TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

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FOR

PROMOTING USEFUL KNOWLEDGE.

VOL. II.—NEW SERIES.

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ADVERTISEMENT.

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.*"

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AMERICAN PHILOSOPHICAL SOCIETY,

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OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

Elected since the publication of the First Volume of the New Series of their Transactions.

(Those whose names are marked with an asterisk,(*) are since dead.

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OBITUARY NOTICE

OF

ROBERT PATTERSON, LL.D.

Late President of the American Philosophical Society.

It has been a custom in this Society, that on the death of the President, an oration in honour of the deceased should be delivered by one of the Members; and it was very much the wish of the Society that this tribute of respect should have been paid to their late worthy and respected President Dr. Robert Patterson. It was omitted, however, in consequence of his positive request, communicated by the friend who attended him during his last illness. Nevertheless it was thought proper that a short memorial of his useful and well spent life should be placed on the records of the Society.

Robert Patterson was born on the 30th of May, 1743, near Hillsborough, in the north of Ireland. His family was respectable, though not affluent. His great-grandfather, John, emigrated from Scotland during the persecution of the Presbyterians by the house of Stewart, and suffered with his fellow Protestants at the memorable siege of Derry. The subject of this Memoir was sent to school at an early age, and soon became distinguished for his love of learning. He was particularly conspicuous for his progress in Mathematics. To this object, indeed, his genius so strongly impelled him, that in a short time he was able to give lessons to his master.

The French having made a descent on the coast of Ireland about the year 1759, a martial spirit was excited in the youth of that kingdom which became universal. Patterson, then a youth of sixteen, burning with patriotic ardour, was enrolled in a militia company, of which he was made serjeant. He devoted himself to his military exercises, and soon became so distinguished for his skill and good conduct, as to attract the attention of the officers of a British regiment stationed near Hillsborough, who offered to procure him a commission, if he would go into the King's service. This he declined; the duties of civil life being more congenial to his nature. He chose rather to remain in a situation where he might pursue his studies, while he enjoyed the society of his family. Having completed his education, he determined to try his fortune in America; and accordingly embarked for Philadelphia, where he arrived, in October, 1768, without friends, and almost without money, having shared with a fellow passenger the contents of his slender purse.

On his arrival in Philadelphia, he visited some of the members of the religious society to which he belonged, and was received by them with great kindness and hospitality. One of them indeed went so far as to offer him the loan of a sum of money sufficient to establish him in mercantile business. Though he did not accept this offer, having determined to make the business of teaching the main object of his life, yet he remembered it to his last moment with unceasing gratitude.

After spending a week in Philadelphia, he set out on foot for Bucks County, for the purpose of seeking employment as a schoolmaster. In this he was successful. He was immediately engaged in his favourite pursuit. His first school was in Buckingham, and one of his first scholars Andrew Ellicott, afterwards celebrated for his mathematical knowledge displayed in the service of the United States. In no part of the world is more respect paid to that truly respectable character, the instructor of youth, than in the United States. Instances are frequent, where those who have commenced their career as schoolmasters have risen to the highest honours of the State. This is a sound feeling, and as long as it prevails there will be no danger of want of education.

The regular publication of the Nautical Almanac, established by Dr. Maskelyne about the time when Patterson taught in Buckingham, turned the attention of the principal navigators in the American ports to the calculations of the longitude from lunar observations, in which they were eager to obtain instruction. Availing himself of this desire, he removed to Philadelphia, where he soon had for his scholars the most distinguished commanders who sailed from this port.

In the year 1771, the parents of Dr. Patterson, two of his brothers, and two sisters, attracted no doubt by his success and the encouraging accounts received from him, came to this country. One of his brothers, a presbyterian clergyman, is still living, at Pittsburg, and one of his sisters, a widow lady, in Philadelphia. In the year 1772, having accumulated the sum of five or six hundred pounds, he was persuaded by a friend whom he consulted, to invest it in merchandise, and open a country store in New Jersey. But never was there a man less fitted for this business. His books indeed were kept with mathematical correctness; but to the drudgery of a retail salesman he was unequal. Every customer seemed an intruder who detained him from his studies. He was soon sensible that nature never designed him for a store keeper. He seized therefore the first opportunity of closing his mercantile concern, and resuming his former avocation. This he was enabled to do to advantage, being appointed Principal of the Academy at Wilmington, in the State of Delaware, about the beginning of the year 1774. On the 9th of May, in the same year, he was married to Ame Ewing, daughter of Maskell Ewing, Esq. of Greenwich, Cumberland County, New Jersey. With this lady, who has now the misfortune of lamenting his death, he lived in the most affectionate union for upwards of fifty years. They had eight children, two of whom died in infancy. His son Robert, with hereditary talents improved by liberal education, succeeded his father in the office of Vice-Provost of the University of Pennsylvania some years before his death, and fills his place with great reputation. About the time that Dr. Patterson took charge of the Academy at Wilmington, the differences between Great Britain and her colonies were hastening to a crisis. The First Congress, assembled at Philadelphia in the autumn of the year 1774, gave intimations to the people that it would be prudent to prepare for the event; and immediately after the battle of Lexington in April, 1775, the whole country by an unanimous impulse formed itself into associations for the purpose of learning the military exercise. So ignorant were they of every thing like military art, that every person who could perform the common manual exercise became a man of consequence, and was looked up to by his neighbours. Then it was that Dr. Patterson reaped the fruits of his youthful labours in Ireland. Ardently devoted to the cause of the colonies, he tendered his services as a military instructor, which were thankfully accepted. Three companies were put under his direction, whom he attended before sunrise in the morning, and after the dismissal of the school in the afternoon. Saturday was the field day, when all the companies met, and were trained together. As soon as the militia of Delaware were organised by authority, he received from the Committee of Public Safety the commission of adjutant in a regiment commanded by Colonel, afterwards Governor, M'Kinley. Soon after the Declaration of Independence, many students in the Wilmington Academy from the West Indies and the Southern States were called home, and the duties of the Professors were suspended. Under these circumstances, Dr. Patterson, determining to share the fate of the country, removed to a small farm which he had purchased in the neighbourhood of his father in law, in New Jersey. Having placed his family in safety, he went into service with the militia who were opposed to the enemy. After the disastrous campaign of 1776, he returned to his family, but had not been at home a week, when the militia were again called out to immediate service, the British army having almost overrun the State of New Jersey. He did not hesitate to obey the call, and repaired immediately, with his rifle on his shoulder, to the appointed rendezvous, with the intention of serving in the ranks. But before the troops were ready to march, he received from Governor Livingston the commission of brigade major, with orders to join General Newcombe's brigade. In this office he was honourably engaged in active service, until the British army evacuated Philadelphia and New Jersey in 1773, when the brigade was disbanded.

The critical period in the destiny of the United States was now past. The capture of Burgoyne's army and the alliance with France afforded a moral certainty of the ultimate establishment of their independence. Such was the confident opinion of the people, and accordingly they began to turn their thoughts towards civil affairs, and the important business of education. The old College and Academy of Philadelphia were new modelled, their foundation enlarged, and a University created. Patterson was well acquainted with Dr. Ewing, the Provost of the University, and applied to him for employment as a mathematical teacher. The Provost received him with great kindness, and told him he was the very man they wanted, and advised him to offer himself without delay to the Board of Trustees as a candidate for the Professorship of Mathematics. In consequence of this advice, he entered into the University in December, 1779. He was appointed first a Professor and afterwards Vice-Provost, in which station he continued until the year 1814, when he resigned, and was succeeded by his son. During this long period he performed his official duty with great integrity, industry, and ability, and rendered essential services to the University and the country. This was his proper sphere. With laborious application he ran the course which nature had pointed out, and his efforts were crowned with complete success. But arduous as were his duties in the University, he found time for other useful employments. Being highly esteemed by his fellow citizens, he was elected a member of the Select Council of Philadelphia, of which he was chosen President in 1799. In this assembly his habits of business, and his love of order and regularity, were extremely serviceable. Of this the Council were very sensible, and on his resignation honoured him with an unanimous vote of thanks.

In the year 1805, he received from Mr. Jefferson, President of the United States, with whom he had been in habits of friendship, the unsolicited appointment of Director of the national Mint. This office he filled with great reputation until his last illness, when he resigned, and his son in law, Dr. Moore, was appointed by President Monroe in his place.

In the year 1816 the Trustees of the University of Pennsylvania, in testimony of their approbation of his long tried talents and services, conferred on him the honorary degree of Doctor of Laws.

That he should be a Fellow of the American Philosophical Society was a matter of course. He was elected in 1783, and remained an active, zealous, and useful Member to the time of his death. He was chosen Secretary in 1784, Vice-President in 1799, and ultimately in 1819 raised to the Chair which had been filled by Franklin, Rittenhouse, Jefferson, and Wistar. His zeal for the interests of this Institution was always conspicuous, and he conducted himself during his Presidency to the entire satisfaction of the Society.

Nature had been liberal to Dr. Patterson. She endued him with strength of body and solidity of understanding. His mind was peculiarly adapted to the exact sciences, in which he made considerable progress, and was certainly a distinguished teacher. He was not however satisfied in any case with mere abstract mathematical truth, but always sought for its application to some practical purpose. This appears from his works which are all elementary, and his numerous papers published among the Transactions of our Society. His practical knowledge of mathematics was held in high estimation. Our most ingenious mechanicians were in the constant habit of resorting to his judgment and advice. But one, and the most important, trait in his character is yet to be mentioned,—his *fervent and unremitted piety.* From early youth to the last moment of his protracted life, it penetrated and pervaded his whole mind, and influenced all his conduct. He belonged to what is commonly called the Scotch Presbyterian Church, of which he was an elder nearly half a century, and which will long have cause to lament his loss.

His constitution was so remarkably strong, that he reached the limit of his long existence almost without sickness, and was even robust until within a few months of his death. At length the powers of life gave way, and, without pain, and apparently without disease, he died on the 22d of July, 1824, in the 82d year of his age.

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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

NEW SERIES

No. I.

Descriptions of Insects of the families of CARABICI *and* HYDROCANTHARI *of Latreille, inhabiting North America. By Thomas Say.—Read, 26th Aug.* 1819.

IN the first Volume of the New Series of the Transactions of this Society, I commenced the regular description of our North American insects, by a Monograph of the indigenous Cicindeletæ; a Linnæan genus which occupies the first station in the improved classification of Latreille.

I now proceed to lay before the Society descriptions of such of our native insects, as were included by Linné, in his three genera, *Carabus*, *Dytiscus*, and *Gyrinus*. The two former of these, but more particularly the first, are now considered as great families, constituting numerous genera, and agreeably to the order in which I have enumerated them, immediately succeeding the Cicindeletæ, in the system which I have adopted.

The Carabii are very numerous, are insectivorous, terrestrial, commonly inhabiting moist places, under stones, or fallen trees, under bark or on flowers, &c. They generally run briskly when disturbed, and many species diffuse a fœtid odor, or discharge a peculiar, pungent, acetous gas.

The Dytiscii are much less numerous than the preceding, but are equally nourished by animal food. They inhabit the waters, occasionally visiting the surface for the purpose of respiration; they move with rapidity and ease through the water and the air, but on land their gait is embarrassed by the natatory form of the posterior feet.

The Gyrinii, which are now included in the same family with the Dytiscii, are comparatively few in number of species, and those few are so intimately united in nature by a similarity of character and habit, that no division has yet been found necessary in the genus, which still remains unchanged as it was first established in the artificial system. These insects, like those of the preceding Linnæan genus, are insectivorous and aquatic; they do not, however, like them, remain at the bottom to seek their prey, but chiefly confine themselves to the surface. They describe graceful curvatures or gyrations on the surface of the water, with a pleasing facility of movement, without exhibiting to the eye the oar-like feet by which that celerity is effected. When alarmed, they dive to the bottom with swiftness, carrying with them a globule of air, that their respiration may not be suspended. When irritated, they eject a lactescent fluid, which, in many instances, diffuses an agreeable odor, somewhat similar to that of the Calycanthus floridus of botanists. They fly with much ease and chiefly at night, but their movements on land are uncouth and embarrassed.

After thus briefly noticing the most prominent features exhibited by these insects, it may be proper to observe, that the descriptions are drawn out from such specimens only as have fallen under my own observation, and which I had an opportunity of examining and comparing together, in order the more effectually to indicate their differential characters. The individuals are chiefly preserved in my cabinet; and for such as I do not possess, I have carefully referred to those collections from which I have described them. I have scrupulously retained all the specific names, which have been given by the late Rev. F. V. Melsheimer, in his Catalogue of the insects of Pennsylvania; excepting only such as have been previously employed in the same genera by other entomologists; and so far as I could ascertain them by the aid of the scientific intelligence of his son the Rev. J. F. Melsheimer, who has liberally furnished me with specimens from his collection. I am also indebted to Mr. Thomas Nuttall, who has confided to my care his entire collection, with permission to avail myself of the opportunity of describing such of them as are new.

I have not thought it necessary to draw out the generic descriptions at length, as this has already been done with sufficient detail by Professor Bonelli of Turin; whose excellent papers I have not yet had the good fortune to peruse. If, in the description of some of the species, I have been anticipated by the labours of this, or any other author, I shall immediately relinquish my claims, and do justice to the real discoverers, when their labours shall meet my eye.

To the inflexible Linnæan entomologist, who may object to the numerous genera which are here adopted, I will merely observe, that each of those divisions which are here called families, he may regard as only genera, (as they coincide with those of Linnæus.) and to each of the species described he may add the characters of those divisions which are, in this essay, called genera; thus the system as it stands, complicated as it is by the vast accession of discoveries of recent date, will afford him every facility, which he might suppose to result from a scrupulous adherence to the Linnæan method.

The modern entomologist will readily perceive that I have not adopted all the genera of M. Bonelli, but that many of these are included under the genus Feronia of Latreille. In this respect I had no option; having no definitions of such genera, with the exception of those contained in the Règne Animal, many of which are too brief to be exclusively relied upon.

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ENUMERATION OF SPECIES.

Brachinus.

B. fumans.

Cymindis.

1. C. sinuatus.
2. C. decorus.
3. C. viridipennis.
4. C. purpureus.
5. C. pilosus.

Lebia.

1. L. tricolor.
2. L. vittata.
3. L. atriventris.
4. L. ornata.
5. L. viridis.
6. L. platicollis.

Galerita.

G. Americana.

Odacantha.

1. O. Pennsylvanica.
2. O. dorsalis.

Scarites.

S. subterraneus.

Pasimachus.

1. P. depressus.
2. P. subsulcatus.

Clivina.

1. C. bipustulata.
2. C. viridis.
3. C. lineolata.
4. C. pallida.
5. C. sphæricollis.
6. C. globosa.
7. C. pallipennis.

Morio.

M. georgiæ.

Harpalus.

1. H. caliginosus.
2. H. bicolor.
3. H. eraticus.
4. H. Pennsylvanicus.
5. H. faunus.
6. H. herbivagus.
7. H. similis.
8. H. vulpeculus.
9. H. iripennis.
10. H. viridis.
11. H. hylacis.
12. H. rusticus.
13. H. carbonarius.
14. H. agricolus.
15. H. Baltimoriensis.
16. H. cænus.

Feronia.

1. F. musculis.
2. F. basilaris.
3. F. impuncticollis.
4. F. angustata.
5. F. obesa.
6. F. lineola.
7. F. pallipes.
8. F. atrimedea.
9. F. longicornis.
10. F. unicolor.
11. F. stygica.
12. F. mœsta.
13. F. sigillata.
14. F. placida.
15. F. tartarica.
16. F. muta.
17. F. submarginata.
18. F. impunctata.
19. F. ventralis.
20. F. adoxa.
21. F. gregaria.
22. F. terminata.
23. F. autumnalis.
24. F. limbata.
25. F. parmata.
26. F. cupripennis.
27. F. convexicollis.
28. F. honesta.
29. F. 8-punctata.
30. F. nutans.
31. F. cincticollis.
32. F. decora.
33. F. decentis.
34. F. extensicollis.
35. F. ochropeza.
36. F. lucublanda.
37. F. chalcites.
38. F. caudicalis.
39. F. interstitialis.
40. F. obsoleta.
41. F. punctiformis.
42. F. recta.
43. F. hypolithos.

Abax.

A. coracinus.

Epomis.

E. tomentosus.

Chlænius.

1. C. sericeus.
2. C. æstivus.
3. C. lithophilus.
4. C. emarginatus.
5. C. pusillus.
6. C. laticollis.
7. C. impunctifrons.
8. C. nemoralis.
9. C. solitarius.
10. C. Pennsylvanicus.

Dicælus.

1. D. purpuratus.
2. D. dilatatus.
3. D. furvus.

Panagæus.

1. P. crucigerus.
2. P. fasciatus.

Cychrus.

1. C. elevatus.
2. C. unicolor.
3. C. stenostomus.
4. C. bilobus

Calosoma.

1. C. scrutator.
2. C. calidum.

Carabus.

