mistake when he identifies it with the impression, Tab. 14.

The fact is, that there are not less than six (probably more) fossils of vegetable origin, occasionally occurring in the coal strata, all which, under certain circumstances, present a reticulated surface, and seem on this account to have been designated *squamata schemata*, by Dr. Richardson, (Luid. p. 111.) Blumenbach in his Handbuch, terms them paradoxical fossils, and notices their having been found in the Grisons, and in Scotland. All of them are found in the argillaceous ironstone, and some in the coal shale, but the species in question appears very frequently in the argillaceous sandstone, and occasionally in the coal.* The imperfect state of the various specimens render it almost impossible to give a description from any one, such as shew the habitus of the plant, being generally deficient in the marking; and such as have the marks in the highest perfection, generally displaying only a part of the cylinder. From the former we learn, that the original had a cylindrical trunk dividing not unfrequently into branches,

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* A specimen of this kind evidently gave rise to the story (afterwards retracted) of a fish found in coal. Parkinson, Vol. III. p. 250.

but not strictly dichotomising; was probably furnished with a cylindrical pith or central body which resisted putrefaction longer than the surrounding substance, and had its surface divided into rhomboidal projections the interstices between which form a kind of net work or lattice work, the longer diameter of the rhombs being parallel with the axis of the cylinder. From the fragments which exhibit the markings of these rhombs in the most distinct manner, we become acquainted with three distinct species of configuration, apparently arising from the epidermis, the inner bark, and the wood of the prototype; and which for convenience (though the supposition is still open to more close enquiry) we shall distinguish by the names of *epidermal*, *cortical* and *ligneous*.* In the *epidermal* appearance the rhombs are divided by lines forming a net work, so that the rhombs are quite approximate; these lines are not right lines, but waved in a manner which, as Mr. Parkinson observes, is extremely difficult to express by drawing, and which eludes description. From an examination of very perfect specimens belonging to this class, the marks upon the separate rhombs are found to be the following: the upper angle, for about one third of the vertical diameter, is elevated and rather rough with a depression in the centre. The lower side of this elevated triangle runs out in the middle in a ridge towards the lower corner of the rhomb; in the sinus formed by this ridge, and the lower ridge of the triangular elevation, there appears on each side an oval cicatrix, Plate VI. fig. 3.

Or thus: From the lower corner of the rhomb, a ridge runs in the direction of the longer diameter. When it has got somewhat beyond the centre, it divides into two arcs which go off towards the upper side of the rhomb. The space included between these arcs and the upper corner is elevated and rough, and has in the middle a depression, and in the sinus of the

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* We presume that ligneous may signify *belonging to wood*, as well as *made of wood.*

arches, where they leave the central ridge there is on each side an oval cicatrix. The configuration resembles that on the scales of the cones of some species of pine pretty closely at first sight, but seems much more analogous to those on some of the Cacti, as the cones of pines have neither the depression nor the cicatrices which in the Cacti might be occasioned by the aculei with which they are armed.

In the *cortical* appearance the lines between the rhombs are of some breadth, the ridge appears broader and less defined, and forms with the contracted superior elevation only one protuberance, in which the two cicatrices are perhaps never visible, and the central depression assumes the figure of a squamula. Mr. Martin's Plate XIV. seems to have been taken from a specimen of this kind; but it must be remarked that neither this nor the preceding class of appearances are often as distinct as described, the former being generally completely flattened so as to lose its relief, though it still retains traces of the various figures, and the latter degenerating into a mere central protuberance. Plate VI. fig. 4 and 5, represent the matrix and cast of part of a fine specimen of the cortical impression in sandstone. The ligneous appearance differs extremely from the two former, and only close observation enables us positively to assert that it originates from the same plant. The cancellated appearance is here entirely lost, the surface is slightly striated with a scarcely perceptible rising under the central ridge, and a minute but distinct raised dot in the place of the depression in the epidermis. It has all the appearance of the peeled stem of a plant which had been furnished with small branches or spines in quincuncial order. Plate VI. fig. 6. is part of a large specimen in ironstone, which was thickly enveloped with bituminous matter, the outer coat of which, and the matrix, exhibited the epidermal appearance.

From these three appearances, variously modified, the different aspects of this protean fossil may be explained. It frequently happens, that the cast and impression are from different integuments, the space separating them being occupied by carbonised or bitumenised vegetable matter. Thus in the most perfect specimen of the ligneous appearance which we have met with, and from which our figure is sketched, the impression was the epidermal; at other times the impression is epidermal and the cast cortical, and again not unfrequently both cast and impression epidermal, cortical or ligneous. The manner of accounting for these varieties is obvious, it only requires us to suppose the cast and the impression, or matrix, to have been formed, while part of these integuments were still in their natural state, which being thus inclosed was, afterwards, changed into bitumen or coal.

The appearance of some specimens seems strongly to suggest the idea that the bark was furnished or composed of strong longitudinal fibres, and almost all betray a tendency to be striated in a vertical direction.

The few specimens which exhibit traces of a pith, inform us that it also was very finely striated in a longitudinal direction, but afford no further information respecting the internal organisation of the original.

With respect to the singular, extremely beautiful, and regular markings of this fossil, their cause, use and nature appear to have been hitherto but little elucidated; from repeated and numerous observations we were led to believe that they could be no other than the cicatrices left by the fall of leaves or stipulæ, somewhat resembling those which may be observed on the stalk of the cultivated variety of the cabbage, or on pulling off the footstalks of the leaves of the Nymphæa from the root; with the difference that in the fossil these cicatrices are arranged close together, and that they are elongated in a direction parallel to the trunk. If this be supposed, the depression in the epidermal appearance, corresponding with the minute protuberance in the ligneous, probably indicated the woody fibre running along the midrib of the leaf from the wood of the trunk; the rough projection would be the part to which the vessels forming the upper plate of the leaf would be attached, the cicatrices on either side of the central ridge would mark the progress of air or sap vessels to the under plate of the leaf from the bark; and the spaces around or beside them. the attachment of two bundles of parenchyma abutting against the lower part of the petiole as is usually the case, and afterwards expanding so as to form the under surface of the leaf.

This solution still appears sufficiently natural, but a close examination of some of the genus Cactus, but particularly the Cerei, as hinted above, incline me to think that we shall ultimately find a pretty close analogue among them, in which a fibre or leaf will correspond with the upper depression, and a couple of aculei with the lower cicatrices. This will obviate the difficulty of supposing a plant so thickly beset with the petioles of leaves as to be totally covered by them; at the same time we must acknowledge that the manner in which our fossil sends off its branches, is wholly dissimilar to any of the Cacti we know.

The impressions of this vegetable in the different substances before mentioned, are often extremely beautiful, from the highly finished relief with which they are ornamented, those in shale are also of a neatness surpassing the most elegant productions of the graver, nor are those in the coarser matrix of argillaceous sandstone unsightly, being generally very perfectly marked by coal. The impressions in sandstone are generally much more perfect than the casts themselves, few of which exhibit the markings very distinctly.

The varieties of form and size in which these fossils occur, are very numerous. Those which exhibit the whole circumference of the cylinder* are generally about two and a half or three inches in diameter, and we have not seen a detached specimen above a foot or fifteen inches in length. Impressions considerably longer not unfrequently occur among the rubbish of stone quarries, but we could never obtain the entire

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* The compressed cylindrical specimens of vegetable fossils are seldom (we believe *never*) equally distinct all round, one side being generally more or less obliterated, and not unfrequently lost in the matrix, which is easily explained, if the substance was in a horizontal position when the petrefactive process took place.

casts. The flattened impressions in the coal shale are often considerably larger, one found at Shelf, near Bradford, containing near three square feet of surface. The size of the markings or rhombs also differ greatly; in some specimens in ironstone, they are scarcely one quarter in length, in others above an inch, and in one indistinct specimen in sandstone, a rhomb might be traced above three inches long.

The uncertainty involving this fossil is greatly increased by the scarceness of good cylindrical specimens, and the great varieties of shape which the fragments assume, perfectly flattened, compressed or beset in almost every direction, so that it is difficult to conceive how they could possibly originate from a cylindrical trunk; to which may be added, that the markings of the rhombs are always much more perfect in these fragments.

It may also be deserving of notice that the quantity of coaly matter attending these remains is, generally speaking, much greater than in the two former species, and sometimes forms a hard durable coat, though more frequently it crumbles away on being rubbed.

This species does not occur in the clay beds with the Phytolithus verrucosus, nor have we discovered it in Calliard; the specimens above alluded to in coal were no more than a trace of the rhomboidal configurations in a white matter, resembling a drawing with white lead on the surface of the coal.

Sp. III. Phytolithus *parmatus*, Plate VI. Fig. 1. and Plate VII. Fig. 1.

Grew. Mus. Tab. VII. 274? *(Scheuchzer, Herb. Diluv. p.* 119.*)*

With the exception of Grew, whose name is introduced only on the authority of Scheuchzer, this fossil appears to have escaped the notice of all former writers on petrifactions to whose works we have ever had access. It is possible that parts of it may have been mistaken for fragments of the last species, but the more complete specimens (and the best we have been able to obtain are very far from being as complete as those of the former reliquia) possess characters so strikingly singular as to distinguish them immediately from the whole class. The specimens which we have obtained have all been from the iron works at Low Moor and Shelf, both near Bradford; and the mass either the argillaceous ironstone, or the coal shale. We never have detected a trace in any other stratum, which probably would have been the case had it existed in them, though it certainly must have been a vegetable of much rarer occurrence, or much less capable of the petrefactive process than either of the former.

The specimens we have seen do not authorise us to assert that it is ever found in a cylindrical form, as they all present only an extended surface. However, such specimens of the former species are by far the most common, and yet its more perfect shape is undoubtedly cylindrical, this circumstance by no means implies that the reliquium in question may not have owed its origin to a vegetable that was also cylindrical.

The surface of this fossil presents an appearance in some degree resembling the last species, being also reticulated; but even these reticulations, on close examination, are wholly different; they are formed by projecting decussated lines, which thus include rhomboidal spaces, bearing none of the marks so interesting in the Phyt. cancellatus; but simple depressions. They also differ very perceptibly in being less than is generally the case in middle sized specimens of the latter.

But the most remarkable and inexplicable part of the organisation of this fossil consists in a series of circular or oval scutellæ or shields, placed close to each other in a right line across the surface. The various specimens hitherto met with having been merely fragments, and the difficulty of finding any thing analagous to these scutellæ in the vegetables of the present creation, render it unwarrantable to apply any appellation to them as gemmæ, buds, flowers, &c. which might lead to the conclusion, that their origin was ascertained; we are hitherto quite in the dark with respect to their nature, and could only offer the vaguest suppositions, notwithstanding considerable diligence was bestowed in the search after circumstances which might throw light upon them. It therefore only remains to describe them such as they appear, and to endeavour to reconcile their various appearances by the simplest conjectures we can form.

Three distinct kinds of appearances of this fossil have come under our notice, two of which from a degree of resemblance with appearances of the last species we may call the epidermal and ligneous. The third is widely different from any thing we have met with among these fossils, but easily accounted for by supposing projecting spines or fibres cut transversely at a distance from the vegetable, and leaving traces of their section on a plate of shale.

The *epidermal* appearance is that usually met with, in which the parmæ are surrounded by a raised margin; the included disk swells towards the central umbo or boss in curiously disposed rugæ, and the boss is generally more or less excavated in the centre. These configurations on the surface of the shields vary in almost every specimen, yet so that it is not difficult to trace their analogy, and the identity of the different marks. The raised margin is constant, and there is always a tendency of the other lines and protuberances towards the centre, not in the direction of the radii, but in a manner slightly resembling the figures on the back of an engine-turned watch-case, produced by describing several circles, whose centres are situate in the circumference of another circle round the middle of the plate. But the protuberances sometimes appear only as lines of projecting points, at others like continued ridges, and again as ridges indented into a series of projections, which are so placed as to give part of the disc a reticulated appearance; a precise idea, however, of the arrangement of these marks can hardly be formed but from an attentive examination of the specimens themselves, or their representations, when it will be found that notwithstanding their variety they are regulated by that law of order so universal in organised nature, which, while admitting infinite modifications, retains inviolate the characteristic principle. Plate VII. fig. 1. represents the largest and one of the most perfect specimens that we have met with. The specimen is in argillaceous iron ore from Shelf.

The series of parmæ is generally bounded on each side by a rather indistinct ridge, beyond which the surface has the recticulated appearance at first described.

The general shape of the parmæ does not much vary, except becoming oval from lateral compression, but the size is not constant, and it is remarkable, that while those in ironstone exceed two inches in diameter, those in the shale seldom arrive at one. Perhaps the consistence of the original was different at different stages of its growth, and consequently better suited for preservation in one medium at one time, and in another at a different.

To determine the number of parmæ which form a series, or how the series ends, is out of our power; we have observed six or seven in some specimens, but they were apparently equal in size, and there was no reason visible why the row should be nearer its termination at one end than another. The total appearance of the fossil has a curious resemblance to that of some of the Jungermaniæ preparing for fructification when highly magnified.

Of the *ligneous* appearance we have hitherto met with a single instance, but it is a comparatively perfect specimen, and very well defined, so that notwithstanding the wide difference of aspect, we do not hesitate to refer it to the same original. Plate VI. fig. 1. exhibits a representation of the concave part or matrix of this specimen.

The reticulated appearance is here wholly wanting; the surface has an appearance more resembling the bark of the beech, apparently indicating an organisation, the fibres of which are at right angles to the series of parmae. The rugae of the parmae are almost wholly obliterated, but the umbo is more decidedly and neatly marked. It forms a distinct flattened conical protuberance slightly furrowed and excavated at the apex. The margin continues distinct and raised. But the most singular circumstance attending this appearance of the fossil is, that no traces of organisation are visible which do not seem to be continued in the epidermal covering. Parallel with the series of parmae, and at no great distance from it, there is a narrow groove alternately shallower and deeper, from which at distinct intervals there appear to have issued minute fibres, if the cicatrices left will warrant the supposition. It must also be remarked, that this groove is to be traced only on one side of the fossil, but that it is again repeated at some distance.

The specimen in question is in ironstone, but of the size of those usually found in shale, and the surface is not flat, but curved in a direction perpendicular to the row of parmae. The *third appearance* alluded to above, consists merely of an elegant arrangement of minute points, issuing in curved lines from a centre, which we have once or twice met with in shale. The manner in which they are placed, seems sufficiently to indicate that it belongs to this species, and we should be apt to infer from this mode of appearance that in the original, fibres rose perpendicularly to the surface of what has furnished our fossils, from the protuberances on the parmae, transverse sections of which gave rise to the impressions in question.

The idea has suggested itself that the configurations on the parmae bear some resemblance to the arrangement of the fibres in the leaves of plants while still twisted together in the bud, as they appear on a transverse section, but the central umbo forbids our supposing them to have originated from mere buds, a circumstance indeed which their very position renders improbable. The fact seems to be, that we have no sufficient data to form any competent idea of the prototype.

The quantity of coaly matter accompanying this petrefaction, seems fully equal to that in the former species.

The above four species form by far the greater part of the fossil reliquia belonging to indeterminate vegetables occurring in the coal strata, which we have had an opportunity of examining. We have formed the description of them, not from solitary detached specimens, but, unless where the contrary is mentioned, from the observation of numbers, and can therefore lay them down with some degree of confidence. In the course of our enquiries it may be naturally supposed that various other specimens of different fossils fell into our hands, some of these possessed characters distinguishing them decidedly as particular species, but want of number prevents our tracing the boundaries within which their varieties may range; of the more remarkable of these we shall add a catalogue with such observations as we are enabled to make. Other fragments seemed apparently different from any of these species, but from our limited acquaintance with the varieties of the latter, or their imperfect state, would not warrant any decisive conclusion; and again, some of the species described by Da Costa, Mr. Parkinson and others have hitherto eluded our research, or are wholly wanting in the strata we had an opportunity of examining. Confident that it has not been the result of unwillingness to learn, we shall as little hesitate to acknowledge our ignorance as to communicate our experience.

Sp. V. Phytolithus *reticulatus.*

This species may perhaps ultimately prove to be the same with that last described, either in a different state, or from a different part of the plant. It is not altogether uncommon in the ironstone, and probably gives rise to some of the cancellated configurations on the coal shale. Its appearance is much like the reticulated part of the Ph. parmatus, but from our being uncertain which is matrix and which cast in the specimens we have obtained, we are at a loss whether to describe it as divided into rhomboidal cavities by projecting lines or as studded with protuberances, the interstices of which form a netted appearance. The former seems more probable from the circumstance that in what we esteem the most perfect species of this fossil the projecting lines seem in some degree to proceed from a ridge or midrib running across the surface.

Some specimens which we have seen are singularly bent, as if the articulations of the closed fist had been pressed into the substance, while soft.

All that we have hitherto met with have been in the black argillaceous ironstone, and had a coating of bituminous matter of considerable thickness and tenacity.

They were from Low Moor and Shelf.

Sp. VI. Phytolithus *Martini.*

On plate 14, of Mr. Martin's Petrif. Derb. fig. 2. there is a fragment of a rather large reticulated impression in an ironstone nodule; this we suspect, though not without much doubt and hesitation, to belong to a curious fossil, coinciding with the three former species in the cancellated surface, and which may perhaps be a variety or young specimen of Phyt. cancellatus; should it prove to be distinct, which we are inclined to think it is, we wish to distinguish it by the name of that diligent and accurate naturalist.

We have never, as far as we know and can recollect, been able to meet with the cast, though we have found several specimens of the matrix of this fossil in the brown argillaceous ironstone. The most perfect of these, shews distinctly that the original resembled the branch of a tree about an inch in diameter, nearly cylindrical and nearly straight, dividing into two in a mode apparently resembling the smaller branches of the Pinus picea. The surface appears to have been deeply and very distinctly cancellated, but as far as we can discover, without the central depression and cicatrices of Phytolithus cancellatus. The rhombs are also different in shape, the longer diameter being transverse, instead of parallel, with the axis of the cylinder. We cannot positively ascertain whether this matrix was left hollow, or whether (which is more probable) the substance of the vegetable was substituted by pyrites, which had fallen out before it came into our hands, but it shews the form of the original very completely, the whole circumference of the cylinders of both branches being complete for some length.*

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* This species seems to bear a superficial resemblance to that which Mr. Parkinson describes and figures. Org. Rem. Vol. I. p. 427, and Pl. IX. fig. 1. and which led him into error with respect to the origin of the Phytolithus cancellatus. We have frequently met with his fossil in nodules of ironstone, the place of the original vegetable being generally substituted by pyrites; impressions of it, or what we take to be such, also occur in the coal shale, but to an attentive observer, in possession of good specimens, there is little danger of confounding it with any of our species. The surface of Mr. Parkinson's fossil is evidently scaly, analogous to the cone of Pinus abies, the matrix generally insinuating itself beneath the projecting scales, so that parts are inevitably broken off in detaching the pyrites, which produces indeed a reticulated appearance, but by no means as perfect as in our species; in Phyt. Martini, the termination has not yet been met with, but it is probably very different from that of Mr. Parkinson, and it is hardly likely that its cast would present the radiated fibrous arrangements, visible

Sp. VII. PHYTOLITHUS *transversus.* Plate V. Fig. 3.

This very simple but perfectly distinct fossil seems hitherto to have escaped the notice of naturalists. We have obtained tolerably perfect specimens in sandstone, and have traced it in the ironstone. It appears to be a simple cylindrical trunk transversely closely striated, without any traces of leaves or fibres. All the specimens which we have found were considerably compressed, the longest about six inches long, and not quite a half inch broad, (in its flattened state) the broadest less than an inch in diameter. They were all equally thick at both ends, nor was there any indication whereby a guess could be formed, which was the upper and which the lower extremity, or whether it belonged to a horizontal creeping root. The general appearance was much like that of a very large earthworm. From the fineness of the striae or annuli, and these probably being only superficial, it is not unlikely that some of the indistinct cylindrical fossils, and other fragments discernible in the upper beds of argillaceous sandstone, may belong to this species.

Sp. VIII. PHYTOLITHUS *Dawsoni*, Plate I. Fig. 7.

From the kindness of Jos. Dawson, Esq. of Royd's Hall, near Bradford, one of the proprietors of the extensive iron works at Low Moor, I received a specimen exhibiting on one side a cast, and on the other an impression, in bitumen or coal, of a fossil which is evidently very distinct from any of the preceding.

in the latter. The latter is very decidedly the petrefaction of some part of fructification, if not the cone of a Pinus, which analogy prevents us supposing of the former on account of its being branched. We therefore think ourselves justified in omitting Mr. P.'s fossil in this catalogue, and including ours under the head of indeterminable species of vegetable fossils.

This fossil is longitudinally divided by pretty deep sulci into ribs of considerable breadth, which have been beset with fibres or leaves placed, so that the cicatrices or marks where the fibres left the wood in each rib alternate with those on the adjoining. It seems natural to suppose that the original was an upright cylindrical trunk, with foliage arranged in this manner, but the solitary specimen does not furnish us with means to determine how many series of leaves there were in the circumference, much less what their former texture may have been. The impression in coal has considerably larger ribs than the other, and lies on the under side of the thin plate forming the specimen in a different direction from the other. The substance appears to be the grey argillaceous coal shale.

In the possession of Mr. Salt, of Sheffield, was a fossil, allied to the former; it was a compressed cylinder, and very perfect on one side; the leaves were inserted in the manner above described, beneath each of the cicatrices was a slight protuberance, and the whole was faintly transversely striated. It was not divided into ribs by sulci like the preceding, though the marks of the petioles gave it a somewhat striped appearance.

Sp. IX. Phytolithus *notatus.* Plate VII. Fig. 3.

This species, which seems to be intermediate between Phytolithus Dawsoni, and Phytolithus tessellatus, we obtained from the coalpits of Dunkerton, Somersetshire. The mass is slate clay, invested on both sides with bitumenous matter, bearing longitudinal series of cicatrices, of a rounded pentagonal form, with a central mark; the series separated by very distinct sulci. Where the bituminous matter is removed, the slate clay itself exhibits a fibrous surface, no traces of the cicatrices, but under the central mark a projecting point. The latter appearance we suppose to be the ligneous, and that on the bitumen the epidermal impression. Parkinson, Org. Rem. Vol. I. Plate V. fig. 8, represents a somewhat similar fossil. The original of Phytolithus notatus must have been of considerable size, our specimen being seventeen inches long, and above nine broad, though imperfect on one edge; and the cicatrices do not sensibly vary in magnitude.

Sp. X. PHYTOLITHUS *tessellatus*, Plate VII. Fig. 2.

The solitary specimen here represented is ironstone from Shelf. Like the two former it is marked by longitudinal sulci, dividing it into ribs, which are again crossed by transverse separations, giving it a tessellated appearance.

Besides these species which may be looked upon as ascertained, though from a comparatively small number of specimens there are some which still involve considerable doubt. We shall only notice two. Of the first only a single decided specimen came to our view; its form was cylindrical, slightly bent, the surface in a very faint degree striated, but the whole surrounded by an unusual quantity of coaly matter. It is remarkable that the fossil itself was scarcely at all compressed, while the coal was very much so, presenting the appearance of a continued fin along either side. The specimen assists in elucidating a circumstance very frequently attending those petrefactions, in which part of the original vegetable matter is transformed into coal. In such fossils the cast is sometimes very neat and complete, as in the present instance, while the matrix on the contrary is very indistinct, at other times the cast is very obscure, while the matrix exhibits all the markings very neatly.* From these observations it would appear, that sometimes the cast set or hardened before the

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* This is very generally the case with the impressions and casts of Phytolithus cancellatus, in the argillaceous sandstone rag, and often occasions grievous disappointments in collecting.

matrix, sometimes the matrix before the cast, and that one or the other continued soft, after the vegetable matter had undergone that degree of liquefaction which must evidently have taken place before it was converted into the coaly substance which we now find. When on the contrary the vegetable matter assisted decomposition till both the cast and the matrix had become fixed, both must exhibit equally perfect traces of the original form, which is sometimes the case. It seems also impossible from the above, to imagine the operation of fire to have had any share in effecting any of these changes.

The second indistinct class of fossils which obtains very generally and exclusively in the sandstone, consists of broad stripes of carbonaceous matter pervading the rock, and leaving on the surface of the stone an impression resembling a leaf. They may perhaps, be owing to the remains of some cylindrical trunk, but from this never being found perfect, (except the last mentioned specimen be of this nature) and from their great size, this is hardly probable. We have found them above four feet in length, and eight broad, and bent into various portions of cylinders, indeed in some quarries there is scarcely a stone of the rag which does not contain a fragment. If they be supposed to be leaves, they are certainly very different from those linear leaves, whose impressions are not uncommon in the coal shale.

Thus far we have in some measure succeeded in unravelling the intricacies occasioned by these mysterious relics of a former creation. But still the numberless stains in the sandstones, the blotches which appear in splitting them, and the perforations and cavities which occur among them, are sufficient proofs that we are acquainted with only a small part of the vegetable riches of that world. To patient investigation, and the concurrence of favourable circumstances, we leave their consideration, with a wish that the few hints put down may encourage others to take up the subject—and proceed.

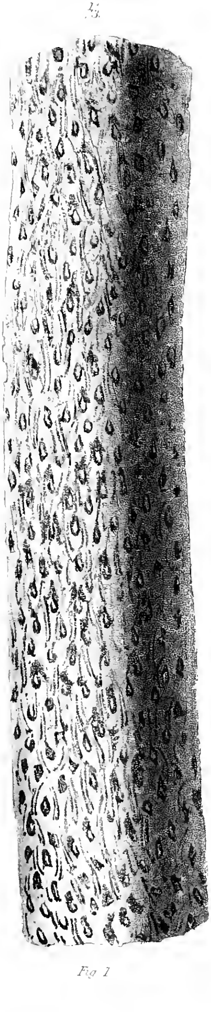

Fig 1

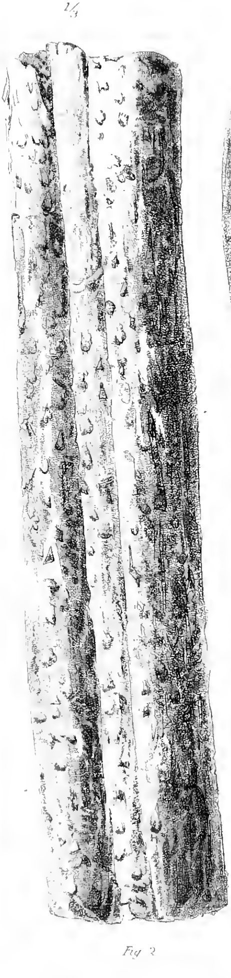

Fig 2

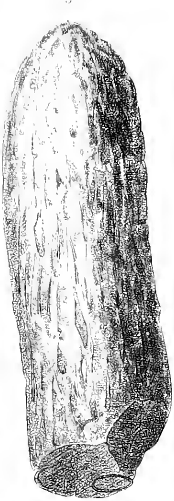

Fig 3.

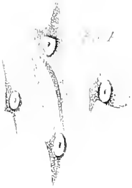

Fig 4

Fig 5

Fig 6

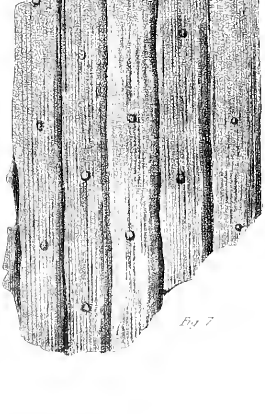

Fig 7

Eng. by J. Hill

PLATE V

Fig 1

Fig 2

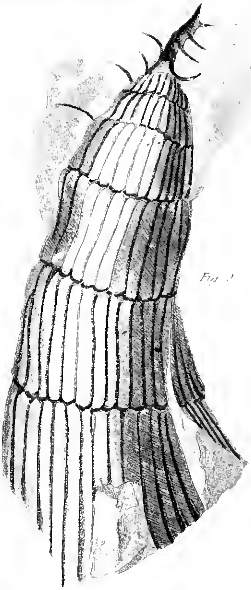

Fig 3

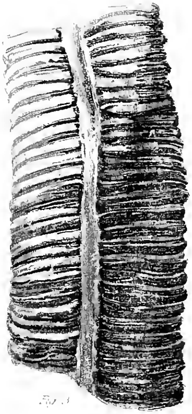

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Fig. 1.

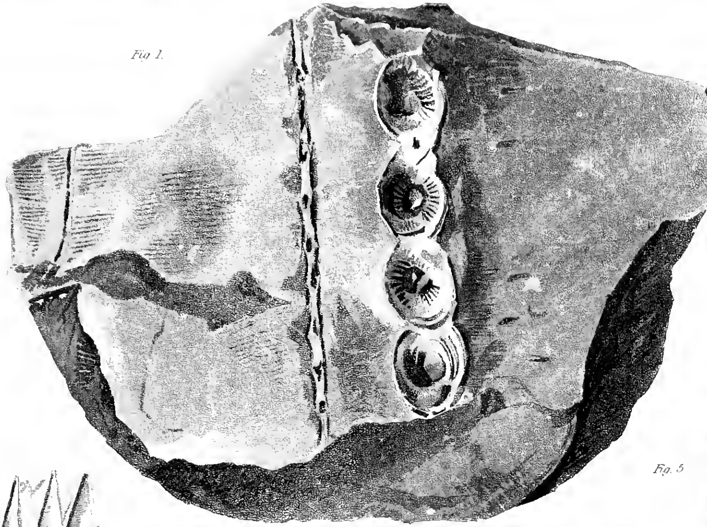


Fig. 5.

Fig. 4.

Fig. 3.

Fig. 2.

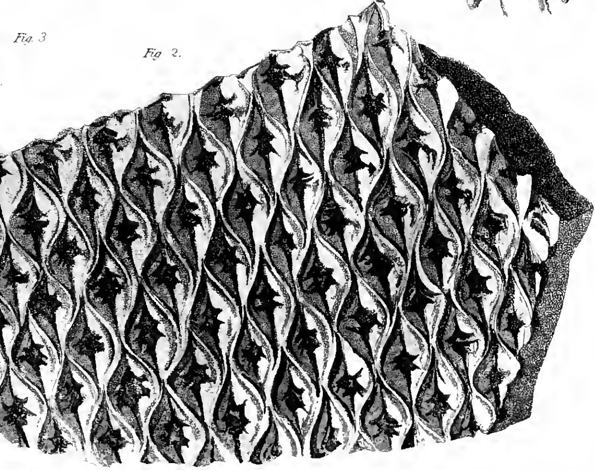
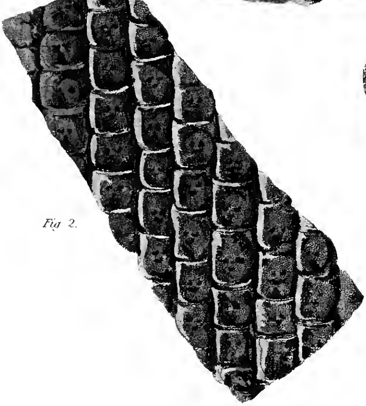


Fig. 6.

Engd by J Hill

Fig 1

Fig 2.



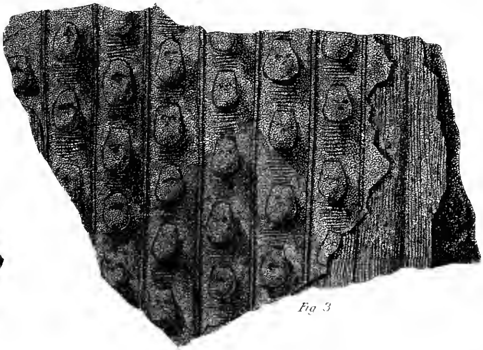


Fig 3

Eng.^{d} by J Hill

REFERENCE TO THE PLATES.