1. C. silvosus.
2. C. interruptus.
3. C. limbatus.
4. C. serratus.

Nebria.

N. pallipes.

Omophron.

O. labiatum.

Elaphrus.

E. riparius.

Nothiophilus.

N. semistriatus.

Bembidium.

1. B. honestum.
2. B. punctato striatum.
3. B. levigatum.
4. B. dorsalis.
5. B. contractum.
6. B. niger.
7. B. oppositum.
8. B. affinis.
9. B. inornatum.
10. B. flavicaudus.
11. B. proximus.
12. B. lævum.
13. B. variegatum.
14. B. tetracolon.

Trechus.

1. T. conjunctus.
2. T. partiarius.
3. T. rupestris.

Dytiscus.

1. D. fimbriolatus.
2. D. verticalis.
3. D. mediatus.
4. D. tæniolis.

Colymbetes.

1. C. erytropterus.
2. C. fenestralis.
3. C. ambiguus.
4. C. seriatus.
5. C. nitidus.
6. C. bicarinatus.
7. C. venustus.
8. C. glyphicus.
9. C. obtusatus.
10. C. stagninus.

Laccophilus.

1. L. maculosus.
2. L. proximus.

Hydroporus.

1. H. undulatus.
2. H. oppositus.
3. H. niger.
4. H. catascopium.
5. H. lacustris.
6. H. affinis.

Hydrocanthus.

H. iricolor.

Haliplus.

1. H. 12-punctatus.
2. H. triopsis.

Gyrinus.

1. G. Americanus.
2. G. emarginatus.
3. G. analis.
4. G. limbatus.

DESCRIPTION OF SPECIES.

ORDER AND SECTION.—COLEOPTERA PENTAMERA.

Tribe I. ENTOMOPHAGA.—*Family II.* CARABICI.

Genus BRACHINUS. *Web. Fabr.*

Anterior tibia emarginate; elytra truncated at tip; palpi filiform; labium subquadrate; neck none; abdomen with interior vesicles inclosing a caustic, volatile, and detonating fluid; nails simple.

Species.

B. *fumans*, ferrugineous; elytra blue-black; venter, testaceous-black.

Brachinus fumans, ferruginous; elytra blackish azure. *Fabr. Syst. Eleut. p.* 219.

Body ferrugineous, with numerous minute hairs.
Head front longitudinally impressed; each side near the base of the antennæ.
Thorax with a longitudinal impressed line from the head to the scutel.
Scutel minute, blackish brown.
Elytra blackish-azure; about seven slightly impressed, very obtuse grooves, more distinct near the suture, and obsolete at the outer margin; separating lines rounded.
Venter dark reddish brown.
Length eleven-twentieths of an inch.

Rather common under stones, &c. in various parts of North America. In common with the other species of the genus, it discharges from the posterior extremity of the body, when alarmed or irritated, a caustic fluid; this is remarkable by an audible detonation, with its accompanying cloud of smoke, as in the discharge of a gun.

Genus Cymindis.

Anterior tibia emarginate; elytra, truncated at tip; exterior maxillary palpi filiform; labiales terminated by a securiform joint; neck none; body depressed and destitute of the secretory organs which furnish the detonating fluid; nails pectinated.

Species.

1. C. **sinuatus*, black; feet testaceous; elytra with a pale humeral spot and margin.

Length, one-fourth of an inch.

Body punctured, glabrous; antennæ, labrum, and palpi rufous.

Thorax transverse, slightly contracted behind, lateral edge abruptly and minutely excurved behind, forming a minute acute angle, basal lines obsolete, basal edge sinuately rounded.

Elytra blackish brown, with a pale, rufous, humeral spot, margin and obsolete gemminate spot behind, striæ acute, punctured, interstitial lines flat, broad.

Postpectus, punctures obsolete.

Feet testaceous.

Venter impunctured.

Found by Mr. J. Gilliams in Maryland.

2. C. *decorus*. *Head* blue; *thorax* rufous; *elytra* green polished.

Length, three-tenths of an inch.

Carabus decorus alatus, cyaneus, thorace pedibusque rufis. *Fabr. Syst. Eleut.*

Head blackish-blue, obsoletely punctured; beneath purple-black; *antennæ* fuscous; two basal joints rufous-obscure; *mouth* black; mandibles rufous beneath.

Trunk rufous, impunctured; beneath somewhat paler.

Thorax with an impressed line, and obsolete transverse rugæ.

Elytra green polished, with punctured striæ; deflected edge purplish.

Feet rufous; tips of the thighs, and base of the tibia black; penultimate tarsal joints bilobated.

Venter obscure blueish black.

Found by Mr. Nuttall on the Missouri.

3. C. **viridipennis.*—Elytra green, polished, margined with cupreous.

Carabus prasinus. *Melsh. Catalogue.*

Inhabits Pennsylvania; rare.

Body destitute of hairs.

Head purple-black; *vertex* glabrous; *front* impressed each side near the antennæ; *antennæ* testaceous, rather darker towards the tip.

Thorax green tinged with purple; a longitudinal impressed line, and transverse, minute, parallel rugæ; posterior angles angulated; beneath purple-black, green each side.

Feet purple-black, paler towards the tips; penultimate tarsal joint bilobate.

Scutel testaceous.

Elytra striate, green, polished, reflecting in some lights a slight purpurescent tinge: outer margin cupreous; striæ distinct, acute, distant, the marginal one with distant punctures from the humerus to the apex.

Venter blackish.

Length half an inch.

This was sent to me by Dr. J. F. Melsheimer: I have not found a specimen, and therefore have considered it as a rare species. The name *prasinus* having been already applied to a different species has rendered it necessary to change it.

4. C. **purpureus* purple or violaceous; antennæ, mouth, and tibiæ black.

Length nearly seven-twentieths of an inch.
Head obsoletely punctured, deep violaceous.
Antennæ fuscous, three basal joints rufous, obscure.
Trunk deep violaceous; a longitudinal impressed line, and transverse obsolete rugæ.
Elytra deep violaceous, obsoletely punctured; and with minutely punctured, acute, distant striæ; a line of marginal punctures; *tibia* and *tarsi* black-brown; penultimate tarsal joint bilobate.
Venter violaceous; *tail* black.

In form and magnitude resembles C. *viridipennis*, but is more depressed, and wider. Brought by Mr. Nuttall from the Missouri.

5. C. **pilosus* black-brown, punctured; mouth, antennæ, and feet rufous; elytra with punctured striæ and interstitial lines.

Carabus pilosus. *Melsh. Catal.*

Body somewhat hairy.
Head deeply punctured; no distinct frontal impression.
Antennæ and *mouth* rufous.
Thorax with numerous, profound, approximate punctures, and a longitudinal impressed line which hardly attains the anterior edge.
Elytra with punctured obtuse striæ which are sub-equal to the interstitial lines; punctures transverse, dilated, approximated; interstitial lines punctured.
Epipleura rufous, punctured; *feet* rufous; *pectus* punctured.
Venter obscure, rufous, with distant minute punctures.
Length two-fifths of an inch.

I have not met with a living specimen of this insect: it is rare.

Var. α. A longitudinal, rufous, humeral spot; punctures of the interstitial lines numerous, dilated.—In the Philadelphia Museum.

Var. β. Thorax black margined with rufous; a longitudinal, rufous, humeral spot.

Var. γ. Thorax, head, and humeral spots rufous.

The thorax of this species seems to vary in the length of its transverse diameter.

Genus Lebia. *Latr. Bonell.*

Anterior tibia emarginate; elytra truncated at tip; palpi filiform; terminal joint cylindrical, hardly truncate; thorax wider than long; penultimate tarsal joint bilobate; nails pectinated.

Species.

1. L. **tricolor*.—Head black; mouth, antennæ, thorax, and feet ferruginous; elytra green, polished.

Length about three-tenths of an inch.

Head black, polished; *front* minutely corrugated; *vertex* glabrous.

Mouth, labrum, and *antennæ* ferruginous or pale testaceous.

Thorax ferruginous, glabrous, or very minutely rugose; a longitudinal impressed line; margin depressed and somewhat dilated; angles rounded; beneath ferruginous.

Feet colour of the thorax.

Scutel colour of the thorax.

Elytra profoundly striate; striæ impunctured; interstitial lines convex; marginal line interrupted by punctures from the humerus to the apex.

Venter blackish.

Length about three-tenths of an inch.

Not uncommon in Pennsylvania. Found also by Mr. T. Nuttall on the Missouri. The name of *Lebias* has been more recently applied by Cuvier, to designate a genus of fishes.

2. L. *vittata* rufous; elytra black, with a white fillet and yellowish margin; feet black.

Length rather more than one-fourth of an inch.

Winged; *thorax* orbicular, rufous; *elytra* black, with a white vitta. *Fabr. Syst. Eleut. I. p. 202. Mus. D. Yeats.*

Antennæ black; *head* rufous; *scutel* small, rufous; *elytra* glabrous, shining black with a longitudinal white fillet in the middle; *body* ferruginous; *legs* black. *Turt.*

Antennæ black; *head* rufous; *eyes* black; *thorax* rufous, hardly broader than the head; *scutel* rufous; *elytra* black, slightly striated; exterior margin and triangular spot around the scutel rufous; a longitudinal white line on each; beneath fulvous; *feet* black with half of the thighs rufous. (Length of figure one-fourth of an inch.) *Oliv. Ill., p. 98, pl. 6, fig. 69, a. b.*

Body impunctured, nearly destitute of hairs.

Head rufous; *antennæ* black-brown, rufous at base; *palpi* black.

Trunk rufous, glabrous.

Thorax with an impressed longitudinal line.

Elytra with acute distant striæ; two parallel black vittæ,—the outer one originating on the humerus and abbreviated near the middle of the tip,—inner one originating at the middle of the base, becomes common before the middle of the suture, and is abbreviated near the inner angle of the tip; an elongated common whitish triangle at base, a white vitta on the middle, and a pale rufous margin and tip.

Feet deep black; *nails* pectinated; *coxæ* rufous.

Venter rufous.

Var. a.—Colour of the outer margin extended round the base to the scutel, thighs rufous at base, common black vitta continued to the tip.

If the figure given by Olivier be correct, the specimens here described must be considered a variety. Several individuals were brought from the Missouri by Mr. Nuttall. They are occasionally taken, in Pennsylvania, on flowers. When recent, it is of a much more bright red than when long preserved in the cabinet. The red becomes pale, and the white vitta yellowish.

Caught in Mr. R. Haines's garden, Germantown.

3. L. **atriventris* ferruginous; elytra deep purple; venter black.

Length one-fourth of an inch.

Body impunctured, naked or with very few hairs.

Antennæ brown; three first joints ferruginous; *palpi* blackish.

Thorax, disk convex; margin towards the hind angles depressed; hind angles rounded; a longitudinal impressed obsolete line.

Elytra deep-blue, with acute, distant, not deeply impressed striæ, a series of punctures on the external margin from the humerus to the middle of the tip; punctures more distant on the middle of the margin.

Nails pectinated; *venter* purple-black.

Found under stones, &c.

4. L. **ornata* rufous; head and elytra black; the latter with a yellowish edge and four spots.

Carabus 4-notatus. *Melsh. Catal.*

Length, male one-fifth—female one-fourth of an inch.

Body impunctured and almost destitute of hairs.

Head black; three basal joints of antennæ rufous.

Trunk rufous, paler beneath.

Thorax with an obsolete longitudinal impressed line; disk somewhat convex; margin depressed.

Feet pale; *nails* pectinated.

Elytra striated; striæ acute, distant; two large subtriangular or subovate spots near the base; two smaller ones near the tip; and outer edge yellow.

Venter pale yellow or reddish brown.

Var. a. The two basal spots of the elytra wanting.
Var. β. Head corrugated.—Probably a distinct species.

This species varies in the form of the basal spots, which are sometimes elongated or confluent with the margin, and either abbreviated or attaining the base. The posterior spots also occur enlarged, so as to be confluent with the apicial margin. It strongly resembles *Dromius 4-maculatus*, but the venter is not black, and the spots of the elytra are differently formed.

On flowers, (the blossom of the blackberry, &c.) in May, June, July, and August.—Not uncommon.

The name 4-*notatus* has already been made use of in this genus; I have therefore been compelled to change it.

5. L. **viridis* green, polished, immaculate; antennæ, palpi, and feet black.

Length upwards of one-fifth of an inch.
Body impunctured, nearly destitute of hairs.
Head green, with a few obsolete punctures; *antennæ* black-brown; *labrum* and *palpi* blackish; *nasus* cupreous.
Trunk green polished; beneath darker.
Thorax with an impressed line.
Elytra obsolete; striæ distant, acute; outer margin punctured; a single puncture near the inner tip.
Feet black; *nails* pectinated.
Venter blackish-green.

Var. a. Dark purplish blue; striæ of the elytra indistinct, beneath purple-black; antennæ black.

Very common on flowers. The thorax and elytra, when examined by a high magnifier, are granulated.

6. L. **platicollis* rufous; elytra black-brown edged with rufous; margin of the thorax depressed.

Length, nearly two-fifths of an inch.

Head dark rufous; tips of the mandibles and eyes black.

Thorax rufous, impunctured, rather wider than long, widest before the middle, somewhat narrowed behind; hind angles very obtuse; margin depressed; dorsal line slightly impressed; basal lines obsolete.

Elytra blackish-brown, with a pale rufous edge; striæ acute: interstitial lines flat.

Feet testaceous.

Venter dusky; blackish towards the tip, and on the tips of the segments.

Var. a. A humeral, submarginal, pale, rufous, longitudinal spot; disk of the thorax dark rufous, margin pale.—Museum of Mr. Peale.

This species is perhaps a *Dromia*.

Genus GALERITA. *Fab.*

Anterior tibia emarginate; elytra truncate at tip; palpi securiform; tongue exserted, coriaceous in the middle, membranaceous each side, and pointed at tip; neck distinct; penultimate tarsal joint bilobate.

Species.

G. *Americana* black; thorax and feet ferruginous; elytra black-blue.

G. *Americana* black: *thorax* ferruginous: *elytra* azure. *Fab. Syst. Eleut. II. p.* 214. *Latr. Regne Animal.*

Carabus lanus. Fab. Syst. Eleut. I., 136. 51.

Carabus bicolor. Drury Ent. I., tab. 42, *fig.* 2.

Zuphium Americanum. Lamarck. An. San. Vert., Vol. 4, *p.* 505.

Antennæ reddish, filiform, a little longer than half the body; *head* black, advanced; *thorax* narrow, subcordate, reddish; *elytra* black or bluish black, striated; beneath black; *feet* reddish, long. *N. Amer. Cab. of M. Gigot d'Orcy, Oliv.* 3, *p.* 63, *t.* 6, *f.* 72.

Galerita Americana. Edinb. Encyc.

Length three-fourths of an inch.
Body with very short dense hairs.
Head black; *front* with two indented lines; *vertex* with an obsolete rufous spot; *antennæ* testaceous; second, third, fourth, and tip of the first joints black; *palpi* testaceous.
Thorax and *feet* ferruginous.
Elytra black-blue opake; about eight distant, acute, impunctured striæ.

Very common under stones, &c. in various parts of the United States, and in Florida. Found also by Mr. Nuttall on the Missouri.

Genus Odacantha. *Fabr.*

Anterior tibia emarginate; elytra truncated at tip; head attenuated behind; palpi filiform; tongue exserted, coriaceous in the middle, and membranaceous each side.

Species.

1. O. *Pennsylvanica* black; elytra rufous, with punctured striæ at the base; marginal spot, sutural spot and tip, black.

Agra Pennsylvanica. Edinb. Encyc.
Drypta Pennsylvanica. Lamarck. An. San. Vert. IV., p. 505.

Body with a few distant hairs.
Head black, destitute of punctures, polished; *antennæ*, four basal joints rufous.
Thorax black, with excavated punctures each side, which disappear near the tips; a longitudinal impressed line each side above.
Feet pale testaceous; *knees* dusky or black; *tarsi*, penultimate joint entire.
Elytra rufous, striate with punctures which are obsolete behind the middle; a large, common, longitudinally oblong-oval, black spot on the middle, and common, transverse, terminal, larger one, which is connected by the black hind

margin with a spot on the middle of the margin, which is also generally connected with the common middle one.
Venter glabrous, black, often with a slight testaceous shade before.

Not uncommon beneath stones, &c. Found also by Mr. T. Nuttall on the Missouri. It has been referred to the genus *Agra*, but the palpi are decidedly those of *Odacantha* as described by M. Latreille.

2. O. *dorsalis.*—Head black; thorax rufous; elytra testaceous; suture black.
Length three-tenths of an inch.

Odacantha dorsalis. *Fabr. Syst. Eleut. I., p.* 229.

Head black; *clypeus*, *labrum*, *mouth*, and *antennæ* rufous.
Thorax cylindrical, somewhat contracted before the base, punctured; punctures numerous, minute, sparse or wanting on the disk; a longitudinal dorsal impressed line, and an obsolete, dilated, dusky vitta on each side.
Elytra yellowish-white, striate; striæ regularly and distinctly punctured; a common blackish sutural line, dilated before the tip.
Pectus pale rufous.
Feet testaceous; *tarsi*, penultimate joint bilobate.
Venter blackish.
Inhabits the southern states.

This ought unquestionably to form a distinct genus from that of the preceding species.

Genus Scarites. *Fab.*

Anterior tibia emarginate and crenate; elytra entire; antennæ short, third and fourth joints moniliform, subequal; labrum short, dentated; mandibles elongated, dentate; palpi filiform; tongue dilated, very short, emarginate at tip; thorax rounded behind; body subcylindrical.

Species.

S. *subterraneus* black, immaculate; head bisulcate before; elytra striated; feet, second pair, with two permanent spines on the tibia.

Length about nine-tenths of an inch.

Black; anterior *feet* digitated; *head* sulcated before; *elytra* striated; striæ smooth. *Fabr. Syst. Eleut. I., p.* 124.

Carabus interruptus. Fuess. Arch. 161, *t.* 29, *f.* 4.

Black; *head* with two longitudinal impressions; *elytra* striated. *Oliv. Ill., p.* 8, *pl.* 1, *fig.* 10.

Head with two indented parallel lines before, half the length of the head; *mandibles* profoundly canaliculate above, teeth above striated; *antennæ* attaining the base of the anterior feet, ferruginous, darker at base; *labium* subcarinate on the middle, with a double impression at base; *gula* with an impressed line which is furcate before.

Trunk somewhat scabrous each side beneath; *thorax*, a longitudinal impressed line and a transverse anterior one; posterior edge emarginate; *feet*, second pair, armed with two permanent prominent spines, on the outer edge below the middle, of which the inferior one is larger; *elytra* distinctly and rather strongly striated: striæ impunctured; margin scabrous; *epipleura* glabrous; *humerus* carinated before, carina terminating abruptly in an angle.

Very common in almost every part of North America.

Genus Pasimachus. *Bonell. Latr.*

Anterior tibia emarginate and crenate; elytra entire; antennæ short, third and fourth joints not moniliform; labrum dentated; mandibles strongly dentate; palpi filiform; tongue dilated, very short, and emarginate; thorax subcordate, truncate behind; body dilated, depressed.

Species.

1. P. *depressus* black, glabrous; thorax and elytra margined with purple; elytra perfectly smooth.
Length eleven-tenths of an inch.

Carabus depressus. Melsh Catal.

Scarites depressus.—Thorax subquadrate, black; *elytra* glabrous. *Fabr. Syst Eleut., p.* 123.

Scarites depressus.—Antennæ black, obscure at tip; *head* with two impressed lines before; *thorax* with a longitudinal impressed line; borders sometimes black-blue; *tarsi* black-brown. *Oliv. Ill., No.* 36, *p.* 5, *t.* 2, *f.* 15.

Body glabrous, black, impunctured.
Head transverse quadrate, with two indented longitudinal lines more than half its length; *antennæ* black-brownish at tip, first joint black: *labrum* unequal; *mandibles* as long as the head, strongly dentate in the middle; tooth in the left one double.
Thorax with an impressed line and two indentations near the base; exterior margin purple; excurved near the base.
Elytra glabrous, perfectly smooth; outer margin purple. with a line of elevated granules.
Tarsi black-brown.
Var. a. Less dilated; margins blue; elytra smooth, with a slight appearance of lines; sternum striated at tip.—From the Missouri.—Cabinet of Nuttall.

This fine large insect is of frequent occurrence in the United States beneath old logs, stones, &c., and is very probably the same as the *depressus* of Cayenne; to which country authors have referred this species.

2. P. **subsulcatus* black, glabrous; thorax and elytra margined with bluish-purple; elytra with obsolete lines.
Length four-fifths of an inch.
Body black, impunctured.

Head impressed, frontal lines profound; *antennæ* with ferruginous hairs towards the tip.
Thorax margined with blued-purple, slightly contracted behind; edge near the posterior angles slightly excurved; dorsal and basal lines very distinct.
Elytra with broad shallow sulcations; with (in some parts) obsolete rudiments of punctures; interstitial lines slightly elevated, convex, obtuse; margin blued-purple, with a regular series of minute, elevated, ocellate granules.

I found several specimens of this insect in Georgia and Florida. It is sufficiently distinct from the preceding; being smaller, more of an oval form, the thorax less contracted at the base, and the elytra subsulcate; the lateral edge also is excurved at the base, which character distinguishes it at once from the *marginatus* of Fabr. and the *sublævis* of Palisot. How closely it may correspond with the *sulcatus* of Macleay I am unable to determine, not having yet seen his work.

I have to regret the circumstance of my not having it in my power to refer to M. Palisot de Beauvois's splendid work on the insects of Africa and America. The seventh number only, belonging to the library of the Philadelphia museum, has yet met my eye; although I have made several attempts to procure an entire copy of the work from Paris.

Genus Clivina. *Latr.*

Anterior tibia emarginate and crenate; elytra entire; labrum entire; mandibles with obsolete teeth; tongue prominent, membranaceous each side; thorax rounded.

Species.

1. C. *bipustulata* black; thorax impunctured; elytra with punctured striæ, and a large obscure rufous spot near the tip and at the base of each.

Length three-tenths of an inch.

Scarites bipustulatus? black; *elytra* striated: a large ferruginous spot behind. *Fabr. I., p.* 125.

Scarites bipustulatus. Melsh. Catal.

Scarites 4-maculatus. Palisot de Beauvois.

Body blackish: beneath piceous.
Head somewhat unequal before; *antennæ* and *palpi* reddish brown.
Thorax black, impunctured: a longitudinal impressed line joining a transverse angulated one before; lateral carinated edge abbreviated and recurved at the tip.
Elytra brown-black, strongly striated; striæ nearly equal to the intermediate lines and punctured, punctures excavated; a large obsolete spot at the base, and a large and more distinct spot near the tips of each, rufous; *epipleura* with large and profound punctures at base.

A large species by no means common. I think it highly probable that the 4-*maculatus* of Palisot is no other than this insect; if so, the spots of the elytra, and especially those of the base, in his figure, are by far too distinct: indeed, the former are always obsolete and sometimes not at all visible.

2. C. **viridis* dark green, beneath blackish: elytra punctured, cupreous on the disk, edge blueish: feet testaceous. *Length* one-fourth of an inch.

Scarites viridis. Melsh. Catal.

Body somewhat hairy.
Head equal, dark cupreous-green; *antennæ* and *mouth* rufous; *mandibles* black at tip.
Trunk beneath reddish black: *thorax* cupreous-green, somewhat hairy: lateral carinated edge abbreviated, very oblique, rectilinear; a dorsal impressed line, and anterior, transverse, angulated one: *elytra* dark cupreous tinged with green, hairy: striæ obsolete, lines of distant punctures obsolete behind, margin greenish, edge blue, an im-

pressed line near the suture excurved at its base near the suture; *feet* testaceous.

3. C. **lineolata* blackish; head with several elevated lines; thorax with three impressed ones; elytra striate.

Length one-fifth of an inch.

Head with several elevated lines, of which the two interior are largest, forming a groove between them, and continued and connivent upon the labrum; behind the elevated lines, punctured.

Thorax, three impressed longitudinal lines; intermediate one attaining the anterior transverse angulated one,—lateral ones abbreviated near the anterior margin; lateral edge continued and projecting into a slight angle behind the middle.

Elytra black-brown or greenish, striate; striæ punctured, profound, and equal to the intermediate lines.

Feet testaceous.

Readily distinguishable from the preceding ones by the elevated frontal lines as well as by the impressed line of the thorax.

4. C. **pallida* pale yellowish; thorax depressed, truncate before, lateral edge minutely angulated behind the middle.

Length one-fifth of an inch.

Body pale, yellowish, immaculate.

Head sulcated each side before.

Thorax little elevated, with a longitudinal impressed line, subquadrate, truncate the entire width before, rounded behind; lateral edge attaining the base, with a slightly projecting angle behind the middle, above which is a small puncture.

Elytra strongly striate-punctured; a marginal series of short transverse lines, forming quadrate intervals.

Found on Chinquoteage island, coast of Virginia, under yellow-pine bark.

5. C. **sphæricollis*.—Thorax globose, with an impressed line; elytra with punctured distant striæ.

Length one-fifth of an inch.

Body impunctured, with a few scattered hairs, beneath black.

Head black, longitudinally indented each side; *mouth* and *antennæ* rufous.

Thorax purple-black, rounded before and behind: lateral edge obsolete near the base, more distinct before, and destitute of any angle behind; an impressed dorsal line.

Elytra reddish-brown or bronzed, with punctured striæ; striæ distant.

Feet dark rufous.

Venter black.

Differs from the succeeding species, in being larger and in having the striæ more distant from each other,—or, in other words, less dilated.

This and the two following species belong to the genus *Dischyrius* of Bonelli.

6. C. **globulosa* black; mouth, antennæ, and feet rufous; elytra with punctured obtuse striæ.

Length, from one-tenth to five-fortieths of an inch.

Scarites globulosus. Melsh. Catal.

Head black, longitudinally indented on each side; *mouth* and *antennæ* rufous; *neck* beneath rufous.

Trunk beneath black, tinged each side with rufous.

Thorax purple-black, globose, rounded before and behind; lateral edge obsolete near the base, more distinct before, and destitute of a projecting angle behind: an impressed dorsal line.

Elytra black, striate-punctured; punctures equal in length to the intermediate spaces and nearly equal in breadth to the interstitial lines.

Feet rufous; *venter* black.

This resembles *Scarites gibbus*, of which no description has been given, sufficiently characteristic, to enable us to judge of their differences. It may not be improper to observe here, that the same figure of Fuess. Arch.—the 17th of plate 29, has been referred to, both for the S. *gibbus* and *Carabus? globator*; it is probable therefore that they are one species, particularly as Herbst calls it *globator*, and has the S. *gibbus* of Fabr. as a synonym.

7. C. **pallipennis* reddish-brown, beneath black; elytra pale yellowish.
Length three-twentieths of an inch.
Body impunctured, beneath black, sides reddish-brown.
Head reddish-brown; *antennæ* and *mouth* paler.
Thorax globose, somewhat truncated before, rounded behind, colour of the head, a longitudinal impressed line, lateral edge obsolete behind.
Elytra pale yellow or whitish, striated: striæ distant, with obsolete punctures; an obsolete blackish oblique spot at base, another at tip, and a still less distinct one behind the middle.
Feet rufous.
Venter testaceous-black, and (like the trunk) margined with rufous.

Found at Egg-harbour, coast of Virginia and Florida, and is common.

Genus Morio. *Latr.*

Anterior tibia emarginate; elytra entire; palpi filiform; antennæ moniliform, joints subequal; tongue prominent, truncate at tip, and membranaceous each side; mandibles acute.

Species.

M. *Georgiæ* deep black above, beneath piceous-black; nasus with four elevated lines.

Length nearly three-fifths of an inch.

Scarites Georgiæ piceous blackish; *thorax* subcordate; *elytra* canaliculate, striæ subcrenate, those of the margin dentate. *Palisot de Beauvois, Vol. I., No. 7, pl. 15, f. 5.*

Body elongated, black, immaculate.

Head, an elevated line and groove over the eyes and base of the antennæ, two indented frontal lines; *nasus*, four elevated longitudinal lines; *antennæ*, ferruginous hairs at tip, basal joint piceous; *labrum* piceous-black, emarginated at tip; *mandibles* canaliculate on exterior base.

Thorax glabrous, narrower behind; angles acute; a strongly impressed dorsal line, and an abbreviated indented one each side at hind angles; exterior margin with six or eight hairs; a slight emarginure before the hind angles; no abbreviated stria near the scutel.

Elytra striate; striæ impunctured, slightly crenate, marginal one more conspicuously so; marginal interstitial line ocellately punctured from base to tip; humeral angles slightly acute.

I found two specimens under the bark of a decaying tree, in South Carolina; I have not met with any in this state.

Genus Harpalus. *Latr.*

Anterior tibia emarginate; four anterior tarsi dilated in the male; elytra entire; antennæ filiform, joints subcylindrical; labrum subquadrate, entire, or very slightly emarginate; palpi filiform; tongue exserted, cylindrical and coriaceous in the middle, and membranaceous each side, tip truncate, unarmed; neck none.

Species.

1. H. *caliginosus* black; antennæ, palpi, tarsi, and anterior coxæ ferruginous-brown.

Length one inch, *breadth* two-fifths nearly.

Apterous; *thorax* square, black-obscure; *elytra* striate; *antennæ* testaceous. Inhabits North America. *Fabr. Syst. Eleut. I., p.* 188.

Antennæ and *palpi* ferruginous-brown; *head* smooth with two slightly impressed points before; *thorax* broad, smooth; *scutel* small, triangular; *body* black; *thighs* with a range of small impressed points. *Oliv. III.* 35, *pl.* 6, *f.* 64, *and pl.* 7, *f.* 81.

Carabus politus. Melsh. Catal.

Head glabrous; *antennæ*, *palpi*, and edge of the *labrum* ferruginous-brown; an indented puncture each side on the front; *labrum* slightly emarginate at tip; *labium* unarmed in the sinus.

Trunk beneath punctured.

Thorax with numerous minute punctures, longitudinal line obsolete, area of the hind angles depressed and confluently punctured, posterior angles acute.

Tarsi and *coxæ* of the two anterior pairs of feet ferruginous-brown.

Elytra striate; striæ impunctured; margin opake, with numerous minute punctures and a few larger ones.

Venter black, rarely piceous.

The largest species of the genus in this country; when irritated it diffuses a very pungent vinegar-like odour. If the species described by Fabricius is in reality apterous, as he supposed it to be, this insect is a distinct species; and the name given by Mr. Melsheimer will be retained. It is very common.

2. H. *bicolor?* black, beneath deep piceous; antennæ, palpi, and feet testaceous.

Length, male less—female more than three-fifths of an inch.

Winged: *body* above black, beneath ferruginous. Inhabits North America. *Mus. D. Lewin. Fabr. S. Eleut. I., p.* 195.

Resembles *C. ruficornis; head* black; *thorax* almost square, with a longitudinal line impressed in the middle, and two impressions posterior; *elytra* black, striated; *body* beneath brown, more or less clear. *Cab. of M. Bosc. Oliv. III., p.* 57, *tab.* 11, *f.* 92, *b., Length* seven-tenths of an inch.

Carabus ostraceicornis. Melsh. Catal.

Head black; *antennæ* and *mouth* rufo-testaceous; *gula* piceous.

Thorax glabrous on the disk; a dorsal impressed line; area of the hind angles depressed and confluently punctured. posterior angles rounded.

Elytra striate, striæ impunctured, margin with numerous punctures: *pectus* and *postpectus* piceous-black, piceous on the disk, with obsolete punctures.

Feet testaceous, pale; *venter* piceous-black; *tail* paler.

A very common insect under stones, &c. It does not perfectly correspond with the description of *bicolor* of authors, but I do not know what other insect they allude to. Mr. Marsham describes this insect as an inhabitant of Great Britain.

3. H. **eraticus* reddish-brown, beneath testaceous; elytra fuscous: thorax a little contracted at base.

Length three-fifths of an inch nearly.

Body glabrous, reddish-brown, beneath testaceous.

Head not darker than the thorax; *antennæ* fuscous towards the tip.

Thorax broad as the elytra, gradually contracted behind, marginal groove somewhat dilated, dorsal and basal lines distinct, continued to the base, anterior transverse line widely curved, base not wider than the tip, each side obsoletely punctured, basal edge rectilinear, lateral angles obtuse slightly rounded.

Elytra darker than the thorax, striate, striæ impunctured. interstitial lines convex.

Feet pale testaceous.

It is very probable that this species may prove to be the H. *Pennsylvanicus*, instead of the following one, as the thorax, in being narrowed behind, agrees with the figure Olivier has given of that insect.

4. H. *Pennsylvanicus* reddish-brown; head darker, beneath testaceous; thorax punctured each side at base.
Length three-fifths of an inch.

Reddish-brown; *head* dusky; *shells* striate; *body* beneath, *antennæ*, and *feet* testaceous. Inhabits Pennsylvania. *Turt., p.* 470. *Degeer.* 4, *t.* 17, *f.* 22.

Head brown-testaceous, obscure; *thorax* brown-testaceous, nearly as broad as elytra, with a somewhat impressed line; *elytra* striated, brown-testaceous; *body* beneath and *feet* testaceous. *Cab. of M. Banks. Oliv. Ill., p.* 72, *t.* 8, *f.* 92.

Head dusky reddish-brown; *labrum* darker, tip excepting the central portion depressed and hairy; *mandibles* black at tip; *antennæ* testaceous, paler at base.
Pectus and *postpectus* testaceous; *thorax* reddish-brown, as broad as the elytra, transversely quadrate, angles rounded, a dorsal slightly impressed line, base each side impressed and confluently punctured.
Elytra striated, striæ impunctured; interstitial marginal lines obsoletely punctured, exterior one with a few larger sub-ocellate punctures.
Feet pale testaceous; *venter* pale testaceous.