Plate IV. fig. 1 and 2. Upper and under sides of *Phytolithus verrucosus*.
fig. 3. Termination of *Phyt. verrucosus*.
fig. 4, 5 and 6. Different appearances of the areolae on *Ph. verrucosus*.
fig. 7. *Phytolithus Dawsonii*.

Plate V. fig. 1. Termination of *Phytolithus sulcatus*, in ironstone.
fig. 2. Termination of *Ph. sulcatus* with part of the matrix exhibiting the whorls of leaves, in sandstone.
fig. 3. *Phytolithus transversus*, in sandstone.

Plate VI. fig. 1. Ligneous impression of *Phytolithus parmatus*, being the concave matrix in ironstone.
fig. 2. Fragment of *Phytolithus cancellatus*, the epidermal impression exhibited by the concave matrix in ironstone.
fig. 3. Single rhomb of a very perfect specimen of *Ph. cancellatus*, in ironstone.
fig. 4 and 5. Fragments of the cortical impression, both matrix and cast of *Phyt. cancellatus*, in sandstone.
fig. 6. Ligneous impression of *Ph. cancellatus*, in ironstone.

Plate VII. fig. 1. Epidermal impression of *Phytolithus parmatus* in ironstone.
fig. 2. *Phytolithus tessellatus*, in ironstone.
fig. 3. *Phytolithus notatus*, in slate clay.

No. XIX.

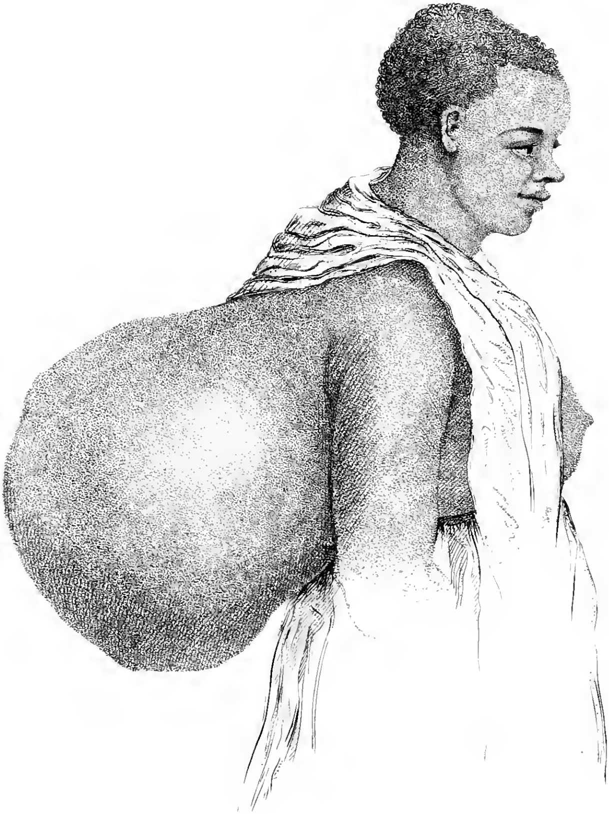
Account of a Large Wen, successfully extirpated by John Syng Dorsey, M. D.—Read, 1817.

THE paper which I have the honour of presenting to the Society, contains the history of a steatomatous tumour, of very unusual magnitude, successfully extirpated.

The patient, Julia Richards, a negro woman, from Carlisle, in Pennsylvania, was aged about forty-five years, and enjoyed good health; she was corpulent, but active, until her exertions were restrained by the incumbrance of her tumour.

She stated that it had been first noticed about eighteen years before I saw her;—that it had grown gradually, and had never been painful. When she applied to me, her attitude in walking resembled that of a woman carrying a large and heavy sack. On examination, I found the tumour arising at the upper part of the back, extending equally on both sides, and although pendulous from its weight, yet the root of it was very large. The annexed engraving, (Plate VIII.) represents it better than it can be described;—the dimensions were as follow.

Circumference at the neck or narrowest part of the tumour, two feet ten inches.



J. S. Dorsey del. & Sc.

Circumference at the thickest part, vertically, three feet nine inches.

Circumference horizontally, three feet one inch and a half.

The circumference of the waist after the wen was removed, was two feet nine and a half inches, so that the narrowest part of the tumour was thicker than the patient's body.

The surface of the tumour was tolerably regular, but very large and numerous veins were seen in various parts of it.

The patient was admitted into the Pennsylvania Hospital, and on the 22d of February, 1815, I proceeded to remove the tumour. Having previously administered an opiate, I placed her (at the suggestion of Dr. Physick,) on her face upon the table, fifteen minutes before commencing the operation, and directed assistants to elevate the tumour in such a manner as to empty it as completely as possible of blood, and I was greatly delighted to perceive the change in the size of the superficial veins, which resulted from this simple expedient, many of them contracted and could not be perceived.

The operation was commenced by external incisions calculated to preserve skin enough to cover the surface left by the removal of the tumour, and this skin being dissected and turned back, which was the most tedious part of the operation, the tumour by large and rapid incisions, was detached from its base and removed. It adhered to some of the spinous processes of the vertebræ, and to the muscles and tendons near the spine. The operation occupied twenty-one minutes; and the loss of blood was very trifling.—The skin was found to adapt itself very well to the denuded parts, and was secured by strips of adhesive plaster, compresses and bandages.

The greater part of the sore united by the first intention; no unpleasant symptoms occurred, and the patient was discharged cured, on the 15th April. She is at this time, and has been ever since the operation, perfectly well.

The tumour was found to weigh twenty-five pounds, but when filled with blood, was probably much heavier.

The tumour of Eleanor Fitzgerald, described by Mr. John Bell; and that of a negro woman, published in the Medical Repository of New York, (Vol. III. New Series) were of enormous magnitude, but adherent by small bases. The basis in the present instance was very great, and I am not aware that so large a tumour has been ever before extirpated.

Remarks.—The most important practical precept derived from this case, is the influence of position on the circulation of the blood. I once attended an operation on a tumour of comparatively small size, seated on the back, the extirpation of which was found impracticable, in consequence of bleeding from the superficial veins. In the treatment of hemorrhagy from blood vessels in the extremities, and on certain local inflammations, an elevated position is often found of great importance. I have seen a bleeding from an artery in an aneurismal arm, in which circumstances precluded the use of a ligature or tourniquet, effectually arrested by an elevated posture, the hand being constantly kept in a vertical position.

These remarks, although somewhat digressive, are in my opinion of too much importance to be omitted. The practice of employing position to empty blood-vessels for surgical purposes, in the case alluded to, and others, so far as I know, originated with Dr. Physick, and my own experience has afforded numerous proofs of its value, and convinced me that it has been too much neglected by surgeons.

No. XX.

An Account of an Improvement made on the Differential Thermometer of Mr. Leslie. By Elisha De Butts, M. D. Communicated by Dr. B. S. Barton, one of the Vice Presidents of the Society.—Read, June, 1814.

THE results to which the European philosophers were directed by their investigations upon the nature and propagation of heat, have been sufficiently important to attract the attention of every person engaged in the pursuit of natural science. The mystery which involved the connexion that existed between heat and light, has been to a certain degree removed by the observations and experiments of Lambert, De Saussure, Scheele, Pictet, and Herschell, which have shewn that the rays of heat can be separated from those of light by refraction, and by plane diaphanous bodies. When a sun-beam was compelled to pass through a prism, the rays of heat occupied a space nearly distinct from that occupied by the primary colours, and upon further examination, the greatest quantity of heat was found to occupy a portion of surface one inch and a half beyond the illuminated spectrum of component rays; but as these experiments made it sufficiently evident, that a very close analogy subsisted between the character of the laws which govern the actions of heat and light, it became particularly desirable to have an accurate view of some feature in the one or the other sufficiently prominent to mark the distinction, and to guide our conceptions. This has been accomplished by Mr. John Leslie.

The patient research and the mathematical precision, with which he conducted a long and troublesome series of experiments, constituting in the aggregate a system of knowledge of much immediate practical utility, entitle him to a place in the highest rank among the cultivators of this branch of natural philosophy. The principal instrument which he made use of, and to which he was indebted for his most important results, was the Differential Thermometer, for an account of which, with his method of using it, I must beg leave to refer to his book.

As I was extremely desirous to repeat his experiments, and to pursue the subject, I made every exertion to procure a Differential Thermometer, but from the extreme delicacy of the instrument, and the difficulty of uniting the tubes as directed by Mr. Leslie, I could not obtain one, even from the best artists, possessing a sufficient degree of accuracy. My mirrors, made with great precision in Paris, were therefore almost useless. This difficulty was, however, soon removed by a new form of the Differential Thermometer, which I was by a variety of expedients led to adopt; and as it appears to me to possess some advantages superior to that of Mr. Leslie, I have taken the liberty to present one to the Society.

The principal advantage which appears to me to be derived from this form of the Differential Thermometer, is the facility with which it may be made. To render this more evident, it will be necessary to call the attention of the Society to the description of the Differential Thermometer as invented by Mr. Leslie.—" Two glass tubes of unequal lengths, each terminating in a hollow ball, and having their bores somewhat widened at the other ends, a small portion of sulphuric acid tinged with carmine, being introduced into the ball of the longer tube, are joined together by the flame of the blowpipe, and afterwards bent into nearly the shape of the letter U, the one flexure being made just below the joining, where the small cavity facilitates the adjustment of the instrument; which, by a little dexterity, is performed by forcing with the heat of the hand a few minute globules of air from the one ball into the other. The balls are blown as equal as the eye can judge, and from 4-10ths to 7-10ths of an inch in diamemeter. The tubes are such as are drawn for mercurial thermometers, only with wider bores; that of the short one, and to which the scale is affixed, must have an exact calibre of a fiftieth or sixtieth of an inch; the bore of the long tube need not be so regular, but should be visibly larger as the coloured liquor will then move quicker under any impression. Each leg of the instrument is from three to six inches in height, and the balls are from two to four inches apart. The lower portion of the syphon is cemented at its middle to a slender wooden pillar inserted into a round or square bottom, and such that the balls stand on a level with the centre of the speculum. A moment's attention to the construction of this instrument will satisfy us that it is affected only by the difference of heat in the corresponding balls, and is calculated to measure such differences with peculiar nicety. As long as the balls are of the same temperature, whatever this may be, the air contained in the one will have the same elasticity as that in the other, and consequently the intercluded coloured liquor, being thus pressed equally in opposite directions, must remain stationary. But if, for instance, the ball which holds a portion of the liquor be warmer than the other, the superior elasticity of the confined air will drive it forwards, and make it rise in the opposite branch above the zero, to an elevation proportional to the excess of elasticity or of heat."*

The difficulty of procuring the above instrument arising from the great dexterity necessary in uniting the tubes by the flame of the blow-pipe, and the difficulty of carrying it to a distance in consequence of its shape and delicacy of construction, induced me to endeavour to discover some expedient by which I should be in possession of a thermometer, acting

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* Leslie's Inquiry, p. 9.

according to the principles which governed Mr. Leslie's, but more portable and less difficult of acquisition. Having procured, in the summer of 1811, all the apparatus necessary for the experiments upon radiant heat, except the Differential Thermometer of Mr. Leslie, I attempted to make one capable of answering my purpose, by immersing the open termination of a common thermometer tube, blown at the other end into a ball of 7-10ths of an inch in diameter, into concentrated sulphuric acid, tinged with carmine,* contained in an ounce phial; and by luting the mouth of the phial to exclude the external air, and introducing into the tube in the usual way a little of the acid, I had an instrument which appeared capable of assisting my observations; but I soon perceived that it laboured under an imperfection incompatible with the accuracy required in a series of experiments so delicate as those in which I was engaged. I remarked that when I removed the instrument from a room of a given temperature to a room the temperature of which was higher, a sudden depression of the fluid occurred, although after a few minutes had elapsed, it resumed its former position, and when the instrument during an experiment was placed with the ball in the focus of one of the mirrors, a depression of the fluid occurred to a greater degree than the quantity of radiant heat in the focus would have produced. It also appeared frequently to have lost in a great measure its sensibility; or the fluid was not depressed to the degree which from previous observation I was convinced it should have been. I at length found that these irregularities were connected with accidental changes in the atmospheric temperature, by which the air in the ball was sooner affected, from the extreme thinness of the glass, than the air contained in the phial, the glass of which was comparatively very thick.

The imperfect conducting power of glass with relation to heat, by free communication, and the proof given by Mr.

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* The ordinary thermometrical fluids will not answer the purpose. Spirit of wine is *totally inadmissible*.—Leslie on Heat, p. 410.

Leslie, in his Seventh Experiment, p. 30, that its character is similar with relation to radiating heat, rendered the method of removing the imperfection of my instrument sufficiently obvious. It was only necessary to equalise the opposition made to the passage of heat to and from the upper and lower portions of included air, and as it would improve the beauty of the instrument, and increase the facility of inclosing it in a tube or case, I determined to have the quantities of air above and below as nearly as possible, equal. I therefore procured a glass tube closed at one end, in the middle of which I caused a ball to be blown almost as thin as the common thermometer-ball. Into this, concentrated sulphuric acid tinged with carmine, was poured, until the fluid stood at the point C. (Plate IX. fig. 1.) A thermometric tube with a ball also blown very thin, and an inch in diameter, open at its other end, was introduced into the glass containing the acid, until its open termination had passed about 1-10th of an inch below the surface of the acid on the point *b*. The stem of the thermometer was made sufficiently large to be embraced closely by all that portion of the lower glass above the ball. The instrument was placed upon its stand, as in the figure, and white lead in oil was laid on with a camel-hair pencil in repeated coats, at the point *a*, until there was no longer any connexion between the external and inclosed air. When the cement was perfectly dry, the upper ball was heated as usual, by which a small portion of air was thrown into the lower ball, and upon removing the heating cause, the acid of course rose to the required height in the tube. The scale was adapted to it by first marking the distance of the part of the tube at which the fluid stood, from the part at which the glasses were cemented; then, determining the temperature of the atmosphere by a common thermometer, the lower ball of the instrument was plunged into water ascertained to be 10° of Fahrenheit colder. This produced a determinate depression of the fluid in the tube, which in this thermometer happened to be exactly at the point of junction. The space between the above two points was divided into 100 parts or degrees, 10 degrees upon this scale indicating of course one degree of Fahrenheit. The instrument was then ready for use, and I had the gratification of finding it free from any imperfection calculated to mislead during the progress of experimental observation.

The capability which it possesses of being applied to fluids, when we wish to detect very minute variations of temperature, is in many cases of considerable importance, as for example, in certain chemical combinations, in which the quantity of heat evolved upon mixing fluids, cannot be appreciated by the common thermometer.

In experimenting upon that part of the subject of radiant heat, which by a strange confusion of ideas has been termed radiating cold, by placing the lower ball of the instrument in the focus of the mirror, the quantity of heat lost by radiation will be indicated by the depression of the coloured acid.

To those persons who have considered attentively, the Photometrical experiments of Mr. Leslie, the easy application of this instrument to a similar purpose will be evident, by making the upper ball of black glass, or by adapting a metallic ball to the top of the tube, and it may perhaps be considered as a more convenient form than Mr. Leslie's, from the facility of inclosing it in a glass tube or case, which is essential to an accurate Photometrical result.*

Having made use of the instrument presented to the society now more than three years, and finding that during that time, it was honoured with the approbation of my scientific friends to whom I had an opportunity of showing it, I have taken the liberty of presenting to the society the above short description of it.

ELISHA DE BUTTS.

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* Leslie's Inquiry into the Nature of Heat, p. 423.

No. XXI.

Description of a Rolling Draw-Gate, as applied to Water-Mills. Invented and Communicated by Nathan Sellers.—Read, April 19, 1811.

BEING part owner of a saw-mill, working under a head and fall of about eighteen feet, by double geers, and finding the expense of repairs very considerable, it was agreed by the owners to remove the complex works, and to substitute the common flutter-wheel, which being more simple, would be less expensive and troublesome. This they intended to do, in the usual way, by bringing the water to the wheel by an open shoot placed nearly perpendicular under a head of about three feet; the gate or draw to be flat in the bottom of the head. But, as the power of the mill would be increased by extending a close head down to the wheel, I was very desirous that this should be done; and the only objection to it was the difficulty of starting the gate under so heavy a press of water—say about 14 feet. To remove or obviate this difficulty, was the subject of my frequent thoughts, and as the persevering labours of the human mind, to effect useful purposes, seldom fail, the following principle or method occurred, was adopted, and answered my utmost expectation.

The method will be best explained by a miniature model, which I have made, and herewith send to the Philosophical Society, at the request of one of their members. A drawing of this model is exhibited in Plate IX. fig. 2.

I call this invention a rolling draw-gate.

It consists of a roller, (which I recommend to be made of cast iron,) five or six inches diameter, well turned, with a gudgeon of about three inches long, and three inches diameter, at each end. and at one end a square of four or five inches extended beyond the gudgeon, to fit a lever on, for turning the roller when fixed in the head. As much of this roller as the length of the buckets in the water wheel, was cast but half a roller, *b*, so as to leave a flat side as broad as the diameter of the cylinder. The cylinder *b*, is to be fixed between the sides of the descending trunk or head, *a*, conducting the water down to the wheel, with its flat side towards the back of the trunk, and with its whole cylindrical ends and gudgeons let into the side planks, and the square-ended one passing through to receive the lever by which the roller is to be worked. When thus fixed, and when the flat side of the roller is parallel with the back of the descending trunk, it will leave an aperture of nearly half its diameter, for the water to pass. Then, by turning the roller so that the lower edge of the flat part approaches the back of the trunk. the aperture is lessened, and by turning it still further. the aperture is closed, by the said lower edge impinging on the back of the trunk in an angle of 40 or 45 degrees. Then to shut the bottom of the trunk so as to prevent the water from running on the other side. or behind the roller. a plank is fitted in grooves cut in the side planks of the trunk, and key'd so as to fit nicely on the cylindrical part of the roller. which, in turning. slides close in contact with the grooved edge of this bottom plank. The front planking of the descending trunk fits nicely on this bottom plank, which is kept up tight by keys underneath in the grooves cut in the side planks to receive the bottom plank. Being thus constructed. by turning the cylinder by means of the lever affixed to it, the aperture may be nicely regulated to the state of the water or weight of the work—and this under a very great press of head, because it falls on the flat part of the cylinder equally on each side of the centre of motion, and has therefore as much tendency to shut the aperture as to prevent its being opened.

The society are at liberty to retain the model and use it as they see proper. Should any person wish to apply it, I have no objection, and if any advantage results from its application, it will give me pleasure.

NATHAN SELLERS.

Philadelphia, April 11, 1811.

No. XXII.

Description of an Indian Fort in the neighbourhood of Lexington, Kentucky, by C. W. Short, M. D. Communicated by Mr. John Vaughan, Oct. 4, 1816.

Lexington, Aug. 31, 1816.

Sir,

Shortly before I left Philadelphia, my attention was drawn by Mr. Correa (who by one month's residence in my country, learnt more about it than I had during my whole life) to an ancient work in the neighbourhood of this place, which I have but just had it in my power to visit, and the following sketch is the result of a slight survey I made of it. Knowing your curiosity on these subjects, I send it to you hoping it may not be uninteresting to you.

C. W. SHORT.

Mr. John Vaughan, Philadelphia.

Description of the Work and Explanation of the Figure.

(See Plate IX. Fig. 3.)

aaaa. The wall, 14,000 yards in circumference, made of earth raised from a ditch on each side—the ditch being generally deeper on the exterior. The wall for the greater part of its course seems to run on an elevated piece of ground; at *h*, however, it is overlooked by an eminence rising immediately from the bottom of the exterior ditch, to the height of six or eight feet more than the wall; this eminence has every appearance of being the work of nature. At *f*, on the contrary, the line runs on the side of a hill, sloping exteriorly. The wall is here formed of earth thrown from the outer side only, and its summit is on a level with the inner ground.—*c c c* are small gate-ways, opening towards the south, and are about six feet wide—*d* is another, ten feet, and *e* the main gate-way, fifteen feet wide. The wall in its circuit is broken in several places by ravines: those marked *g g g*, appear to have existed when the wall was formed, for it may be perceived descending to the bottom and rising from it. These ravines, when swelled by rains, empty their waters in different directions. The smaller hollows marked *h h*, have all the appearances of more recent formation, and seem to have washed away the wall in making a passage to the chief ravine *g*. At *i i*, there are two singular pits or excavations made on the top of the wall, about two feet deep, at present, and four or five in circumference. At these places the wall is evidently widened. The wall, in its highest part, (between the gate *d* and the ravine *g*.) is about ten feet from the bottom of the exterior ditch; its average height may be said to be five. A small part of the area from *j* to *k* has been in cultivation, and here the wall is almost obliterated by the plough; however it may be traced by the difference in the colour of the soil, the line of the wall being marked by a yellow clay. The thickness of the wall at the base may be eight or ten feet. The figure formed by it is an irregular oval, its longest diameter being 500, and its transverse 400 yards long, comprehending an area of very uneven ground, the centre of which is perhaps higher than any in its vicinity; this is proved by the ravines, which make off in every direction from it. Nothing particular is perceived in walking through it, except about the centre a small mound or nodule two or three feet high, and a number of pits or depressions of the form of fallen-in graves. The whole ground is covered with timber of a large size, and of the usual growth in the neighbourhood—sugar maple, black walnut, white ash, hickory and beech. Those on the top of the wall and in the ditch, appear of an equal age and size with the others. There is no living water in the bounds of the lines, nor have any singular reliques been discovered about them.

No. XXIII.

Description of an Improved Piston for Steam Engines, without Hemp Packing. By P. A. Browne, Esq.—Read, Nov. 1816.

To the President, &c. of the
Am. Phil. Society.

GENTLEMEN,

I TAKE the liberty of communicating to your respectable body an improvement I have lately made in mechanics. It consists of a Piston which operates without any packing, being perfectly air-tight, and requiring much less power than any hitherto used.

From the following description and the drawing which accompanies this letter, the principle will be perfectly understood; and the model which I send to be viewed by the society, will show that it is capable of being reduced to practice.

The foot of the piston rod (Plate IX. fig. 5. *a.*) which gradually widens at the bottom, passes into and fits upon a flat circular piece (*b.* fig. 6.) the size of the cylinder (which has the shoulder or shoulders hereafter described) and with the circular plate hereafter described, keeps the parts of the piston next described, in their places.

Between the above piece and the circular plate hereafter described are three* or more segments or pieces of brass† or other metallic substance, or other substance (A. fig. 6.) of the thickness required by the power of the engine,‡ the outer extremities of the whole of which, when placed together. will form a circle equal in size to the cylinder; the shape of the inner parts of these pieces differs according to their number, but must always be such as to admit between them the wedge of the triangular form next described.

Between each of these segments or pieces, and exactly filling the interstices between them is a wedge of a triangular form of the same material (B. fig. 5, 6.) the base of each of which triangular wedges rests upon or against a circular spring (*c.* fig. 5, 6.) or spiral or other springs§ fixed, if circular, around, and if spiral, against the sides of the piston rod.

Over these is another circular plate (*d.* fig. 5.) of the size of the cylinder, through a hole in the centre of

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* The segments are said to be three or more, because there may not be less than three, but they may be increased to any number. For small pistons, say for engines not exceeding in power that of two horses, and moderate sized pumps, three pieces are best calculated, and it is believed that scarcely any power will require more than eight.

† The segment or pieces, and the triangular wedges, may be of brass or other metallic or other substance. It is believed that brass, from its known durability when liable to friction, is preferable to any other metallic substance, they may however be composed of steel or any other metal, or even of wood or other substances.

‡ The thickness of the segments or pieces, and of course the wedges, must be regulated by the power of the engine; it must be sufficient to exclude the air, and not so thick as to create unnecessary friction. It is believed that for a power less than four horses, it need not exceed one inch, for a power greater, and not exceeding twelve horses, one and a half inch; and two inches thick, will answer for any larger power now in use.

§ There may be one circular spring encompassing the piston rod, and acting equally against the base or end of each wedge, which is preferable; or there may be as many spiral or other springs, of equal force, as there are wedges, each acting on a wedge. Two things must be carefully attended to, 1st. That the spring or springs, (if more than one) act equally on each wedge, so that the pressure of the piston on the cylinder may be uniform, and 2dly. That the spring or springs have just sufficient force to make the cylinder air tight, and yet not enough unnecessarily to increase the friction.

which the piston rod passes. This plate rests upon a shoulder (*e.* fig. 5.) or shoulders, permanent on the lower piece first above described, and projecting from the piston rod. This piece is confined down to its place on the shoulder or shoulders, by a clamp, (*f.* fig. 5.) or other fastening, and a nut (*g*, fig. 5.) or nuts, which screw on the piston rod.

By means of the circular pieces, kept asunder by the shoulder or shoulders, the segments, wedges and spring or springs, are gently confined so as to be prevented from rising or falling from their places, but the spring or springs are allowed to expand, and the wedges are thereby constantly and equally pressed in a direction from the piston rod against the segments, and they against the cylinder, in such a manner as to make it completely air-tight, but at the same time so as to create very little friction as the piston moves up and down.

The advantages of this piston over any hitherto known, are great and obvious.

It is more simple, and of course cheaper than any metallic piston hitherto invented.

It is less liable to get out of repair than any piston now in use; it rather improves by use, for as the friction gradually wears away the segments, so also does it the angles of the wedges, and the whole becomes perfectly smooth, while the exact circular form is preserved unimpaired.

It saves the power of the engine by diminishing the friction. It is well known that the common packing, in order to be air-tight, is required to be large and compact, and a very large proportion of the force of the engine is employed in overcoming its resistance. This piston is more uniform in its pressure, and presents a much smaller surface for friction, being at the same time equally air-tight. It is confidently believed that the power required to drive a steam engine of a three horse power, with the common hemp packing, would drive one of a four horse power with this piston.

It will also be found to possess essential advantages in pumps of all sorts, especially those for hot liquor, which is so destructive to hemp packing, but which will not in the least injure the metallic piston above described,*

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* It has been objected to this piston that it will not be air-tight; the objection however has, it is presumed, been obviated by the use of Dr. Cartwright's metallic piston, which is metal against metal, and which is nevertheless found to operate successfully. Dr. Cartwright's piston is composed of eight radii of a circle or wedges each propelled by a separate spring placed between the piston-rod and wedge, is more complicated, and consequently more liable to get out of repair than this piston, which is perfectly simple and not liable to accidents. It might also be added that the pressure of a number of springs cannot be so uniform as that of one spring, which is all that is used in this improvement.

No. XXIV.

On Bleaching. By Thomas Cooper, Esq.—Read, June 20, 1817.

THE discovery of Scheele, that muriatic acid distilled over manganese, had, among other peculiar properties, that of destroying vegetable colours, was afterwards applied by Berthollet to the improvement of the common processes of bleaching.

Sometime about the year 1788, a meeting of the manufacturers of Manchester was called, to consider of the proposals of a Mr. Bonneuil or Bonjour, I now forget which, who offered to communicate a new mode of bleaching on receiving a reward for the discovery. Mr. Henry, Mr. Charles Taylor, (afterwards Dr. Taylor, Secretary to the Society of Arts at the Adelphi,) myself, and Mr. Jos. Baker, undertook to consider the subject and report. We met at Mr. Taylor's house, and having little doubt of the process being connected with the discoveries of Scheele, we distilled common muriatic acid over manganese, and found of course its effect of destroying most vegetable colours.

Considering that manganese was dirty, and the residuum worthless, I proposed using red lead in lieu of manganese, and we distilled the common muriatic acid over red lead, with equal effect. Some small portion of the muriat of lead, however. appeared by the result of our experiments to come over, and injure the whiteness of the cloth. I proposed to obviate this, by using the common ingredients of muriatic acid, viz. common salt and oil of vitriol, on the supposition that a combination would be formed between the oil of vitriol and the lead, insoluble and incapable of sublimation. This proposal was subjected by us in common to experiment, and appeared to succeed.

The applicant for a reward on making the discovery, not finding the manufacturers of Manchester willing to close with his proposal, applied in London for a patent, which I was directed to oppose. The argument took place before the master of the rolls, Macdonald; Graham for the patent right, and myself in opposition; and the patent was relinquished. Mr. Graham's client was so mortified at his ignorance of a question which it was extremely difficult to render familiar to a gentleman of the bar, that he left the room, and I heard no more of him.

On my return to Manchester, my friend and neighbour, Mr. Joseph Baker, the owner of some oil of vitriol works, near Worsley, a few miles from Manchester, wrote me a note, informing me that he had made a great improvement on my proposal of manufacturing the bleaching liquor from red lead instead of manganese. He had added some muriatic acid to red lead in a common wine decanter, and stopping it tight with the stopper, he found the decanter strong enough to confine the effervescent liquor and vapour. Without making this known, we tried the process on a large scale of about 100 gallons, with perfect success.

Mr. Tenant soon after took out his patent for distilling the bleaching liquor with oil of vitriol, common salt and manganese; Mr. Rupp also, of Manchester, published his method, which, as to proportions, was much better than Mr. Tenant's. The best proportions appear to me to be *three* common salt, *two* oil of vitriol, *one and a half* manganese. The manganese was at that time imported from the neighbourhood of Exeter, at the rate of ninety shillings sterling, the ton.

Mr. Baker's process was so much superior, superceding at once all the use of retorts, distillery apparatus, fuel, receivers, alkali, lime, and almost all attendance, that I engaged with him in the firm of Baker & Co., as bleachers. For three or four years, we bleached about 1800 callicoes a week, beside muslins, muslinets, and goods of every other description. The oxymuriatic acid *will not alone* produce a white colour; we used it as a *finish* at the close of the process of bleaching, with excellent effect and perfect safety. Indeed it superceded entirely the necessity of laying the goods down on the grass. The whole quantity daily wanted, was daily made by one of the partners; at first, without, and during the last year, with, the assistance of one confidential person. It was always used so weak, that no injury could arise to the cloth, and excepting in some accidental cases, attributable to the usual process of vitriolic souring, as well as to the bleaching liquor, no damage did occur.

I know not that the process has been used since I left Manchester in the year 1793. No one knew of it, or did use it before that period, excepting Joseph Baker & Co.[*] Five and twenty years interval since we were in the habit of using it, will justify the present publication, as the firm was dissolved about the year 1793, and the business discontinued. But from no considerations whatever arising either from the want of success or want of profit in the practice of this mode of bleaching; which I consider at present, as so superior in all respects to any other known to me as now in use, that injuring no one, I may venture to publish it for the consideration of those who may have occasion hereafter to bleach with the oxymuriatic acid or its combinations.