5. H. **faunus* dark reddish brown; antennæ, palpi, and feet paler; thorax punctured behind.
Length half an inch.

Carabus faunus. Melsh. Catal.

Body reddish-brown obscure, beneath rather paler.
Head, nasal suture distinct; *antennæ* and *palpi* pale testaceous.
Thorax quadrate. hardly narrowed before or arquated at

the sides, hind angles rounded, dorsal line faintly impressed, basal lines dilated and with the hind margin conspicuously punctured, lateral margin depressed, punctured.
Elytra striate, striæ with distant minute punctures, punctures of the marginal line not ocellate.
Feet pale testaceous.

Of this insect I have seen but two specimens; one of which was sent me by my friend Dr. J. F. Melsheimer of Hanover.

6. H. **herbivagus* deep black-brown, beneath piceous-black: labrum piceous-black; thoracic angles rounded; feet reddish-brown.
Length seven-twentieths of an inch.
Head black; *antennæ* and *palpi* testaceous.
Thorax, impressed line obsolete, lateral basal lines very distinct, margin somewhat depressed, posterior angles rounded, not depressed or punctured above.
Elytra, striæ impunctured, tip obtusely rounded, marginal punctures continued, edge ferruginous.
Feet reddish-brown.

Not uncommon. Very much resembles the next, but differs from it by the more obtuse termination of the body, &c. This may possibly be the H. *dubius* of Palisot, but his description is not sufficiently detailed to enable us to determine satisfactorily.

7. H.* *similis* blackish, beneath piceous-black; elytra greenish or cupreous; labrum ferruginous; posterior thoracic angles subacute; feet pale testaceous.
Length seven-twentieths of an inch.
Head purple-black; *antennæ* brown, base and *palpi* testaceous; *labrum* ferruginous.
Thorax purple-black, hind angles subacute and with the

margin slightly depressed, impunctured, dorsal line obsolete, basal lines subimpressed.
Elytra dark green or cupreous; striæ impunctured, edge ferruginous, tip acutely rounded.
Feet pale testaceous.

I collected this species in North Carolina, where it appears to be rather common. It is distinguishable from the preceding only by immediate comparison: the tips of the elytra when taken together are more acute, the labrum ferruginous, hind thoracic angles more acute, feet much paler, and the thorax more distinctly transverse.

8. H. **vulpeculus* rufous; elytra brownish, impunctured; posterior thoracic angles rectangular.
Length nearly two-fifths of an inch.
Body glabrous, beneath obsoletely punctured.
Head with the mandibles black at tip.
Thorax a little contracted behind, base each side depressed and punctured, dorsal line obsolete, lateral angles rectangular, basal edge rectilinear.
Scutel dark rufous.
Elytra blackish-brown, striæ profound, impunctured, interstitial lines convex, impunctured.
Pectus and *postpectus* obsoletely punctured; *feet* paler.

This, at first view, resembles *Feronia interstitialis*.
I have but a single specimen, which is a female.

9. H. **iripennis* black; elytra black-blue iridescent; feet testaceous.
Length one-fourth of an inch.
Body black, beneath dark piceous.
Antennæ, *labrum*, *mouth*, and *feet* rufo-testaceous, the latter paler.
Thorax somewhat wider than long, widest in the middle, hardly narrower at base than at tip; lateral edge piceous.

almost regularly arquated; angles obtusely rounded; basal edge rectilinear; dorsal and basal lines obsolete; base with numerous slight punctures.
Elytra blackish, with blue and iridescent reflexions.

10. H. **viridis* green, beneath black; feet rufous; thorax punctured; elytra with minute hairs.
Length two-fifths of an inch.
Head tinged with bronze; *antennæ* and *palpi* rufous; *labrum* piceous.
Thorax before and at base slightly bronzed; punctures numerous, obsolete on the anterior disk.
Elytra slightly tinged with brassy, with acute, impunctured striæ, and numerous short hairs; interstitial lines flat.
Feet rufous.

Bears some resemblance to *Feronia lucublandus*.

11. H. **hylacis* black; labrum, mouth, and feet testaceous; abdomen piceous; base of the thorax narrowed, angles obtuse.
Length three-tenths of an inch.
Body black, beneath piceous.
Labrum, *mandibles* excepting at tip, *palpi*, three basal joints of the *antennæ*, and *feet* rufo-testaceous; *antennæ* dusky.
Thorax of equal diameters, narrower at base than the elytra, broadest in the middle; lateral edge regularly arquated: angles very obtuse, posterior edge rectilinear; a longitudinal, slightly impressed, continuous line; basal lines very distinct.
Elytra with a very slight greenish shade: striæ not distinctly punctured; interstitial lines depressed; basal joint of the anterior and intermediate tarsi dilated and granulated beneath, the remaining joints hardly dilated.

The first or basal joint of the anterior and intermediate tarsi only is dilated, and it is granulated beneath as in *cœnus*, and of course does not, strictly speaking, belong to this genus. The *Baltimoriensis*, *carbonarius*, *agricolus*, *cœnus*, and *rusticus* have also granulations or rather close set hairs on the dilated tarsi of the male. On account of this distinctive character, I should have referred them all to that division of *Feronia* in which M. Latreille places *Epomis*, &c., did not that author expressly state that insects of that division ought to have the two anterior tarsi only of the male dilated.

12. H. **rusticus* deep black-brown; base of the antennæ, mouth beneath and palpi, and posterior thoracic angles reddish-brown; glabrous beneath.
Length from two-fifths to half an inch.

Carabus rusticus. Melsh. Catal.

Antennæ brown, two basal joints reddish-brown; *labium* black; *maxillæ* and *palpi* reddish-brown.
Thorax glabrous, a dorsal impressed line, and two abbreviated ones at base; margin not depressed, but continuing the general curve to the edge; hind angles obsoletely reddish-brown.
Elytra, striæ impunctured; second, fourth, and sixth interstitial lines punctured near the tip, marginal one with ocellate punctures not interrupted in the middle.
Pectus and *postpectus* not hairy.

Var. a. Elytra reddish-brown.

Very similar to H. *carbonarius* and equally common; but is readily distinguishable by the colour of the thoracic angles, naked breast, punctures of the interstitial lines, &c.

13. H. **carbonarius* black; palpi and base of the antennæ piceous; sternum and postpectus somewhat hairy.

Length nearly eleven-twentieths of an inch.

Carabus carbonarius. Melsh. Catal.

Antennæ blackish-brown, basal joints piceous; *palpi* piceous at the tips of the joints; *vertex* with an obsolete piceous spot visible in a particular light.

Thorax, dorsal line not deeply impressed; exterior and posterior lateral margin depressed and somewhat rugose; basal lines not definite; base not narrowed.

Elytra, striæ impunctured, punctures on the marginal interstitial line few and hardly ocellate, sixth interstitial line punctured near the tip; *sternum* a little hairy from the head to the tip; *postpectus* somewhat hairy on the disk.

Venter, first segment hairy beneath.

A very common species.—The hairs beneath are small, and require the aid of the microscope to be discovered.

15. H. **agricolus* black; palpi and antennæ piceous, the latter paler at base; sternum and postpectus glabrous.

Length from nine-twentieths to one half of an inch.

Antennæ dusky piceous, basal joint light piceous; *palpi* piceous, paler at tip; *vertex* with an obsolete, piceous spot, visible in a particular light.

Thorax slightly narrower at base, dorsal line distinctly but not deeply impressed, lateral margins depressed and a little rugose, spaces of the basal lines deeply impressed and densely punctured.

Elytra, striæ profound, impunctured; sixth interstitial line with a single puncture.

This species resembles the preceding one, but it has a shorter and more robust form, and the thorax is somewhat narrower at the base than in the middle, which is not the case in *carbonarius*. It is also common.

16. H. **Baltimoriensis* black; elytra reddish-brown, blackish on the disk; feet pale testaceous.

Length two-fifths of an inch.

Carabus Baltimoriensis. Melsh. Catal.

Nasus with about three hairy punctures each side at tip; *antennæ* black-brown, base, *labrum*, *palpi*, and base of the *mandibles* pale reddish-brown.
Thorax black, somewhat narrower behind, posterior angles acute, dorsal line distinct, basal lines dilated, and with the posterior margin conspicuously punctured.
Scutel blackish.
Elytra, base, exterior and posterior margins reddish-brown, common disk blackish.
Feet testaceous.

Distinguished from all the preceding ones by the thorax being much narrowed behind.

17. H. **cænus* blackish slightly tinged with green; palpi and base of the antennæ testaceous.
Length seven-tenths of an inch.

Carabus cænus. Melsh. Catal.

Head green-black slightly tinged with cupreous; *antennæ* brown, three basal joints and *palpi* testaceous.
Thorax black very slightly tinged with green, transverse; hind margin punctured as broad as the middle, and equal to the base of the elytra; dorsal and posterior lines distinct, beneath black.
Elytra striate, striæ impunctured, acute, interstitial lines flat.
Feet testaceous; *thighs* testaceous-black; dilated *tarsi* granulated beneath.

Genus Feronia.* *Latr.*

From this genus, as defined by Latreille, in the Règne Animal, I have distinguished *Abax*, *Epomis*, *Chlænius*, and *Dicelus*, as distinct genera.

* This name is also made use of in botany, and ought therefore to be changed.

Species.

1. F. **musculis.*—Body oval, piceous; thorax at base as broad as the elytra.

Length one-fifth to one-fourth of an inch.

Body oval, dark piceous or blackish; beneath piceous.

Labrum piceous; *antennæ* and *palpi* rufous.

Thorax from the middle to the base as broad as the base of the elytra; hind angles subacute, not depressed; lateral margin not depressed, but with an elevated line; dorsal and basal lines indistinct.

Elytra striate, striæ indistinctly punctured, lateral interstitial line serrate before and behind on the inner edge.

Feet rufous or piceous.

This species I found common on the eastern shore of Virginia, in October, on the blossoms of the kinks bush. When caught, like very many of the tribe, they diffuse a strong fœtid odour. In Florida I took several specimens on the wing in a conflagrated salt marsh.—Belongs to the genus *Amara* of Bonelli.

2. F. **basillaris* oval, blackish-bronzed, beneath black; feet piceous; thorax punctured each side at base, and as broad as the elytra: palpi blackish.

Length three-tenths of an inch.

Carabus samaragdulus. Melsh. Catal.

Body oval, blackish-bronzed or purplish-black; beneath black.

Antennæ deep-brown, three basal joints rufous; *palpi* black.

Thorax from the middle to the base as broad as the elytra, numerous distinct punctures each side at base, posterior angles acute, margin not depressed.

Elytra striate, striæ punctured, marginal interstitial line serrate on the inner edge, margin tinged with green.

Feet deep piceous.

Closely resembles *impuncticollis*, but the striæ of the elytræ and the hind angles of the thorax are punctured.—The name *samaragdulus* having been appropriated to a very different insect, I have substituted that of *basillaris*. It belongs to the genus *Amara* of Bonelli.

3. F. **impuncticollis* oval, blackish-bronzed, beneath black; thorax impunctured and as broad at base as the elytra; palpi blackish.
Length three-tenths of an inch.
Body oval, slightly attenuated behind, blackish-bronzed or purplish-black; *antennæ* brown, three basal joints rufous; *palpi* black.
Thorax from the middle to the base as broad as the base of the elytra, base impunctured, hind angles acute, dorsal and basal lines distinct, margin not depressed.
Elytra somewhat narrowed behind, with impunctured striæ, lateral interstitial line serrate on the inner edge.
Feet piceous-black.

This insect is not uncommon in Pennsylvania; it was also found by Mr. Nuttall on the Missouri.—Corresponds with the characters of the genus *Amara* of Bonelli.

4. F. **angustata* oval, blackish-cupreous, beneath black; feet rufous; thorax impunctured, as broad as the elytra: palpi rufous.
Length hardly one-fourth of an inch.
Body oval, above blackish-cupreous, beneath black.
Antennæ and *palpi* pale rufous.
Thorax from the middle to the base as broad as the elytra, impunctured, posterior angles acute, margin not depressed, dorsal and basal lines distinct.
Elytra striate, impunctured, marginal interstitial line serrate on the inner edge.

Feet rufous.

Taken by Mr. Nuttall on the Missouri. Resembles *basillaris* and *impuncticollis*, but is much smaller, and differs from the first by being impunctured, and from the last by the colour of the antennæ, palpi, feet, &c. Belongs to the genus *Amara* of Bonelli.

5. F. **obesa* black, beneath piceous; antennæ, mouth, and feet rufous.
Length more than two-fifths of an inch.
Body black; *antennæ* and *mouth* reddish-brown; *nasus* and *labrum* very dark reddish-brown.
Thorax slightly margined, much punctured at base, dorsal line slightly impressed, basal lines distinct.
Elytra with striæ very distinctly punctured, interstitial lines depressed, beneath piceous.
Abdomen and *feet* reddish-brown.

A very short and wide species, belonging to the genus *Amara* of Bonelli. It was found at Harrowgate, the seat of my friend Mr. J. Gilliams.

6. F. *lineola* pale yellowish-testaceous; elytra each with a black line.
Length three-tenths of an inch full.

Carabus lineola winged, ferruginous; *elytra* with a black line. *Fabr. Syst. Eleut., I, p.* 197. *Mus. D. Banks*, Inhabits North America.

Carabus lineola.—Elytra striate; *thorax* paler, with two black linear spots. *Turt.*

Carabus lineola ferruginous; *thorax* equal, with two points; *elytra* with two black lines.

Like C. *ferruginosus*; *antennæ* ferruginous, as long as thorax; *head* ferruginous; *thorax* a little narrower than the elytra, ferruginous with two points black obscure; *elytra* ferruginous, striated, a line upon each bifurcated anteriorly; *body* beneath brown-ferruginous; *feet* ferruginous. *Cab. of M Banks. Oliv. III., p.* 78, *pl.* 7, *fig.* 75.

Head testaceous-yellow; *antennæ* subglabrous, and with the palpi paler; a black transverse line on the vertex; and tips of the mandibles and eyes black.

Thorax colour of the head, transverse, subquadrate, rather narrower than the elytra, angles rounded, a dorsal impressed line which is somewhat indented before, a black longitudinally rhombic spot each side of the middle, an irregular smaller one each side at base, and a transverse obsolete arquated one before; all beneath and *feet* paler, anterior ones five-spined on outer edge of the tibia, two terminal spines approximate.

Elytra paler than the thorax, each with a black, abbreviated, vitta, furcate before, and an abbreviated, black, obsolete band at base, striate; striæ acute, distant, impunctured; margin impunctured.

Var. a. Thorax rufous, immaculate; head black.

This species I might have referred to C. *furcatus* of Fabr., had he not quoted for *lineola* a figure of Olivier's which agrees very well with this insect; an agreement to which, when combined with his accompanying description, no doubt can be attached.

Is not *furcatus* the same insect? I should suppose the species named *comma* to be also closely allied to it.

7. F. *pallipes.* Head black; thorax and elytra pale testaceous, the former black on the disk, and rounded at the posterior angles,—the latter with an abbreviated black vitta; beneath black; feet pale.

Length, male one-fourth—female three-tenths of an inch.

Carabus pallipes winged, black; *thorax* rounded; *thorax* and *elytra* with a pale margin; *feet* pale. *Fabr. Syst. Eleut. I., p.* 200. *Mus. Dr. Hunter.* Inhabits North America.

Antennæ black, pale at base; *head* black; *mouth* ferruginous; *elytra* striate, black, border pale. *Turt.*

Antennæ ferruginous, obscure; *head* black; *mouth* and *palpi* ferruginous; *thorax* black, margined with ferruginous; *elytra* striated black, border ferruginous pale; *body* beneath black; *feet* pale. *Cab. Dr. Hunter.*

Oliv. Ill., p. 89, *pl.* 9, *f.* 99. Carolina.

Carabus furcatus. Melsh. Catal.

Body beneath black.
Head deep black; *antennæ* and *palpi* ferruginous.
Thorax pale testaceous; a large black spot occupying the disk, sometimes distinguished into several obsolete lines, a longitudinal impressed abbreviated line.
Feet pale; anterior ones six-spined on the outer edge of the tibia, two terminal spines approximate.
Elytra paler than the thorax, striated, impunctured, each with a broad, black, abbreviated vitta, which is separated from the suture by the first elevated line.

Var. a. Pale testaceous beneath.
Var. β. Elytra with a common black disk, formed by the junction of the vittæ at the suture.
Var. γ. Thorax immaculate.

Very like a *lineola*, but is a little smaller, and more depressed; and otherwise sufficiently distinct. I should have been in doubt whether this species or the next was the true *pallipes* of Fabr., had it not been for the specific character "*thorax rotundatus*" applied by that naturalist to his insect, a character more decidedly applicable to this species.