Three or four large cylindrical wooden vessels or barrels, (See Plate IX. fig. 7.) about five feet by four feet, made of oak, with staves 2 1-2 inches thick, (having a plug-hole on the top to admit a large funnel, through which the ingredients were poured in. and at the bottom of one of the ends a plug through which the liquor was let out) were supported on a strong frame or trestle in the middle room of a building ap-

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[*] Mr. Hulme, who as a bleacher occupied the same grounds that Baker and Co. occupied a mile from Bolton, and where he carried on the business of a bleacher, so lately as 1816, informs me he never heard of this process.

propriated for the purpose. They rested on the frame, by gudgeons projecting from the end. The ends were strengthened by two strong cross plates of iron, to which the gudgeons were attached, and also a handle at one end to turn them round. Into each of these, 75lbs. of common salt, 40lbs. of oil of vitriol, and from 25 to 30lbs. of red lead were put, through the funnel. Then, the vessels were filled about three fourths with water. The plug on the top drove in, with a bit of cloth to tighten it: one man turned each vessel round for about ten minutes or a quarter of an hour. The liquor was then completely made, and left to settle. It was not stronger than to admit a wine glass full to be drank without much difficulty. The barrels were thus filled in the upper room through a hole in the floor; into which room no one entered but the person who poured in the ingredients. The barrels were turned round by a man in the middle room; they reached of course nearly up to the ceiling or the under part of the room above, where they were filled. They were permitted to stand an hour, if not wanted sooner, and then let off into the cuirs containing the goods to be bleached, down a pipe, which permitted the bleaching liquor to go down to the bottom of the cuir first, and then to rise up through the goods, previously deprived of moisture by being run through the squeezers.* The cuirs were covered by a close cover; the contents of one vessel was let off at a time, and the person who opened the plug and fixed the pipes, retired immediately to avoid the smell of the acid. The acid liquor was permitted to stay on the goods for twenty minutes after it had lost all odour of oxymuriatic acid, and had acquired the smell, taste and character of common muriatic acid: at this period, it emitted no offensive odour whatever.

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* The common squeezers were cylinders made of any hard white wood. The squeezers for finishing the finer kind of goods, beside hollow copper cylinders with heaters withinside, were of the best kind of white paper, closely pressed and compacted by means of strong screws at the ends, and then accurately turned in a lathe.

These machines, wherein the liquor was made, would admit of being changed six or eight times a day if necessary, so that some thousand gallons might be daily manufactured with ease by one man.

We had no fuel, no furnaces, no retorts, no luting, no vessels capable of fracture, no alkali to neutralize the liquor, no series of wooden receivers; all of which constitute the apparatus actually in use at the present day! Half a dozen men, could have supplied the whole of the bleaching liquor necessary for the whole manufacture of the place at that time.

The sulphat of lead could be reduced by the common methods; we usually sold it.

The liquor was too weak and diluted to act injuriously on the goods: being weaker than the usual sourings with oil of vitriol and water. The spent liquor was thrown away, but I think might have been saved with profit.

The goods were very carefully washed at the dash wheel, after the process.

The plate accompanying this paper, (Plate IX. Fig. 7.) shews the barrel in which the ingredients were put; the frame or trestle, the funnel, inserted from the room above, (which is not a necessary but a convenient distribution of the apparatus) the covered *cuir* (pronounced keer,) containing the goods to be exposed to the action of the acid, the pipe going to the bottom, so that the oxymuriatic vapour should not be unnecessarily dissipated in the air; and the pipes fitting in to each other, when the liquor is required to be emptied from the barrels.

The other parts of the plate, fig. 8, 9, relate to the method now usually employed for the first part of the bleaching process, in France and in England. I have already said that no good, merchantable, white, can be made even on cotton, much less on linen goods, by means of the oxymuriatic acid alone. The goods must first be soaked for four and twenty hours, to soften the loose dirt, grease, &c.; this soaking should be stopped, and the goods taken out, when air-bubbles appear in the tub, for that is the sign of incipient fermentation, which would rot the cloth. The goods are then to be taken out, and very well dashed; then squeezed and put into a tub, or cuir, to be percolated with an alkaline liquor. The old process was this: to a cuir containing about 250 calicoes weighing from ten to eleven pounds each, about seventy pounds of potash was taken: this was dissolved in a cast iron boiler placed even with the ground, or nearly so, with a fire underneath it. The potash being dissolved, a man with a ladle and long handle, poured the boiling hot solution on top of the cloth; the liquor percolated through the cloth (this is termed *bowking*)—ran out by a pipe at the bottom, into the boiler; so that for twelve hours, there was a constant current of boiling hot solution of potash, percolating through the mass of cloth; the man distributing it as evenly as he could. The cloth being taken out next morning, was dashed, squeezed, and again placed in a cuir, and in like manner bowked (bucked, from a bucking tub) that is, percolated with solution of alkali for twelve hours, in the proportion of thirty-five pounds of pearl ash to 250 pieces; dashed and squeezed as before. The pieces then undergo a souring in dilute sulphuric acid. Then dashed, squeezed, and a third time submitted to the same process of bowking with about fifteen pounds of pearl ash, and about five pounds of white soap: the next morning the pieces are taken out and dashed; and after being well squeezed, are submitted to the operation of the oxymuriatic bleaching liquor. Then dashed, dried, and made up. If necessary the oxymuriatic souring is repeated.

The expense of manual labour was afterwards superseded, by pumping the liquor out of the iron boiler, and discharging it on the surface of the mass of cloth in the cuir: but this method, though a saving of labour, was still very expensive, from the wear and tear of the pump-gear. The modern method is as follows. (See fig. 3 and 9.) An iron boiler is employed, having a flange, or hollow rim on the outside, in which an iron or wooden tub or cuir, without a bottom, can be let in or fixed: this by tight packing can be made steam tight. On the inside of this iron boiler, there are three or four projecting knobs, on which an iron grate rests, so as to be moveable: which when placed upon its supports or knobs, within side the boiler, serves as a bottom to the cuir.

The quantity of ashes and water required, being put into the boiler, the grate is let down, and a pipe fixed in the middle of it reaching to within three or four inches of the bottom of the boiler, and at top, higher by an inch or two than the cloth. The cloth is arranged within side the cuir, resting on this moveable grate, and surrounding the pipe in the center; and is piled up to within five or six inches of the top rim of the cuir. A fire is made below the boiler, which is not more than one half or two-thirds full of liquor. The compact mass of cloth on the grating, scarcely permits any steam to pass through it: the heated steam thus confined, becomes highly elastic, presses upon the surface of the liquor, and forces it up the pipe to the top, where it escapes in a jet, which by means of a tin cover against which it is thrown, is evenly distributed over the surface of the cloth, percolates through it, and escapes through the grating of the moveable bottom that supports the cloth, into the boiler. The cloth by this means is exposed to a much greater degree of heat than in the old process, for the expansive force of the steam must be raised so as to force the liquor up the pipe, from near the bottom of the boiler below, to the surface of the mass of cloth above. Hence not near so much alkali is necessary in this method of steaming as in the old one, for it acts much more powerfully. To a cuir of cast iron that will hold about six hundred callicoes, they do not now use more than half a hundred weight of potash, in the first bowking: and the goods are prepared for the bleaching liquor in two bowkings, with an intermediate souring of any dilute sulphuric acid, instead of three bowkings as before.

When the cloth is taken out, the grate is also taken out, with its pipe in the center; water is poured in, and the boiler washed out, the washings being discharged by the waste pipe and cock below.

This method of bleaching, I understand, is introduced on a small scale into very many private houses in France, and no doubt with good effect.

No. XXV.

Description and Use of a Simple Appendage to the Reflecting Sector, by which it is rendered capable of measuring all possible Altitudes, on Land, by Reflection from an Artificial Horizon. By Robert Patterson.—Read, September 19. 1817.

SINCE the discovery of the reflecting sector, various attempts have been made to extend the limits of its capacity in measuring angles. This becomes especially necessary in taking altitudes on land, by means of an artificial horizon, or reflecting horizontal surface; since, in this case, the altitude measured is, from the construction of the instrument, but *one half* of that pointed out by the index on the limb: thus, an octant will not measure an altitude of more than 45°, a sextant, not one of more than 60°, a quintant, not one of more than 72°; and beyond this, the limits of the sector has seldom if ever, been extended. It is, indeed, perfectly obvious, that no instrument of this kind can, by means of a reflecting horizontal surface, measure an altitude of 90°; for, then, the incident ray and the reflected ray must coincide, and both pass through the eye of the observer—which is evidently impossible. Nay, when the altitude exceeds 75°, the head of the observer will, almost unavoidably, intercept the incident ray, in its passage to the reflecting surface. Besides, the field of view, from the obliquity of the index speculum, will then become too much contracted to afford an easy observation.

No improvement, therefore, in the construction of this instrument, can ever be expected to answer the purpose of measuring all possible altitudes by means of a common artificial horizon: but with the aid of the following very simple appendage, this purpose will be completely answered, even by the common octant.

The whole apparatus, to be used with the reflecting sector, consists of three parts.

1. An artificial horizon, or horizontal reflecting glass plane, with its adjusting screws.
2. A spirit-level.
3. A reflecting inclined plane.

The two first parts of this apparatus, as well as the manner of adjusting them, are well known, and, therefore, need not here be described.

Plate IX. fig. 4, represents a side view of the reflecting inclined plane, nearly of its natural size. It is composed of

1. A triangular frame of cast brass A B C. The thickness of the frame is about 1-4th of an inch, its breadth about 1 3-10ths, and the lengths of the sides A B, B C, each about 2 inches: so that the bases A B, B C, may be nearly of the same dimensions with the face of the index speculum of a reflecting sector.

2. A plate of ground glass, cemented on the plane A C with black sealing-wax, or any other black cement, the polish being previously taken off the lower surface, to prevent a double image:—*a c* represents the edge of this glass. The inclination of the reflecting surface *a c* to the base A B, [angle A] should be made about 35°, and to the base A C, [angle C] about 45°. The quantity of these angles must, however, be accurately determined; and this may be done by either of the following methods.

METHOD FIRST.

1. Make a reflecting sector [octant or sextant] fast in a vice, or in any other convenient way, with its plane perpendicular to the horizon, and the speculum of the index, when this points to *o* on the limb, nearly horizontally.

2. Lay a thin, flat piece of board, metal, or glass, on the face or frame of the index speculum, and on this place the spirit-level, extending in the direction of the index; then gently move the index up or down the graduated limb, till the air-bubble of the spirit-level settles under the central mark on the tube; and note the degree, minute, and part, to which the index then points.

3. Under the spirit-level introduce the reflecting inclined plane, resting on its base A B, and its angle A pointing to the limb of the instrument.

4. Move the index up the limb, till the air-bubble of the spirit-level again settles under the central mark on the tube; noting, as before, the degree, minute, and part, to which the index now points.

5. Take the difference between this arch and that to which the index pointed when horizontal, if both on the same side of the *o*, but their sum, if on opposite sides; and the *half* of this sum or difference will be the quantity of the angle A. In a similar manner, laying the inclined plane on its base B C, may be found the quantity of the angle C.

In this way, by repeated trials, and taking a mean, you may, with a sensible spirit-level, find the angles of the inclined plane with great accuracy; and these angles, it is evident, can never afterwards be subject to any variation.

The above method was suggested to me by Mr. F. R. Hassler, some years ago, when preparing an apparatus of this kind for Mr. Jefferson.

METHOD SECOND.

1. Let the index error of your reflecting sector be ascertained, by measuring the apparent diameter of the sun on each side of the *o*, and taking a mean, as it is commonly done.

2. Place the inclined plane with its base AB on the face of the index speculum, the angle A pointing to the limb of the instrument, and, in this position, make it fast to the speculum, by means of a *spring-clamp* of wire, sheet brass, or the like.

3. With your eye at the eye-hole, or telescope of the instrument, defended by a shade or coloured glass, look through the transparent part of the horizon-glass, directly at the body of the sun, and, moving forward the index, proceed as in finding the index error;* noting the degree, minute, and part, on the limb to which the index points, at the apparent coincidence of centers; then, this arch, allowing for the index error, previously found, will be *double* the angle A of the inclined plane.

4. In a similar manner, by placing the inclined plane with its base BC on the index speculum, and angle C pointing to the limb of the instrument, you may find the quantity of the angle C.

Instead of the sun, you may make use of any well-defined, illuminated, object on land; as the top of a chimney, the ridge of the roof a house, or the like; in which case, no shade will be necessary to defend the eye, and the mean of a number of observations will perhaps be equally accurate with that obtained from an observation of the sun.†

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* If the reflected image of the sun should appear *at one side* of that seen by direct vision, then, by giving the inclined plane a small angular motion on its base, you may adjust this side-error by bringing the two images into apparent coincidence.

† If a light shade be placed behind the horizon-glass, then, the image of a terrestrial object, if moderately illuminated, will be seen by reflection from

Directions for the use of the above apparatus, in measuring all possible altitudes of the sun, by means of a reflecting sector.

The sector being adjusted, or its index error ascertained; the artificial horizon placed in the sun, and, by means of the spirit-level and adjusting screws, brought to a true level in all directions—then

CASE I.

When the altitude is not less than 10°,* and does not exceed the limits of the instrument, viz. 45° for the octant, and 60° for the sextant, it may be found, in the usual way, by reflection from the artificial horizon.

CASE II.

When the altitude is less than 10°.

1. On the artificial horizon, place the reflecting inclined plane on its base A B, with its angle A directly towards the sun.

2. Measure the altitude above the plane A C; and then from this altitude *subtracting* the angle A of the plane, the remainder will be the altitude above the horizon.

In this position of the plane, any *depression* of an object not more than 25° below the horizon, and, by the octant, any altitude not exceeding 10°, or, by the sextant, not exceeding 25°, may be measured.

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the transparent part of the horizon-glass, and thus the apparent coincidence or contact will be more accurately observed.

* When the sun is less than 10 deg. above the reflecting plane, the field of view will be too much contracted; but this circumstance, by the above apparatus, may always be avoided.

CASE III.

When the altitude exceeds the limits of the instrument.

1. On the artificial horizon, place the inclined plane on its base A B, with its angle A directly opposite to the sun.

2. Measure the altitude above the plane A C, and then to this altitude *adding* the angle A of the plane, the sum will be the altitude above the horizon.

In this position of the plane, any altitude from 45° to 80°, may be measured by the octant, and any altitude whatever above 45°, by the sextant.

CASE IV.

When the altitude exceeds 80°, and the octant is used.

1. On the artificial horizon, place the inclined plane on its base B C, with its angle C directly opposite to the sun.

2. Measure the altitude above the plane A C, and then to this altitude adding the angle C of the plane, the sum will be the altitude above the horizon.

REMARKS.

I. The sun's image reflected from the artificial horizon, when not silvered, will appear nearly of the same degree of brightness with that, after two reflections, from the specula of the instrument—a circumstance of some importance in making accurate observations.

II. In taking a meridian altitude of the sun, it will be necessary to turn round the reflecting inclined plane, (when this is used) according to the change of sun's azimuth, so that the end farthest from the observer may point directly towards the sun. If the inclined plane be turned gently backwards and forwards with one hand, (the instrument being held by the other) while making the observation, then, the two images of the sun will appear alternately to recede from and approach each other, and thus the apparent contact of the limbs will be accurately observed as they pass each other.

III. By means of this inclined plane, the common octant may have its range extended to that of the sextant, or even to that of the quintant, thus—Attach this inclined plane to the index speculum resting on its base A B, with the angle A upwards; then, the reflecting surface of the inclined plane may be considered as the index speculum; and, with this, any angle or altitude, measured in the usual way, will be equal to *that* pointed out by the index on the limb, *increased* by the quantity of the angle A of the inclined plane.

IV. By the aid of this inclined plane, the horizon glass of the octant for the back observation, may be very accurately adjusted, or the index error ascertained thus:—

1. Attach the inclined plane, by means of the spring-clamp, with its base B C resting on the back part of the index speculum frame, and the angle C downwards.

2. Move forward the index on the limb till it points to *double the complement* of the angle C of the inclined plane.

3. With your eye at the eye-hole, look through the transparent part of the back horizon glass, directly at the sun, and moving the lever of this glass, bring the reflected image to coincide with that seen by direct vision—and then this glass is adjusted. Any small error of adjustment may be found afterwards, by taking a mean of the two contacts of limbs, as in adjusting for the fore observation.

Any error in the parallelism of the face of the index speculum, to the back part of its frame, may be very accurately ascertained thus:—

1. Make the sector fast in a vice, &c. as directed in the first method of finding the angles of the inclined plane.

2. Lay a piece of index speculum glass on the face of the index speculum, and on this place the spirit-level, in the direction of the index.

3. By moving the index, bring the air-bubble to settle under the central mark on the tube, and note the degree, minute, and part, to which the index then points.

4. Place the same piece of glass, or any other plane surface, on the back part of the speculum frame, projecting a little beyond its outer edge.

5. On this projecting part place the spirit-level, touching the edge of the frame, and, moving the index, if necessary, bring the air-bubble again to settle under the central mark on the tube, noting, as before, the degree, minute, and part, to which the index now points; then *half the difference* between this and the former arch will be the error in the parallelism of the face and back part of the index speculum; for which proper allowance must be made in the above adjustment of the back horizon glass.

V. The altitude of the moon, or of a bright star, or of any terrestrial object, sufficiently illuminated, may, it is obvious, be taken in the same manner as that of the sun. In this case, however, if the reflecting inclined plane were of silvered glass, the observation might, no doubt, be made with greater ease and accuracy.

Fig. 1.

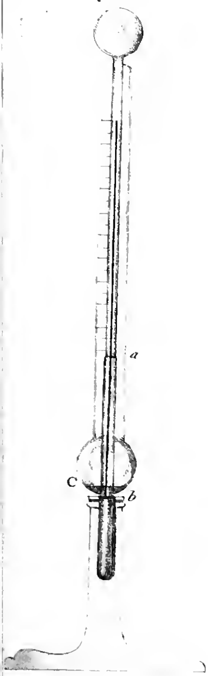


Fig. 2.

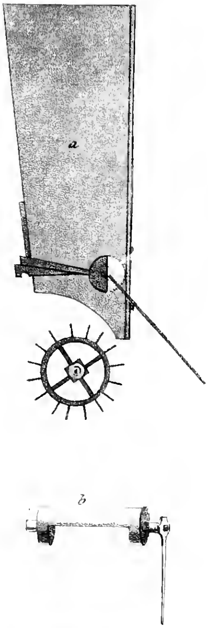


Fig. 3.

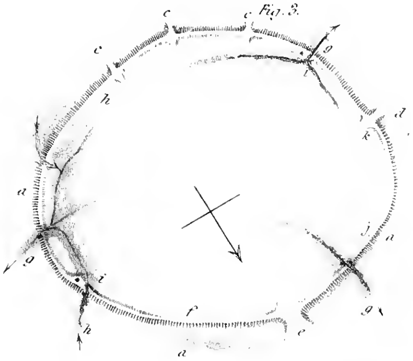


Fig. 4.

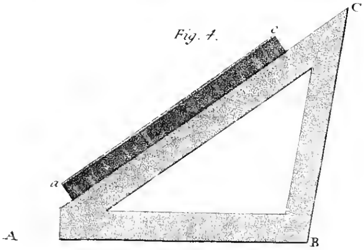


Fig. 6.

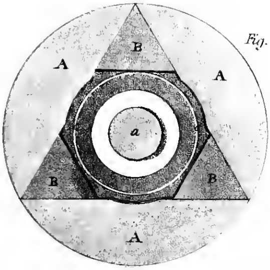


Fig. 5.

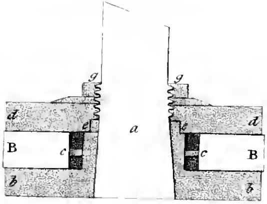


Fig. 8.

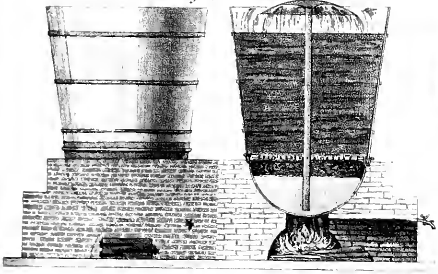


Fig. 9.

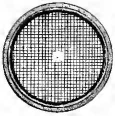
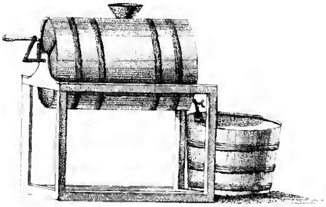


Fig. 7.



Engd by J. Hill.

No. XXVI.

Description and Use of a very simple Instrument for setting up Sun-Dials, and for many other useful Purposes. By Robert Patterson.—Read, October 17, 1817.

HAVING occasion, some time ago, to set up a sun-dial, for a friend in the country, a method of doing this occurred to me, which, from its great simplicity, as well as accuracy, and the variety of other useful purposes for which it may be employed, I flatter myself, the Society will not think unworthy of their notice.

Description of the Instrument made use of for the above purpose.

This instrument. in its most simple form, consists of

1. A square prism or block of wood, about three inches long, and 1 1-2 on the side.

2. A wooden scale or index, about 8 inches long, 1 1-2 broad. and 1-4 thick. Along the flat sides of this scale, there are drawn, by a carpenter's gauge, three or four fine lines, parallel to the opposite edges of the scale. Near one end of this scale, there is inserted a brass pin or piece of wire, projecting about 1 or 2 inches perpendicularly above the surface ;

and near the opposite end there is erected a strip of pasteboard, or the like, with a straight black line, drawn on its inner surface, parallel to the pin or wire, and both terminating in the same gauge-line drawn along the surface of the index. Into the center of one side of the square block is firmly inserted a brass pin, projecting about half an inch perpendicularly above the surface, and terminating with a few threads of a screw. This pin passes through a hole in the center of the index, which, by means of a screw-nut, may be made fast in any position required.

Use of the above Instrument, with the aid of a common Semicircular Protractor, in setting up a Sun-Dial made for any plane, whether horizontal, vertical, or reclining.

1. Inverting the instrument, place the protractor on the lower side of the index, with its graduated side uppermost, and its straight edge in contact with the square block.

2. By moving the index, bring the center of the protractor, and the degree, &c. of the sun's present declination, counted from 90° as 0, both exactly above the same gauge-line drawn on the index; observing, that when the declination is north, and the instrument to be used in the forenoon, or south, and to be used in the afternoon, then, the declination must be taken on the *right hand* of the 90°, and vice versa.

3. The dial being placed on its proper stand, or plane for which it was made, the sun shining, and, when circumstances will allow, not less than 45° of azimuth from the meridian, (but the nearer to due east or west the better) place the instrument with the square block in contact with that side of the gnomon of the dial next to the sun, and the index resting on its upper edge.

4. With one hand, depress the index, and with the other, gently move round the dial on its stand, till the shadow of the pin, inserted in the index, falls exactly on the black line drawn on the opposite piece of pasteboard. The dial is then truly

placed; and, in this position, after repeated trials, by way of verification, may be permanently fixed.

The rationale of the above process, as well as of what follows, will, it is presumed, be sufficiently obvious, without any explanatory figure, or additional elucidation.

The above instrument, with a little variation, and additional apparatus, may be employed with considerable accuracy in the practical solution of many other useful problems, as will now be explained.

Variation in the Instrument.

Instead of the pin, &c. in the index, let there be attached to its opposite ends a pair of sight-vanes, nearly such as in the common surveying instruments. One of these, however, may have a narrow slit of about 1-20th of an inch, and the other a wider one of about 1-8th of an inch, extending nearly their whole length. The index being about 8 inches long, the sight-vanes may be about 5 or 6 inches high. Also, let a saw-kerf, about 3-4ths of an inch deep, be cut along the lower side of the square block, opposite to that on which the index is attached, and parallel to the two opposite sides of the block.

Additional Apparatus.

This consists of

1. A simple Jacob-staff; being, merely, a circular board, or tablet, of about seven inches in diameter, with a large hole in the middle, and supported by three diverging legs.

2. A stand, with a universal gnomon, consisting of—(1.) A circular board of about seven inches in diameter, supported by three brass screws, which serve as feet, and, by means of a spirit-level, to make it horizontal. (2.) A square pillar,

erected on the center of this circular board, about 6 inches long, and 1 1-2 on the side. A brass pin, terminating with a few threads of screw, is firmly inserted into the lower end of this pillar, which passes through a hole in the center of the board: and thus, by means of a screw-nut, below the board, the pillar may be fixed in any position required. The top of this pillar is slit down, by a saw, about 5 inches, the kerf being parallel to two opposite sides of the square pillar. This kerf is made to receive (3.) A universal gnomon, being an oblong rectangular piece of sheet or cast brass, about 7 1-2 inches long, and 4 broad; having a brass pin passing through its center, and the upper end of the pillar, with a couple of nut-screws on the opposite ends, by which to make it fast in any position required. Along the sides of this gnomon, there are to be drawn three or four fine gauge-lines, parallel to the opposite edges, as directed with respect to the index.

Problems which may be practically solved, with considerable accuracy, by the above Apparatus.

PROBLEM I.

To find the angular altitude or depression of any visible object.

Solution 1. On the tablet of the Jacob-staff, set the stand, with its feet in three deep holes, made to receive them, to prevent sliding.

2. By means of the spirit-level, bring the upper surface of the circular board of the stand, and also the upper edge of the gnomon, into a true horizontal position.

3. Slip the kerf of the index-block on one of the vertical ends of the gnomon, where, by its friction, it will be prevented from moving.

4. Elevate, or depress, the index, and move round the pillar of the stand, till the eye, placed at the narrow slit of one of the sight-vanes, shall see the object through the slit in the opposite vane. If the sun be the object, the eye may be defended by a coloured shade, or piece of smoked glass; or, the lucid line passing through the broader slit may be made to fall upon the narrower slit in the opposite sight-vane.

5. Remove the index from the gnomon, and then, by the protractor, you may measure the angle which the index makes with its square block, which will be the altitude, or depression, or complement thereof, according as the angle is measured from the end, or from the side of the square block.

PROBLEM II.

To draw a true meridian line, on any plane level surface.

Solution. 1. Place the protractor with its straight edge close against one side of the upright pillar, and elevate the gnomon till the center of the protractor, and the degree, &c. of the latitude of the place, reckoned from 90° considered as 0, both fall exactly above the same gauge-line, drawn along the side of the gnomon.

2. By means of the protractor, set the index to the sun's declination, as directed in setting up a dial.

3. Set the stand on the surface where the meridian line is to be drawn, and, by means of the screws and spirit-level, bring the circular board to a true horizontal position.

4. The sun shining, and not too near the meridian, proceed as directed in setting up a dial; turning round the upright pillar, till the lucid line, from the broader slit, falls upon, and is bisected by the narrower slit, as in the last problem. The gnomon and the two sides of the square pillar parallel thereto, will now coincide with the meridian of the place; and then, by means of a straight edge, placed in contact with one of the meridian sides of the square pillar, the meridian line may be transferred to the given surface.

PROBLEM III.

To find the azimuth or bearing of any visible object.

Solution. 1. Place the stand on the tablet of the Jacob-staff, and then proceed, in every respect, as directed in drawing a meridian line; only, that in this case, you may look directly at the sun, as directed in finding his altitude, in Prob. I.

2. Depress the elevated end of the gnomon, till its upper edge appears, by the spirit-level, to be horizontal.

3. Slip the kerf of the index-block on the upper edge of the gnomon, and, your eye being placed at the narrow slit eye-vane, turn round the index till you see the object through the broader slit of the opposite vane.

4. Remove the index, and then, by the protractor, you may measure the azimuth, as directed in Problem I. in measuring an altitude.

PROBLEM IV.

To find the hour of the day.

Solution. 1. Proceed, in every respect, as directed in Prob. III. art. 1.

2. Slip the kerf of the index-block on the elevated end of the gnomon; and, if the sun shines bright, turn round the index with the broader slit vane towards the sun, till the broad lucid line is bisected by the narrow slit in the opposite vane. Or, if the sun be obscure, you may place your eye at the narrow slit, (defended by a coloured shade, &c. if necessary) and looking directly at the sun, turn round the index, till it appears opposite the center of the broader slit.

3. Remove the index, and you may then, by the protractor, measure the hour-angle from the meridian, as directed in measuring an altitude or azimuth. If the index be previously set to some whole degree in advance, then, by waiting till the sun appears opposite to the middle of the slit,

you may ascertain the time with great accuracy. Or, if you take a mean of the times per watch, corresponding to the four contacts of the limbs with the sides of the slit, you may ascertain the error of watch, generally within less than a minute.

Note I. It is easy to conceive, how the reverses of some of the foregoing problems may be solved. For instance,

1. The meridian and latitude of the place being given—to find the time, declination, and azimuth of the sun.

2. The meridian and declination being given—to find the latitude, time, and azimuth.

3. The latitude and time being given—to find the meridian, declination, and azimuth; and this at any time of the day. &c. &c. &c.

Note II. Having the declination of the moon, or of any other planet, or fixed star, together with the latitude of the place, it is obvious that the meridian may be found by these as well as by the sun. And if their right ascensions be given, together with that of the sun, then, you may also find the hour of the night.

Note III. It will readily occur how the above instrument may be employed to find the variation of the magnetic needle.

Note IV. Though the error in the solution of the above problems, arising from the refraction of the sun, &c. may generally be neglected, as very small; yet *this*, when thought necessary, may be readily allowed for, as follows:—

1. Ascertain, by means of the spirit-level and protractor, &c. the *value*, in altitude, of some one of the screws of the circular stand; i. e. how many revolutions and parts correspond to the change of a degree in altitude.

2. Place *this* screw directly towards the sun, &c.; then after levelling, and previously to making the observation, turn *forward* the screw so much as the refraction corresponding to the estimated altitude requires.

No. XXVII.

Observations made at an Early Period, on the Climate of the Country about the River Delware. Collected from the Records of the Swedish Colony, by Nicholas Collin, Rector of the Swede's Church at Philadelphia.—Read, January 19, 1816.

PART I.

THE Swedish government established this colony with a view to the acquisition of a valuable territory, and to obtain new sources of profitable commerce. Accordingly, a civil administration was formed, and a company was incorporated by a charter for trading with America, Africa, and Asia. Several ships of war and other good vessels were fitted out, at divers times between 1635 and 1656, for conveying the people, military stores, merchandise, and all requisites for the settlement. Land along both shores of the river was purchased from the Indians. The first important settlement was about the place where Wilmington now stands; and a fort was built near the mouth of Christiana Creek in 1638. Governor Prinz, who arrived in 1643, chose Tinicum, about fifteen miles higher on the Delaware, for his residence, and fortified the place. A church was also built there. The colony was advancing in prosperity. but still weak in population, when the Dutch, who had a much stronger establishment on the North River, invaded and conquered it, in 1755. Sweden, then engaged in war with six European powers, could not undertake an immediate recovery; and after a few years it became (with the other Dutch territories in North America) an English conquest.

Since the separation from Sweden, very few natives of that country have come hither; and among them, scarcely any women. The descendants of the colonists increased from their own stock, and from intermarriages with persons of the other European nations. Many of the last mentioned acquired the Swedish language, and adopted the Swedish mode of worship, in consequence of having, for a long while, no churches of their own. The Swedish colonists made extensive, but not compact, settlements, on both sides of the river, and on the creeks that empty into it, forty miles below and twenty above Philadelphia.

A religious connexion with the mother country continued after the conquest. One of the colonial clergymen remained until his death in 1688. A mission from Sweden commenced in 1697. Three parishes were soon after formed, one in Pennsylvania, another in the (present) state of Delaware; and a third in West New Jersey. Three respective churches were also constructed: in Southwark, near Philadelphia, on Christiana-Creek, where the fort had stood, and on Racoon-Creek, in New Jersey, twenty miles below this city, by land. Their parochial records furnish some information for my subject.

The earliest observations are contained in the Treatise of *Thomas Campanius Holm*, entitled, *Kort Beskrifning om Nya Sverige, &c.* that is, "A Short Account of New Sweden, &c." 4to. printed at Stockholm, 1702. A copy of it is in the public library of Philadelphia, but, on account of the language, can be of use to but very few, without translation. He was a grandson of the rev. *John Campanius*, a worthy clergyman of the colony, who resided there above five years, and translated the Swedish Catechism into the language of the Delaware Indians. The memoirs of this ancestor, Colonial Documents in the Swedish archives, and accounts from other persons who had been there, (among whom was his own father.) enabled him, as the preface mentions, to compose this book. The following matters of our subject are worthy of notice. As the old style was then in use, I have altered the dates conformably to the new style.