It is not uncommon, and appears to be a general inhabitant of this country. Nuttall found it on the Missouri.

8. F. **atrimedea* pale rufous; head, disk of the thorax and of the elytra black; beneath black; feet testaceous; posterior thoracic angles acute.
Length one-fourth of an inch.
Body black beneath.
Head black; *antennæ*, base rufous; *palpi* rufous.
Thorax rufous, with a black disk; edge slightly excurved near the hind angles; hind angles acute; dorsal line dis-

tinct; basal lines indefinite, indented; base each side punctured.
Elytra with impunctured striæ and depressed interstitial lines, pale rufous or testaceous with a common black disk, which is dilated behind the middle and attenuated before.
Feet testaceous.

A greater portion of the antennæ and feet were wanting in the specimen, but one of the anterior tarsi which was remaining was much more dilated than that of the preceding species. From the Missouri. Nuttall.

9. F. **longicornis* apterous, dark piceous, beneath paler; antennæ rufous; feet testaceous.
Length rather more than half an inch.

Carabus longicornis. Melsh. Catal.

Body glabrous, dark piceous, beneath piceous.
Front longitudinally indented each side; *antennæ* rufous, half as long as the body, the joints attenuated towards their bases; *labrum* truncate, rufous; *palpi* rufous.
Thorax contracted behind, edge slightly excurved at the hind angles, anterior transversely indented line profound, dorsal line at base abruptly canaliculate, basal lines dilated, suborbicular, profound, scabrous, extending from near the dorsal line to the angle.
Elytra, interstitial lines of the disk convex, glabrous, striæ obtuse, punctures approximate, transverse, extending upon the sides of the striæ, sixth and seventh striæ obsolete.
Feet testaceous.

This species is not of frequent occurrence, inhabits moist places under stones. It appears to belong to the genus *Percus* of Bonelli.

10. F. **unicolor* apterous, glabrous, black; tips of the an-

tennæ brownish; tarsi piceous; striæ of the elytra punctured.

Length seven-tenths of an inch.

Body glabrous, black, impunctured.

Head, antennæ brownish towards the tips, joints attenuated towards the bases; *labrum* truncate; *palpi* piceous.

Thorax transverse, contracted behind rather abruptly, tip of the posterior angles obtusely rounded, sublobate; dorsal line not attaining the base, basal lines indented, excurved to the angles, anterior transverse line obsolete or wanting, lateral edge much rounded, abruptly excurved behind.

Elytra convex, striæ not deeply impressed, punctures longitudinal, abbreviated striæ near the suture, obsolete marginal interstitial line serrate with ocellate punctures, third line with a single puncture near the middle.

Feet black; *tibia* at tip and *tarsi* dark piceous.

This species is referable to the genus *Pterochistus* of Bonelli.

11. F. **stygica* apterous, black, glabrous, impunctured; striæ impunctured; basal thoracic lines dilated.

Length more than three-fifths of an inch.

Carabus stygicus. Melsh. Catal.

Body black, impunctured, glabrous.

Antennæ rather surpassing the base of the thorax, brownish towards the tips, the joints attenuated towards their bases; *palpi* rufous.

Thorax, diameters subequal, gradually a little contracted behind, edge not excurved at the hind angles, hind angles not prominent, rounded, basal lines double, dilated, orbicular, and scabrous, base wider than the petiole.

Elytra slightly tinged with brown, striæ indented, impunctured, interstitial lines convex, third with a single puncture behind: *wings* none.

Feet black; *tibia* and *tarsi* deep piceous.

Belongs to the genus *Pterostichus* of Bonelli.

12. F. **mœsta* apterous, black, glabrous; thorax as broad as the elytra, much contracted behind; elytra very obtusely rounded behind, striæ impunctured.
Length seven-tenths of an inch.
Body black, glabrous, impunctured, rounded behind.
Antennæ brownish or ferruginous towards the tips; *palpi* piceous.
Thorax before the middle as broad as the base of the elytra, much contracted behind, posterior angles obtusely rounded. dorsal line very distinct, basal ones excavated, slightly punctured and placed at the lateral angles, base not wider than the petiole, basal edge rectilinear.
Elytra slightly tinged with purplish, very obtusely rounded behind, striæ profoundly indented, impunctured, interstitial lines very convex, third with about four distant punctures.
Postpectus, peduncle punctured each side.
Feet, *thighs* robust; *tarsi* piceous.

Is distinguished from *stygicus* by the very narrow thoracic base, and very obtuse termination of the body.

13. F. **sigillata* apterous, black, glabrous; thorax slightly contracted behind, anterior transverse line acute and deeply impressed; elytral striæ punctured.
Length more than seven-tenths of an inch.
Body black, glabrous, impunctured.
Antennæ brownish towards the tip; *labrum* dark piceous; *mandibles* obliquely striated above conspicuously; *palpi* piceous.
Thorax broadest before the middle, gradually a little contracted behind. dorsal line acute, impressed, continued, anterior transverse line acute, deeply impressed resem-

bling a suture, area of the basal lines indented, each with two shorter oblique lines, lateral edge slightly curved, not perceptibly excurved near the base, basal angles rounded, base much wider than the petiole.

Elytra, striæ not very deeply impressed, distinctly punctured, abbreviated striæ near the scutel, obsolete, interstitial lines depressed, third one with two distant obsolete punctures behind the middle: *wings* none.

Pectus in some lights slightly tinged with green; *tarsi* piceous.

Resembles *tartaricus*, but is distinguished by the thoracic hind angles being less acute and the elytral striæ punctured; from *unicolor* it is at once distinguished by the less rounded form of the thorax and its less contracted base; from *stygicus*, to which by form it is more closely allied, it may be readily separated, by the punctured striæ, &c.

Found on Mr. R. Haines's farm, Germantown.

It belongs to the genus *Pterostichus* of Bonelli.

11. F. **placida* blackish, glabrous; thorax transversely sub-orbicular, margined; elytra with acute impunctured striæ. *Length* seven-twentieths of an inch.

Carabus peltatus. Melsh. Catal.

Head purple-black slightly tinged with green; *antennæ* blackish, rufous at base; *palpi* rufous or piceous.

Thorax a little narrower than the elytra, transversely sub-orbicular, blackish, slightly tinged with green; margin depressed, edge a little recurved, particularly at the hind angles, which are not excurved; dorsal line and anterior transverse line impressed, basal lines almost obsolete in the concavity of the lateral base, which is a little rugous.

Elytra blackish with an obsolete purplish tint; striæ not profound, acute, impunctured; interstitial lines very slightly convex.

Pectus and *postpectus* black; *feet* black; *tibia* and *tarsi* piceous; *abdomen* black.

15. F. **tartarica* entirely black, immaculate, glabrous; striæ of the elytra impunctured.

Length three-fourths of an inch.

Body glabrous, black.

Head, frontal lines distinct; *antennæ* with ferruginous hair towards the tips, joints attenuated towards their bases; *labrum* truncate.

Thorax large, transverse, gradually a little contracted behind, base nearly equal to the base of the elytra, dorsal line profoundly and equally impressed, anterior transverse line more profoundly impressed, confluent with the marginal groove at the anterior angles, basal lines strongly impressed, excurved, and distinctly confluent with the marginal groove behind the angles, lateral edge excurved at the hind angles, posterior angles acute.

Elytra, striæ impunctured, interstitial lines very convex, third with three remote punctures, one near the base, one near the middle, and one towards the tip.

Feet black; *tarsi* piceous.

16. F. **muta* black; thorax punctured each side at base; elytra with obsoletely punctured striæ.

Length half an inch.

Carabus adoxus. Melsh. Catal.

Body glabrous, black.

Antennæ ferruginous towards tip, joints attenuated towards their bases; *palpi* piceous.

Thorax in the middle as broad as the elytra, gradually a little contracted to the base, where it is very slightly excurved; base somewhat depressed, and distinctly punctured each side, dorsal line distinctly continued to the base.

Elytra, striæ obsoletely punctured, interstitial lines convex, third one with a puncture at the base, one in the middle, and one near the tip.
Feet black; *tibiæ* and *tarsi* piceous: *postpectus* punctured each side.

Differs from *adoxus*, to which it is closely allied, in having less robust antennæ, vestiges of punctures in the elytral striæ, the thorax more rounded and less excurved at the posterior angles, and the dorsal line not abbreviated behind.

17. F. **submarginata* blackish, glabrous, all beneath piceous; thorax with a depressed margin, the edge reflected, base each side, and elytral striæ punctured.
Length half an inch.
Antennæ and *palpi* deep piceous; *labrum* truncate, piceous.
Thorax in the middle as broad as the elytra, base punctured, marginal groove dilated, piceous, resembling a narrow depressed margin and reflected edge, dorsal line distinct, lateral edge not excurved near the hind angles, base wider than the petiole, posterior angles prominent and rounded.
Elytra, striæ punctured, interstitial lines convex, third one with a puncture behind the middle and one near the tip.
Feet piceous; *postpectus* punctured each side behind the intermediate feet, and at the base; *venter* impunctured.

This species very much resembles *decentis*, but the thorax is more dilated, and the elytra narrower. It may be distinguished by having the postpectus punctured both at base and each side.

18. F. **impunctata* black, glabrous, impunctured; antennæ and palpi pale rufous; feet testaceous.
Length a little more than two-fifths of an inch.
Body black, impunctured, glabrous.

Antennæ slender, extending beyond the humerus, and with the *palpi* pale rufous.
Thorax broadest rather before the middle, contracted behind, margin a little depressed behind, the edge somewhat recurved, posterior angles obtusely rounded, base impunctured.
Elytra profoundly striated, striæ impunctured, interstitial lines convex, the third one with two distant punctures.
Feet testaceous.

Resembles *submarginatus* and *decentis*, but is entirely destitute of punctures; the form of the thorax also is perfectly distinct. I caught it on Mr. R. Haines's farm in Germantown.

19. F. **ventralis* black, glabrous, all beneath piceous-black; thorax at base not wider than the pedicel of the postpectus.
Length rather more than two-fifths of an inch.
Body above black, polished, beneath piceous-black.
Antennæ piceous, with ferruginous hairs towards the tip; *labrum* deep piceous; *palpi* piceous.
Thorax before the middle as broad as the elytra, gradually much contracted behind, base hardly wider than the pedicel. lateral margin not depressed, edge not excurved behind, dorsal line slightly impressed, basal lines distinct, conspicuously punctured.
Elytra narrowed behind, striæ punctured, interstitial lines hardly convex.
Pectus impunctured; *feet* rufo-testaceous; *postpectus* and *venter* punctured.

Very like *submarginatus;* but the form of the thorax is very different. It was taken in Missouri by Mr. Nuttall.

20. F. **adoxa* apterous, black, glabrous, impunctured; striæ impunctured; basal thoracic lines not dilated.
Length half an inch.

Carabus adoxus. Melsh. Catal.

Body black, glabrous, impunctured.
Antennæ robust, the joints attenuated towards their bases, and with the *palpi* dark rufous; *labrum* truncate, dark rufous.
Thorax large, impunctured, gradually contracted behind, edge excurved at the hind angles, dorsal line not attaining the base, basal lines strongly impressed, cutting the base near the angles; *pectus* impunctured; *postpectus* punctured.
Elytra, striæ impunctured, interstitial lines convex.
Feet piceous; *abdomen* piceous.

Corresponds with M. Latreille's definition of the genus *Pterochistus* of Bonelli.

21. F. **gregaria* dark reddish-brown; limbs and margin of the thorax paler, thorax at base equal to the base of the elytra.

Carabus gregarius. Melsh. Catal.

Length two-fifths of an inch.
Body dark chesnut, blackish each side beneath.
Head dark chesnut: *eyes* and *mandibles* at tip black; *antennæ* and *palpi* reddish-brown, the former half as long as the body.
Thorax rather longer than broad, impunctured, lateral margin distinct and with the posterior margin paler, the latter rather broader than at tip and equal to the base of the elytra, dorsal and posterior lines indistinct, angles rounded.
Elytra with impunctured striæ, margin paler and distantly punctured, without emargina near the tip, but regularly rounded in that part.
Epipleura distinctly canaliculate to near the tip; *feet* colour of the antennæ, long: *venter* blackish.

Belongs to the genus *Calathus* of Bonelli and Latreille.

22. F. **terminata* deep reddish-brown; elytra darker: antennæ and feet testaceous; thorax not contracted behind. *Length* seven-twentieths of an inch.

Carabus terminatus. Melsh. Catal.

Body dark reddish-brown.
Eyes blackish; *antennæ* and *palpi* testaceous, somewhat darker at tips.
Thorax transverse, with a distinct, depressed margin each side, not narrowed behind, posterior angles subacute, attaining the humeral ones, dorsal line indistinct.
Elytra somewhat opake, darker than the thorax, striæ impunctured, suture and edge paler, marginal punctures distinct, a distinct sinus near the tip.
Feet testaceous; *venter* and *postpectus* blackish each side.

This species appertains to the genus *Calathus* of Bonelli.

23. F. **autumnalis* blackish-brown; antennæ and feet testaceous, lateral edge not distinctly excurved behind. *Length* three-tenths of an inch.

Carabus autumnalis. Melsh. Catal.

Body depressed, deep blackish-brown.
Head black; *antennæ* and *mouth* yellowish testaceous, the former brownish towards the tip.
Thorax a little narrower behind, broadest before the middle, margin not depressed, dorsal and basal lines distinct, posterior angles subacute, hardly attaining the humeral angles, lateral edge not distinctly excurved behind.
Elytra blackish, polished, striæ impunctured, edge with a very obtuse sinus near the tip, marginal interstitial line serrate within.
Feet testaceous.

It seems to belong to the genus *Calathus* of Bonelli.

Resembles *terminatus*, but is smaller, and the thorax is a little narrowed behind, and is destitute of a depressed margin.

24. F. **limbata* dark reddish-brown: thorax rounded; elytra deeply margined with testaceous; postpectus pedunculated.
Length from one-fourth to three-tenths of an inch.

Carabus limbatus. Melsh Catal.

Body deep reddish-brown.
Antennæ at base, and *palpi* paler.
Thorax suborbicular, margin not depressed, edge consisting of a simple elevated line, anterior angles subacute, dorsal line indistinct, basal lines indented; *pectus* paler.
Feet testaceous: *petiole* distinct.
Elytra with distinctly punctured striæ, disk black-brown to the fifth stria, remaining margin testaceons, marginal interstitial line with a few larger punctures behind, none in the middle.

Rather rare.

25. F. **parmata* black; thorax rounded; feet testaceous; elytra margined with testaceous; postpectus pedunculated.
Length three-tenths of an inch.

Carabus parmatus. Melsh. Catal.

Body black.
Antennæ and *palpi* rufous.
Thorax transversely suborbicular, destitute of depressed margin or elevated edge.
Feet pale rufous; *petiole* very distinct.
Elytra striate, impunctured, disk black-brown to the sixth stria, margin pale rufous, marginal interstial line slightly punctured on the inner edge.
Venter black.

Much resembles F. *limbata*, but the striæ of the elytra are not punctured and the edge of the thorax is destitute of an elevated line.

26. F. **cupripennis* green, polished; common disk of the elytra cupreous, brilliant.

Carabus metallicus. Melsh. Catal.

Length seven-twentieths of an inch.
Head green; *antennæ*, *labrum*, and *palpi* black.
Thorax impunctured, green varied with purple, rather narrower than the elytra, regularly curved each side to the bases, posterior angles none, dorsal and basal lines distinct, the latter dilated.
Elytra cupreous, brilliant, margin green, striæ acute, impunctured. interstitial lines flat.
Pectus and *postpectus* dark green.
Feet green; *tibia*, and *tarsi*, and *trochanters* piceous.

Var. a. Elytra brilliant green slightly tinted with cupreous; head and thorax tinged with purplish.

A very beautiful and brilliant insect. The name *metallicus* having been applied to a very different insect, the above is substituted for it.

27. F. **convexicollis* green varied with cupreous, all beneath black; thorax submarginated, punctured behind.
Length more than seven-twentieths of an inch.
Body beneath black.
Head green, with slight cupreous reflections; *labrum* purple-black; *mandibles* black.
Thorax green, elevated portion cupreous, margin depressed more perceptibly towards the hind angles, breadth greatest in the middle, hardly contracted behind, base as broad as as the elytra and punctured.
Elytra green slightly varied with cupreous, particularly at the sutural base, striæ with indistinct, distant punctures, interstitial lines somewhat convex, third one with three distant punctures behind the middle.
Postpectus punctured each side; *feet* black.

I have seen but a single specimen, which was deficient in antennæ, palpi, and also in tarsi, with the exception of two joints of the second pair; these were not dilated. It was brought from Missouri by Mr. Nuttall.

28. F. **honesta* black; beneath and feet piceous; above impunctured; thoracic lines profoundly indented; lateral edge excurved behind.

Length more than three-tenths of an inch.

Body black with a piceous shade, beneath piceous.

Antennæ and *palpi* rufous; *labrum* piceous.

Thorax impunctured, broadest before the middle, gradually contracted behind, dorsal and basal lines profoundly indented, lateral edge excurved near the base, basal angles rectangular.

Elytra piceous-black, deeply striated, striæ impunctured, interstitial lines convex, third one with a puncture near the middle.

Postpectus each side and peduncle punctured.

Feet piceous; *venter* punctured each side at base.

29. F. 8-*punctatus* green; elytra with a common cupreous disk, third interstitial line with four distant, large, excavated impressures.

Length full three-tenths of an inch.

Carabus 8-punctatus. Fabr. Syst. Eleut. I., p. 186.

Body beneath dark green.

Head green slightly varied with cupreous; *antennæ* and *palpi* black.

Thorax green, somewhat cupreous on the disk, rounded behind, lateral curve equal, hind angles none, dorsal line distinct, basal ones profoundly impressed.

Elytra green opake, common disk to the fourth stria cupreous, polished, striæ acute, interstitial lines flat, third one with four distant, profoundly excavated, quadrate impressures.

Feet piceous.

Remarkable by the very conspicuous elytral series of dilated punctures. Mr. Marshal describes this species as a native of Great Britain.

30. F. **nutans* green, polished, beneath black; elytra cupreous: feet testaceous at base.
Length seven-twentieths of an inch.
Head green, beneath black; *antennæ*, *labium*, and *palpi* black.
Thorax impunctured, green, rather narrower than the elytra, broadest in the middle, regularly arquated each side to the base, posterior angles none, dorsal and basal lines distinct, the latter dilated, orbicular, base not wider than the petiole.
Elytra dark cupreous slightly tinted with greenish, striæ impunctured, interstitial lines nearly flat.
Pectus and *postpectus* black.
Feet piceous; *thighs* testaceous at base.
Venter black.

Closely approximated to *cupripennis*, but may be distinguished by the colour of the under part of the body, base of the thighs, and elytra. The specimen I bought several years ago in New York.

31. F. **cincticollis* piceous-black, beneath somewhat paler; thorax margined: elytral striæ impunctured.
Length nine-twentieths of an inch.
Body black tinged with piceous, impunctured, beneath piceous.
Antennæ and *palpi* rufous.
Thorax narrower than the elytra, contracted behind, margined, margin rufous, somewhat recurved, edge excurved near the posterior angles, which are obtuse.

Elytra, striæ impunctured, acute, seventh one obsolete, interstitial lines slightly convex, third with two or three punctures.

Pectus and *postpectus* impunctured; *feet* piceous.

32. F. **decora*. Head deep green; thorax rufous; elytra dark cupreous.

Length seven-twentieths of an inch.

Head deep green, purplish at base; *antennæ* and *palpi* rufous, dusky at tip; *labrum* and *nasus* purplish.

Thorax pale rufous, narrower than the elytra, broadest before the middle, a little contracted behind, hind angles obtuse, dorsal line slightly impressed, basal ones distinct.

Elytra, disk obscure cupreous to the eighth stria, margin green, interstitial lines somewhat convex, striæ impunctured.

Pectus pale rufous; *postpectus* black slightly purpurescent, impunctured.

Feet testaceous; *abdomen* black, piceous behind.

33. F. **decentis* black, depressed; third interstitial line tripunctate: thorax each side at base depressed and punctured: feet black.

Length eleven-twentieths of an inch.

Carabus gagathes. *Melsh. Catal.*

Body black, depressed, glabrous.

Antennæ piceous black: *palpi* dark piceous.

Thorax narrower than the elytra, slightly contracted behind, margin somewhat depressed behind, edge recurved, posterior edge very slightly excurved, posterior angles not rounded, dorsal line indented, anterior transverse line angularly and deeply indented, base each side excavated and confluently punctured.

Elytra, striæ with transverse, numerous, lineolar punctures, interstitial lines convex, the third one with three remote,

lateral punctures, of which one is obsolete and placed near the base on the exterior side, one near the middle on the anterior side, and one near the tip.
Feet black; *tarsi* piceous; *postpectus* with a few punctures at base each side before the intermediate feet.

This species occurs not unfrequently. As Panzer has given the name *gagathes* to a German insect which is distinct from this species, I have of course adopted a new one.

34. F. **extensicollis.* Head and thorax greenish; elytra green or purplish, beneath piceous-black; feet testaceous.
Length seven-twentieths of an inch.

Carabus extensicollis. Melsh. Catal.

Head dusky green; *antennæ* and *palpi* rufous; *labrum* truncate.
Thorax narrower than the elytra, longitudinal, immargined, blackish-purple or greenish, gradually contracted behind, slightly excurved at the hind angles, base somewhat scabrous, basal lines dilated, concave, dorsal line distinct.
Scutel blackish-purple.
Elytra green or purple, striæ impunctured, interstitial lines convex, third one with four or five obsolete remote punctures.
Feet testaceous.

35. H. **ochropeza* blackish; thorax rounded behind; elytra with perlaceous reflections; feet testaceous.
Length one fourth of an inch.

Carabus ochropezus. Melsh. Catal.

Body glabrous, blackish, beneath piceous.
Antennæ brown; base and *palpi* rufous.
Thorax somewhat rounded, posterior angles very obtusely

rounded, dorsal line obsolete, basal lines excavated, base with numerous small punctures, edge dull rufous.
Elytra dark brown or blackish, with obsolete perlaceous reflections, striæ impunctured, interstitial lines depressed, sutural edge and deflected margin rufous or piceous.
Pectus and *postpectus* impunctured.
Feet testaceous.

Var. a. Elytra blackish-testaceous, almost destitute of the perlaceous reflections.

36. F. **lucublanda* green or reddish-purple, polished, all beneath black: head and thorax impunctured, margin of the thorax depressed.
Length eleven-twentieths of an inch nearly.

Carabus lucublandus. Melsh. Catal.

Body glabrous, green, polished, beneath black.
Head impunctured; *antennæ* and *palpi* brown rufous at base, three basal joints of the former with a dusky carina.
Thorax impunctured, widest in the middle, a very little narrowed behind by a regularly curved edge, base nearly as broad as the elytra, basal angles rectangular, obtuse, lateral margin very distinctly and abruptly depressed, dorsal line acute, lateral ones, two on each side, indented.
Elytra green or reddish-purple, margin purplish-opake, interstitial lines convex, impunctured, the third with two or three remote punctures, striæ purplish within, impunctured.
Feet blackish-piceous or rufous.

Agreeably to M. Latreille's definition of the *Poecillus* of Bonelli, this insect probably belongs to that genus: the carina of the antennæ is not confined to the third joint, but is extended to the second and first, and is very definite and striking; but the character attributed to that genus of " thorax narrowed behind" is not sufficiently obvious in our insect. Wings perfect.

The name *Pœcilia* designates a genus in icthyology.

37. F. **chalcites* green, polished, beneath black; feet black; head and thorax impunctured, margin of the thorax not depressed.
Length half an inch.

Carabus chalcites. Melsh. Catal.

Body glabrous, green, polished, beneath black.
Head impunctured; *antennæ* brown, rufous at base, third joint with a blackish carina; *labrum* black; *palpi* piceous.
Thorax impunctured, not contracted behind, dorsal line distinct, base as broad as the elytra, basal lines two each side, margin not depressed, basal angles rectangular, acute.
Scutel green or cupreous.
Elytra polished, green, slightly tinted with cupreous, margin opake, interstitial lines convex, impunctured, striæ within black and with indented lines each side.
Feet black; *tibia* and *tarsi* deep piceous.

Common. Brought also from the Missouri by Mr. Nuttall.

This species belongs to the genus *Poecillus* of Bonelli. It seems to resemble the *Harpalus viridi-æneus* of Palisot, but the thorax is less contracted at base, has four basal lines, and the feet are blackish.

38. F. **caudicalis* winged; black; joints of the antennæ attenuated at their bases; thorax with the exterior edge excurved at base; elytra with slightly punctured striæ.
Length less than half an inch.
Body black, glabrous, polished.
Antennæ and *palpi* piceous.
Thorax contracted behind, lateral edge excurved near the

basal angles, dorsal line very distinct, continued to the base with a much shorter one at the lateral angles, space of the basal angles depressed and punctured, basal lines distinct, not attaining the basal edge.
Elytra, striæ impressed, slightly punctured, interstitial lines convex.
Pectus and *postpectus* each side punctured; *feet* dark piceous.
Somewhat allied to *F. adoxus*, but is winged, the antennæ are far less robust, the thorax is smaller, punctured at the basal angles, and slightly punctured in the striæ of the elytra.

39. F. **interstitialis* rufous; elytra brownish, punctured, with iridescent reflections; posterior thoracic angles rounded.
Length full seven-twentieths of an inch.
Head rufous; *mandibles* black at tip.
Thorax rufous, transverse, quadrate, widest in the middle, edge curving equally, base depressed each side and with numerous punctures, anterior margin punctured, and a few remote punctures on the disk, dorsal line impressed, posterior angles obtusely rounded.
Elytra blackish-brown with iridescent reflections, striæ profound, interstitial lines convex, conspicuously and densely punctured, edge rufous.
Pectus pale rufous; *feet* rufo-testaceous; *postpectus* black.
Venter rufous.
It was brought from Missouri by Mr. Nuttall, and is very rare in Pennsylvania.

40. F. **obsoleta* totally deep black, immaculate, impunctured, glabrous.
Length one-fourth of an inch.
Body black, glabrous, impunctured
Antennæ at base deep blackish-piceous.
Thorax narrower than the elytra, rounded rather wider be

fore the middle, hind angles slightly projecting, the edge not excurved, base impunctured, dorsal line obsolete, basal lines wanting.
Elytra. striæ obsolete or slightly impressed, impunctured.
Feet black-piceous; *tibiæ* rather lighter.
Seems to belong to the genus *Argutor*.

41. F. **punctiformis* black; thorax rounded behind, basal lines punctiform; elytral striæ punctured.
Length seven-twentieths of an inch.
Body black, glabrous.
Antennæ brown, piceous at base; *palpi* blackish.
Thorax, lateral curve regularly rounded, posterior angles very obtusely rounded, dorsal line obsolete, basal lines each in the form of a dilated puncture, base impunctured.
Elytra, striæ slightly punctured, interstitial lines depressed, third one with three remote punctures.
Pectus and *postpectus* impunctured.
Feet black; *tibiæ* and *tarsi* blackish-piceous.
Probably referable to the genus *Argutor*.

42. F. **recta* piceous-black; antennæ, palpi, and feet rufous; thoracic impressed lines very distinct, posterior angles rounded.
Length rather less than three-fifths of an inch.
Body piceous-black, glabrous, beneath rather paler.
Antennæ brownish, base and *palpi* rufous; *labrum* piceous.
Thorax as broad as the elytra, edge regularly curved, posterior angles abruptly rounded, base impunctured, dorsal line very distinct, basal lines longitudinally rectilinear, profoundly indented.
Elytra, striæ punctured, interstitial lines convex, in some lights a faint pearlaceous gloss.
Pectus and *postpectus* impunctured; *feet* rufous.
Resembles *Harpalus ochropezus*, but is decidedly not of

that genus. It corresponds with the genus *Argutor* of Bonelli.

43. F. **hypolithos* apterous, black, glabrous: feet rufous, striæ of the elytra punctured.
Length more than eleven-twentieths of an inch.
Antennæ dark piceous: *palpi* rufo-piceous.
Thorax narrowed behind, dorsal line deeply impressed, surface obsoletely transversely wrinkled, basal lines dilated, distinctly indented, angles obtusely rounded, lateral edge regularly arquated.
Elytra, striæ not deeply impressed, irregularly punctured.
Thighs and *coxæ* rufous; *tibia* and *tarsi* dark rufous.

This species seems to belong to the genus *Pterostichus* of Bonelli, and it may be distinguished from those which we have mentioned to be referable to that genus by the colour of its feet.

Genus Abax. *Bonel.*

Anterior tibia emarginate; antennæ moniliform: elytra entire, united; wings none; labium with the intermediate tooth obtuse or truncated; thorax large, transversely quadrate, basal angles each with two abbreviated striæ; anterior tarsi of the male with three dilated joints.

Species.

A. **coracinus* black, beneath piceous-black; elytra striate, a line of marginal ocellate punctures.
Length three-fifths of an inch.

Carabus coracinus. Melsh. Catal.

Body beneath piceous-black.
Head black; a deeply impressed, acute, transverse line between the bases of the antennæ, equally distinct with the

articulation of the labrum; *eyes* prominent: *labrum* deep piceous; *antennæ* hairy, brown, piceous and glabrous at base, somewhat shorter than the thorax.

Thorax black, somewhat transverse-quadrate, anterior and posterior diameters equal, anterior angles rounded, little prominent, posterior ones rectangular, attaining the outer humeral angles, lateral edge obscure piceous, margin obsoletely purple, a dorsal impressed line and basal abbreviated one each side.

Elytra blackish faintly tinged with reddish purple, striated, striæ acute, minutely punctured, a marginal line of ocellate punctures, which are more distant in the middle; *epipleura* reddish-purple.

Genus Epomis. *Bonel. Latr.*

Anterior tibia emarginate; two anterior tarsi dilated in the male, and furnished beneath with dense, granuliform papillæ; antennæ filiform; labrum entire; palpi with the terminal joint dilated, obtriangular.

Species.

E. **tomentosus* dusky cupreous opake; elytra and feet black.
Length three-fifths of an inch.

Carabus tomentosus. Melsh. Catal.

Head inpunctured, dark cupreous; *antennæ* black, two basal joints rufous; *labrum* piceous; *palpi* black.

Thorax cupreous, with numerous, green, confluent punctures, as broad as the elytra at base, and gradually contracting by a curved line to the head.

Elytra greenish-black, striate, striæ distinctly punctured.

Pectus and *postpectus* black, punctured; *feet* black; *abdomen* black.

Not uncommon in Pennsylvania. A specimen was brought from the Missouri, by Mr. Nuttall, which varies in being entirely green above.

Genus Chlænius. *Bonel. Latr.*

Anterior tibia emarginate; two anterior tarsi dilated in the male and furnished beneath with dense, granuliform papillæ; antennæ filiform, joints elongated; labrum entire: palpi filiform.

Species.

1. C. *sericeus* green, beneath black; antennæ and feet pale rufous: head punctured.

Length about three-fifths of an inch.

Carabus sericeus alatus, ater, capite, thorace, et elytris viridi-nitentibus, antennis pedibusque rufis. *Forst. Nov. Sp. Ins. Cent. Oliv. Encyc. Meth.*

Carabus Fosteri. Turt. Linn. II., p. 464.

Carabus sericeus. Melsh. Catal.

Body green, beneath black, with very short numerous hairs.

Head polished, punctured; *antennæ*, and *palpi* pale rufous, the former paler at base; *labrum* rufous; *mandibles* ferruginous at base.

Thorax distinctly transverse, densely punctured, polished, dilated in the middle, posterior lateral edge rectilinear or slightly excurved, dorsal and basal lines very distinct, base rather narrower than the elytra.

Elytra not wider behind the middle, with numerous minute punctures, striate, striæ acute, minutely punctured, interstitial lines flat.

Feet rufous; *pectus* and *postpectus* punctured; *abdomen* with minute punctures.

Var. a. Elytra purplish.

Very closely resembles the next, but differs in the less elongated form of the thorax. Common in the middle states and was brought from the Missouri by Mr. Nuttall.

2. C. **æstivus* green-cupreous; elytra purple-black; antennæ and feet rufous; head punctured.
Length seven-tenths of an inch.

Carabus amethystinus. Melsh. Catal.

Body greenish-cupreous, beneath black, with very short numerous hairs.
Head polished, punctured; *antennæ* and *palpi* rufous, shaded towards the tips; *labrum* ferruginous; *mandibles* blackish.
Thorax as long or rather longer than broad, dilated in the middle, posterior lateral edge rectilinear or slightly excurved, densely punctured, polished, dorsal and basal lines very distinct, base narrower than the elytra.
Elytra dark purple, opake, perceptibly a little dilated behind the middle, with very minute, numerous punctures, striate, striæ a little obtuse, punctured, interstitial lines depressed, a little convex.
Pectus and *postpectus* punctured; *feet* rufous; *abdomen* minutely punctured.

This cannot be *amethystinus* of authors, if the figure of that insect by Olivier be correct.

3. C. **lithophilus* green, beneath black; head punctured; feet testaceous; antennæ fuscous, paler at base.
Length less than seven-twentieths of an inch.
Body green, with very short, numerous hairs, beneath black.
Head punctured; *front* smooth; *antennæ* fuscous, base and *palpi* testaceous, the latter dusky at tip; *labrum* and *mandibles* piceous-black.
Thorax wider somewhat behind the middle, transverse-quadrate, lateral edge regularly and equably curved, posterior angles slightly rounded, surface densely punctured, punctures large, dorsal line acute, posterior ones dilated.
Elytra villous, minutely punctured, striæ punctured, interstitial lines flat.