Campanius arrived at the aforementioned *Christiana* fort, the 26th of February, 1743. On the 6th and 7th of the same month, the vessels had suffered much from a violent snow-storm in the bay, near *Horn-kil*, now Lewistown. He kept an account of the weather for every day during the years 1644 and 1645. Our author gives a summary of the first, p. 48, 51, which is, concisely, as follows:—

January.—The winter began about the 21st, with severe cold, and then much snow. Afterwards came rain and a thick fog, with occasional sunshine, until the end of the month. During this time the winds were NW. ESE. SE. S.

February.—At first high and cold wind, then snow and sleet, with intervals of warm sunshine, until the 11th; winds N. NE. WNW. S. From the 11th until the 21st, cold and clear, sometimes pretty warm, wind generally E. The residue varied with rain, hail, clear and cold; winds S. N. S.W. E. N.W.

March.—In the first week cold and clear, with some snow, winds N. N.E.; in the second, calm, pleasant; in the third, rain, with thunder and lightning, sometimes hail and wet snow; winds N. NE. SE. SW.; in the remainder clear and pleasant, sometimes rain, high winds, and night frosts, winds S. SW. N. W. SE. SW. WNW.

April.—Blustering until the 11th, with rain, hail, thunder and lightning, sometimes warm sunshine, winds ranging from N. to S. on the west side; until the 21st generally cloudy, rainy, and raw cold, with occasional sunshine; winds N. NW. WNW. ENE. SE.; afterwards generally clear and warm, with some white frost at night; but sometimes cloudy and rainy, with thunder and lightning, winds E. W. SW. WNW.

The first half of *May* had clear warm sunshine and gentle rains, winds E. ENE. S. SW. The other half was partly serene, partly blustering, with rain and hail, thunder and lightning, winds SW. NW. N.

June was clear and warm, with some windy rains, winds E. ENE. S. SW. until the 11th; then much rain fell for some days, but with intervals of sunshine, winds W. S. N. The last two weeks were generally warm, with clear sunshine, sometimes a little rain, one night thunder and lightning; all this with the wind from W.

The middle of *July* was generally cloudy and rainy, winds W. and WNW. The other parts had clear, warm sun, with rain now and then, and winds W. WSW. E. ENE. Thunder and lightning happened in all the month.

The first three weeks of *August* were warm and sunny, with some rain; winds N. WNW. W. until the 11th, afterwards E. ENE. The other part was generally dry and warm, with occasional rain, thunder and lightning, winds W. WNW. N.

September began cloudy and wet, became clear and temperately warm for a week, then grew raw, cold and rainy, but in the latter half was calm, clear and warm, with rain at times. Thunder and lightning happened in the beginning; afterwards cold rain in the last third part. The winds were ENE. WNW. SW. S. W. until the 11th, N. WNW. ENE. WSW. S. SW. until the 21st, N. WNW. W. until the end.

October had clear and warm sunshine, sometimes clouds and rain, and some nights white frost, until the 21st, winds E. W. and also ENE. WNW. in the latter half of that time; from then till the end generally cloudy, rainy, chilly weather, winds N. WNW. W. E.

November had generally clear sunshine; the first ten days also some clouds and rain, a little snow, and white frost some nights, winds N. NW. ENE.; the next third part, clear cold, that made a little ice on the water, occasionally somewhat cloudy, winds WNW. S. N. SW.; afterwards mostly warm sunshine, sometimes rain, thunder and lightning, and violent gales, winds WNW. SW. W.

December had until the 11th, clear weather, but cold and frosty, sometimes rain and snow, winds W. WNW. S.; from thence until the 21st clear sunshine and cold that made ice on the shores, now and then snow, winds W. NW. E. N.; during the residue warm, and sometimes clear sunshine.

Our author found from the diary of the next year, that it much resembled this; yet had less of thunder and lightning, greater heat in August and September, and that the autumn was dry and pleasant, sometimes cool.

Campanius returned to Sweden in the year 1648. The vessel left Cape Henlopen on the 29th of May, espied land on the 4th of June, (*probably Newfoundland*) and on the 13th passed Plymouth in England, p. 65. This extraordinary celerity was produced, no doubt, by a strong westerly wind, although no mention is made of it.

The last governor *Rising*, and the engineer *Lindstrom* came over together in 1654, and returned home after the Dutch conquest. They wrote accounts of the country, and the latter formed also a map of it. From these, which were preserved in the archives of Sweden, our author copied several matters, as the following:—"The winter begins in December, and ends in January, continuing only seven, eight, or at the most, nine weeks; but is, while it lasts, equal in cold to any in Sweden. It sometimes comes on with such violence, that the river would be covered by thick ice in three or four nights, if the billows of the sea were not so forcibly driven into it. When departing, it suddenly breaks up in all the creeks, and the ice drives with the ebb tide to the sea like mountains, and with such a roaring crash, as if a great number of large cannon were discharged. Soon after this the weather becomes quite warm." p. 49.

"It doth not often rain, but when it does, it is generally with lightning and thunder, tremendous to the sight and hearing. The whole sky appears to be on fire, and nothing can be seen but smoke and flames." p. 48.

Our author had been informed, that in the winter 1657, the river was in one night frozen so hard that a deer could run over it; this was, however, an extraordinary case, which the oldest Indians had never known. He also remarks, that this winter was the same when, in the month of February, *Charles Gustavus*, king of Sweden, passed with his army from Holstein over the Belts to the Danish Islands and Copenhagen. p. 46.

He says that the heat of summer was usually greatest from the latter part of July till the same of September, and some years so violent, that people anxiously desired clouds and rain, as these immediately cooled the air. p. 47.

He represents the climate, on the whole, as temperate, healthy, and agreeable, having in all the seasons far more of clear sunny weather, than rainy and cloudy.

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In the account of animals the following merits notice:—"The white-headed geese arrive in the beginning of April from the south, and remain about two weeks. Afterwards come the white-speckled, which continue an equal time, and proceed northward. In autumn, from the latter part of September until the same time in October, geese arrive in the river, which are all grey, and proceed southward with loud clamour, and in amazing numbers." p. 31. quoted from *Rising*.

Campanius mentions, among animals, Elks: which, perhaps, in early times came so far southward; and the name of *Elk River* in Maryland renders this probable:—He describes a curious scale-fish under the name of *sea-spiders* thus: "They are always driven by the south wind on the shore of *Spinnelluden*,* in great numbers, not being able to make a return to the sea. They are in size equal to turtles, and are covered by similar coats, but with a yellow horny shell. They have many feet, and a tail a foot long, like a triangular saw,

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* Spinnel-udden signifies Spider-point, and is the place now called Bombay-Hook.

sharp enough to cut the hardest wood. When well boiled and prepared, they are as good as lobsters." p. 41.

He also writes about another fish thus:—Opposite to Poaetquessing Creek,* a kind of fishes resort, which has big teeth, beats the water violently, and spouts it like whales. It is not found in any other part of the river. The Indians call it *Manitto*, p. 43.

Among the observations on vegetable products these may be remarked:—*Lindstrom* relates, that "The white and yellow Maise (Indian Corn) was used for bread, but the red, flesh-coloured, blue, dark, and speckled, was malted for beer, which became very strong, but not clear." p. 33.

Grapes of the several kinds, which we still have, grew in profusion on both sides of the river. Campanius says, that a vine four feet in circumference grew near Christiana Creek. p. 42.—He mentions peach-trees as growing among others, in several places. It is very improbable that they had been planted by Europeans. The remarkable abundance and variety of this valuable tree, before their decay for the last thirty or more years, proved their congeniality with the climate.

Swedish names of many places marked in the map of Campanius were given from various animals and trees, which abounded there: for example, *Wolf-creek*, *Deer-creek*, *Heron-point*, *Eagle-creek*, *Grape-point*, *Beach-creek*, *Hickory-island*, *Turtle-creek*, *Pike-creek*. They, with Indian names of the same kind, consequently illustrate the natural history of the country. Several of these are found in the vocabulary of the Rev. *Campanius*, annexed to his Catechism, and are inserted by our author. *Chwo*, pronounced, by the help of the Greek *omega*, very broad, signifies a pine-tree, and *Hacking* means a wood, or land generally: from these was named *Cohackin*, a district in Gloucester County, New Jersey, some miles below Philadelphia, which has many pine-trees, and still that name. *Tulpa*, turtle, accounts for the name of *Tulpehocken*, in Penn-

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* This place is some miles above Philadelphia, and still retains nearly that name.

sylvania, as the land-turtles are still numerous in this and other states. *Tanketitt manunckus siorens*, *small wicked birds*, was the name for a species, now called *blackbirds*, because their numerous and voracious flocks plundered the Indian corn. The Swedes called them *magis tjufvar*, or *maise thieves*. In the abovementioned Catechism, which displays a judicious regard to the condition of the Indians, the comment on the Lord's Prayer, enumerates the various comforts of life, and among the principal articles of nourishment, deer and *Moose*, or elks, which implies the frequency of these animals.

Hurricanes were called *Mochijric Schackhan*, *mighty winds*, on which he remarks that such violent gales came suddenly with a dark-blue cloud, and tore up oaks that had a girt of three fathoms.

The Swedes preserved a constant peace with the Indians by their kind treatment and readiness for defence, and lived in such familiar intercourse with them, that many could speak the language. It is, therefore, a matter of regret, that further valuable information respecting this, and other concerns of that people, was lost by the cessation of the colony. The Swedish government had given strict orders for good behaviour to them as native proprietors of the land, forbidding all encroachment by violence or fraud. It had also enjoined a careful investigation of all valuable vegetable, mineral, and animal productions of the country. The cultivation of the respective sciences was also retarded by the conquest, because the Dutch made commerce their main pursuit, and the English were for a considerable time, few and illiterate.

PART II.

After the loss of the colony, a supply of clergymen was prevented by the difficulty of communication, and by the wars and other weighty affairs of Sweden. The last colonial missionary was infirm by old age for a long while, and after his demise, there was a vacancy for some years. The parochial records had, probably, been lost, as the rev. *Andrew Rudman*, and *Eric Bjork*, who arrived in 1697, found only an imperfect remnant. They formed a list of all the families, noting the names and ages of the members. The whole number of persons was about eleven hundred. This, compared with the original stock, which, though not on record, might be conjectured from the known number of vessels that had brought them, proved a considerable increase. Not a few among them were aged; and families generally had many children. This was a very probable effect of a healthy climate, and good morals. The testimony of William Penn confirms this:—"As they are people proper and strong of body, so they have fine children, and almost every house full; rare to find one of them without three or four boys, and as many girls; some six, seven, and eight sons. And I must do them that right: I see few young men more sober and laborious." *History of Pennsylvania, by Robert Proud*, Vol. I. p. 261.

The Swedes had, besides the church on *Tinnicum*, a lesser one on *Crane-point*, not far from *Christiana* fort, on the other side of the creek, erected in 1666. A blockhouse, raised for defence, on the Delaware, in (the present) Southwark, was also fitted for public worship in 1676. All three were decayed, and otherwise incompetent. By the laudable zeal of these clergymen, the *Christiana* church was finished in 1699, and that at Philadelphia in 1700. *Bjork* became rector of the first, and *Rudman* of this. The people in Jersey contributed to the building of these, and worshipped in them for a while.

The church on *Racoon Creek* was erected in 1704. A small chapel was added in 1717, fourteen miles below it. The two first mentioned are still extant, but in lieu of the others, new ones have been built. The respective parochial records give the following information until the end of 1744.

Among the persons numbered in 1697 were about sixty natives of Sweden, who arrived while it owned the colony. In the course of thirty years, almost all died. They were, generally, above seventy; several near or past eighty; some nearer ninety; and some beyond that age: a woman, for a long time a widow, was ninety-two: one man was an hundred; and his widow, who survived seven years, was ninety-seven. A man, the last of these Swedes, died 1742, aged ninety-seven.

Among the offspring of the colonists deceased by this time, some were beyond seventy, or near eighty; but not many had passed sixty. Some of the living were between seventy and eighty. A couple had been married sixty-three years: the wife died eighty-eight years old, 1744. A man aged ninety-seven, died 1740: but it is not certain whether he was born here or in Sweden.

Old people died, very generally in December, January, and February. Many children also died in those months, but a greater proportion between the latter part of June and the middle of October. The first part of summer was commonly the most healthy to all ages.

Pleurisy was frequently mortal, especially in 1728, (to a great number in Penn's Neck, a part of the Jersey Parish.) The small-pox frequently killed children, and in some years also youth and grown persons: many from the beginning of May, 1716, until February, 1717; and from the beginning of March until the last of December, 1731.

Some years the number of deaths was much increased, without any disease prevailing. Probably the intemperance of the seasons was, partly, the cause.

In the autumn of 1699, when the yellow fever was destructive in Philadelphia, the Swedes in the country were also sickly, and several died; but no mention is made of it, nor of any prevailing disease. Two brothers died, one of dysentery combined with fever.

Intermittent fevers were common near the marshes, and often shortened life, although not immediately.

Mortality of children was always great. The death of youth of both sexes, was not rare. Among the married, young women died often, but the middle aged commonly survived their husbands.

Marriages were early and generally prolific. Younger widowers and widows were also commonly re-married. Population increased accordingly; so that during this period, viz. from 1697 until 1744, the whole number of births and deaths were in the proportion of five and two.

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Stormy winds were frequent. Many cases of danger and drowning on the Delaware, and the creeks are mentioned. In March, 1701, when a corpse was carried from Jersey for burial at the Philadelphia church, three of the attendants were lost. Several persons were killed by strokes of lightning, at divers times.

A man died by the bite of a rattle-snake in the middle of August, 1716, in a place then abounding with them.

Rudman mentions a violent snow-storm in the last of December, 1697.

His successor *Sandel* has left several interesting notes, which I shall quote verbatim, altering the dates to the new style.

" On Michaelmas day, the 10th of October, fell a heap of snow that laid twenty-four hours on the ground. Afterwards it became clear and very cold. The oldest people said that such had never before happened. On the 18th of the same in the evening, a hurricane arose which caused great damage. In Maryland and Virginia, many vessels were cast away, several driven to sea, and no more heard of. Ten tobacco-houses belonging to one man were overturned. In Philadelphia, the roof of a house was torn off. A great number of large trees were blown down. This storm also took place in England, and was destructive.

"In 1704, in the latter part of November and December, and in January, 1705, we had many, great, and lasting snow-storms. Few persons could remember such a severe winter.

"The winter of 1708 was very cold. Many persons observed places frozen over, which never had been so before. It also continued very late; the 5th of April, the cold with a piercing wind was so intense, that water thrown upon the ground at noon, immediately froze.

"In June, July, and August, 1705, during six weeks, was a great deal of bad weather.

"The beginning of 1714 was uncommonly warm. I saw a wild flower in the woods the 8th of February. The spring was also very mild. Some rye was in ear the 10th of April.

"In May, 1715, a multitude of locusts came out of the ground every where, even on the solid roads. They were wholly covered with a shell, over the mouth, body and feet; and it seemed very wonderful, that they could with this penetrate the hard earth. Having come out of the earth, they crept out of the shells, flew away, sat down on the trees, and made a peculiar noise until evening. Being spread over the country, in such numbers, the noise was so loud that the cowbells could scarcely be heard in the woods. They ripped the bark on the branches of the trees, and put maggots in the openings.* Many apprehended that the trees would wither in consequence of this, but no symptom of it was observed next year. Hogs and poultry fed on them. Even the Indians did eat them, especially on their first coming, broiling them a little. This made it probable that they were of the same kind with those that John the Baptist eat. They did not continue long, but died in the month of June.

"This year was very fruitful. A bushel of wheat cost two shillings, or two shillings and three pence: a bushel of corn twenty-two pence: of rye twenty pence. There was also

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* Their eggs.

plenty of apples: a barrel of cider cost, at first, only six shillings."

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Eneberg, a clergyman of this church, remarks: 1732, in the latter part of November, ice made the river impassable: 1733 there was much snow in January.

Rector *J. Dylander* wrote the following narrative of an earthquake: " 1737, December 17th, at 11 o'clock at night an uncommon earthquake happened: the houses were shaken, the windows rattled, and the shock was more felt in the upper stories. Two hours before came a violent shower from SW. which lasted only half an hour. After this, the air cleared, and became very calm. But just as the town-clock struck 11, a breeze was heard in the west, which increased more and more, and was heard near the ground, until the house began to shake, so that persons in bed felt as if rocked to and fro, and those on the floor could hardly keep standing, and plates and glasses fell down in some houses. This lasted in some places one minute, and in others two; but it went over the country with the same effect, so far as reports have come, on both sides of the river."

P. Tranberg, rector of the Jersey church, writes in 1727. This was a hard winter that distressed the people and the minister. The two following years the parochial records have many funerals.

The observations on the climate during the Swedish colony are the first that were made in this part of America. Records made after the arrival of William Penn, may be collected from different sources, and the whole would, if properly examined and arranged, afford very interesting information.

No. XXVIII.

Research concerning the Mean Diameter of the Earth. By R. Adrain.—Read, Nov. 7, 1817.

THE figure of the earth approaches nearly to that of an oblate spheroid of revolution, the axis being to the equatorial diameter in the ratio of 320 to 321. When this figure is made use of in navigation, geography, &c. the calculations become much more abstruse and laborious than when we consider the earth simply as a sphere. In certain cases, where extreme accuracy is necessary, the oblate figure must be taken into account; but in general, the globular figure will still be retained, as sufficiently accurate for most purposes, of great simplicity in theory, and of easy calculation in practice.

But, if we substitute a sphere instead of the spheroid with which the figure of the earth very nearly coincides, we are by no means at liberty to choose the diameter of the sphere without restriction: we must select a sphere agreeing with the spheroid in as many important circumstances as possible. Of these the following deserve particular attention.

I. The sphere should be equal in magnitude to the spheroid.

II. The mass of the sphere should be equal to that of the spheroid.

III. The surface of the sphere should be equal to the surface of the spheroid.

IV. The length of a degree of a great circle on the surface of the sphere should be a mean of all the degrees of great ellipses on the surface of the spheroid.

V. The radius of the sphere should be a mean of all the radii of the spheroid.

VI. The gravity on the surface of the sphere should be equal to the mean gravity on the surface of the spheroid.

When the spheroid differs very little from a sphere, as in the present case, so that we may neglect, as inconsiderable, all the powers of the ellipticity above the first, we are led to a remarkable coincidence; for all these conditions are fulfilled by one and the same sphere. The determination of this sphere is the object of the following calculations.

PROBLEM I.

To determine the radius of a sphere equal in magnitude to a given oblate spheroid of small ellipticity.

SOLUTION.

Let a and b be the greater and less semiaxes of the spheroid, $r=$ the radius of the required sphere, and $\pi=$ the circumference of a circle to the diameter unity.

By mensuration, the magnitude of the spheroid is $\frac{4\pi}{3}.a^2b.$ and that of the sphere is $\frac{4\pi}{3}.r^3$; we have therefore $\frac{4\pi}{3}.\,r^3=\frac{4\pi}{3}.\,a^2b$, consequently $r^3=a^2b$.

It is evident, therefore, that the radius r is the first of two mean proportionals between a and b.

When a and b are nearly in the ratio of equality, let $b=a-c$, and by substitution $r^3=a^3-a^2c$, of which the cube root, retaining only the first power of c, is $r=a-\frac{1}{3}e$; or which is the same thing, $r=b+\frac{2}{3}e$, or $r=\frac{2a+b}{3}$.

According to these formulæ r is the first of two arithmetical means between a and b, and may be found by taking from the greater one third of the difference, or by adding to the less two-thirds of the same difference.

When the less semiaxis b is denoted by unity, and the greater by $1+\delta$, the ellipticity being δ, we have $r+1=\frac{2}{3}\delta$.

We may easily determine in what latitude the semidiameter of the spheroid is equal to the radius of the equivalent sphere.

For this purpose, let ϱ = radius or semidiameter of the spheroid in the latitude λ; and when only the first power of δ is retained, we have, by the nature of the ellipse,

$$\varrho=1+\delta\cos^2\lambda.$$

And since $r=\varrho$, we have

$$1+\delta\cos^2\lambda=1+\frac{2}{3}\delta,$$

therefore $\cos^2\lambda=\frac{2}{3}$, or $\sin^2\lambda=\frac{1}{3}$; consequently the latitude $\lambda=35°\ 16'$, in which the semidiameter of the spheroid is equal to the radius of a sphere equal in magnitude to the spheroid.

When the densities of the sphere and spheroid are uniform and equal, it follows from this proposition that their masses are equal, when $r=1+\frac{2}{3}\delta$.

PROBLEM II.

To determine the radius of a sphere, of which the mass may be equal to that of a given oblate spheroid of small ellipticity, when the density is variable.

SOLUTION.

Conceive the spheroid to be divided by concentric spheroidal surfaces into an infinite number of similar orbs having their axes proportional to the axes of the whole spheroid; and suppose the density in each orb to be uniform, but variable from one orb to another, according to any law whatever. Draw, from the center of the spheroid, a radius to the parallel in which the square of the sine of the latitude is $\frac{1}{3}$; with the several distances from the center to the points in which this radius cuts the surfaces of the orbs, describe spherical surfaces, comprehending an infinite number of spherical orbs; and suppose the density in each spherical orb to be the same with the density in the corresponding spheroidal orb.

It evidently follows from the preceding solution, that the magnitudes of the corresponding spherical and spheroidal orbs are equal; because these orbs are the differences of spheroids and of corresponding spheres respectively equal to them. And since by supposition the density is the same in two corresponding spherical and spheroidal orbs, the masses in these orbs are equal, and therefore the sum of the masses of all the orbs in the sphere is equal to the sum of the masses of all the orbs in the spheroid; that is, the mass of the sphere is equal to the mass of the spheroid: the radius of the sphere being equal to the radius of the spheroid in latitude 35° 16′. We have therefore, $r=1+\frac{2}{3}\delta$, where $r=$ the radius of the required sphere as in the preceding problem.

PROBLEM III.

To determine the radius of a sphere, of which the surface may be equal to that of a given oblate spheroid of small ellipticity.

SOLUTION.

Retaining the preceding notation, let x be an abscissa reckoning on the less axis from the center, and y the corresponding rectangular coordinate of the elliptic meridian, and by the property of the ellipse the equation of the meridian is

$$a^2x^2+b^2y^2=a^2b^2.$$

From this equation we easily find the differential of the spheroidal surface to be

$$\frac{2\pi a}{b}.dx\sqrt{b^2+\frac{a^2-b^2}{b^2}.x^2},$$

the integral of which may be given in general terms by logarithms; but in our problem the ellipticity is supposed to be very small: we may therefore proceed as follows.

Put $b=1$, $a=1+\delta$, and we have $a^2-b^2=2\delta$, the powers of δ above the first being neglected; the preceding differential thus becomes $2\pi(1+\delta).dx\sqrt{1+2\delta x^2}$.

But $\sqrt{1+2\delta x^2}=1+\delta x^2$, and therefore the differential of the surface becomes $2\pi dx(1+\delta+\delta x^2)$,
of which the integral beginning with x is

$$2\pi\left\{(1+\delta)x+\frac{\delta x^3}{3}\right\}.$$

When $x=1$ we have half the surface $=2\pi(1+\frac{4\delta}{3})$, therefore, the whole surface of the spheroid is $4\pi(1+\frac{4\delta}{3})$.

Again, the surface of a sphere to the radius r is $4\pi r^2$, we must therefore have $4\pi r^2=4\pi(1+\frac{4\delta}{3})$;

whence $r^2=1+\frac{4\delta}{3}$, and consequently $r=1+\frac{2\delta}{3}$.

This result gives precisely the same value of r as in the preceding problems; it is manifest, therefore, that a sphere of which the radius is equal to the semidiameter of the spheroid in latitude 35° 16′ will have its surface and solidity respectively equal to those of the spheroid.

The surface of the spheroid of small ellipticity may be easily determined in a different manner, as follows.

Let λ denote the reduced latitude, or as it is called by Delambre, the geocentric latitude, which is the angle contained betwen ϱ and a; and by conics, retaining only the first power of δ, we have

$$\varrho=1+\delta\cos^2\lambda;$$

the value of ϱ being the same in terms of λ as when λ is the common latitude, the powers of δ above the first being rejected. Also ϱ may be considered as at right angles to the meridian, because the sine of the angle which ϱ makes with the true elliptic meridian does not involve δ, but δ^2, δ^3, &c.

In this case the element of the meridian will be denoted by $\varrho.d\lambda$, which multiplied by the length of the parallel $2\pi\varrho\cos\lambda$, gives $2\pi\varrho^2.d\lambda\cos\lambda$ for the differential of the spheroidal surface. But $\varrho^2=1+2\delta\cos^2\lambda$, therefore the differential of the surface is

$$2\pi(d\lambda\cos\lambda+2\delta.d\lambda\cos^3\lambda),$$

of which the integral beginning with λ is

$$2\pi\left\{\sin\lambda+\delta(2\sin\lambda-\frac{2}{3}\sin^3\lambda)\right\}.$$

This expression when $\lambda=\frac{\pi}{2}$ becomes $2\pi(1+\frac{4\delta}{3})$, and therefore the whole surface $=4\pi(1+\frac{4\delta}{3})$, which coincides exactly with the result of the preceding investigation.

PROBLEM IV.

To find a sphere, on which the degree of a great circle may be a mean of all the degrees of great ellipses of a given oblate spheroid of small ellipticity.

SOLUTION.

Since the degree is always proportional to the radius of curvature, it is obvious that the proposed problem is equivalent to the following:

To find a sphere, of which the radius may be a mean of all the radii of curvature of the spheroid.

The semiaxes of the spheroid being denoted by 1 and $1+\delta$, and the latitude by λ; let R be the radius of curvature of the meridian in latitude λ, and R' the radius of curvature of the central ellipse at the point where it cuts the meridian at right angles in the same latitude.

By conics and the differential calculus we have

$$R=1+\delta(2-3\cos^2\lambda), \text{ and } R'=1+\delta(2-\cos^2\lambda);$$

the latter R' being the same with the radius of curvature of the vertical section cutting the meridian at right angles in latitude λ, when we neglect the powers of δ above the first.

Again, let A be the angle which a vertical or central ellipse makes with the meridian in latitude λ, and R'' the radius of curvature of this section in the same latitude; and by the differential calculus we have $R''=R+(R'-R)\sin^2 A$.

Multiply this equation by dA, and we have

$$R''dA=RdA+(R'-R).dA\sin^2 A,$$

which is the measure of the sum of all the radii of curvature in the angle dA: and the integral beginning with A is

$$RA+(R'-R).\left(\frac{A}{2}-\frac{1}{4}\sin 2A\right)$$

expressing the measure of the sum of all the radii of curvature in the angle A. When $A=2\pi=$ a circumference, this sum becomes $\pi.(R+R')$, which, by putting for R and R' their values given above in terms of δ and λ, is expressed by

$$2\pi \{ 1+2\delta \sin^2\lambda \}:$$

and this is the proper measure of the sum of all the radii of curvature at any point of the meridian.

Now in any equal particles of surface it is evident that an equal number of radii of curvature may be drawn; we must therefore multiply the preceding sum

$$2\pi \{ 1+2\delta \sin^2\lambda \}$$

by the differential of the spheroidal surface

$$2\pi.d\lambda \cos \lambda \{ 1+2\delta \cos^2\lambda \},$$

and the product $4\pi^2.(1+2\delta).d\lambda \cos \lambda$ is the differential of the sum of all the radii of curvature. The integral beginning with λ is $4\pi^2.(1+2\delta) \sin \lambda$, which, when $\lambda=\frac{\pi}{2}$, is $4\pi^2.(1+2\delta)$: and the double of this, viz. $8\pi^2.(1+2\delta)$ is the measure of the sum of all the radii of curvature on the surface of the spheroid.

By reasoning in a similar manner with a sphere to the radius r, we have the sum of all the radii at any point $=2\pi r$, which multiplied by the differential of the spherical surface $2\pi r^2.d\lambda \cos \lambda$ gives $4\pi^2 r^3.d\lambda \cos \lambda$ for the differential of the sum of the radii of the sphere. The integral beginning with λ is $4\pi^2 r^3.\sin^2\lambda$; which, by making $\lambda=\frac{\pi}{2}$, and then doubling, becomes $8\pi^2.r^3$ for the measure of the sum of all the radii in the sphere.

Lastly, when the radius of the sphere is a mean of all the radii of curvature of the spheroid, the two integrals found above must be equal; we have therefore, $8\pi^2.r^3=8\pi^2.(1+2\delta)$, whence $r^3=1+2\delta$, and consequently $r=1+\frac{2}{3}\delta$, which is the radius of the required sphere, and agrees exactly with what has been found in the solutions of the preceding problems.

Nearly related to this problem is the following, the solution of which being nearly similar to that just exhibited, need not be given in detail.

PROBLEM V.

To find a sphere of which the curvature may be equal to the mean curvature of a given oblate spheroid of small ellipticity.

SOLUTION.

The curvature being inversely as the radius of curvature, we have only to use every where the reciprocals of R, R′, R″, instead of these quantities themselves in the preceding solution. The curvature of the meridian and of the great ellipse at right angles to it will be measured by $1-\delta.(2-3\cos^2\lambda)$, and $1-\delta.(2-\cos^2\lambda)$; and the value of the required radius of the sphere is found as before $r=1+\frac{2}{3}\delta$.

PROBLEM VI.

To find a sphere of which the *n*th power of the radius may be a mean of the *n*th powers of all the radii of an oblate spheroid of small ellipticity.

SOLUTION.

The solid angle at the center of the spheroid, or the corresponding spherical surface to the radius unity, is the measure of the number of radii that can be drawn to the corresponding elementary particle of surface on the spheroid. This solid angle or spherical surface is expressed by $2\pi.d\lambda\cos\lambda$, which, multiplied by ϱ^n gives $2\pi\varrho^n.d\lambda\cos\lambda$ for the differential of the sum of nth powers of the radii in the spheroid.

But since $\varrho=1+\delta.\cos^2\lambda$, therefore $\varrho^n=1+n\delta\cos^2\lambda$, and therefore the differential just found, becomes

$$2\pi\{d\lambda\cos\lambda+n\delta d\lambda\cos^3\lambda\}.$$

The integral of this, beginning with λ, is

$$2\pi\left\{\sin\lambda+n\delta\left(\sin\lambda-\frac{1}{3}\sin^3\lambda\right)\right\},$$

which, when $\lambda=\frac{\pi}{2}$ becomes $2\pi\left\{1+\frac{2n\delta}{3}\right\}$; and the double of this, viz. $4\pi\left\{1+\frac{2n\delta}{3}\right\}$, is the sum in the case of the spheroid.

Again, r being the radius of the sphere, we obtain by a similar method $4\pi.r^n$ for the sum of the nth powers of the radii: and since, when r^n is a mean of all the ϱ^n the latter sum must be equal to the former; we have therefore

$$4\pi r^n=4\pi.\left\{1+\frac{2n\delta}{3}\right\},$$

whence $r^n=1+\frac{2n\delta}{3}$, and extracting the nth root, we have $r=1+\frac{2}{3}\delta$; the same result as in the preceding problems.

In like manner we may find the radius of the sphere such that its nth power may be a mean of the nth powers of all the radii of curvature in the spheroid: and the result will be the same as before.

PROBLEM VII.

To find a sphere such that any function of its radius may be a mean of the similar functions of all the radii of an oblate spheroid of small ellipticity.

SOLUTION.

Let $\phi(\varrho)$ be any function of the radius ϱ, and according to what was shown in problem 6th, the differential of the sum of all the $\phi(\varrho)$ in the spheroid is $2\pi.\phi(\varrho).d\lambda\cos\lambda$, or which is the same thing, $2\pi d\lambda\cos\lambda.\phi(1+\delta\cos^2\lambda)$.

But $\phi(1+\delta\cos\lambda)=A+B\delta\cos\lambda$, in which A and B are numbers deduced from unity according to the form of the function ϕ: the preceding differential therefore becomes

$$2\pi.\left\{Ad\lambda\cos\lambda+B\delta.d\lambda\cos^3\lambda\right\},$$

of which the integral beginning with λ is

$$2\phi.\left\{A\sin\lambda+B\delta(\sin\lambda-\frac{1}{3}\sin^3\lambda)\right\}.$$

This integral, when $\lambda=\frac{\pi}{2}$, becomes $2\pi.\left\{A+\frac{2}{3}B\delta\right\}$, the dou- of which $4\pi.\left\{A+\frac{2}{3}B\delta\right\}$ is the measure of the sum of all the similar functions of ϱ in the spheroid.

Again, let us denote the required radius r by $1+a$, and the differential of the sum in the sphere is $2\pi d\lambda\cos\lambda.\phi(1+a)$.

But since $\phi(1+\delta\cos^2\lambda)=A+B.\delta\cos^2\lambda$, therefore $\phi(1+a)=A+Ba$, as is evident by writing a instead of $\delta\cos\lambda$, and A and B are the same numbers for the sphere as for the spheroid: the differential of the sum in the sphere is therefore $2\pi d\lambda\cos\lambda.(A+Ba)$, of which the integral, beginning with λ, is $2\pi\sin\lambda.(A+Ba)$; and by putting $\lambda=\frac{\pi}{2}$, and doubling the result, we have the sum of all the similar functions of the radii in the sphere expressed by $4\pi.(A+Ba)$.

Now this sum must be equal to that found in the case of the spheroid; we have therefore

$$4\varpi.(A+Ba)=4\pi.(A+\frac{2}{3}B\delta),$$

whence $A+Ba=A+\frac{2}{3}B\delta$, and consequently $a=\frac{2}{3}\delta$, and therefore $1+a=r=1+\frac{2}{3}\delta$ as before.

By a method nearly similar, we may resolve the following problem. To find a sphere such that any function of its radius may be a mean of the similar functions of all the radii of curvature in the spheroid.

Each of the last two problems comprehends the other, and all those in the preceding part of this paper, with many others which it is unnecessary to mention: we have therefore good reason to conclude that the mean diameter of the earth is truly determined by the formula $r=a-\frac{a-b}{3}$, or which amounts to the same thing $r=b+\frac{2}{3}(a-b)$, or $r=\frac{2a+b}{3}$, or more simply by $r=1+\frac{2}{3}\delta$.

PROBLEM VIII.

To determine the gravity which ought to be assigned to the earth's surface when taken as a sphere.

SOLUTION.

Let g and g' be the gravities at the pole and equator of the terrestrial spheroid, and, by the theory of gravity on the surface of revolving spheroids, the gravity in latitude λ is $g'+(g-g')\cos^2\lambda$, which, multiplied by the differential of the surface $2\pi\varrho^2.d\lambda\cos\lambda$, gives

$$2\pi d\lambda\cos\lambda\,(1+2\delta\cos^2\lambda)\,.\,(g'+(g-g')\cos^2\lambda),$$

or

$$2\pi\{g'd\lambda\cos\lambda+(g-g'+2g'\delta).d\lambda\cos^3\lambda\}$$

for the differential of the measure of the whole gravity on every part of the surface of the earth. This differential integrated so as to begin with λ gives

$$2\pi \left\{ g' \sin\lambda + (g - g' + 2g'\delta).(\sin\lambda - \frac{1}{3}\sin^3\lambda) \right\};$$

which by taking $\lambda = \frac{\pi}{2}$, and doubling the result, gives

$$4\pi. \left\{ g' + \frac{2}{3}(g - g' + 2g'\delta) \right\}$$

for the measure of the whole gravitation on the surface of the spheroid.

This quantity divided by the whole surface of the spheroid, or of the sphere having an equal surface, viz. by

$$4\pi.(1 + \frac{4}{3}\delta),$$

the quotient $g' + \frac{2}{3}(g - g')$, or $\frac{2g + g'}{3}$, is the mean gravity required.

It is easy to perceive that this gravity also belongs to the latitude 35° 16′ in which $\cos^2\lambda = \frac{2}{3}$, as in the determination of the mean radius r.

In this latitude 35° 16′ in which the surface of the mean sphere cuts the surface of the terrestrial spheroid, the attraction towards the sphere is equal to the attraction towards the spheroid, whether we suppose the densities of both to be uniform, or to vary according to the law adopted in the solution of the second problem, when the powers of δ above the first are neglected. We may conclude, therefore, that the radius of the required mean sphere and the gravity on its surface should be equal to the semidiameter and gravity of the terrestrial spheroid in latitude 35° 16′.

Having determined the most probable axes of the terrestrial spheroid from the measurement of degrees of the meridian by a method which I discovered several years ago, and published in *The Analyst;* the resulting mean radius was found to be 3959.36 English miles. The diameter of the earth taken as a sphere is therefore 7918.7, the circumference 24877.4, and the length of a degree of a great circle 69.104, or $69\frac{1}{10}$ English miles very nearly.

No. XXIX.

An Improvement in the common Ship-Pump. By Robert Patterson.—Read, July, 1795—but afterwards mislaid.

NOTWITHSTANDING the numerous improvements that have, from time to time, been proposed in the construction of *ship-pumps*, yet, after all, the common *lifting pump* still remains in general use.

The paper, now submitted to the consideration of the society, is an attempt towards an improvement in *this* pump, by means of a very simple appendage, that may be readily applied at any time, when wanted, and by which a very considerable proportion of the manual labour, usually employed, will be saved.

The following is a description of this appendage, with the manner of its application and use.

I. Let a plug of white pine, cedar, or any other suitable wood, or of cork, be made, very nearly cylindrical, so as exactly to fit the bore of the pump above the nozle.

II. Through the axis of this plug, a hole is to be bored, of the size of the pump-rod: and then the plug is to be split or cut through the axis or center of the hole.

III. Place this plug round the pump-rod, and let it be firmly inserted into the bore of the pump, above the nozle; and there secured by a pin or bolt driven through the pump, just above the plug, so as to prevent it from being raised by the force of the water acting against it. The part of the pump-rod that works in the plug may be made as round and smooth as possible, in order to prevent friction, and the passage of water through the hole. With the same view, the hole may be lined or packed with oakum, and a stratum of oil or slush placed over the plug.—It will be advisable to have the nozle inserted as *low down* in the pump-tree as practicable, and thus, the vertical hole through the plug will be the less affected by the angular motion of the pump-rod.

IV. Round the nozle of the pump, let there be fastened one end of a pretty wide open hose, of leather or painted canvas; the other end passing over or through the side of the vessel, and hanging down into the water. The pump, with this simple appendage, may be considered as a *syphon*, having the shorter leg outside, and the longer leg inside of the vessel; and the height to which the water will *in effect* have to be raised, by the action of pumping, will be no more than the *difference* between the height of the water in the hold and that outside of the vessel; and thus, frequently, more than *half* the usual labour of pumping will be saved.

REMARKS.

I. The height to which the water will, *in effect*, have to be raised by pumping, is that stated above, on the supposition of the vessel being at rest, or in still water: But if under way, and sailing with any considerable velocity through the water, as is generally the case when the pump is most employed, then the labour of pumping will be still further diminished. For, it is easy to demonstrate, from the principles of hydraulics, that the velocity of the open end of the hose through the water will have the effect of raising the water from the hold to a height equal to that from which a heavy body descending would acquire that velocity (neglecting the effect of friction.) Thus, a velocity of little more than 4 1-2 knots per hour, would raise the water *one* foot; and a velocity of somewhat less than 9 1-2 knots, would raise the water *four* feet, &c. &c. And this effect will be still further increased by the *traction* of the external water on that issuing from the hose; which, in ordinary cases, will be far from inconsiderable.

II. The best way of applying the labour of men, or other animals, in the working of pumps or other machines is, when practicable, that in which both the *weight* of the animal, and the *strength* of its muscles are employed; and in which short intervals of exertion and rest, or of greater and less exertion, constantly succeed each other. The action of rowing a boat will serve as a very good example of this application of labour.

III. It follows from the above principle, that the manner of applying the labour of man in working a pump, in the common way, is perhaps the most injudicious that can well be conceived. His body serves only as a fulcrum for his arms to work on, its weight contributing little or nothing to the effect produced; this depending almost entirely on the exertion of the strength of his arms, and that in a direction which is, in general, the most fatiguing, and least effective possible; not to mention the constant reiterated *checks* which must be given to the action of the pump-handle, in its alternate up-and-down motion.

IV. The manner of working the pump which I would propose, as free from all the above inconveniences and imperfections, is the following.

1. Let the pump-brake, or handle, be in the form and position of a pretty heavy pendulum, and of such a length as that its natural oscillations may be nearly the same with those given it by the action of pumping.

2. Into this pendent pump-brake, let there be firmly fixed a long cylindrical pin, to serve as the immediate handle, and at right angles to the plane of the pendulum's motion.

3. Let the men working the pump be seated on a bench of a suitable height, with their feet pressing against a cleat or footstool, fastened to the deck; and in this position they will produce all the advantages which can possibly be derived from the exertion of animal force.

4. By placing the pendulum in such a position that its oscillations may correspond with the pitching or rocking of the vessel, the pumping, in ordinary cases, may, by this means, be frequently effected without manual labour.

5. By suffering a quantity of air to pass into the pump along with the water, the labour of pumping will be considerably alleviated, from the compressibility and diminished weight of the column of the mixture of air and water in the pump-barrel; and yet the total effect, in proportion to the quantity of force applied, will remain the same.

No. XXX.

Observations on those Processes of the Ethmoid Bone which originally form the Sphenoidal Sinuses. By C. Wistar, M. D. President of the Society, Professor of Anatomy in the University of Pennsylvania.—Read, Nov. 4, 1814.

IT had been long believed that the Sinuses, or cavities in the body of the Os Sphenoides, were exclusively formed by that bone, when Winslow suggested that a small portion of the orbitar processes of the Ossa Palati contributed to their formation.*

Many years after Winslow's publication, Monsieur Bertin described two bones which form the anterior sides of those sinuses, and contain the foramina by which they communicate with the nose.†

These bones he denominates "Cornets Sphenoidaux," and states that they are most perfect and distinct between the ages of four years and of twenty; that they are not completely formed before this period, and that after it, they appear like a part of the Sphenoidal bone.—According to his account they are laminæ of a triangular form, and are origi-

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* In his description of the Ossa Palati, printed in the Memoirs of the Academy of Sciences, for 1720.

† See Memoirs of the Academy of Sciences, for 1744.

nally in contact with the anterior and inferior surface of the body of the Os Sphenoides, so that they form a portion of the surface of the cavity of the nose.—He believed, that as they increase in size, they become convex and concave, and present their concave surfaces to the body of the sphenoidal bone, which also becomes concave, and presents its concavity to those bones; thus forming the sinuses.

This account of Mr. Bertin has been adopted by Sabatier, and also by Boyer, who has improved it by the additional observation, that these triangular bones are sometimes united to the Ethmoid, and remain attached to that bone when it is separated from the Os Sphenoides. Bichat and Fife have confirmed the description of Boyer.

The specimens of Ethmoid and Sphenoid bones, herewith exhibited to the society, will demonstrate, that in certain subjects, about two years of age, there are continued from the posterior part of the cribriform plate of the Ethmoid, *two Hollow Triangular Pyramids*, which, when in their proper situation, receive between them the azygos process of the Os Sphenoides.—(See Plate X. Figures 1, 2, 3. with the explanation.)

The internal side of each of these pyramids applies to the aforesaid azygos process; the Lower Side of each forms part of the upper surface of the Posterior Nares; the External Side at its basis is in contact with the Orbitar Process of the Os Palati. The base of each Pyramid forms also a part of the surface of the Posterior Nares, and contains a foramen which is ultimately the opening into the Sphenoidal Sinus of that side.

In the Sphenoidal Bones which belong to such Ethmoids as are above described, there are no cells or Sinuses; for the Pyramids of the Ethmoid bones occupy their places. The azygos process which is to become the future septum between the Sinuses, is remarkably thick, but there are no cavities or Sinuses in it.

The sides of the Pyramids which are in contact with this process are extremely thin, and sometimes have irregular foramina in them, as if their osseous substance had been partially absorbed.* That part of the external side of the Pyramid which is in contact with the orbitar process of the Os Palati is also thin, and sometimes has an irregular foramen, which communicates which the cells of the aforesaid orbitar process.

Upon comparing these perfect specimens of the Ethmoid and Sphenoidal Bones of the subject about two years of age, with the Os Sphenoides of a young subject who was more advanced in years, it appears probable, that the azygos process and the sides of the Pyramid applied to it, are so changed, in the progress of life, that they simply constitute the septum between the Sinuses; that the External Side of the Pyramid is also done away, and that the Front Side and the Basis of the Pyramid only remain; constituting the Cornets Sphenoidaux† of M. Bertin.

If this be really the case, the origin of the Sphenoidal Sinuses is very intelligible.

Explanation of the Figures in Plate X. referred to above.

FIG. I.

Represents the upper surface, or cribriform plate, of the Ethmoid Bone.

a. Crista Galli.
b b b b. Cribriform Plate.
c. Surface denominated Os Planum.
d d. Hollow Triangular Pyramids.
e. Space between the Pyramids for receiving the Azygos Process of the Os Sphenoides.

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[*] See *e*, fig. 3.

[†] "Cornet" is the word applied by several French anatomists to the Ossa Turbinata of the nose; they seem to have intended to express by it a convoluted lamina or plate of bone.

FIG. II.

A Lateral View of the Bone.

a. Christa Galli.
c. Os Planum.
d. Triangular Pyramid.

FIG. III.

The Bone Inverted.

a. The Nasal Plate of the Ethmoid Bone, which constitutes the upper portion of the Septum of the Nose.
g g. Those portions of the Ethmoid which are called Superior Turbinated Bones.
ff. The Cellular Lateral portions of the Bone.
d d. The Triangular Pyramids.
e. Space between the Pyramids for the Azygos Process of the Os Sphenoides—a foramen on the internal side of one of the Pyramids.

The fine drawing of the Ethmoid Bone for this plate, was done by my friend M. Lesueur, whose talents are so conspicuous in the plates attached to Peron's "Voyage de Déscouvertes aux Terres Australes."

No. XXXI.

An Account of Two Heads found in the Morass, called the Big Bone Lick, and presented to the Society, by Mr. Jefferson. By Caspar Wistar, M. D.

THE two heads which are the subjects of the following observations, were selected from a large number of bones presented to the society by our much venerated President Jefferson. Being satisfied that the morass near the falls of Ohio, called the *Big Bone Lick*, still contained many animal remains which were worthy of attention, he engaged General Wm. Clarke, who is so honourably known to the world by his Journey to the Pacific Ocean, to explore it, and furnished him with all the means necessary for so expensive an undertaking.

Gen. Clarke accomplished the business committed to him with great promptitude, and procured several large boxes of bones.—It was Mr. Jefferson's determination to present to this society, a complete specimen of every new thing found there, which was any way interesting, and to send to the Institute of France, the duplicates which remained after the selection for the society was made. With this view he requested me to examine the collection, and, in a very impressive manner, expressed his intention in favour of the society. as above stated.

I found that the great mass consisted of the bones of the large animal, formerly of this country, to which the name of Mastodonte has lately been given by M. Cuvier. Among these were also some large teeth, which I supposed to have belonged to the Elephant of Siberia, and several specimens of smaller teeth of the same kind, with the lower jaw-bones to which they belonged, evidently of young amimals. There were also several tusks; one similar to that which Mr. Peale procured with his skeleton of the Mastodonte, and some others of the Elephant of Asia or Africa.

Besides these there were several mutilated heads. Two, which were in the best preservation, are the subjects of the following memoir. Several others, which probably are of the genus Bos, are so decayed, that it is impossible to decide confidently respecting them.

There are also some single bones of the extremities of smaller animals.

As the society, in consequence of the great ingenuity and industry of Mr. Peale, have the use of a skeleton of the Mammoth, which is complete in all respects but the head; I made a large selection of bones of the Mastodonte for the Institute, but reserved for the society all the fragments which belonged to the head.

The mutilated and decayed heads, as they were all single specimens, I reserved for the society, and also a large proportion of the teeth, and lower jaw-bones of the Siberian Elephant, with the other bones above mentioned. By some accident the young teeth and jaw-bones of the Siberian Elephant have not reached us.* The other bones arrived, and the following account of the two heads, which are in the best state of preservation, is the commencement of my description of the collection.

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* Probably they went to France by mistake.

In Plate X. fig. 4 and fig. 5. are two views of one of these heads, which I believe to have belonged to an animal of the genus Cervus. The figure 4, exhibits the upper and posterior surfaces of the cranium and horns, as they appear when the head is viewed from behind. The figure 5, represents a profile view. The upper surface of the left portion of the cranium has been abraded, the line which separates the natural from the abraded surface begins at *a* fig. 4, and extends backwards in the manner represented in the plate. The surface of the cranium to the right of this line appears uninjured.

The breadth of the cranium at its narrowest part, from *b* to *b*, fig. 4, is 4.75 inches, the distance from *c* to *c* is 7 inches. The depth of the cranium from *e* fig. 5, at the margin of the occipital surface, to the most distant part of the great foramen of the occipital bone, is 5.25 inches. From *d*, in the same figure, to the body of the sphenoidal bone immediately under it, 4.7 inches. The length of the cranium, from *e* above mentioned, to *f*, which is the middle of the space between the horns, is 6.37 inches.

If it belonged to the genus Cervus, it was one of the largest species of that genus.

That it might be compared with the two other large species of Cervus which now exist here, viz. the round horned Elk of Mr. Jefferson, the Cervus Wapiti of Dr. Barton; and the Moose, or Cervus Alces; there are two similar views of the craniums of each of these animals. The figures 6 and 7, Plate X, exhibit the cranium of the Round Horned Elk; and figs. 8 and 9, in Plate XI. that of the Moose or Cervus Alces. The horns of each of them, as they would have prevented the view, are represented as sawed off.

The comparison of figures 4 and 5, with figures 6 and 7, shews that the lately discovered cranium resembled that of the Round Horned Elk at the occiput, although it differs from it greatly in the position and the projection of the horns.

There is also in the Round Horned Elk a considerable prominence of the frontal bone, between the bases of the horns, (see *g* figs. 6 and 7.) which does not appear to have been the case in the newly discovered head. The horns of this last mentioned head have a concavity or depression of the under surface near the root, (see *b b* fig. 4.) which is not the case in the Round Horned Elk.*

The cranium of the Moose or Cervus Alces, (fig. 8. fig. 9. Plate XI.) is very different. The occipital portion is conconcave exteriorly, and the superior margin has an angular indentation in the middle of it, (see *e*, fig. 9.) There is a remarkable prominence of the frontal bone, between the horns, which extends considerably towards the nose (*a* fig. 8, *a* fig. 9.) The horns of it project laterally like those of the newly discovered head, and they have a concavity of the under surface near the root.

Having measured the two last mentioned craniums, for the purpose of comparing them with the first, I found that, in the Round Horned Elk, the width in the narrowest part, a little posterior to *b*, *b*, fig. 6, is 4.5 inches, and at *c*, *c*, is 6.4 inches. The depth of the cranium from the upper part of the margin of the occiput to the most distant part of the occipital foramen, is 4.5 inches. The distance from the middle of the upper margin of the occipital surface, to a central point between the horns, is 4.4 inches.

In the Moose or Cervus Alces the distance from *b*, to *b*, fig. 8, is 4.3 inches—from *c*, to *c*, 6.9 inches. The depth of the cranium from the upper margin of the occiput to the most distant part of the occipital foramen is 5.3 inches—Distance from *e* to *a*, fig. 9, is 5.3 inches, on a straight line.

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* The Round Horned Elk has not received from European naturalists the attention which is due to so superb an animal; although he has been described by Mr. Jefferson in his Notes on Virginia, Dr. Barton in his Medical and Physical Journal, and the late Dr. E. Smith in the Medical Repository.—Few persons who have not seen him when his horns are of full size, (more than four feet in length,) can form an adequate idea of his appearance.

I believe that each of these last mentioned heads is at least of the ordinary size, as their horns are large; and it appears, from a comparison of the respective measurements, that the head lately discovered is larger than either of them.

The second head is also very different from that of any animal now known here, and therefore two views of it are exhibited in Plate XI., viz. fig. 10 and fig. 11. For the purposes of comparison, there is in the same plate a posterior view of the head of the common ox, fig. 12; and a similar view of the head of the bison of this country, fig. 13.

In the size and form of the horns, fig. 10, fig. 11, this head has some resemblance to the genus Bos, but it differs from the domestic animals of that genus in several important particulars.

In those animals the horns are placed at the junction of the facial and occipital surfaces of the cranium (see fig. 12.) at a very considerable distance behind or above the eyes; whereas in this head (fig. 10, fig. 11.), the horns are at a considerable distance in front of the occipital surface, and not far from the orbits of the eyes. This difference is very apparent when the posterior view of this head, see fig. 11, is compared with fig. 12, the similar view of the head of the common ox.

There is less difference between this head, fig. 11, and that of the bison, fig. 13; for the horns of the bison are also at some distance in front of the occipital surface, although not so far as those of this head. By comparing fig. 12, fig. 13, and fig. 11, it will appear that the position of the horns of the bison, is midway between that of the horns of the common ox, and of this head; and that the concavity (*h*) under and behind the horn, in each of the specimens, is varied in regular gradation.

The head under examination, differs from the heads of the ox and the bison, in the facial surface; for in those animals that surface is uniformly flat or plane, whereas in this head, there is a convexity of that portion of it which is between the horns, (see *i* fig. 10, *i* fig. 11.) so that those portions of the facial surface, which are before and behind the horns, form a considerable angle with each other.

In this circumstance, and also in the position of the horns, it has some resemblance to the heads of the deer, sheep, and goat, but I believe it did not belong to either of those genera.

The horns are not of a deciduous nature like those of the *genus Cervus*, but appear to consist of bone of the ordinary kind, like those of the *ox*, *goat*, *sheep*, or *antelope*. They differ also from those of the *sheep* and *goat*, as they project from the lateral surface of the cranium like those of the genus Bos, and not from the upper surface like those of the above-mentioned animals. They are also round and conical like those of the genus Bos, while the horns of sheep and goats are generally more or less angular.

The occipital surface of this head (see fig. 11.) resembles strongly that of the bison (fig. 13.), the rough surface *k* fig. 11, being produced by abrasion.

Was not this animal nearly allied to the bison?

Pl. X.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

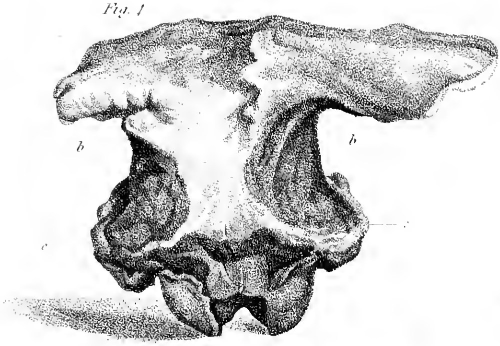

Fig. 5.

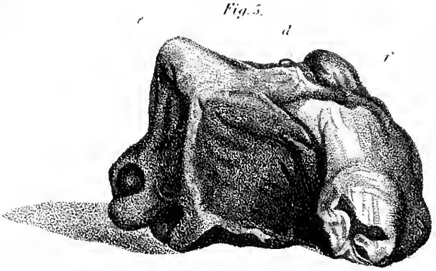

Fig. 6.

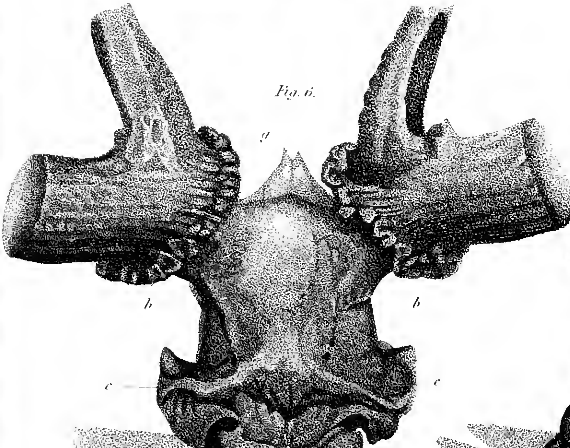

Fig. 7.

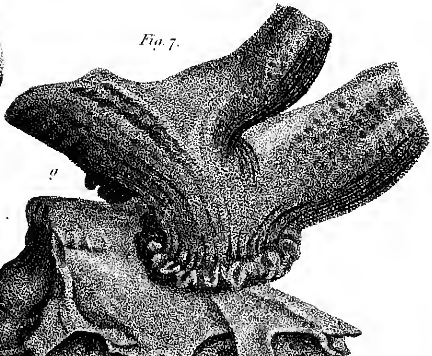

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Fig. 8.

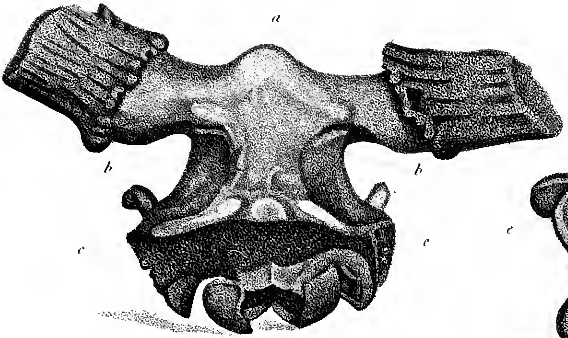


Fig. 9.

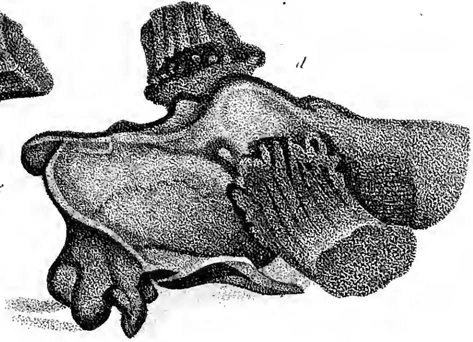


Fig. 10.

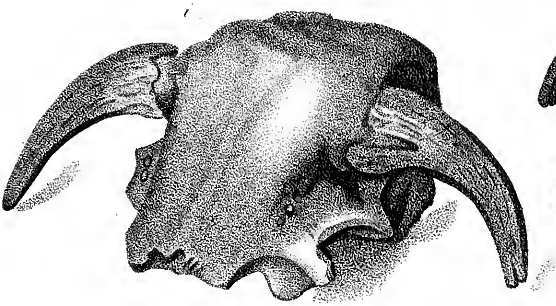


Fig. 11.

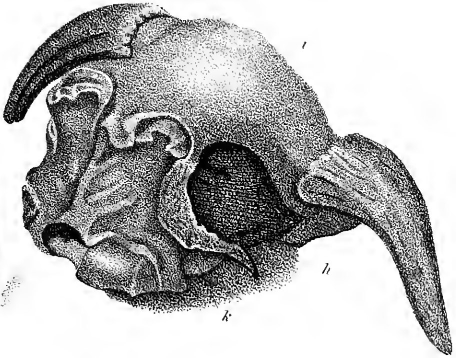


Fig. 12.

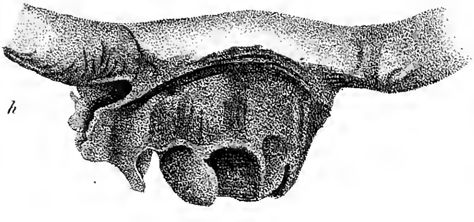
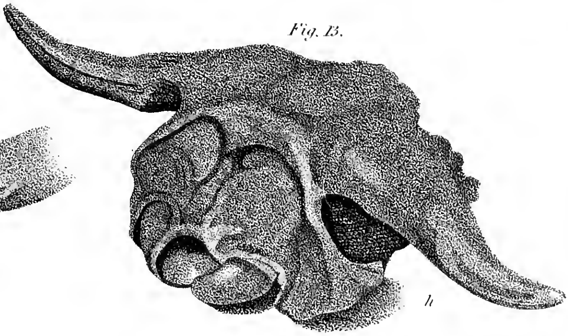


Fig. 13.



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No. XXXII.

An Account of a Case of Disease, in which one side of the Thorax was at rest, while the other performed the motions of Respiration in the usual way. By C. Wistar, M. D.—Read, December, 1814.

THERE are no actions of the human body which appear more completely associated with each other than those of the Intercostal Muscles, on the different sides of the Thorax. The simultaneous movements of the different ribs, and the regular dilatation of the Thorax, seem to depend upon this association.

The following statement will however evince, that the action of the Intercostal Muscles, of one side of the Thorax, may be completely suspended, while the muscles of the other side perform their accustomed motions most perfectly. It also affords a satisfactory explanation of this unusual occurrence.

In the course of last summer a gentleman was attended, by Dr. Monges and myself, for an Hæmoptysis which occasioned his death. During his indisposition, we observed that one side of his Thorax was neither dilated nor contracted during respiration, and that the ribs on that side were perfectly quiescent, although those of the other side performed more motion than usual, and therefore dilated that side of the Thorax to an uncommon degree. We first noticed this some days before his death, and it continued so without any alteration during the remainder of his life. He made no complaints of pain or uneasy sensations, on the side which was without motion, but said that he had sensations on the other side, which he believed were produced by the passage of blood from the ruptured blood vessels. Some years before, he had suffered with Hæmoptysis, and a consequent cough and expectoration; but he recovered from this so much, that he was strong and rather corpulent at the time of his last attack. Upon dissection, the cause of this extraordinary mode of respiration was very obvious. *That cavity of the Thorax which was without motion, was filled with Pus. The volume of the lung of that side was greatly diminished, and the cellular structure of the organ entirely done away.*

No. XXXIII.

Description of several species of Chondropterigious Fishes, of North America, with their varieties. By C. A. Le Sueur. —Read, Oct. 17th, 1817.

I. ORDER.

Branchiæ fixed.

First Family, (CYCLOSTOMUS, Dumeril. Sucker.)

Genus PETROMYZON.—Linn.

Characters.

Seven *branchial apertures* on each side of the neck.
One *spiracle* on the top of the head.
Mouth discoidal, furnished with papillæ on its circumference, interiorly toothed.

SPECIES..

1. PETROMYZON *Americanus.* *Back* slightly carinated; *dorsal* fins separated, the first low, and about half the length of the second, which is high on the anterior part, and gradually decreases to the tail.