Pectus and *postpectus* with dilated glabrous punctures: *feet* rufo-testaceous; *venter* with villous punctures.

Closely allied to *sericeus* and *æstivus*, but is much smaller.

4. C. **emarginatus* green-cupreous: elytra purple-black; antennæ and feet rufous; head punctured: labrum deeply emarginated.

Length eleven-twentieths of an inch.

Body green tinged with cupreous, with very short numerous hairs.

Head polished, punctured; *antennæ* and *palpi* rufous; *labrum* profoundly and obtusely emarginate, ferruginous.

Thorax transverse-quadrate, dilated in the middle, polished, densely punctured, lateral edge curved regularly to the hind angles, dorsal and basal lines very distinct, base nearly equal to the base of the elytra.

Elytra dark-purple, opake, with numerous very minute punctures, striæ punctured, interstitial lines depressed.

Pectus and *postpectus* punctured; *feet* rufous; *abdomen* minutely punctured.

Very like C. *æstivus*, but is readily distinguished by the curvatures of the thoracic edge being regularly continued to the posterior angles, and by the more deeply emarginated labrum. Not uncommon.

5. C. **pusillus* green, polished: elytra purple; antennæ and feet rufous; head punctured: labrum deeply emarginate.

Length less than seven-twentieths of an inch.

Body with very short numerous hairs.

Head green, polished, punctured; *antennæ* and *palpi* rufous, brownish towards the tips; *labrum* piceous, deeply emarginate.

Thorax with large punctures, a little contracted behind, posterior lateral edge somewhat excurved, dorsal line not deeply depressed, basal ones indented.

Elytra purple, interstitial lines convex, with distinct punctures, striæ with the punctures not larger than those of the interstitial lines.

Feet pale rufous.

Not a common species. Known by its small size.

6. C. **laticollis* dark violaceous; elytra black; antennæ and feet rufous; head punctured; thorax at base as broad as the elytra.

Length rather more than three-fifths of an inch.

Body hairy, deep violaceous glossed with green, beneath black.

Head punctured; *antennæ* reddish-brown, base and *palpi* rufous; *labrum* truncate, ferruginous.

Thorax densely punctured, transverse-quadrate, narrowed before, base not contracted, as broad as the elytra.

Elytra with numerous minute punctures, striæ with small punctures, interstitial spaces perfectly flat.

Feet rufous; *abdomen* with small punctures.

Approximates closely to *æstivus* and *sericeus*, but differs in the form of the thorax, which is proportionally larger. Brought from the Missouri by Mr. Nuttall.

7. C. **impunctifrons* dark green; elytra black; antennæ and feet rufous; head impunctured; thorax at base as broad as the elytra.

Length three-fifths of an inch.

Body dark green, beneath black; *elytra* black.

Head green, polished, impunctured; *labrum* emarginate, ferruginous.

Thorax obscure green, transverse-quadrate, punctured, punctures minute, base as broad as the elytra.

Elytra black, punctures numerous, minute, striæ with distinct punctures.

Feet rufous.

Distinguishable from all the preceding ones by the glabrous front, and small size of the thoracic punctures. Rare.

8. C. **nemoralis* cupreous-green, beneath black; elytra purple-black: antennæ and feet rufous; head impunctured: thorax at base narrower than the elytra.

Length half an inch.

Carabus amethystinus. Melsh. Catal.

Body with very short, numerous hairs, cupreous-green; *elytra* dark purple, beneath black.

Head glabrous, polished; *labrum* ferruginous, truncate; *antennæ* and *palpi* rufous.

Thorax broadest in the middle, posterior lateral edge slightly excurved, base narrower than the elytra, punctures numerous, small, impressed lines distinct.

Scutel not darker than the elytra.

Elytra deep purple obscure, with numerous minute punctures and punctured striæ, interstitial lines depressed.

Sternum slightly tinged with green: *feet* rufous.

Is at once distinguished from *æstivus* by the impressed front, and from *impunctifrons* by having the thorax narrowed behind. Common in Pennsylvania. I found it also in Georgia and Florida.

9. C. **solitarius* green, polished, beneath piceous; feet pale; head impunctured; thorax at base narrower than the elytra, subcordate.

Length near eleven-twentieths of an inch.

Body green, polished, beneath piceous-black.

Head impunctured; *antennæ* brownish, paler at base; *labrum* truncate, pale ferruginous.

Thorax dilated before the middle, contracted behind, dorsal lines and base punctured, disk each side impunctured.

Scutel purplish.

Elytra green, polished, striæ indented, obtuse, punctures distinct, intervals not equal to their length and becoming obsolete towards the tip, interstitial lines convex, with very distinct punctures.

Feet pale, joints somewhat darker; *tail* pale.

Differs from all the preceding ones in having the lines intervening between the striæ convex. It was taken on the Missouri by Mr. Nuttall.

10. C. **Pennsylvanicus* green, polished, beneath piceous: elytra blackish; feet rufous; head impunctured; interstitial lines of the elytra somewhat convex.

Length not quite half an inch.

Carabus Pennsylvanicus. Melsh. Catal.

Body green, polished; *elytra* dark purplish, with an obscure greenish margin; beneath deep piceous.

Head impunctured; *antennæ* brown rufous at base; *labrum* ferruginous, slightly emarginate.

Thorax dilated in the middle, punctured, somewhat contracted behind, edge slightly excurved near the base.

Elytra with numerous minute punctures, striæ with approximate punctures which are obsolete towards the tip, interstitial lines convex.

Feet rufous.

Resembles *nemoralis*, but is known by the convex interstitial lines and less profoundly emarginated labrum.

Not common.

Genus Dicælus*. *Bonel. Latr.*

Anterior tibia emarginate; two anterior tarsi dilated in the male and furnished beneath with dense, granuliform papillæ; antennæ filiform; labrum profoundly emarginate.

* Since the prefatory observations to this essay were printed, I have had the good fortune to find, in the library of this Society, the fifth volume of the Class of Physical and Mathematical Sciences of the Memoirs of the Imperial Academy of Turin. This volume is particularly interesting to me at this time, as it contains a portion of the essay on the Linnæan *Carabii* by M. Bonelli, entitled "Observations entomologiques". From this essay I have made a few quotations in this genus.

Species.

1. D. *purpuratus* blackish; thorax margined with purple: elytra purplish.

Length nine-tenths to eleven-tenths of an inch.

Carabus purpuratus. Melsh. Catal.

Dicælus purpuratus thorace transverso, niger, purpureo irroratus, elytris sulcatis, corpore abbreviato, dilatato. *Bonel. Obs. Entom.* Vide *Mem. de l' Acad. Imper. de Turin.*

Body beneath black, impunctured.

Head black; *antennæ* with ferruginous hairs towards the tip.

Thorax black, tinged with purple, margin purple or purple-blue, depressed lateral edge reflected.

Elytra blackish glossed with purple, striæ profound, impunctured, interstititial lines very convex; beneath black.

2. D. *violaceus* above and beneath violaceous: antennæ, mouth, and feet black.

Length one inch and one-tenth nearly.

Dicælus violaceus thorace transverso, quadrato, violaceus, antennis, pedibusque nigris, elytris sulcatis. *Bonel. Obs. Entom.* Vide *Mem. de l' Acad. Imper. de Turin.*

Head black obsoletely tinged with purplish; *mouth* and *antennæ* black.

Thorax with the disk black, but faintly tinged with violaceous; this colour is very obvious on the lateral and posterior margins.

Elytra deeply striated; the disk is less distinctly violaceous than the margin, and in a particular light exhibits a slight greenish tinge; beneath violaceous, more particularly on each side; *epipleura* bright violaceous.

This seems to be more especially an inhabitant of the southern and south-western states. The second and third interstitial lines from the suture, in my specimen, are connected before the middle by a transverse line.

3. D. **dilatatus* black, impunctured, immaculate; striæ obsoletely punctured towards the tip.
Length four-fifths of an inch.

Carabus dilatatus. Melsh. Catal.

Thorax entirely black, margins depressed, lateral edge slightly reflected, dorsal line abbreviated, depression of the base distinctly sinuated before.
Elytra totally black, striæ profound, obsoletely punctured towards the tip, interstitial lines very convex, subcarinated.

4. D. *elongatus* black, impunctured, immaculate, striæ impunctured.
Length three-fifths of an inch.

Carabus furvus. Melsh. Catal.

Dicælus elongatus thorace subquadrato, niger, elytris sulcatis, corpore elongato. *Bonel. Obs. Entom.*

Antennæ gradually becoming ferruginous towards the tip.
Thorax of nearly equal diameters, contracted before, margins depressed, lateral edge slightly reflected, dorsal line continued to the base, basal depression not distinctly sinuated before, basal lines distinct.
Elytra black, striæ profound, impunctured, interstitial lines very convex; humeral elevated line elongated.

5. D. **sculptilis* black; elytra with serpentine striæ and sculptured interstitial lines.
Length four-fifths of an inch.
Body entirely black, immaculate.
Thorax, margins depressed, lateral edge slightly reflected, dorsal line abbreviated.
Elytra, striæ very irregularly serpentine, punctured, interstitial lines irregular, unequal, a few adventitious punctures distinct from the striæ arranged in circles or irregular figures.

This species was brought from Missouri by Mr. Nuttall.

6. D. *splendidus*. Thorax violaceous; elytra cupreous brilliant.

Length nine-tenths of an inch.

Head black.

Thorax widest in the middle, very slightly narrowed at base, lateral and posterior margins depressed, lateral edge reflected, disk less obviously violaceous than the margins.

Elytra highly polished, margin violaceous, humeral carina extending two thirds the length of the elytra, striæ profoundly impressed, beneath blueish purple.

Feet black.

This is the most splendid species of the genus yet discovered. It was brought from Missouri by Mr. Nuttall.

Genus Panagæus. *Latr.*

Anterior tibia emarginate; elytra entire; exterior maxillary and labial palpi with the terminal joint sub-securiform; tridentate, middle tooth short, obtuse; tongue short; head small; labium much wider at base; neck distinct, abrupt; thorax orbicular; abdomen subquadrate; antennæ filiform.

Species.

1. P. **crucigerus* black, hirsute; elytra with four large fulvous spots.

Length nine-twentieths of an inch.

Body black, opake, punctured.

Head with obsolete punctures; *antennæ* with a few rufous hairs towards the tip.

Thorax transversely sub-oval, widest behind the middle, punctures numerous, dilated, and distinct, edge abruptly excurved near the posterior angles, which are small, prominent, acute.

Elytra with obtuse striæ, punctures dilated, each elytrum with two large fulvous spots, of which one is near the base, rounded, attaining the margin, and the other near the tip, orbicular, and distinct.

Pectus, *postpectus*, and *abdomen* each side at base with dilated punctures.

Closely resembles the *Crux major* of Europe, but is a much larger insect. I found a specimen on the sea beach of Senipuxten, eastern shore of Maryland, which was cast up alive by the waves, the last of September.

2. P. **fasciatus* ferruginous, hirsute, punctured; elytra fulvous, with a black band and tip.

Length seven-twentieths of an inch.

Head punctured; *nasus* impunctured, glabrous; *antennæ* fuscous; *palpi* black.

Thorax widest behind the middle, convex, punctures numerous, large, lateral edge deeply and widely excavated behind, posterior angles prominent, distinct.

Elytra fulvous, with a common black band rather behind the middle, contracted on the disk, and dilated at the suture and margin, deflected base and tip black, striæ obtuse, punctures large, distinct, transverse; *epipleura* with a distinct, impressed, punctured stria.

Pectus and *postpectus* with dilated punctures; *feet* black.

Venter deep piceous, punctured each side at base.

Very distinct from the preceding species, and is a rare insect.

Genus Cychrus. *Fabr.*

Anterior tibia entire; elytra entire, embracing the abdomen; external maxillary and labial palpi dilated, compressed, sub-securiform, or obconic; mandibles elongated, bidentate near the tip; labium profoundly emarginate, not wider at base than at tip; labrum elongated, very profoundly emarginate; tongue very small; abdomen robust, convex.

Species.

1. C. *elevatus* blackish; elytra reddish-cupreous, brilliant; humeral edge and lateral margin of the thorax reflected, the latter hardly contracted behind.

Length nearly four-fifths of an inch.

Cychrus elevatus thoracis margine reflexo, elytris violaceis, corpore atro. *Fabr. Syst. Eleut. I., p.* 166.

Carabus elevatus aptère; bords du corcelet arrondis, relevés; corps noir; élytres violettes. *Oliv. Ent., No.* 35, *p.* 46, *t.* 7, *f.* 82.

Head black very slightly tinted with violet, impunctured; *antennæ* brownish towards the tips.

Thorax black, slightly tinted with violaceous, dilated and reflected each side, gradually more reflected to the hind angles, hardly contracted behind, surface concave, with small, numerous, irregular punctures, base nearly as broad as the base of the elytra, basal edge falcate each side, basal angles prominent, acute.

Elytra cupreous-red, brilliant, striæ numerous, obtuse, interstitial lines narrower than the striæ, obtuse, humeral edge dilated, reflected, elevated, and rounded; *epipleura* confluently punctured.

Pectus with a few punctures at base, lateral margin with minute punctures: *postpectus* and *venter* each side at base with large punctures.

The original brilliant pigment of the elytra, which is of a reddish-cupreous colour, is very readily rubbed off even by a touch of the finger, leaving a blackish ground. The *elevatus* of authors is said to be an inhabitant of South America, probably through error.

2. C. *unicolor* blackish; elytra reddish-cupreous, brilliant; humeral edge and lateral margins of the thorax reflected, the latter contracted behind.

Length more than one inch.

Cychrus unicolor thoracis margine reflexo, corpore atro, elytris striatis *Fabr. Syst. Eleut., I. p.* 166.

Carabus unicolor aptère ; bords du corcelet arrondis, relevés ; corps noir ; élytres striées. *Oliv. Ent. No. 35, p. 47. pl. 6. fig. 62.*

Head black slightly tinged with blue ; *antennæ* brown at tip.

Thorax blackish-blue, lateral margins reflected, disk a little convex and with an impressed line, lateral margins widely reflected, widest rather before the middle, and narrowed behind, posterior angles rounded.

Elytra bright cupreous-red or purplish, with numerous striæ in which are large, dilated, and confluent punctures, beneath black.

The descriptions of the *unicolor* by Fabricius, Olivier, and others do not satisfactorily correspond with our insect, inasmuch as the whole body is stated to be black. They also state, but perhaps through error, that its native country is South America.

This fine species is rare in Pennsylvania, and I have seen but a single specimen of it, which was presented to me by Mr. William Hyde of this city ; it was caught on the bank of the Susquehanna river.

The form of the thorax in Olivier's figure, above quoted, is incorrect in having its greatest diameter placed much too far backward.

3. C. **stenostomus* black ; elytra dark cupreous, margins not reflected ; basal thoracic lines distinct.

Length half an inch.

Cychrus stenostomus. Melsh. Catal.

Head black, glabrous, impunctured ; *antennæ* brownish towards their tips.

Thorax black tinged with blue, rounded, widest in the middle, contracted behind, margin not reflected, base narrower than the elytra, punctured, basal edge rectilinear, dorsal line very distinct, basal lines profound, impressed, obtuse, and punctured.

Elytra bronzed or dark cupreous, striæ numerous, obtuse, interstitial lines narrower than the striæ, obtuse, edge dark blue, humeral edge not dilated nor reflected; *epipleura* punctured.

Pectus punctured at base; *postpectus* and *venter* each side at base punctured.

4. C. **bilobus* reddish-cupreous, beneath black, margins not reflected, basal thoracic lines obsolete.

Length two-fifths of an inch.

Body beneath black.

Head black with a very slight violaceous tint; *antennæ* and *palpi* pale piceous.

Thorax reddish-cupreous tinted with violaceous, brilliant, broadest rather before the middle, much narrowed behind, lateral margin not dilated nor reflected, base depressed and much punctured, basal lines obsolete, basal edge rectilinear, not wider than the pedicel of the postpectus, disk somewhat bilobated, being convex each side and gradually indented in the middle by the dorsal line, anterior margin depressed and rugose in the middle.

Elytra reddish-cupreous, striæ numerous, punctured.

Pectus beneath, *postpectus*, and *abdomen* each side punctured.

Genus Calosoma. *Weber.*

Anterior tibia entire; elytra entire; exterior maxillary and labial palpi with the terminal joint hardly larger than the preceding joint; mandibles unarmed, robust; labrum transverse, bilobate; labium profoundly emarginate and with a short acute tooth in the middle; antennæ, second joint one third as long as the following one; thorax transversely suboval; abdomen subquadrate.

Species.

1. C. *scrutator* violaceous: thorax with a golden margin; elytra green margined with reddish-cupreous.

Length from twenty-three-twentieths to five-fourths of an inch.

Carabus scrutator. Oliv. Ent., No. 35, *pl.* 3, 32, *a. b.*

Calosoma scrutator. Fabr. Syst. Eleut., Pars 2, *p.* 213. *Melsh. Catal.* and *Leach Zool. Misc. Vol. II., p.* 93, *pl.* 93.