This fin is attached to the *caudal* fin by the common skin, which slopes suddenly where it joins the latter; the *branchial* apertures are furnished with a little cartilaginous point on the hind part; the *body* is subequal as far as the second dorsal fin, it thence gradually decreases; when the mouth is contracted, the *head* is a little sloping, and presents a cylindric, and obtuse snout; the *eyes* are of a middling size, and are round under the skin—*iris* yellowish white, with a dark brown circle, *pupil* black; the *nostrils* project into a small tube; the *teeth* are of several forms, some compound, and others simple—those of the throat are five in number, pretty strong, the inferior ones cordate, and denticulate, the lateral ones curved, and likewise denticulate, the two superior teeth do not appear to be denticulate: these teeth are surrounded with several other kinds of teeth: the inferior tooth is of a semicircular form, and has seven sharp points, the superior one has two points: on each side there are four other bicuspidate teeth, placed obliquely; these last are followed by from five to six simple teeth, which describe curved lines, and diminish in size as they approach the rim of the mouth: above the upper double tooth, and likewise the two lateral teeth, there is a large simple tooth: behind the lower tooth there are nine perpendicular ranges of teeth, regularly disposed; the colour of the *sides* is composed of red, brown, yellow and blue, mingled together; the *back* is black the whole length of the keel, and the base of the dorsal fins—this colour is the basis or commencement of the lateral marbling, which is composed of small spots, oblong, irregular and transverse, grouped together; *caudal* fin long above, short below, terminated by three angles, that of the middle indicates the extremity of the tail—the lower part of the caudal fin is short, perpendicular, and composed of small rays, four or five lines long, and placed at the extremity of the expansion of the skin, which connects it with the tail. Length thirty inches.

In several of the lakes and rivers of North America there is found a fish of this genus, to which the common appellation of Lamprey is given by the inhabitants; but I cannot determine whether the one described is the same or not. Its general resemblance to those serpents which are dreaded, occasions its being destroyed as soon as taken, and therefore it is difficult to arrive at a knowledge of the species. Of the one described, I was so fortunate as to procure several individuals, at Philadelphia, in the spring of the year 1816.

Dr. Mitchill, in the Transactions of the Literary and Philosophical Society of New York, has given a short description of a Petromyzon, which he considers to be the same as the *P. marinus* of Europe. My species I regard as new, at least I find no account which answers to it in any work to which I have access.

In Bloch's figure of the *P. marinus*, tome 2, tab. 77, there are represented eight points to the large inferior tooth—in his description he mentions seven. La Cèpede gives to his six points. The figure of the latter is greatly preferable to that of the former.

The European Lamprey is an inhabitant of the ocean; ascends rivers early in the spring; and, after producing its young, returns to the sea. It is viviparous. History informs us that the death of Henry the First of England was occasioned by a too luxurious indulgence in a dish of Lampries.

2. *P. nigricans.* *Dorsal* fins white, elevated, the second higher than the first and angular on its anterior part; *head*, *back*, and *caudal* fin blackish blue; *abdomen* bluish white; *eyes* very large, *iris* silvery, *pupil* black.

The *nostrils* are united in a tube, placed a little before the eyes, and between the latter there is a small whitish spot; the *branchial* openings are very oblique, the first smaller than the rest, and placed near the eye; disposition of the *teeth* the same as in the preceding species—those of the throat are three in number, the lateral ones in the form of a comma, those of the middle of a reversed heart-shape; first *dorsal* fin rounded behind, and elevated on the anterior part; second *dorsal* fin elevated before, and thence gradually descending to the caudal fin, to which it is connected by the common skin, as in the first species; *caudal* fin terminated in a triangular form; the sides are marked by small, and very faint, transverse bands. Length of specimen six inches.

This species, compared with a figure of the *P. niger* of Europe, which I made at Rouen, after a careful examination of several fine individuals, presents the following difference: It is shorter, thicker on the anterior part, and much more compressed at the first dorsal fin; the head is broader across the eyes.

This fish is not sought after in particular. It appears in the spring with the shad and herrings, and is only occasionally caught.

The European species, mentioned above, is very common in the markets of Rouen, and is highly prized as an article of food.

Genus AMMOCŒTES.—Dumér.

Characters.

Seven *branchial apertures* on each side of the neck.
Lips not united into a disk, not furnished with teeth.
Eyes not apparent.

1. AMMOCŒTES *bicolor*. *Dorsal* fins low, separated, the second united with the *caudal* fin, which is rounded; *back* and *sides* reddish, *abdomen* white, the colours separated by an undulating line.

Anterior part of the *body* subcylindric, posterior part compressed, and tapering to the tail; *nape* of the neck elevated; *head* declivous, prolonged into a *snout* furnished with a lip, having two short rounded lobes—these lobes, when the mouth is closed, embrace and conceal the lower lip, which is very short; the *nostrils* on the head are small, and placed in the centre of a white, oval, pellucid disk, easily moveable; on the inside of the upper lip, there are small granules, and at the opening of the throat small ramified papillæ; the *branchial* apertures are placed in a longitudinal depression, oblique, and a little curved, the first aperture is above the angle of the mouth; on each side of the head there is a whitish spot, which should seem to indicate the position of eyes, that this species is deficient of, in common with the **P. ruber* of Europe.

The annular or ribbed appearance of the sides of this fish is owing to the muscles, which are endued with great strength, in order to enable it to burrow in the muddy sands of rivers, where it penetrates in a serpentine manner, by means of its snout, the large lip of which performs the function of a terrier. The European species is generally taken when the small rivers are cleansed of the superabundant sand and mud which obstruct their channels. This last is much sought after for food; but the American species is commonly rejected, as is almost every animal that either has a real, or fancied, resemblance to a snake. This fish is used for bait.

The above described species was taken in the Connecticut river. I am indebted for it to Doctor Hunt of Northampton, Connecticut.

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* Lampetra cæca; Willughby, p. 107, G. 3. fig. 1.—Pet. rouge; La Cèpede, tome 2, page 100.

II. ORDER.

Branchiæ free.—Cuvier.

Genus ACIPENSER.

Characters.

Mouth situate beneath the head, retractile, toothless.
Snout bearded beneath.
Body elongated, and furnished with several ranges of bony tubercles. LA CEPÈDE.

1. ACIPENSER *rubicundus*. *Head* covered with bony plates, which are rough, radiated, and irregularly configurated; it is flat above, declivous, and terminated in a somewhat roundish *snout*, which is furnished with four transversely flat cirri, placed nearer the end than the mouth; *eyes* round, *pupil* vertical; colour of the *back* yellowish red, of the *sides* olivaceous red; the *body* of this species is very elevated at the tubercle of the neck; the *dorsal* tubercles are nine, the two last terminated in a point; the *side* tubercles are thirty-five in number, pretty equally placed, and lonzenge-shaped; there is no appearance of plates on the abdomen; behind the dorsal fin there are several rudiments of plates; the *skin* is marked throughout with small groups of spines, which render it very disagreeable to the touch when the animal is dry, but when recent, these spines are less sensible on account of the mucous which covers them; each *operculum* is furnished with a large radiated shield; behind the eyes there are small plates, which extend along the border of the snout; below the eyes there is a semicircle of small tubercles; the *nasal* apertures, which are two on each side, are placed before the eyes, the posterior one is perpendicular, the anterior one roundish, and near the summit of the former; *mouth* transverse, small, lips thick; the *pectoral* fins are situate very low, in a horizontal posi-

tion, and have about fifty rays each; *ventral* triangular, with about twenty-eight rays, and placed near the anus; *anal* fin longer than broad, with twenty-two rays; the *dorsal* fin is triangular, and has its centre perpendicular to the anterior base of the anal, its rays about forty in number; the *caudal* fin is crescent-shaped, its upper lobe strait and pointed, its lower lobe large and triangular; the *tail* is covered with small, lozenge-shaped, osseus tubercles; all the rays of the fins are hirsute. This individual was full four feet long; its head was six inches in length, between the eyes it measured three inches, and from the eyes to the tip of the snout likewise three inches.

This fish is not sought after for the table. When taken by the fishermen in their seines, they occasionally salt it down, as a substitute for more esteemed food. The useful qualities of sturgeons appear to be not yet fully appreciated in America, particularly in those parts which have experienced the benefits of agriculture and commerce, or where more valued fishes are found in abundance.

This species inhabits Lake Erie, and Lake Ontario. Mr. Thomas Nuttall, Botanist, informed me that this species also inhabits Lakes Huron, and Michigan; that it is eaten by the Indians, who take it by means of a harpoon or dart, to the end of which is attached a long line, in order to enable them to play the animal until he is exhausted. Mr. Nuttall asserts, from his own experience, that this sturgeon is good palatable food.

For a figure of this species, see Plate XII.

First variety. *Head* short, flat above; twelve irregular plates on the *back;* on the *sides* there are thirty-four plates, small, some of them hardly indicated, the lateral line, which is more distinct than in the foregoing, running through them, gives them the semblance of a rosary.

This variety is likewise found in the waters of the lakes Erie and Ontario; and differs from the preceding in the head, which is much shorter, and the dorsal tubercles, which are more numerous, more irregular in their proportions, and their situation; *eyes* as in the foregoing; the *body* a little more round; the *fins* have little difference; and the *skin* is also muricated in a similar manner; colour the same. The individual described was two feet five inches long.

Second variety. *Head* convex, without a sensible prominence on the occipital shield; *snout* smaller, and more pointed than that of the *rubicundus; back* with fourteen oblong, carinated plates. This specimen, which was about four feet long, differs from the rest in the small lateral tubercles, which were thirty-four in number, irregularly formed and placed; the head more convex than in the others; the skin is equally furnished with minute spines, some simple, and some in groups, somewhat stronger than those of the foregoing. This variety is in the collection of the Academy of Natural Sciences of Philadelphia. It appears to have been of the same colour as the others, and holds a middle rank between them. Discovered in the river Ohio, by Mr. Thomas Say, of Philadelphia.

2. *A. brevirostrum.* *Head* large, convex; *snout* short, pointed, with a black spot near its extremity; the four *beards* are flat, disposed in pairs, and placed nearer the nostrils than the end of the snout; *nostrils* near the eyes, though lower, the posterior one larger than the anterior one, which is small and almost round; *pupil* of the eyes round, *irides* golden; the length of the head, from the tip of the snout to the end of the operculum, is a fifth part of that of the body; *body* elongated, with five ranges of tubercles; *back* with nine tubercles, and one at the base of the dorsal fin—these plates are pretty regular, oblong, radiated, and surmounted with a sharp keel; *sides* with twenty-six tubercles, irregular, largest on the anterior part of the body, and oblong on the posterior part, the latter presenting a small carina: Sometimes one remarks between these tubercles, the rudiments of others; the plates of the *abdomen* are oblong and small, on the left side five, on the right side three, placed opposite to the centre of the

former; before each abdominal fin there is a small tubercle; the *skin* above is of a blackish colour, tinged with olive, with oblique black bands, and other corresponding ones, of a paler hue, on the sides; the deep colour of the upper parts does not transgress the lateral line formed by the tubercles; *sides* reddish, mixed with violet; *abdomen* white; the *fins* are of a medium size.

The head, which is remarkable in this species, varies a little in the varieties which follow; in this it is short in proportion to its breadth, between the eyes it is depressed, and in width two inches and a third—between the auricular orifices three inches—from the end of the snout to the eye two inches and a quarter—length of the whole head six inches and a half; the auricular orifices are situate one inch and a half behind the eyes, and near the rim of the bony shields of the head; the plates in general of this species are rugose, and regularly radiated; the skin, which appears smooth, is nevertheless furnished with small spinous asperities, which render it disagreeable to the touch, and there is a kind of regularity observable in the dispositions of these spines, which are scattered equally over the whole skin; this regularity is not perceptible in the *A. rubicundus* and its varieties, the spines of which are more numerous, and more serrated.

The individual described was a female; its length two feet, nine inches, from the tip of the snout to the fork of the tail, which was furnished with lozenge-formed plates.

This species is rare, I have been enabled to behold but two specimens. It inhabits the river Delaware.

First variety. *Length* one foot, seven inches; *body* with five rows of tubercles, all very intire, well defined and radiated, surmounted with a carina, projecting behind into a spine; the two first *abdominal* plates are imbricated, the remainder at equal distances, and seven on each side; *side* plates twenty-six; *dorsal* plates nine, and one at the base of the fin; between the dorsal fin and the tail, and likewise between the anus and anal fin, and the last and caudal fin, there are sometimes one simple plate, and sometimes several plates, in this species; the head only presents the difference of its snout being a little more elevated, and it is not convex between the nostrils; the small asperities of the body are nearer together, and more numerous, than in the preceding. Inhabits the Delaware.

Second variety. *Dorsal* plates ten, including that at the base of the fin, *lateral* plates twenty-three, *abdominal* seven, all pretty regular and radiated, without carina and spines—these plates appear to have replaced those of the first growth, they not having been worn or rubbed; *head* large, short, and resembling that of the first described of this species; *snout* larger. and rounder than in the first variety; *length* of specimen two feet, four inches. Taken in the Delaware.

Third variety. This individual resembled the last in its form and size, but had its *snout* more pointed, flatter above, and more elongated, narrower, and more concave; *body* with five rows of tubercles, those of the back nine, including the one at the base of the fin, regularly radiated, raised into a sharp keel, and terminated in a central point; *lateral* plates twenty-three, slightly carinated; the plates of the *abdomen* are seven, with a hardly perceptible keel—the form and disposition of the tubercles are pretty regular; between the lateral plates there are several smaller ones. It is very remarkable that the left side only of this specimen had a range of eleven tubercles, and several rudiments of others, situate between the lateral and abdominal rows. Inhabits the Delaware.

This species, which is not the object of a special fishery, is nevertheless more sought after, and commands a higher price, than the large common species, which attains to the length of about ten feet. The *A. brevirostrum*, and its varieties, are brought to the Philadelphia market in the vernal season. and fetch from twenty-five to seventy-five cents a-piece. They are eaten by the common people only.

3. *A. maculosus.* *Mouth* large; *pectoral* fins large, broad; the plates between the abdominal fins, the anal fin, and the tail, simple; *snout* greatly elongated, and rounded at its extremity; *body* conic-pentagonal, with five rows of tubercles, all rugose and radiated, having a very sharp, compressed keel, which projects behind in an acute point; *dorsal* plates thirteen, including that at the base of the fin, which are imbricated above, but below seem blended with the skin; *lateral* plates thirty-three, very near each other; *abdominal* plates ten, strong and approximate, the two first almost united into one: the tubercles are of the same colour as the body, which is of a reddish olive, with black spots; the skin is covered with small asperities, simple, and united in groups, the extremities of which are directed backward; the *head*, which is long, broad between the eyes and channelled, measures the fourth part of the whole of the animal; *eye* pretty large, oblong, pupil round and black, iris yellow; the anterior *nostril* is small, oval, and placed somewhat higher than the other, which is larger and longer; the bone which forms a kind of keel beneath the snout is very small; the four *cirri* are placed on a transverse line, at equal distances, nearer the eyes than the tip of the snout.

Pec. 45 to 48.—Dors. 45.—Ven. 30 to 35.—An. 25 rays.

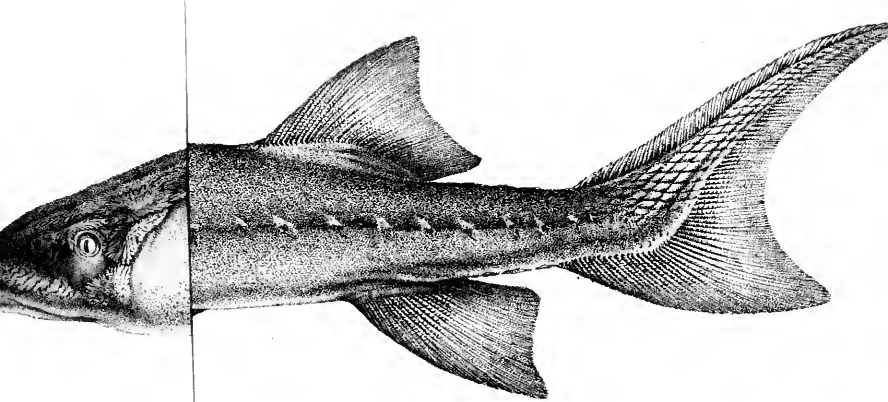
According to the observations of Mr. Thomas Say, who discovered this species in the river Ohio, it does not appear that it grows to a large size. The above description was made from two fine specimens, which belong to the Museum of the Academy of Natural Sciences of Philadelphia; one of them measured fourteen and a half inches in length, the other seven inches and a half.

The following species, though specifically distinct, yet has so general a resemblance to the foregoing, that I have thought it necessary to give a description of it. I have considered it the species described by Dr. Mitchill in the first volume of the New York Historical and Philosophical Society's Transactions, under the name of *oxyrinchus;* although I must confess, from the Doctor's want of precision, that there is room for doubt whether it is the same or not. However, to avoid the evil of an unnecessary multiplication of names, I have adopted his specific appellation.

A. oxyrinchus? Mouth transverse, very narrow; *pectoral* fins small; the plates between the dorsal and caudal fins, the abdominal and tail, are double; the *dorsal* plates are ten in number, including that at the base of the fin; the quintuple series of tubercles are radiated, carinated, and terminated backward in a point; *lateral* plates twenty-five, *abdominal* nine; the head is nearly the same as that of the *maculosus*, but it is a little shorter; the body is four times the length of the head; the *eyes* are smaller than those of the preceding, pupil the same, irides golden; the long snout is subacute, and furnished below with a strong and rough bone; the three centre dorsal tubercles are the largest, the rest decreasing in size on either side, whereas those of the *maculosus* are all nearly equal in size—the latter the colour of the body, the former whitish; the *skin* is rough; colour of the *back* yellowish olive—below the lateral plates, with the abdomen, white; the dorsal plates, and likewise those of the sides, approximate, and there is between each tubercle a black spot. The largest specimen of this species which I have seen, was from three to four feet in length. Inhabits the Delaware.

P. 36 to 38.—D. 38.—V. 28 to 30.—A. 23 to 25 rays.

PL. XII



C. H. Lehner

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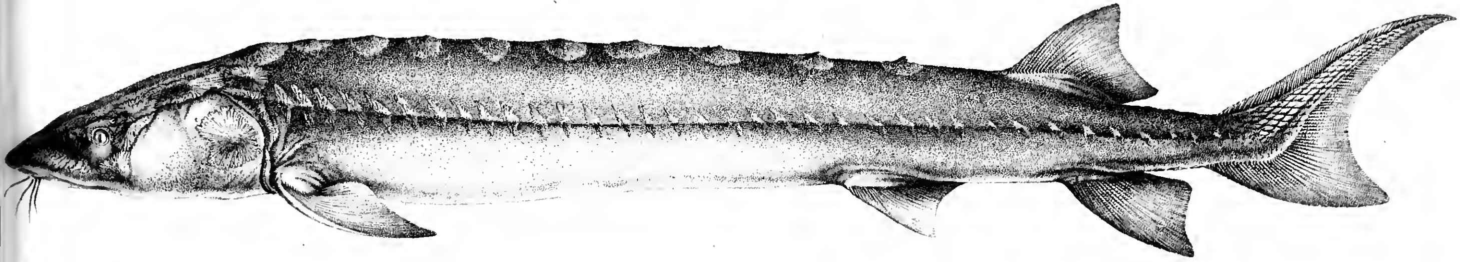
PL. XII



No. XXXIV.

Investigation of a Theorem, proposed by Dr. Rittenhouse, respecting the Summation of the several Powers of the Sines; with its Application to the Problem of a Pendulum vibrating in Circular Arcs. By Owen Nulty, Professor of Mathematics in Dickenson College, Pennsylvania.—Communicated in a Letter to Dr. R. M. Patterson.—Read, Nov. 15th, 1816.

Carlisle, Aug. 12th, 1816.

Dear Sir,

IN the third volume of the Transactions of the American Philosophical Society, Dr. Rittenhouse mentions, in a letter addressed to your father, that he had discovered a very elegant theorem for determining the times of vibration of a pendulum in given arcs of a circle, and that it depended on another respecting the summation of the several powers of the sines to a given radius. The first of these theorems has never, I believe, been communicated to the public; but the second, which is very remarkable, is announced by Dr. Rittenhouse in the following terms: "If a fraction, of which the denominator is the index of the given power, and the numerator the same index diminished by unity and multiplied by the square of the radius, be multiplied by the sum of the next but one lower power of the sines, the product will be the sum of the given power." This curious law, however, was inferred merely from a partial process, and Dr. Rittenhouse concludes his paper by requesting a demonstration of it. As this subject has not been resumed in any of the subsequent volumes of the transactions, I have thought the following investigation would not be uninteresting to you.

Let y denote the sine at any point of the quadrantal arc, of which the radius is given and represented by a. Then, as Dr. Rittenhouse obviously means, by the sum of any power of the sines, the sum of all the y's involved to that power, we have the sum of the sines truly expressed by the sum of all the y's, the sum of the squares of the sines by the sum of all the y^2's, the sum of their cubes by the sum of all the y^3's, and, in general, the sum of their nth powers by the sum of all the y^n's. But, the sum of the y's, corresponding to every point of the given quadrantal arc, is evidently expressed by the integral $\int y\,\mathrm{d}z$, $\mathrm{d}z$ being an element of that arc; the sum of the y^2's is expressed by the integral $\int y^2\mathrm{d}z$; the sum of the y^3's, by the integral $\int y^3\mathrm{d}z$; and, in general, the sum of the y^n's, by the integral $\int y^n\mathrm{d}z$; so that the following integrals

$$\int y\,\mathrm{d}z,\ \int y^2\mathrm{d}z,\ \int y^3\mathrm{d}z,\ \ldots\ldots\ \int y^n\mathrm{d}z,$$

or their equals,

$$\int\frac{ay\,\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}},\ \int\frac{ay^2\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}},\ \int\frac{ay^3\mathrm{d}z}{(a-y^2)^{\frac{1}{2}}},\ \ldots\ldots\ \int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}},$$

($\mathrm{d}z$ being $=\frac{a\,\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}$,) taken between the limits $y=0$ and $y=a$, will express the sums of the successive powers of the sines. Now, the first of these integrals is evidently $=c-a(a^2-y^2)^{\frac{1}{2}}$, and the second, or its equal $\frac{a}{2}\left[\frac{a^2\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}-\mathrm{d}.y(a^2-y^2)^{\frac{1}{2}}\right]=\frac{a^2}{2}.$ $\text{arc}(\sin=y)-\frac{ay}{2}(a^2-y^2)^{\frac{1}{2}}+c'$; therefore these expressions, taken between the limits $y=0$ and $y=a$, give the sums of the first and second powers of the sines $=a^2$ and $\frac{a^2}{2}.\text{arc}(=90°)$, respectively: the same as found by Dr. Rittenhouse. Again, the integrals affected with the third, fifth, seventh .... mth powers of y, when m is any odd integer whatever, may be immediately obtained by the rule for integrating binomials, and consequently the sums of the odd powers of the sines will be known. And, moreover, the integral affected with y^4 may be found by means of the integral affected with y^2, already found, and the integral affected with y^6, by that affected with y^4, and, in general, the integral affected with y^p by means of the integral affected with y^{p-2}, p being any even integer whatever; and then, the sums of the even powers of the sines will also be known. We might then tabulate the results, both in this and the last case, and infer the law observed by Dr. Rittenhouse. But, as this mode of proceeding appears indirect and rather tedious, I think it preferable to find the integral $\int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}$, by means of the integral $\int\frac{ay^{n-2}\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}$, n being any integer whatever. For this purpose, let $\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}$, be decomposed into the factors ay^{n-1} and $\frac{y\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}$, and then, by virtue of the formula $\int x\mathrm{d}z=xz-\int z\mathrm{d}x$, we have

$$\int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}=-ay^{n-1}(a^2-y^2)^{\frac{1}{2}}+(n-1)\int ay^{n-2}\mathrm{d}y.(a^2-y^2)^{\frac{1}{2}}=$$

$$-ay^{n-1}(a^2-y^2)^{\frac{1}{2}}+(n-1)\int\frac{ay^{n-2}\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}(a^2-y^2)=$$

$$-ay^{n-1}(a^2-y^2)^{\frac{1}{2}}+(n-1)a^2\int\frac{ay^{n-2}\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}-(n-1)\int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}},$$

and therefore,

$$n\int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}=-ay^{n-1}(a^2-y^2)^{\frac{1}{2}}+(n-1)a^2\int\frac{a^{n-2}\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}.$$

Taking these integrals between the limits $y=0$ and $y=a$, which correspond to the extremities of the quadrantal arc, we have, after dividing by n,

$$\int\frac{ay^n\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}=\frac{(n-1)a^2}{n}\int\frac{ay^{n-2}\mathrm{d}y}{(a^2-y^2)^{\frac{1}{2}}}:$$

or, the sum of any power n of the sines is constantly equal to the fraction $\frac{(n-1)a^2}{n}$ multiplied by the sum of the $(n-2)$ power.

I have now, as I believe, presented a complete solution of the problem relating to the sines, and confirmed the truth of the law observed by Dr. Rittenhouse. Another desideratum, however, still remains; and that is, either to recover, if possible, Dr. Rittenhouse's original theorem, for determining the times of vibration of a pendulum, in given arcs of a circle, or, at least, to show that a connexion may subsist between a theorem fulfilling the same object, and that just exhibited for the summation of the several powers of the sines. I have attempted this, in the following research.

Let the arc described by a pendulum, when it arrives at a vertical passing through the point of suspension, be denoted by A. Conceive A to be divided into two parts B and z, and suppose B described at the end of the time t. Put $2a=$ the versed sine of A, and $x=$ that of z. Then, the element of the space described being equal to the velocity multiplied by the element of the time, and the velocity being evidently equal to that acquired by falling through $2a-x$; that is $=[2g(2a-x)]^{\frac{1}{2}}$, we have $\mathrm{d}B$, or $\mathrm{d}(A-z)$, or $-\mathrm{d}z=[2g(2a-x)]^{\frac{1}{2}}\mathrm{d}t$; therefore, $\mathrm{d}t=\frac{-\mathrm{d}z}{[2g(2a-x)]^{\frac{1}{2}}}$; but, $\mathrm{d}z=\frac{r\mathrm{d}x}{[(2r-x)x]^{\frac{1}{2}}}$, r being the radius of the arc described; therefore,

$$\mathrm{d}t=\frac{-r\mathrm{d}x}{[2g(2a-x)x(2r-x)]^{\frac{1}{2}}}.$$

Assume $x=a-y$; then $[(2a-x)x]^{\frac{1}{2}}=(a^2-y^2)^{\frac{1}{2}}$, $-\mathrm{d}x=\mathrm{d}y$, and

$$(2r-x)^{-\frac{1}{2}}=(2r-a+y)^{-\frac{1}{2}}=(2r-a)^{-\frac{1}{2}}\left(1+\frac{y}{2r-a}\right)^{-\frac{1}{2}}=$$

$$(2r-a)^{-\frac{1}{2}}\left[1-\tfrac{1}{2}\left(\frac{y}{2r-a}\right)+\frac{1.3}{2.4}\left(\frac{y}{2r-a}\right)^2-\frac{1.3.5}{2.4.6}\left(\frac{y}{2r-a}\right)^3+\right.$$

$$\left.\ldots\ldots\ldots\frac{1.3.5\ldots\ldots 2n}{2.4.6\ldots.(2n+1)}\left(\frac{y}{2r-a}\right)^n\right];$$ and, by substitution, &c.

$2\int dt = \left(\frac{r}{g}\right)^{\frac{1}{2}} \left(\frac{2r}{2r - a}\right)^{\frac{1}{2}} \left[\frac{dy}{(a^2 - y^2)^{\frac{1}{2}}} - \frac{1}{2(2r - a)} \frac{ydy}{(a^2 - y^2)^{\frac{1}{2}}} + \frac{1.3}{2.4(2r - a)^2} \frac{y^2dy}{(a^2 - y^2)^{\frac{1}{2}}} - \ldots\right]$. Hence, multiplying and dividing by a, and integrating, we have $2t = \frac{1}{a}\left[\left(\frac{r}{g}\right)^{\frac{1}{2}} \left(\frac{2r}{2r - a}\right)^{\frac{1}{2}}\right] . \left[\int\frac{ady}{(a^2 - y^2)^{\frac{1}{2}}} + \frac{1}{2(2r - a)}\int\frac{aydy}{(a^2 - y^2)^{\frac{1}{2}}} + \frac{1.3}{2.4(2r - a)^2}\int\frac{ay^2dy}{(a^2 - y^2)^{\frac{1}{2}}} + \ldots\ldots\right]$. Now, all the integrals, after the first, in this expression, are obviously the same as those found in the preceding investigation for the sums of the sines; therefore, this expression may be said to depend on the theorem respecting the summation of the sines; and thus the connexion of the problems in question is manifest. Again, let the preceding integrals be taken between the limits $y = a$ and $y = -a$, which correspond to $x = 0$ and $x = 2a$, and we have

$2t = \frac{1}{a}\left(\frac{r}{g}\right)^{\frac{1}{2}} \left(\frac{2r}{2r - a}\right)^{\frac{1}{2}} \left[(\text{arc} = a\pi) + \frac{1.3}{2.4(2r - a)^2} . \frac{1.a^2}{2} .(\text{arc} = a\pi) + \frac{1.3.5.7}{2.4.6.8(2r - a)^4} . \frac{1.3a^4}{2.4} .(\text{arc} = a\pi) + \frac{1.3.5.7.9.11}{2.4.6.8.10.12(2r - a)^6} . \frac{1.3.5.a^6}{2.4.6} .(\text{arc} = a\pi) + \ldots\ldots\right] =$, when $\mathcal{A}$ is put $= \left(\frac{2r}{2r - a}\right)^{\frac{1}{2}}$, $\pi\left(\frac{r}{g}\right)^{\frac{1}{2}} \left[\mathcal{A} + \frac{1^2.3.\mathcal{A}}{2^2.4} \left(\frac{a}{2r - a}\right)^2 + \frac{1^2.3^2.5.7.\mathcal{A}}{2^2.4^2.6.8} \left(\frac{a}{2r - a}\right)^4 + \frac{1^2.3^2.5^2.7.9.11.\mathcal{A}}{2^2.4^2.6^2.8.10.12} \left(\frac{a}{2r - a}\right)^6 + \ldots\ldots\right]$; or, denoting the second term within the brackets by B; the third term by C; the fourth term by D; &c., and transforming,

$2t = \pi\left(\frac{r}{g}\right)^1 \left[\mathcal{A} + \frac{1.3.\mathcal{A}}{4^2} \left(\frac{a}{2r - a}\right)^2 + \frac{5.7.B}{8^2} \left(\frac{a}{2r - a}\right)^2 + \frac{9.11.C}{12^2} \left(\frac{a}{2r - a}\right)^2 + \ldots\ldots\right]$; an expression by which the times of vibration may be determined, and which may, very probably, be the lost theorem alluded to by Dr. Rittenhouse.

This elegant formula is entirely new to me. I consider it far superior to the formula, $\pi\left(\frac{r}{g}\right)^{\frac{1}{2}}\left[1+(\tfrac{1}{2})^2\frac{a}{r}+\left(\frac{1\,.\,3}{2\,.\,4}\right)^2\frac{a^2}{r^2}+\left(\frac{1\,.\,3\,.\,5}{2\,.\,4\,.\,6}\right)^2\frac{a^3}{r^3}+\ldots\ldots\right]$, usually given for the same purpose by writers on mechanics. It converges with great rapidity, when a is small in respect to r; and the following calculations show, that, even in the extreme case of $2a=r$, or of the pendulum's moving from a horizontal position and describing a semicircle, the sum of six of its terms is more exact than the sum of fifteen terms of the formula just inserted, and continued to the same number of decimal places.

By the formula just investigated.

$$
\begin{aligned}
2t=\pi\left(\frac{r}{g}\right)^{\frac{1}{2}}\Big[\; & 1.1547005 \\
+\; & .0240562 \\
+\; & .0014617 \\
+\; & .0001116 \\
+\; & .0000094 \\
+\; & .0000008\Big] \\
=\pi\left(\frac{r}{g}\right)^{\frac{1}{2}} & (1.1803402).
\end{aligned}
$$

true to the sixth decimal place.

By the ordinary formula.

$$
\begin{aligned}
2t=\pi\left(\frac{r}{g}\right)^{\frac{1}{2}}\Big[\; & 1.0000000 \\
+\; & .1250000 \\
+\; & .0351562 \\
+\; & .0122070 \\
+\; & .0046729 \\
+\; & .0018924 \\
+\; & .0007950 \\
+\; & .0003427 \\
+\; & .0001506 \\
+\; & .0000671 \\
+\; & .0000302 \\
+\; & .0000138 \\
+\; & .0000063 \\
+\; & .0000030 \\
+\; & .0000014\Big] \\
=\pi\left(\frac{r}{g}\right)^{\frac{1}{2}} & (1.1803386).
\end{aligned}
$$

Believe me, dear sir, with sincere
respect and esteem, your
obedient servant,
OWEN NULTY.

No. XXXV.

A Monograph of North American insects, of the genus Cicindela. By Thomas Say.—Read, 7 Nov. 1817.

IT will perhaps be thought necessary, previous to entering into a technical detail of the characters of the genus Cicindela, and of the indigenous individuals which are comprehended by it, that some account of the manners of this sprightly tribe should be given, and of such circumstances, relating to them, as may serve to present them to the recollection of the general observer. I shall accordingly proceed to state, that these insects usually frequent arid, denudated soils; are very agile, run with greater celerity than the majority of the vast order to which they belong; and rise upon the wing, almost with the facility of the common fly. They are always to be seen, during the warm season, in roads or pathways, open to the sun, where the earth is beaten firm and level. At the approach of the traveller, they fly up suddenly to the height of a few feet, pursuing then a horizontal course, and alighting again at a short distance in advance, as suddenly as they arose. The same individual may be roused again and again, but when he perceives himself the object of a particular pursuit, he evades the danger by a distant and circuitous flight, usually directed towards his original station. It is worthy of observation, as a peculiarity common to the species, that when they alight, after having been driven from their previous position, they usually perform an evolution in the air near the earth, so as to bring the head in the direction of the advancing danger, in order to be the more certainly warned of its too near approach.

They lead a predatory life, and as it would appear, are well adapted to it, by their swiftness, and powerful weapons of attack. The beaten path, or open sandy plain, is preferred, that the operations of the insects may not be impeded by the stems and leaves of vegetables, through which, owing to their elongated feet, they pass with evident difficulty and embarrassment. They prey voraciously upon the smaller and weaker insects, upon larvæ and worms, preferring those whose bodies are furnished with a membranaceous cuticle, more readily permeable to their *instrumenta cibaria.*

The same rapacity is observable in the larva, or imperfect stage of existence, of these insects, that we have occasion to remark in the parent; but not having been endowed by nature with the same light and active frame of body, they are under the necessity of resorting to stratagem and ambuscade for the acquisition of the prey, which is denied to their sluggish gait. The remark is, I believe, generally correct, though liable to many signal exceptions, that carniverous animals display more cunning, industry, and intelligence, than those whose food is herbs, for the acquisition of which, fewer of the mental attributes are requisite; we see throughout the animated creation, that the developement of these qualities, as well as of the corporeal functions, are in exact correspondence with their necessities; and that where a portion of the one is withheld, an additional proportion of the other is imparted. This larva has a very large head, elongated abdomen, and six short feet placed near the head; when walking, the body rests upon the earth, and is dragged forward slowly by the feet. Notwithstanding these disadvantages they contrive means to administer plentifully to an appetite, sharpened by a rapid increase of size. A cylindrical hole is dug in the ground to a considerable depth, by means of the feet and mandibles, and the earth transported from it, on the concave surface of the head: this cell is enlarged and deepened, as the inhabitant increases in size, so that its diameter is always nearly equal to that of the head. At the surface of the earth they lay in wait for their prey, nicely closing the orifice of the hole by the depressed head, that the plain may appear uninterrupted; when an incautious or unsuspecting insect approaches sufficiently near, it is seized by a sudden effort of the larva, and hurried to the bottom of the dwelling, to be devoured at leisure. These holes we sometimes remark, dug in a footpath; they draw the eye by the motion of the inhabitant retreating from the surface, alarmed at the approach of danger.

I shall now proceed to offer some remarks on the affinities of this genus, and endeavour to point out the differential traits, by which it may be distinguished from its congeners. Cicindela, according to Linnæus, included not only all the insects, which would at this day be referred to it, but many others, which, however closely allied by habit, are widely distinct in the formation of their oral organs. These were separated by the celebrated systematists, Fabricius and Latreille, into several new genera, to which well defined essential characters have been affixed. These separations have been made upon the best possible grounds; the convenience of the student, and the approximation to natural method. So circumscribed, Cicindela presents a natural group, in which each individual so perfectly corresponds with the others, as well in its internal organization and parts of the mouth, as in habit. or general form of the body, that the entomologist finds no difficulty in distinguishing it from insects of neighbouring genera, and referring it to its relative situation.

The genera to which allusion is here made, as having affinity with the one under consideration, are principally *Colliuris*, *Therates*, *Megacephala*, *Manticora*, *Elaphrus*, and *Nothiophilus*. In constructing the essential character, I have endeavoured to ascertain such traits as will at once, invariably, distinguish Cicindela from all other known genera of the Pentamerous Coleoptera, and prevent the occurrence of error in the reference of species to it. In external form, Cicindela borders very closely upon the genera here enumerated, and in addition to evidence of frequent recurrence, furnishes us with ample proof, that if habit was the only character consulted in the formation of a system, animals of very different modes of life, and totally distinct in nature, would be blended together by artificial violence. Of the genera above mentioned, the two last are very distinct from Cicindela, by the inarticulated maxillary nail, and by a deep sinus on the inner edge of the anterior tibia, characters which at once approach them to the Carabi, notwithstanding the almost perfect similarity which *Elaphrus* bears to Cicindela in miniature, by the form and proportions of its body. The mentum or chin also of the former, is not divided as it is in the latter genus, and it is worthy of particular remark, that in *Nothiophilus* there exists the spine and recipient cavity of *Elater*. *Colliuris* is composed of two species, natives of the East Indies, and one of South America, distinguished by the cylindrically-conic thorax, more elongated body, and narrow, transverse mentum, which is widely emarginated, without a conspicuous inner division, but in other respects much resembling Cicindela. A genus has been lately formed by Mr. Latreille, under the name of *Therates*, for an insect of the South Sea Islands, which Fabricius had named *C. labiata*. This has a strikingly discrepant peculiarity in the form of the intermediate palpi, which are abbreviated into a spine-like process. *Manticora* includes two species, indigenous to the Cape of Good Hope, which resemble Cicindela by the form of the mentum, in which there is scarcely any difference; the jaws also are similar, and the mandibles not unlike; but a good distinctive character rests in the palpi, of which the posterior are larger than the intermediate ones; the abdomen also is somewhat pedunculated, and embraced each side by the elytra. The last proximate genus which I shall notice, is that of *Megacephala*, of which at least two species, the *Carolina* and *Virginica*, are natives of this country, and are principally found in the southern states. In this genus, as in those before adverted to, there is no difficulty in pointing out good and substantial characters, by which it may be readily known; the anterior palpi are elongated, and reflected, not equal to the intermediate ones, as in Cicindela; the inner division of the mentum is much shorter and the front of the head convex.

Having thus noted the differences existing between this genus and each of its neighbouring genera, I shall next proceed to lay down its characters, distinguishing them into Essential, Artificial and Natural, for the first of which the preceding remarks will furnish materials; and finally, I shall endeavour to describe the species with such accuracy and detail, that they may be readily known.

ORDER V.—COLEOPTERA.

Section I. PENTAMERA.—*Family I.* ENTOMOPHAGA.—*Tribe I.* CICINDELETÆ.

Genus CICINDELA.

Cicindela. *Linn. Fabr. Latr.*
Buprestes. *Geoff.*

Essential Character.

Maxillæ monodactyle.
Mentum trifid, inner division scarcely shorter.
Intermediate and *posterior palpi* subequal, filiform.
Tibia simple.

Artificial Character.

Antennæ filiform.
Clypeus shorter than the labrum.
Maxillæ with two very distinct palpi, of which the exterior one, is nearly equal to the labial palpi, penultimate joint of the latter hairy.

Mentum trifid, the divisions nearly equal in length.

Feet slender, elongated. *Anterior* tibia without a sinus near the tip.

Natural Character.

BODY oblong, of a medium size, agile, winged, hairy, above depressed, and punctured.

HEAD as large as the thorax, exserted, inclined, suboval.

Vertex rugose, elevated each side upon the eyes, concave on the disk.

Antennæ filiform, eleven-jointed, shorter than the body, first joint dilated, attenuated at base, and inserted in the anterior canthus of the eye, with which and with the clypeus it is nearly in contact; second joint very small, rounded, third cylindrical, longest, and with the next dilated at tip, succeeding ones subequal, or gradually decreasing in length, and furnished with a few rigid hairs at their tips, terminal one obtuse.

Clypeus transverse, very short, contracted in the middle.

Labrum coriaceous, very large, transverse, often dentated, exserted, prominent.

Mandibles advanced, prominent, attenuated and incurved towards the tip, dentate within, a large compound tooth at the base, and about three other distinct ones nearer the tip.

Maxillæ corneus, recurved, linear, a little gibbous at the insertion of the palpi, deeply ciliate with rigid bristles within, and armed with a terminal, distinct, moveable, partly incurved nail.

Palpi six, filiform; anterior pair biarticulate, first joint elongated, rectilinear, a little dilated at tip, almost attaining the apex of the maxilla, second joint linear, incurved over the point of the maxilla and attaining the termination of the nail.

Intermediate palpi with the preceding, situate on the back of the maxillæ, quadriarticulate, first joint abbreviated, attenuated at its insertion, second joint cylindric, elongated beyond the tip of the maxilla and equal to the two succeeding ones conjointly, third shorter than the terminal one, gradually dilated to the apex, fourth somewhat enlarged towards the extremity, truncate.

Posterior, or *Labial palpi* pedunculated, approximate at base, nearly equal to the preceding pair, triarticulate, first joint minute, attaining the tip of the inner division of the mentum, second elongated, cylindric, very hairy above, terminal one glabrous, half as long as the preceding, truncate at summit.

Labium membranaceous, short, concealed behind the mentum.

Mentum, corneous, transverse, somewhat concave, trifid, inner division conic, as long or nearly so as the lateral ones, and a little more advanced, lateral ones dilated, and rounded on the external margin, tip conic, the separating sinuses admitting the free motion of the labial palpi.

Eyes large, very prominent, reticulate, obovate, distant from the thorax.

TRUNK. *Thorax* subquadrate, length and breadth nearly equal, generally with an anterior and posterior impressed, transverse line connected by a dorsal, longitudinal one giving to the disk a bilobate appearance.

Scutel triangular, conspicuous, acutely margined.

Pectus hairy, punctured or scabrous, brilliant, prominent between the anterior coxæ, (sternum) about half as long as the coxæ, concave at tip.

Epigastrium usually hairy, punctured, brilliant.

Elytra rigid, as long as the abdomen, depressed, incumbent not deflected, rounded behind, wider than the thorax, humerus prominent, rounded before, suture and margin nearly parallel, disk punctured, granulated, granulæ exceedingly minute.

Wings, hyaline, with a few nerves; cortal margin strong, stigma dilated, with three hyaline spots.

Feet elongated, sub-compressed, slender, formed for running; hind pair longest; anterior pair shortest; *coxæ* of the four anterior ones conic-ovate, of the posterior pair minute and concealed; *trochanters* of the two anterior pairs subtriangular, of the posterior ones large, reniform and prominent; *thighs* nearly equal to the tibia, two anterior pairs, a little dilated near the base and attenuated towards the tip, hind pair linear; *tibiæ* slender, linear, not emarginate within, heel armed with two spines; *tarsi* five-articulate, filiform, longer than the tibia, joints cylindrical, first joint longest, second, third and fourth gradually decreasing in length, the latter not bilobate, terminal joint as long as the third and furnished with two simple, incurved, acute nails; first, second and third joints of the anterior pairs in the male dilated, hairy beneath.

ABDOMEN subcordate or subtriangular, of six distinct segments, five in the female; *tergum* concave on the disk, with an elevated margin; *venter* convex, first segment divided into two remote, almost triangular portions, forming the anterior lateral angles, second segment with two deep, rounded, sinuses near the middle for the reception of the third pair of coxæ, separated by a subtriangular, obtuse portion of the segment; third, fourth and fifth subequal, conspicuously falcate behind at the margin, rather diminishing in size, the last more rapidly narrowed in the male, the sixth segment with an obtuse sinus at the middle tip; *tail* convex above, truncate beneath, with a deeply indented line near the tip in the female.

LARVA. BODY soft, cylindrical, elongated, whitish, with a double, erect, dorsal spine on the eighth segment:

head coriaceous, coloured, depressed and concave above, beneath convex, much broader than the body, rounded, furnished with strong, prominent mandibles, short antennæ, and two stemmata on each side; first, second and third segments, each furnished beneath with a pair of scaly feet, the former with a coriaceous disk; *tail* simple.

FOOD, insects, worms, *&c.* in the different stages of their existence.

SEASON, spring, summer, autumn.

COLOUR, green, purplish or black, often varied with the two former, and exhibiting brilliant metallic tints, the elytra usually with abbreviated bands, lunules and spots of white or yellow.

Obs. The sexes may be distinguished from each other by the three first anterior tarsal joints of the male being dilated, and hairy beneath the last segment of the body, with an obtuse sinus. The tarsi of the female are simple, the tail canaliculate towards the tip.

SPECIES.

1. CICINDELA **Vulgaris.*

C. obscure, on each elytron three whitish bands, two of which are curved, and the intermediate one refracted.
Length more than three-fifths of an inch.
Inhabits North America.

DESCR. HEAD blackish or obscure cupreous, green at base above, front with cinereous hair; *antennæ* first, second, third and fourth joints green, furnished with a few white hairs before, origin of the hairs in punctures, which are more obvious on the basal joint, remaining joints black, opaque; *labrum* white, with three black teeth at tip and four marginal punctures, one of which behind each of the lateral teeth, and one at each anterior angle; *mandibles* white at the base, black within and at the tip; *palpi* above green, beneath purple, the second joint of the labiales white.

TRUNK. *Thorax* quadrate, inconspicuously narrowed behind, obscure cupreous, with distant hairs, submarginal impressed lines blue; *feet* green; *thighs* usually brassy-red above; *elytra* cupreous brown or blackish obscure, with minute, irregular, green punctures; suture and external edge cupreous, each elytron with an external lunule or curved line, originating on the humerus, sometimes interrupted on the margin and curved inwards towards the tip of the elytron, intermediate band refracted, at the centre of the elytron, in an obtuse angle, curved downwards, and terminating near the suture, posterior band, somewhat lunate, terminal.

ABDOMEN. *Tergum* greenish blue, segment brownish or pale at tip; *venter* blue with a purple shade; *tail*, and sinus of the male, purple.

This species I have always been accustomed to refer to C. *trifasciata*, and it is not without considerable hesitation that I venture to give it a distinct name. Mr. Melsheimer considered it as *trifasciata*, and that name in his catalogue refers to the insect under consideration, it is also true, that it corresponds in every particular with the short description of that insect in the *Syst. Nat.* and also in the *Syst. Eleut.*, but this circumstance alone, is not sufficient to warrant us in concluding it to be the same, for in this instance as in very many others wherein brief descriptions are concerned, several distinct species may be referred with equal propriety to the same trivial name. Olivier in his celebrated work, gives us a few additional characters of the *trifasciata*, the most important of which " on voit une raie interrompue, le long de la suture, jusques vers le milieu," is with respect to our insect a good discriminative character, in which this line or vitta, never has existence; the size also as depicted by him, tab. 2, fig. 18, is not quite half an inch, whereas that of the *vulgaris* is full three-fifths. From these characters it must be evident that Olivier's *trifasciata* is a different insect from the one here described, and as he examined the various cabinets in which the insects described by Fabricius are preserved, I rely upon his knowledge of the Fabrician species, particularly as he gives the synonym of that author. Against the correctness of this decision it might be urged, that Fabricius, in his subsequent work *Syst. Eleut.*, does not refer to the above mentioned figure, neither does he quote Olivier at all under his description of *trifasciata;* but this objection, however plausible, will have no weight, when we know that he refers to this very figure, the 18th, of tab. 2, for the C. *punctulata*, an insect with which it has no other than a generic affinity, and for which on comparison it could not be mistaken.

2. CICINDELA **hirticollis*.

C. obscure cupreous, beneath blueish-green, trunk each side cupreous brilliant, hairy; *elytra* with two lunules, intermediate refracted band, and outer margin, white.

C. *hirticollis. Journal of the Academy of Natural Sciences, vol. I. No. 2, p. 20.*

Length rather more than half an inch.

Inhabits Pennsylvania.

DESCR. HEAD cupreous varied with green and blue, front with cinereous hair; terminal joints of the *antennæ* black, opaque; *labrum* white, sinuate on the anterior edge, and furnished with a single tooth and eight submarginal punctures producing hairs; *mandibles* white at the base, within dark green, tip black; *palpi* white, terminal joints green.

TRUNK. *Thorax* with the submarginal lines blue, quadrate not straitened behind; *elytra* obscure, punctured irregularly with green, punctures larger than in the preceding species, more conspicuously serrate at the hind margin and mucronate at the inner tip; anterior lunule originating on the humerus, continued a short distance on the margin, and curved rather towards the base of the elytron, intermediate band divaricated on the margin, so as to attain the lunules, but is sometimes interrupted before the posterior, refracted in a somewhat acute angle at the centre of the elytron, thence recurved nearly parallel with the suture, and dilated at its termination; posterior lunule terminal; *feet* red-cupreous, hairy; *trochanters* purple.

Abdomen. *Venter* blue, segments tipped with brassy; *tail* purple.

This insect does not appear to have been described except in the work to which the synonym refers; it had been previously overlooked, probably in consequence of its proximity in point of colours and marking to the preceding species, which it generally accompanies; but a small degree of scrutiny will detect a sufficient number of discriminative characters, to warrant us in constituting of this insect a distinct species; in size its female is equal to the male of C. *vulgaris*, the punctures of the elytra are much larger, the intermediate band is so widely spread out upon the margin, as nearly to connect the anterior and posterior lunules, and the tip of the anterior lunule is curved towards the base of the elytra and not obliquely towards the tip, as in the preceding species; a striking difference also is perceptible in the upper lip which in that insect is three-toothed, but in the C. *hirticollis* it is one-toothed. Neither this nor the preceding species have been observed to vary in their colours or markings.

3. Cicindela *unipunctata*.

C. dull cupreous, obscure, naked, base of the mandibles; labrum and marginal dot on each elytron white.

C. *unipunctata*, subpurpurascens, labio elytrorumque puncto albis. *Fab. Syst. Eleut. pars 1, p.* 238.

C. *unipunctata*, violette, brillante en-dessous, obscure en-dessus; elytres avec un point blanc. *Oliv. Inst.* 33, *tab.* 3, *fig.* 27.

Length nearly seven-tenths of an inch.

Inhabits the southern states.

DESCR. HEAD entirely rugose, neck above granulate; *clypeus* narrowed in the middle; *labrum* much broader in the middle, white, edge brown, strongly three-toothed before, of which the intermediate one is larger. margin with four punctures, of which two are at the lateral angles and the others at the base of the lateral teeth; *mandibles* white at base, tip black; *palpi* green.

TRUNK reddish-purple on the sides; *thorax* with the lines not deeply impressed or differently coloured, a little narrowed behind; *elytra* with a slight shade of greenish-olive, convex, without a sutural angle or spine behind, irregularly punctured with green; on the posterior half are some larger, scattered, impressed green dots, a few at the base and in an undulated line near the suture; surface somewhat unequal, a conspicuous indentation towards the base of each near the suture and an oblique, abbreviated, obscure one in the centre of the elytron near the marginal spot, which is subtriangular, white and placed on the middle of the margin; a minute, obsolete, white dot is situate at the posterior curve.

ABDOMEN. *Venter* reddish-purple each side near the base; *tail* black.

Of this insect I have seen but a single specimen, for which I am indebted to Mr. J. Gilliams, who caught it in the state of Maryland. It is very possible that it may be a distinct species from the C. *unipunctata* as the figure of that insect by Olivier above referred to, is rather smaller and of a somewhat different habit; nevertheless as his description agrees very well with our insect, I shall consider it as the same until those who have an opportunity of seeing the original may decide.

4. Cicindela *sexguttata*.

C. greenish-blue polished, each elytron with three marginal white dots, the two first, nearly equal, the last transverse and terminal.

C. 6 *guttata*, viridis, nitida, elytris punctis tribus, maginalibus albis. *Fab. Syst. Eleut.* 1, *p.* 241.

C. 6 *guttata*, D'un vert bleuâtre brilliant; élytres avec trois points blanchâtres, sur le bord extérieur. *Oliv. Ent. No.* 33, *pl.* 2, *fig.* 21, *a.*

C. 6 *guttata*, Elle brille du plus beau verd-bleu. Le pattes sont bleues, les yeux blancs. *Herbst. Arch. p.* 149, *pl.* 27, *fig.* 17.

Length of the male more than half an inch.

Inhabits North America.

DESCR. Head green, sometimes glossed with blue; *antennæ*, four basal joints green, remainder black-brown; *labrum* white, edged with brown, three triangular teeth before, and six marginal blackish punctures each of which latter furnishes a hair; *mandibles* white above, tip black; *palpi* green; *eyes* brown.

Trunk green, tinged beneath with blue, but without a cupreous tint, hairs remote and short; *feet* green; *trochanters* brassy; *intermediate tibia* with more numerous short hairs near the tip behind; *elytra* green, brilliant, behind the middle blueish-purple, which deepens towards the tip, punctures numerous, sometimes confluent, hind margin rounded, obscurely serrate, sutural margin not abbreviated nor mucronate at tip, each elytron marked by three marginal white dots, the first placed in the middle of the margin, one at the posterior curve, and the third transverse and terminal; inferior page blackish, marginal spots testaceous.

ABDOMEN. *Venter* blueish-green, segments margined. bronzed, edge and *tail* purple.

Var. α. Elytra each with an additional spot, which is fulvous or white, and generally inconspicuous, placed behind the middle triangularly with respect to the two anterior, marginal ones.

Var. β. Each elytron with a single marginal spot, the two posterior ones wanting.

This insect is common in Pennsylvania, but not so frequent as either *vulgaris* or *hirticollis.* Its characters are strong and discriminative, so that our synonyms are free from doubt, although that of Herbst represents the eyes as white; but this colour is, as in some of the Carabi and many other insects, only to be found in the dried specimen, and is by no means universal. The second variety was brought from the banks of the Missouri, above the confluence of the river Platte, by Mr. Thomas Nuttall.

5. CICINDELA *dorsalis.

C. bronzed, *elytra* white, each with two curved lines on the disk, suture, and curved branch near the base, green; *tail* testaceous.

C. *dorsalis. Journal of the Academy of Natural Sciences, vol.* 1, *p.* 20.

Length nearly three-fifths of an inch.

Inhabits New Jersey.

DESCR. HEAD bronzed, naked, edges green; *antennæ* brown, basal joints green, the third hairy before; *labrum* white, not emarginate at the anterior angles, broad before, and furnished with a single tooth, eight punctures very near the edge, of which six are equidistant on each side of the tooth, the others remote; *clypeus* almost obsolete above; *mandibles* white above and beneath, tips and teeth within black-green, a very strong tooth beneath, near the tip of one mandible, the other simply a little angulated in that part; *palpi* white, tip of the terminal joint of each blackish.

TRUNK, cupreous, covered each side by short, dense, prostrate, cinereous hair; *thorax* bronzed, varied with green, margin and longitudinal dorsal line, hairy; *scutel* green or bronze; *elytra* white, with very minute, irregular punctures, and a few larger ones on the anterior margin; suture and a lunated branch near the scutel, curving on each elytron and abbreviated behind, the middle of the base green, disk with two abbreviated green bracket-formed lines, of which one curves outwards and the other inwards, respectively terminating at one end opposite the centre of the other.

ABDOMEN. *Venter* bronzed, segments margined with purple, having dense, cinereous, prostrate hair each side; *tail* and tip of the last abdominal segments testaceous.

This very fine and beautiful species I discovered a few years ago on the sea beach of New Jersey. In several of the Cicindelæ there is a strong tooth on one of the mandibles near the tip, beneath, pointing downwards, which is very conspicuous in the present species; these teeth are I believe never found on both mandibles, otherwise the mouth could not be properly closed, accordingly the tip of the armed jaw is always beneath the other in repose; neither is the weapon confined to the right or left mandible, but is found upon either indifferently, whilst upon the corresponding part of the other, is usually a very small angle. It must be remarked that this insect seems to approach a species described by Fabricius, as a native of the island of St. Thomas, and I here subjoin his definition, "C. viridi-aenea, elytris albis: sutura lunulaque viridi-aeneis. *Syst. Eleut.*"

6. CICINDELA *marginata*.

C. olivaceous, obscure, sometimes with cupreous reflections; *cheeks* sides of the *trunk* and of the *abdomen*, with short dense hair, each elytron with a whiteish margin, two abbreviate branches, an intermediate refracted one, and two dots at base.

C. *marginata*, viridis, elytris punctis quinque, lunulaque apicis albis. *Fabr. Syst. Eleut.* 1, *p.* 241.

Length of the male more than half an inch.

DESCR. HEAD greenish, olivaceous varied with purple, and edged with blue; *antennæ* purple at base, terminal joints brown; *front* with prostrate hair; *labrum* white, with several minute, obtuse teeth, in the male, with a single more prominent one, and about ten marginal punctures, lateral angles rounded; *cheeks* covered with dense hair; *palpi* white, terminal joint of each black at the tip.

TRUNK on each side cupreous, concealed by short, cinereous hair; *thorax* bronze or olivaceous, posterior impressed line green or reddish; *elytra* olivaceous-obscure, or tinged with cupreous, margin pale, uniting the anterior and posterior lunules, the former with an accessary spot at the middle of the base, and a smaller one interrupted from its tip, the latter continued a short distance upon the sutural margin, intermediate band refracted in a very acute angle, at the centre of the elytron elongated, and dilated behind, terminating at the suture, in a transverse line drawn from the tip of the posterior lunule; *trochanters* testaceous.

ABDOMEN. *Venter* very hairy each side, segments bronzed and margined with purple; *tail* testaceous, of the female blackish-purple.

The markings of the elytra are in many specimens so far obsolete, as to be only distinguishable in a particular light; and they are always less obvious, than those of *vulgaris*, *hirticollis*, *&c.* to the latter of which, this insect, in the distribution of its bands and lunules, bears some resemblance.

7. CICINDELA *obscura.*

C. black, each elytron with two white marginal spots and a terminal lunule.

C. *obscura*, nigra, elytris punctis duobus marginalibus, lunulaque apicis, alba. *Fabr. Syst. Eleut. pars* 1, *p.* 238.

Length nearly half an inch.

Inhabits North America.

DESCR. HEAD black, naked; *antennæ* brown at tip; *clypeus* large; *labrum* white, three-toothed, not emarginate at the anterior angles, margin with about six punctures, of which one is placed each side of the larger, central tooth; *mandibles* white on the exterior base above; *palpi* piceous.

TRUNK black, immaculate; *elytra* tinged with brown on the posterior half, punctures minute, not deeply impressed, two white marginal maculæ, of which the anterior one is smaller, rounded, and placed near the humerus, the other large, triangular, situate in the middle of the margin, lunule terminal; *tarsi* piceous.

ABDOMEN black, naked, immaculate.

Var. α. *Labrum* black or piceous, anterior marginal spot of the elytra wanting.

Very distinct from any other species with which I am acquainted, for the variety I am indebted to Mr. J. Gilliams, who caught it in the state of Maryland.

8. Cicindela *purpurea*.

C. head, impressed lines of the thorax, and margin of the elytra, green, the latter with a central, reclivate, oblique, abbreviated band, terminal line and intermediate dot, white.

C. *purpurea*, purpurine en-dessus, d'un vert bleuâtre en-dessous; élytres avec une band courte, et deux points blancs. *Olivier's Inst.* 33, *t.* 3, *fig.* 34.

C. *marginalis?* thorace elytrisque cupreis; marginibus viridibus, elytris lunulis duabus albis. *Fabr. Syst. Eleut.* 1, *p.* 240.

Length of the male about three-fifths of an inch.

Inhabits North America.

DESCR. Head red-cupreous, hairy with green edges, and two distinct green lines between the eyes, originating at the base of the antennæ, and approximating towards the vertex; *antennæ* green at base, tip brown; *clypeus* blue; *labrum* white, three-toothed, edge black and with about eight marginal punctures; *mandibles* black within and at tip; *palpi* green.

Trunk green, each side golden; *thorax* with a cupreous disk; *elytra* olivaceous-green to a brilliant cupreous-red, margin bright green, each with an oblique, reclivate band near the middle, originating at the green margin, and terminating at a distance from the suture, a transverse line at tip and an intermediate submarginal dot, white; *trochanters* purple; *tibia* hirsute behind.

Abdomen. *Venter* green, sides purple.

Var. *a*. Elytra destitute of the intermediate dots. C. *ramosa*. *Melsheimer's Catalogue*, *p.* 46.

Var. *β*. Head and thorax green; elytra as in the preceding variety.

Var. *γ*. Head and thorax green; elytra immaculate.

Var. δ. Black, opaque above, beneath polished; labrum, lines and spot of the elytra, as in the species; cheeks and venter a little glossed with purple.

C. *tristis?* nigra, elytris mucula media flava. *Fabr. Syst. Eleut.* 1, *p.* 235. (Var.)

This insect is subject to numerous varieties in colour and markings, but those above described are the most striking of any that have fallen under my observation: the anterior band is sometimes obsolete towards the tip, so as to leave a very short perfectly transverse line attached to the margin. The variety *a*, is much more common in Pennsylvania than either of the others. It is probable that the *marginalis* of Fabricius will prove to be the same with this, but Olivier's designation, having the right of priority, will of course be adopted. The variety δ, is a memorable departure from the appearance of the species, no trace of the original colouring remains upon it, but that of the bands, &c. of the elytra, it seems a link in the connecting chain which unites the *purpurea* with the species described by Fabricius, under the trivial name *tristis*, and seems to be alienated from it, only by the presence of an intermediate dot and terminal line, the central reclivate band is precisely the same in form. Nevertheless it is highly probable that the *tristis* is a distinct species, although for the present I have placed it here as a variety, having no opportunity of examining a specimen.

9. CICINDELA *punctulata*.

C. obscure cupreous, beneath varied with blue and purple, each elytron with a few white points and terminal lunule, an undulated line of distant green punctures near the suture.

C. *punctulata*. Bronzèe en-dessus, blue en-dessous; élytres avec quelques points blancs, et une suite de pointes enfoncés brillans. *Oliv. Inst. No.* 33, *tab.* 3, *fig.* 37. *a. b.*

C. *punctulata*, capite thoraceque cupreis, elytris punctatis obscuris: punctis lunulaque apicis albis. *Fabr. Syst. Eleut. pars* 1, *p.* 241.
C. *obscura.* *Melsheimer's Catalogue.*
Length about half an inch.
Inhabits North America.

DESCR. **Head** cupreous obscure, margin cheeks and two lines between the eyes blue; *antennæ* brown, base cupreous; *front* naked; *labrum* white, sinuated on the edge, with a single prominent tooth and six submarginal punctures; *palpi*, labials white, last joint green, external maxillary ones piceous, third and fourth joints green.

Trunk deep blue, varied with purple beneath, sides cupreous; *thorax* colour of the head, impressed lines and lateral margin blue; *elytra* colour of the thorax, irregularly punctured with green, on each an undulated line of distant larger green punctures near the suture, and a few at the middle of the base; five small white dots, of which three are on the disk arranged in an oblique line, one near the humerus, the second central, third near the suture, the fourth and fifth dots marginal situate opposite the two preceding ones, terminal lunule straight, not ascending the suture.

Abdomen. *Venter* varied with purple and blue; *tail* bronzed.

Var. *a.* Elytra destitute of the white dots, the lunule only remaining.

A very common insect, its variations are confined to changes in the number and magnitude of the spots of the elytra; the anterior marginal dot is always minute, and of all the others most frequently wanting, the two anterior spots of the disk also, are often invisible. Fabricius by mistake refers to fig. 18, tab.

2. of Olivier's Insects, for this species, which is intended for the C. *trifasciata*, a native of South America, rather smaller than this insect and totally distinct in its characters.

10. CICINDELA **formosa.*

C. red-cupreous brilliant; elytra with a three-branched, broad white margin.

C. *formosa. American Entomology, pl.* 6.

———— *Journal of the Acad. of Nat. Sciences, p.* 19.

Length seven-tenths, breadth one-fourth of an inch.

Inhabits the sandy alluvions of the Missouri, above the confluence of the river Platte.

DESCR. HEAD red-cupreous, brilliant; *front* hairy; *antennæ* fuscous, basal joint green, second bronzed, third and fourth purple; *clypeus* and *cheeks* deep purple, the latter hairy; *labrum* white, with a blackish three-toothed edge, and six marginal punctures; *mandibles* black, base above white; *palpi*, basal joints testaceous or pale, terminal one green tipped with bronze.

TRUNK deep purple, sides green, hairy; *thorax* colour of the head, scabrous; *pectus* green before; *feet* purple; *coxæ* hairy; *trochanters* bronzed; *elytra* colour of the head and thorax, with a dilated, white, uninterrupted margin, and blueish edge, anterior and posterior branches, short, intermediate band flexuous and oblique, nearly attaining the suture, and with the other branches dilated, equal to the margin: hind angle not conspicuously mucronate.

ABDOMEN. *Venter* exclusively purple, covered with cinereous hair; *tail* bronzed.

The most beautiful, and one of the largest of the North American species; in the arrangement of the bands, &c.

of the elytra, it has some resemblance to the C. *hirticollis*, but is a perfectly distinct species.

11. Cicindela **decemnotata.*

C. green, above tinged with cupreous; elytra margined with bright green or blueish, four white spots and an intermediate refracted band.

C. 10 *notata*. *American Entomology, pl.* 6.
——————— *Journal Acad. Nat. Sciences, p.* 19.
Length three-fifths of an inch, nearly.
Inhabits with the preceding.

DESCR. Head green, varied with cupreous and blue; *front* hairy; *labrum* white, unequal, edge black, and tridentate; *antennæ* fuscus, basal joints variegated; *palpi* dark purple, varied with green.

Trunk green, a little bronzed each side; *thorax* blueish, the bilobate disk cupreous; *scutel* blue; *elytra* dull olivaceous-green, with a slightly cupreous tint, and blue margin, four white dots and refracted band; of the anterior marginal dots, one is placed on the humerus, and the second equidistant from the band, which is refracted at the centre of the elytron, and terminated near the suture, in a transverse line with the penultimate spot, this last is large, submarginal, and orbicular, terminal spot transversely triangular, and with the first interrupting the margin; sutural angle not mucronate.

Abdomen. *Venter* blueish-green, with a few hairs each side; *tail* purple.

The specimen from which this description was taken is a female, it resembles C. *purpurea* in its differently coloured elytral margin, but is sufficiently distinct from that insect by its more numerous spots, &c.

12. CICINDELA *pusilla.

C. body above blackish obscure, beneath black-blue, or greenish; *trochanters* testaceous; *elytra* with two lunules, and intermediate band, which is divaricated on the margin.
C. *pusilla. Journ. Acad. Nat. Sciences, p.* 21.
Length less than half an inch.
Inhabits with the preceding.

DESCR. HEAD dark green, obscure; *antennæ* fuscous, bronzed-testaceous, or greenish at base; *labrum* white sinuate, and brown on the edge, with six or eight marginal punctures; *palpi* testaceous, bronzed at tip; *front* naked.

TRUNK obscure; *thorax* with the impressed lines not differently coloured; *elytra* black, each with two lunules and a recurved band, attenuated, anterior lunule elongated, much narrowed, acute at tip, posterior one, not dilated at the suture, and incurved from the margin; band dilated near the margin into a triangle, recurved before the middle, and passing very obliquely and nearly in a right line, to its termination near the suture, sometimes obsolete at tip; *feet* testaceous, thighs dark green.

ABDOMEN. *Venter* dark blue, segments tipped with bronze, almost naked each side; *tail* purple.

Var. *a.* Elytra destitute of the intermediate band.

This is the smallest of our species, being less than *punctulata*, and of the most sombre colouring: the lunules and band hardly relieve, by a contrast with the general surface, as they are very narrow.

The preceding descriptions were drawn out from specimens in my possession, the three last species, were caught by by Mr. Thomas Nuttall on the Missouri, and now form a part of his collection; to him I am indebted for the permission to describe them. Specimens of those for which I have referred to Melsheimer's Catalogue, were sent me by the Rev. John Melsheimer of Hanover, a zealous entomologist and son of the author of that work, who may justly be entitled the father of entomology in this country.

In order that the present paper may comprehend all the known North American species of this genus, and thereby present a complete Monograph, I subjoin from Fabricius, three descriptions of species, which have not fallen under my notice, I therefore have taken the liberty to translate his descriptions as follow:

13. CICINDELA *violacea.*

C. bright blue polished; *labrum* white.
Inhabits Carolina.
Cabinet of Mr. Bosc.

DESCR. Of a medium size; *body* bright blue, polished, covered with elevated, scabrous punctures; *antennæ* dark brown at tip; *labium* (*labrum*) and base of the mandibles above, white. *Syst. Eleut. part* 1, *p.* 232.

(Is not this referable to the genus Megacephala?)

14. CICINDELA *abdominalis.*

C. black, labrum and lunule at the apex of the elytra, white; *abdomen* rufous.
Inhabits Carolina.
Cabinet of Mr. Bosc.

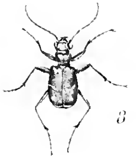
DESCR. Smaller than C. *germanica*; *head* and *thorax* cylindrical, black-cupreous, a little polished; *labrum* white; *elytra* black, an obscure line of impressed punctures at the suture, and white lunule at tip; *body* and *feet* greenish-brassy, polished; *abdomen* ferruginous. *Syst. Eleut. part* 1. *p.* 237.

15. Cicindela *micans.*

C. *Head* and *thorax* cupreous, polished; *elytra* obscure; minute points and lunule at the apex, white.
Inhabits North America. *Syst. Eleut. part* 1, *p.* 238.

It is highly probable that this description was intended to designate an insect very similar to the C. *punctulata*, perhaps the same, or only a variety of it, for it is as characteristic of that species as it can be of any other.

PL. XIII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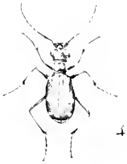
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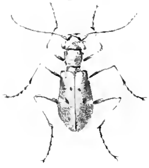


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No. XXXVI.

Description and Rationale of the operation of a simple apparatus, which may serve as a substitute for the Ship Pump, and which will require no manual labour whatever; being a Supplement to the paper No. XXIX. on that subject. By Robert Patterson.—Read, Dec. 5, 1817.

DESCRIPTION.

THE apparatus for the purpose announced in the above title, consists of a long hose, made of pretty stiff leather, passing through the stern of the vessel; the inner end furnished with a copper ferrule, and having a valve opening inwards, is to be immersed under the surface of the water in the hold, and the outer end to fall into the water a-stern of the vessel. This end of the hose is to terminate in a piece of copper tube, of a convenient length, with three or more large holes pierced through its circumference, near the extremity; and to be closed at the end by a moveable lid, projecting a small distance beyond the circumference of the tube. This tube is to be introduced (the lid being removed for the purpose) into a broad metalic socket, (bell-metal or copper) from which project three or more diverging spiral tubes, opening into the socket; which must be made to turn freely, and with as little friction as possible, round the copper tube, and covering the holes

2

perforated through it; the lid being replaced, will prevent the socket from slipping off.

Round the socket, and behind the projecting spiral tubes, are to be firmly fixed, obliquely, three or more copper vanes, resembling those of a vertical wind-mill.

Along the surface of the copper tube, in which the hose terminates, may be fixed an oblong sheet of cork, projecting a small distance above the tube. This will answer two purposes, 1st, by its buoyancy, it will, when the vessel is in motion, prevent the spiral tubes from sinking too much below the surface of the water; and 2dly, it will counteract the tendency which the friction of the socket, turned round by the rotary motion of the vanes striking against the water, will have to twist the leathern hose.

That part of the hose which passing through, comes in contact with the stern of the vessel, may be made of a strong, curving, copper tube, by which it may be fastened to the vessel, and thus be prevented from being dragged out or twisted round by the action of the water. Into the upper bend of this part of the hose may be inserted a small diverging copper tube, through which, by means of a funnel, the hose may be filled with water, or the air which may there accumulate, suffered to escape, and may then be stopped with a cork.

RATIONALE OF THE OPERATION.

The hose being previously filled with water, and the vessel under way, the action of the water against the vanes attached to the socket, will, in ordinary circumstances, produce so great a centrifugal velocity in the outer extremities of the spiral tubes, as to overcome the external pressure of the water, and produce a current from the water in the hold, on the principles mentioned in the original paper, so long as it covers the inner extremity of the hose. If the motion of the vessel should cease, or become too slow to produce the exhaustion of the water from the hold, then the valve at the inner extremity of the hose will be shut, and the hose remain full, till a favourable change of circumstances shall renew the operation.

There is no doubt, that the above apparatus is susceptible of various modifications and improvements, which will readily occur to the practical navigator.

A centrifugal pump is not a new idea—I remember to have seen one in Bucks county, above fifty years ago; constructed by Joseph Ellicot, the father of our associate Andrew Ellicot, by which water was raised from a pretty deep well, for the purpose of irrigation, the rotary motion being communicated to the pump by a simple wind-mill.

No. XXXVII.

Abstract and Results from eight annual statements (1809 *to* 1816), *published by the Board of Health, of the Deaths, with the diseases, ages, &c. in the City and Liberties of Philadelphia. Communicated by John Vaughan.—Read, Jan.* 9, 1817.

GENERAL ABSTRACT FOR EIGHT YEARS.

DISEASES.	1809	1810	1811	1812	1813	1814	1815	1816	TOTAL.
Abortion	3	1	2	0	1	3	0	0	10
Abscess	10	7	15	4	5	6	4	9	60
Angina Pectoris	1	0	1	1	0	0	2	4	9
Asthma	12	11	8	7	13	5	7	16	79
Aneurism	3	2	1	1	1	4	3	4	19
Anthrax	1	0	0	0	0	0	0	0	1
Apoplexy	31	31	46	34	29	25	50	36	282
Aptha	0	0	0	0	0	3	1	7	11
Atrophy	11	15	14	17	18	35	29	29	168
Burns	12	13	12	4	6	12	14	18	91
Cachexy	0	0	0	0	0	5	4	6	15
Cancer	9	8	12	4	8	19	9	14	83
Caries of the Spine	1	1	1	0	2	2	3	4	14
Casualties	19	16	16	9	9	14	16	17	116
Catarrh	13	8	10	17	6	19	21	46	140
Child Bed	1	1	5	3	4	6	7	9	36
Cholera Morbus	153	206	240	157	178	127	94	90	1245
Cholic	8	10	11	5	5	5	18	5	67
Cold	2	0	0	0	0	0	0	0	2
Consumption of the Lungs	311	306	369	339	216	274	347	434	2596
Convulsions	170	183	162	177	166	174	180	167	1379
Chicken Pox	0	1	1	1	0	0	0	0	3
Decay	84	95	86	50	54	46	63	39	517
Diarrhœa	37	18	35	20	31	25	33	33	232
Diabetes	1	1	0	0	0	0	0	0	2
Dislocation	0	1	0	0	0	0	0	1	2
Dispepsia	3	0	0	0	0	0	0	1	4
Dropsy	34	42	75	49	42	35	53	52	382
of the Breast	41	43	35	15	18	29	19	21	221
in the Brain	40	44	47	50	38	40	65	84	408
Drowned	17	26	33	28	16	21	34	34	209
Dysentry	20	27	48	24	69	66	44	30	328
Drunkenness	8	12	8	4	3	5	7	8	55
Diseases in knee joint	3	1	1	2	2	1	2	1	13
Debility	42	44	63	45	42	48	52	58	394
Epilepsy	8	5	11	4	3	7	5	5	48
Eruptions	4	2	1	0	1	0	1	0	9
Erysipelas	2	3	3	4	2	4	7	19	44
Fracture	7	0	2	3	4	4	5	4	29
Carried forward,	1122	1184	1374	1078	992	1069	1199	1305	9323

DISEASES.	1809	1810	1811	1812	1813	1814	1815	1816	TOTAL.
Brought forward,	1122	1184	1374	1078	992	1069	1199	1305	9323
Fever	17	31	32	29	41	25	35	38	248
Intermittent	52	3	5	4	6	5	1	2	26
Remittent		17	14	21	12	12	20	22	170
Bilious		15	23	8	18	4	20	17	105
Nervous	62	7	11	4	5	13	8	6	54
Malignant		3	5	3	6	7	2	2	90
Typhus		39	43	36	102	94	84	78	476
Puerperal	4	12	4	4	2	1	3	24	54
Hectic	1	1	6	5	1	5	3	4	26
Scarlet	3	2	3	1	0	0	0	0	9
Inflammatory	3	5	4	6	1	6	5	4	34
Mortification and Gangrene	13	18	23	17	10	17	12	23	133
Gout	3	1	4	2	3	2	4	7	29
Gravel	1	3	2	1	5	2	3	4	21
Hooping Cough	96	32	54	24	29	23	6	46	310
Hives	33	49	40	20	34	22	20	30	248
Hernia	0	1	1	1	1	2	6	2	14
Hæmorrhage	8	7	8	3	2	10	8	10	56
Hydrophobia	0	0	1	1	1	1	0	1	5
Hysteria	1	0	0	0	0	0	0	0	1
Inflammation of the Brain	11	16	14	11	8	11	21	23	115
Lungs	34	12	10	4	12	6	9	19	106
Stomach	0	25	18	36	26	20	35	8	168
Bowels	50	38	27	27	28	24	15	27	236
Liver	12	20	26	14	18	24	21	22	156
Insanity	13	29	32	30	25	22	36	27	214
Jaundice	4	4	3	3	3	2	2	3	24
Lethargy	0	1	0	0	0	0	0	1	2
Locked Jaw	7	3	8	0	2	2	4	0	26
Measles	0	1	2	20	1	9	7	2	42
Murdered	0	0	0	0	1	0	2	1	4
Old Age	55	44	44	46	33	59	60	55	396
Overlaid	1	0	0	0	0	0	0	0	1
Pleurisy	31	73	67	70	49	65	126	130	611
Palsey	25	10	28	23	14	18	21	22	161
Rheumatism	4	6	9	7	4	8	12	6	56
Rickets	0	2	0	0	0	0	0	1	3
Rupture	0	0	4	0	1	0	0	0	5
Scrofula	10	10	16	6	8	13	19	11	93
Sore Throat	7	17	22	15	15	12	14	19	121
Small Pox, natural	95	33	113	0	0	0	0	97	339
Inoculated	6	1	4	0	0	0	0	0	11
Spina Bifida	0	0	0	0	1	0	0	1	2
Still Born	120	139	137	142	66	96	97	94	891
Stranguary	0	0	0	0	3	1	1	1	6
Suicide	5	6	2	3	1	5	6	8	36
Sudden	14	44	55	32	19	22	36	34	256
Syphilis	11	11	6	5	1	4	7	8	53
Tabes Nephritica	2	1	0	1	0	0	1	1	6
Teething	15	7	20	11	9	10	8	23	103
Thrush	3	1	1	0	0	0	0	0	5
Ulcers	4	2	10	3	1	6	4	2	32
Visceral Obstructions	5	0	0	0	0	0	0	0	5
Worms	13	15	12	10	8	4	11	12	85
Wounds	3	3	0	3	1	2	6	1	19
Unknown	27	31	39	11	7	8	20	36	179
Registered by Board of Health,	2004	2036	2386	1800	1632	1783	2040	2319	16000
In Public Ground, not Registered by Board of Health,	.	.	.	359	659	354			1372
				2159	2291	2137		TOTAL.	17372

The following Abstracts are taken from the general one.

1. *Abstract of registered Deaths from 1811 to 1816 inclusive. (six years) with designation of the sexes.*

	Males.		Females.		Children.	Annual.		
	Above 20 years.	Under 20 years.	Above 20 years	Under 20 years	Unknown.	Totals.		
1811	719	562	525	433	147	2386		
1812	505	419	417	381	78	1800		
1813	521	308	322	388	93	1632		
1814	540	373	425	289	156	1783	Males	6234
1815	763	371	490	284	132	2040	Females	4938
1816	703	450	585	399	182	2319	Unknown	788
	3751	2483	2764	2174	788	. .	Total	11960

2. *Abstract of the Ages of the registered Deaths for eight years.*

Under 1 year,	4106	30 to 40	2065	80 to 90	354	
From 1 to 2	1244	40 to 50	1533	90 to 100	99	
2 to 5	965	50 to 60	1060	100 to 110	16	
5 to 10	580	60 to 70	797	110 to 120	2	
10 to 20	680	70 to 80	573	Unknown	256	
20 to 30	1670	. . .	9245	. . .	15273	
						16000

3. *Abstract shewing the number of Deaths in each Month, for eight years, and whether above or under 20 years.*

	Adults.	Child.	Total.		Adults.	Child.	Total.		
January	661	508	1169	July	636	868	1507		
February	629	462	1091	August	902	1176	2078		
March	741	497	1238	September	889	709	1398		
April	815	506	1321	October	730	574	1304		
May	701	522	1223	November	665	538	1203	Above 20	8542
June	715	615	1330	December	655	483	1138	Under 20	7458
			7372				8628	Total	16000

REMARKS.

The statement for 1817 is not yet published.

No yellow fever prevailed during the eight years referred to in these abstracts.

From some misunderstanding between the local authorities relative to the public burying ground, the Health Officers could, during its three years continuance, only ascertain the *numbers* interred there, without a discrimination of disease, age, or sex, viz. for the years 1812, 359—1813, 659—1814, 354. These numbers amounting to 1372 are added to the General Abstract, and included in the calculation of the proportion the deaths bear to the population. The three abstracts formed from the general one will be little affected by the want of detail as to the 1372, as these may be presumed to bear the same proportions as the deaths of the same years actually registered in the Health Office and detailed in the General Abtract.

In 1810 the Census was taken by the general government and gave the following result, for those parts of the City and Liberties as use the burying grounds from which the returns are made to the Board of Health, and upon which the statements published by them are founded.

City, 53722. Suburbs, 37460. Out-skirts, 3654. *Tot.* 94836. The suburbs and out-skirts are part of the County, the remainder of which has a population of 16374, possessing its own burying grounds, and not subject to the Health Office regulations.

By the General Abstract the total deaths for eight years are 17372, or 2171 yearly, being twenty-three deaths for each thousand on the population of 1810 stated above, but may be rated at twenty-one and a half if we take into view that the population was increasing from 1810, and that the mean population of the term of eight years could not be less than 100,000.

The Census for the same district, was, in 1790, 46177—in 1800, 72141—in 1810, 94836—and for 1820 will (at the same ratio of increase) exceed 125,000; and we may safely estimate the population of the district for 1816, at 115,000. The deaths of that year were 2310, which shews a loss of one in fifty, or twenty in the thousand.

It has been supposed, that the number of inhabitants in the City and Liberties, has rather been under-estimated in each Census, in consequence of a personal tax; which has in many instances occasioned short returns to be made to the officers employed to take it.

These abstracts and remarks are submitted to the Society as containing valuable facts, and have been thrown into the present form in order to facilitate the use of them.

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COPENHAGEN, Analyse des travaux de la Soc. Roy. Vétérinaire, 2d Rapp. 1815. Received from M. P. Pederson, Danish minister.

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Williamson (Hugh—M D.) History of North Carolina, 8vo. Phil. 1812.
—— Littleton's (Ld. Geo.) Letter to West, on convers. of St. Paul, 8vo. Lon. 1799.
Wistar (C —M. D.) His System of Anatomy, 8vo. 2 vols, Phil. 1814.
—— A Descrip. of the Engl. Province of Carolana, by D. Coxe, 8vo. Lond. 1741.
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—— Zeisberger's (David) Morav. Miss. His Sermons to Children, in Delaware Lang. 8vo. Phil. 1813.
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—— Leçons des calculs diff. & integr. par Cousin, 2 part. Paris, 1777.
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By a voluntary contribution of some of the Members, the following Valuable Works were purchased and given to the Society.

Histoire naturelle, générale & particul. edit. rédig. par M. Sonnini, 127 vols. 8vo. Paris, 1798—1807.

Buffon (Ouvrages du Comte de)

—— Théorie de la terre, 3 vols.—Epoq. de la nat. 1 vol.—Minéraux, 12 vols.—Hist. des anim. 1 vol.—Hist. de l'Homme, 4 vols.—Quadrup. 13 vols.—Singes. 2 vols.—Oiseaux, 28 vols.——Total, 64 vols.

—— Suite d'Hist. Nat.

Reptiles, par Daudin, 8 vols.—Mollusq. par Denys de Montfort, 6 vols.—Crustac. & Insectes, par Latreille, 14 vols.—Poissons par Sonnini, 13 vols.—Cetacées, par Sonnini, 1 vol.—Plantes, par Briss. de Mirbel &c. 18 vols.—Tables, 3 vols.——Total, 63 vols.

Humboldt (Alex. de) & Aimé Bonpland. Voyage dans l'intérieur de l'Amerique, dans les années, 1799—1803.

—— Troisième partie—Essai politique sur le royaume de la Nouvelle Espagne, 2 vols. 4to, & Atlas, fol. Paris, 1811.

MAPS, AND PLANS.

Omitted in the preceding List of Donations.

Garnett (John). His Navigation Chart from America to British Channel, 1816.

—— A Chart of the Variation of the Magnetic needle, for the seas between 60° N. and 60° S. by Thomas Yeates, London, 1817.

Kimber (Emmor). A new and correct large Six Sheet Map of the United States, edited by Samuel Lewis, Philad. 1815.

Lafon (B.) Plan of the City and environs of New Orleans, 1816.

Melish (J.) Map of the state of Ohio, by B. Hough & C. Bourne, Phil. 1815.

—— Map of U.S. & contig. Brit. & Span. poss. Phil. 1816, with geog. descrip.

Patterson (Rev. Rob.) Plan of Pittsburg, Penns. by Wm. Darby, 1816.

Plowman (T.L.) Arrowsmith's Map of the World, edited by S. Lewis, Ph. 1810.

Vaughan (John). Atlas of Fred. De Wit, with 100 maps, Amsterd.

Williams (Col. Jonathan). Draft of the fortifications for the defence of N. York.

—— A MSS map of the country 9 miles west of Philadelphia, between Darby Creek and Young's Ford, on Schuylkill, executed under his orders, by Strickland, Brooks, and Kneass, Phil. 1813.

☞ Other maps may be found in the preceding list.—See Astley, Darby, Mayo, Duponceau, Komarewsky, Say, Norris.

DONATIONS FOR THE CABINET.

THE HERBARIUM OF MUHLENBERG, (*of Lancaster, Penns.*)

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Tilghman (W.)—Vaughan (J.)
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This valuable collection was purchased by the donors from his son, Dr. F. A. Muhlenberg, who desirous that it might be retained in the United States, and become the property of the American Philosophical Society, of which his father had been a member, favoured the Society in fixing the price.

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Chambers (G.) Specimens of Fossil Reliquia in limestone, from near Chambersburg Penns.

Clifford (J. D.) Siliceous petrefactions of Eschini, from Huntsville, Miss. Ter.

Correa da Serra (Joseph). Stem of the Moritche Tree of the desarts of Guiana. *Mauritia of Linné.*

Conrad (S. W.) Specimens of Zirconite embedded in Gneiss rocks near Trenton —Of Amber with Pyrites,—and of carbonised wood, N. Jersey.

Collins (Z.) Specimens of Molybdated lead, discovered in the Perkiomen vein, Montgomery county, Penn.

—— Also Blue Iron ore crystallised with Belemnites, mineralised by the same substance, from Gloucester county, N. J.

Cuningham (Redmond). Fragment of an Indian Vase found in a cavity in a mountain, Luzerne county, Penn.

Dearborn (Benj.) His Perpetual Diary on a simple construction.

Debutts (E.—M. D.) A Differential Thermometor described in this vol. p. 301.

Drake (Daniel—M. D.) Various articles found in a Tumulus at Cincinnati.

Dorsey (J. S.—M. D.) A bronze medal struck, 1804, by Bonaparte, in honour of vaccination.

Duponceau (P. S.) 42 silver coins of the Roman Emperors.

Du Pont (de Nemours). A Bust of Turgot to accompany the donation of Turgot's works edited by him.

Gilpin (J. & T.) Two Specimens of paper, (one, writing paper of superior quality) taken from sheets 1000 feet long and 27 inches wide, made at their manufactory, near Wilmington, Del.

Griffiths (Mrs.) Ammonite, from near Burlington, N. J.

Jefferson (Thos.) Two skeleton heads found in the Big Bone Lick, described by the late President Wistar in this volume.—See p. 375, & plates X. & XI.

Jones (T. P.) A large specimen of Elastic marble from the state of N. York.—Granular carbonate of lime.

Lastra (Don Pedro). A large spec. of Rock salt, various minerals, and a mammoth tooth, from Sta Fè de Bogota.

Meade (W.—M. D.) Spec. of Rocks from Ballston and Saratoga, illustrating the geology of that neighbourhood.

M'Clure (W.) Various specimens of Swedish and other European minerals.

M'Euen (T.) Drawing of a machine, and a plan for ascending rapid rivers.
Middleton (J. J.) Specimens of dried plants, from S. Carolina.
Montgomery (J. C.) Spec. of min. from Switz. & Italy, brought by him from thence.
Pennington (F.) Specimen of blue iron earth, from Monmouth county, N. J.
Sansom (Joseph). Silver medals of Washington and Franklin.
Vaughan (John). The Busts of Caspar Wistar and Alexander Hamilton.
Williams (Jona.) Model and plan of a Torpedo boat invented by Robert Fulton.
—— Specimen of Lava brought from Mount Ætna, by Gen. Eaton.

☞ The Cabinet has been also enriched by donations from Mrs. H Barnard, Aug. Bousquet, T. Cadwallader, James Cloud, Sam. Hazard, Dr. Henning, R. E. Hobart, Dr. Harris, J. Lea, W. C. Poultney, J. P. Todd.

Statement of Deaths, with the Diseases and Ages, in the City and Liberties of Philadelphia, from the 1st of January, 1817, to the 1st of January, 1818.—This serves as an Appendix to the communication in page 430 of this volume.

MONTHS.	Adults.	Children.	Totals.	AGES.		SEXES.		
Jan.	98	59	157	Under 1 year,	548	Males of 20 years and upwards,	748	
Feb.	89	81	170	From 1 to 2	138	Ditto under 20 years, .	438	
March,	106	79	185	2 to 5	134			1186
April,	131	76	207	5 to 10	73	Females of 20 years and upwards,	545	
May,	140	73	213	10 to 20	96	Ditto under 20 years, .	379	
June,	119	76	195	20 to 30	256			924
July,	86	103	189	30 to 40	325	Children, principally under 1 year,		
August,	107	123	230	40 to 50	222	whose sex is unknown, . .		107
Sept.	125	108	233	50 to 60	162			
Oct.	86	60	146	60 to 70	106	Total, ...		2217
Nov.	94	48	142	70 to 80	84			
Dec.	112	38	150	90 to 90	61			
				80 to 100	11	☞ The City and Liberties of Philadelphia are supposed to contain about *one hundred and twenty thousand* inhabitants.		
				100 to 110	1			
Totals,	1293	924	2217	Total,	2217			

The Deaths in the preceding statement were caused by the following Diseases and Casualties, viz.

Aphthæ	5	Debility	81	Inflammat. of the Stomach	31
Asthma	8	Diabetes	1	Bowels	29
Abscess	11	Epilepsy	3	Liver	26
Aneurism	1	Erysipelas	7	Bladder	2
Apoplexy	25	Eruptions	7	Jaundice	4
Atrophy	30	Fracture	2	Lethargy	2
Angina Pectoris	2	Fever	47	Locked Jaw	9
Burns	10	Intermittent	6	Old Age	50
Cancer	17	Remittent	21	Pleurisy	88
Casualties	24	Bilious	16	Palsey	32
Catarrh	30	Nervous	6	Rheumatism	9
Child Bed	5	Malignant	4	Scrofula	16
Chulera Morbus	137	Puerperal	14	Sore Throat	10
Chalic	12	Typhus	95	Still Born	110
Consumption of the Lungs	349	Hectic	5	Suicide	2
Convulsions	167	Inflammatory	2	Sudden	33
Concussion of the Brain	3	Gangrene and Mortification		Syphilis	6
Cachexy	2		14	Stone	2
Contusions	2	Gout	6	Suffocation	1
Decay	29	Hooping Cough	21	Scirrhus	2
Diarrhœa	59	Hives	21	Small Pox, natural	52
Dropsy	64	Hernia	1	Spina Bifida	1
of the Breast	20	Hæmorrhage	12	Teething	26
in the Brain	65	Hydrophobia	1	Tabes	1
Drowned	31	Insanity	24	Ulcers	1
Dysentry	33	Inflammation of the Brain	21	Worms	14
Drunkenness	17	Lungs	8	Unknown	52
Drinking Cold Water	2		1160		1606
				Grand Total,	2217

By order of the Board,

JOSEPH PRYOR, *Clerk.*

Health Office, January 20, 1818.

END OF VOL. I.—NEW SERIES.

ERRATA.

Page xiv,	line 32,	for	cause,	*read*	course
114,	line 26,	for	Taurus	*read*	Tauri
117,	line 21,	for	these, or	*read*	these errors, or
122,	line 18,	for	Now r,	*read*	Now if r,
127,	line 24,	for	greater	*read*	greatest
182,	line 12,	for	Factor	*read*	Factors
200,	line 3,	for	Washington	*read*	West Point
227,	line 15,	for	0,000010498	*read*	0,000010509
254,	line 16,	for	busy	*read*	bury
265,	After the title to the Mem. *insert* "Read 2d May, 1817."				
343,	line 6,	for	E. N. E.	*read*	W. N. W.
	line 24,	for	cold rain	*read*	in the cold change; and
344,	line 14,	for	4th, *read* 14th, for		Newfoundland *read* Ireland
	line 15,	for	13th	*read*	23d
397,	line 11,	for	then	*read*	thus

No. 10 of Plate XIII. appears to be a variety of No. 12, in the same plate.