Body beneath green varied with golden cupreous.

Head impunctured, black, with violaceous reflections, orbits above golden; *antennæ* with ferruginous hair towards the tip; beneath green; tooth of the labium very short. hardly prominent.

Thorax impunctured, blackish-violaceous, with an uninterrupted golden margin, dorsal line abbreviated, obsolete, basal lines none, basal edge subrectilinear, the lateral angles not extending backwards.

Elytra bright green with a very slight cupreous reflection; striæ reticulated by much smaller transverse lines which are more deeply impressed in the striæ so as to resemble transverse punctures, striæ fifteen, transverse lines very numerous, fourth, eighth, and twelfth interstitial lines each with several distant impressed punctures, exterior margin reddish-cupreous.

Feet violaceous; *venter* green, incisures each with a golden cupreous base and lateral spot.

Var. a. Head distinctly punctured, disk of the thorax green with a very slight violaceous tint; length nine-tenths of an inch.

This species makes a very near approach to the *sycophanta* of Europe; but as Dr. Leach observes, it differs from that insect in colour, in being less convex, and in having a shorter thorax.

2. C. *calidum* black; elytral striæ reticulated, equal, with a triple row of indented gold dots.

Length from nine-tenths to nine-eighths of an inch.

C. calidum. Fabr. Syst. Eleut.

Carabus calidus. Melsh. Catal.

Head black, with crowded minute confluent punctures; *antennæ* brown towards the tip.

Thorax black, with crowded, minute, confluent punctures, posterior lateral margin reflected, posterior angles rounded and extending backwards beyond the basal line.

Elytra black, striæ reticulated by smaller transverse lines, which, near the base, are much more deeply impressed, so as almost to granulate the interstitial lines, striæ fifteen, transverse lines very numerous, fourth, eighth, and twelfth interstitial lines with several equal, equidistant, dilated, orbicular, impressed, golden dots, and a solitary one near the scutel, exterior marginal groove greenish.

Pectus each side with minute crowded punctures; *sternum* impunctured; *postpectus* each side, and each side of the abdomen with rather larger punctures.

I was formerly misled respecting this insect by that portion of the specific description of Fabricius which ascribes to it an apterous character. In this error I was corrected by Professor Wiedeman of Kiel, who assures me that Fabricius was mistaken, and that his species is certainly winged.

Genus Carabus. *Lin. Latr.*

Anterior tibia entire; elytra entire; exterior maxillary and labial palpi subtriangular, dilated; mandibles not elongated, robust; labrum short, transverse, bilobate; labium profoundly emarginate and with a central tooth; antennæ, second joint half as long as the next; thorax subcordate, emarginate behind; abdomen oval.

Species.

1. C. **sylvosus* apterous, black; thorax and elytra margined with violaceous, the latter with a triple series of excavated punctures.

Length rather more than an inch.

Carabus silvosus. Melsh. Catal.

Body black, glabrous.

Antennæ brownish towards the tips; *palpi*, terminal joint dilated.

Thorax margined, margin violaceous, gradually more recurved to the posterior angles, posterior angles very obtusely round, slightly extending backwards beyond the basal line, base depressed and with the lateral margin somewhat scabrous, dorsal line obsolete, basal lines wanting.

Elytra black, margin violaceous, disk nearly smooth with about thirty striæ of minute impressed punctures and three distant series of remote excavated ones.

All the species of this genus that I have seen, as well as those of *Procrustes, Calosoma*, &c. have the tibia of the second pair of feet of the male densely ciliated near the external tip, with fulvous hair.

2. C. **interruptus* apterous, blackish; elytra slightly bronzed; fourth, eighth, and twelfth interstitial lines interrupted; striæ concave with impressed punctures and elevated ones.

Length nine-tenths of an inch.

Carabus granulatus. Melsh. Catal.

Head black; *antennæ* and *palpi* deep piceous, the former fuscous towards the tip.

Thorax black, with numerous, minute, indented punctures, which are obsolete on the disk, dorsal and basal lines conspicuous, margin towards the posterior angles slightly reflected, posterior angles rounded, prominent behind the the basal line.

Elytra black-bronzed, striæ with a somewhat lateral series of punctures and numerous elevated ones, interstitial lines fifteen, two of which are more conspicuous, fourth, eighth, and twelfth interrupted, interrupted lines acute behind, a submarginal series of elevated punctures.

Feet black; *venter* deep piceous or black.

The impressed punctures of the intervening lines of the elytra are sometimes obsolete or wanting. This species does not agree with the description of *C. granulatus* either as respects the colour of the antennæ or that of the body. And although it corresponds with the description of *tædatus* better than any other insect I have yet seen, yet the differences are so striking as to forbid its being referred to that species. This will be placed beyond a doubt by comparing Olivier's description with the above, and particularly that portion of it relating to the elytra, of which he says that they are "presque lisses ou sans stries bien marquées, avec trois rangées des points enfoncés."

3. C. **limbatus* apterous, black; margin of the elytra purplish; fourth, eighth, and twelfth interstitial lines interrupted.

Length four-fifths of an inch.

Body black, glabrous.

Head obsoletely corrugated above the eyes; *antennæ* fuscous at tip.

Thorax impunctured, rugulous at base.

Elytra margined with purple, striæ with transverse lineolar punctures, interstitial lines elevated, equal, distinct, marginal ones and tips slightly reticulated, fourth, eighth, and twelfth interrupted.

Pectus impunctured; *postpectus* each side at base obsoletely punctured; *feet* black; *venter* each side obsoletely punctured.

This insect very much resembles *C. interruptus*, but differs in the form of the punctures of the elytra and in having this part margined with purple; the form also is less elongated.

Taken by Mr. J. Gilliams in Maryland.

4. C. **serratus* apterous, black; thorax and elytra margined with obscure violaceous, interstitial lines reticulated, three interrupted ones.

Length more than seven-tenths of an inch

Carabus catenatus. Melsh. Catal.

Body black, glabrous.

Head smooth, impunctured; *antennæ* fuscous beyond the middle.

Thorax, exterior margin obscure violaceous, and with the base somewhat scabrous, disk impunctured, dorsal and basal lines obsolete, the latter oblique.

Elytra margined with obscure violaceous, edge near the base slightly serrate, interstitial lines about fifteen, obtuse and smooth, connected by numerous transverse septæ which are equally prominent and obtuse, not continued, fourth, eighth, and twelfth line dilated, interrupted, obtuse.

Postpectus and *venter* each side punctured.

The name *catenatus* has been applied by Panzer to a species inhabiting Carniola.

Genus Nebria. *Latr.*

Anterior tibia entire; elytra entire; exterior maxillary and labial palpi with the last joint elongated, subcylindrical, the latter of equal joints; tongue not longer than the labrum, and not tricuspidate at tip; labrum entire; labium profoundly emarginate, and with an emarginate, obtuse, central tooth; mandibles not dilated at base; thorax truncate, cordate; abdomen oval, depressed; antennæ filiform.

Species.

N. **pallipes* black; thorax dilated, very short; feet testaceous.

Length nearly half an inch.

Body black, glabrous, depressed.

Head with two obsolete piceous spots on the vertex; *mouth* piceous; *palpi* paler at base; *antennæ* rufous, base paler; *labium* elongated, nearly as long as the labrum, bisetous near the tip.

Thorax much abbreviated, as broad as the elytra, much contracted behind, exterior and posterior margins depressed, lateral edge reflected, dorsal line conspicuous, posterior angles acute.

Elytra profoundly striated, striæ punctured on the sides, interstitial lines convex.

Pectus and *postpectus* with obsolete dilated punctures; *feet* testaceous: *venter* piceous towards the tip, impunctured.

In this species the emargina of the anterior tibia is very small and placed very near to the tip, so as to be undiscoverable but by particular examination. Judging from the generic definition which authors have given, this species must differ from the other species of this genus in the form of the labium, which is elongated, acute, as in *Pogonophorus*, and has on each side near the tip a long hair or bristle, instead of spines, as in the latter genus: it does not therefore agree with the character given of the labium of *Nebria*,—"labium subquadrate," "labium short," "nearly quadrate," &c., nor yet with that of *Pogonophorus*, of which this part is tricuspidate. But as it will not agree with any other than the two genera above mentioned, and as it differs from the latter genus in not having the mandibles dilated at base, nor the maxillary palpi much elongated, I have thought proper to place it with the present genus, to which it seems to have the closest affinity.

Genus Omophron. *Latr.*

Tongue very short; antennæ filiform: maxillæ ciliated on the exterior side; body short, nearly hemispherical; thorax trapezoidal, transverse, sinuated, or lobed behind; anterior pair of tibia slightly emarginate on the inner side.

Species.

O. *labiatum* blackish: labrum, margin of the thorax and of the elytra whitish: antennæ, palpi, and feet testaceous.

Length one-fourth of an inch.

Scolytes labiatus niger, labio thoracis elytrorumque margine argenteis. *Fabr Syst. Eleut. I., p.* 248.

Head blackish, base punctured; *eyes* large; *nasus* triangular, piceous, with a yellow hind margin; *antennæ* and *palpi* testaceous; *labrum* white somewhat silvery.

Thorax black-brown, broad as the elytra at base, gradually narrowed before, basal line sinuated each side and angulated in the middle, punctures obsolete on the disk, dorsal line obsolete, basal lines none, lateral margin white somewhat silvery near the edge, edge black-brown.

Scutel not perceptible.

Elytra black-brown, striæ thirteen, towards the tip and margin obsolete, punctures distant, impressed only on the lateral paries of the striæ, interstitial lines convex, margin whitish somewhat silvery near the edge, dilated and undulated behind with several punctiform hyaline maculæ.

Pectus and *postpectus* punctured, piceous; *feet* testaceous; *venter* pale piceous, impunctured.

This specimen I obtained near Great Egg-harbour, New Jersey, on the skirt of a forest.

Genus Elaphrus. *Fabr.*

Antennæ hardly longer than the head and thorax, somewhat more robust towards the tip; external maxillary and labial palpi with the ultimate joint subcylindrical, longer and larger than the preceding joint; labium profoundly emarginate; maxillæ hardly ciliated on their external side; thorax subcylindrical, somewhat dilated in the middle, unequal, longer than broad; anterior tibia emarginate on the inner side.

Species.

E. *riparius?* dark brownish-green, a little bronzed; elytra with dilated, orbicular, impressed spots, and three elevated studs each side of the suture.

Length more than three-tenths of an inch.

E *riparius. Fabr.*

Body dark brownish-green, opake, beneath rather paler. polished, glabrous, punctures very numerous, crowded.

Head slightly corrugated between the eyes; *antennæ* and *labrum* blackish; *mandibles* green each side at base, piceous within near the tip; *palpi* above piceous, beneath paler; *gula* impunctured.

Thorax broadest rather before the middle, narrower than the elytra, a transversely indented curved line before the middle, and a longitudinal abbreviated one, lateral edge hardly prominent, slightly excurved behind, posterior angles inconspicuous, base not wider than the petiole.

Elytra equally punctured with about twenty large, dilated, orbicular, impressed, purplish spots, and two or three equidistant, elevated, elongate, subquadrate, impunctured, bronzed spots each side near the suture, the anterior one largest, a few obsolete elevated lines.

Postpectus green tinged each side with cupreous; *feet* green; *femora* and *tibia* piceous at base; *venter* green, disk impunctured, segments brassy at tip.

Genus NOTHIOPHILUS. *Dumeril.*

Antennæ not longer than the head and thorax, rather more robust towards the tip: external maxillary and labial palpi with the terminal joint subcylindric. large, and longer than the preceding joint; labium profoundly emarginate: maxillæ hardly ciliated on their external side; thorax depressed, transverse. subquadrate; anterior tibia emarginate on their inner side.

Species.

N. **semistriatus* brownish bronze: front corrugated; elytra with punctured striæ and a longitudinal equal space near the suture.

Length rather more than one-fifth of an inch.

Elaphrus semistriatus. Melsh. Catal.

Body brownish bronze, glabrous, immaculate, beneath blackish.
Head with six or eight frontal, longitudinal, elevated lines, abbreviated on the vertex; *nasus* with several elevated lines at tip, and a transverse interrupted one at base; *labrum*, a single impressed, longitudinal line; *antennæ* and *palpi* deep fuscous, paler at base.
Thorax as broad as the elytra, transverse quadrate, broadest before the middle, slightly contracted to the base, punctures numerous, approximated, obsolete each side of the disk, dorsal line impressed, punctured, basal lines indented, lateral edge slightly curved, posterior angles rectangular; *scutel* rounded at tip, impunctured.
Elytra, striæ obtuse with large punctures, interstitial lines hardly wider than the striæ, a dilated, smooth, polished, longitudinal, continued space separated from the suture by a series of impressed rounded punctures.
Pectus punctured; *postpectus* with a few punctures each side; *feet* black.
Var. a. Dark green; tibia piceous.
Var. β. Feet rufous; thorax more contracted behind.

Genus Bembidium. *Latr.*

External maxillary and labial palpi with the penultimate joint largest, dilated; terminal joint abruptly very slender and short; anterior tibia emarginate on the inner side.

Species.

1. B. **honestum* bronzed, beneath dark blueish-green; antennæ, palpi, and feet piceous; thorax much narrower than the elytra, basal line oblique each side.

Length one-fourth of an inch.

Tachys aereus. Melsh. Catal.

Head black, very slightly bronzed; *palpi* piceous, penultimate joint of the exterior ones blackish.

Thorax black, slightly bronzed, impunctured, narrower than the elytra and contracted a little towards the base, broadest rather before the middle, posterior angles acute, prominent, from tip to tip not equal to the diameter before the middle, dorsal lines distinct, basal lines abbreviated, indented, somewhat dilated, marginal groove uninterrupted at the hind angles, basal edge oblique each side.

Elytra bronzed, striæ impressed, not obsolete near the tip, punctures approximated, interstitial lines flat, third with two punctures on the outer edge, one near the middle, and the other behind.

Pectus and *postpectus* impunctured, deep blueish green.

Feet piceous; *trochanters* and base of the thighs paler.

Panzer has applied the name which Mr. Melsheimer adopted to a different insect of this genus.

2. B. **punctato-striatum* blackish, beneath dark green polished, thorax hardly narrower than the elytra, basal line oblique each side.

Length from one-fourth to nearly three-tenths of an inch.

Body all above black obsoletely bronzed, beneath deep green highly polished.

Antennæ fuscous, basal joint rufous; *palpi* rufous at base, darker towards the tip.

Thorax broadest in the middle, narrowed before, somewhat contracted before the posterior angles, breadth from tip to tip of the posterior angles equal to the breadth of the middle, basal edge oblique each side, dorsal line slightly impressed, basal lines indented, conspicuous.

Elytra, striæ impressed, obtuse, not obsolete near the tip, punctures rounded, conspicuous, interstitial lines slightly convex, third one with a dilated indentation near the middle, and another behind.

Humerus obtusely angled; *feet* dark rufous.

Var. a. Body above bright cupreous; impressed elytral spots green; thighs and tibia each at tip greenish.

Very similar to the preceding species, but, independently of colour, it may be readily distinguished from it by the much wider thorax and the impressed elytral spots.

3. B. **levigatum* above green, polished, beneath blackish; elytral striæ not impressed, punctured.

Length rather more than one-fourth of an inch.

Body all above green, polished, beneath blackish, polished.

Antennæ and *palpi* rufous.

Thorax impunctured, broadest in the middle, nearly equal to the base of the elytra, contracted behind, posterior angles rectangular, basal line nearly rectilinear, marginal groove interrupted at the posterior angles by an oblique acutely carinated line, dorsal line slightly impressed, basal ones profoundly indented.

Elytra destitute of impressed striæ, punctures rounded, somewhat dilated, obsolete behind the middle, interstitial lines flattened.

Feet dark rufous; *venter* slightly piceous on the disk.

This species was obtained in Missouri by Mr. Nuttall.

4. B. **dorsalis* greenish polished, beneath blackish; elytra testaceous, with two obsolete undulated bands.

Length upwards of one-fifth of an inch.

Body beneath piceous-black, polished.

Head green somewhat brassy; *front* longitudinally convex in the middle; *antennæ* brown, testaceous towards the base; *palpi* testaceous, darker towards the tip.

Thorax green slightly tinged with cupreous, marginal groove interrupted at the posterior angles by an oblique carinated line, dorsal line obsolete, basal ones dilated, basal edge oblique each side.

Elytra whitish-testaceous, striæ punctured, profound, not obsolete near the tip, interstitial lines hardly convex, third with a transverse linear impression before and one behind the middle, area of the scutel greenish, two fuscous, obsolete, undulated bands behind the middle, the posterior one less definite.

Feet whitish-testaceous.

Found in Missouri by Mr. Nuttall.

5\. B. **contractum* blackish-brown, thorax much contracted behind, base hardly broader than the peduncle, rectilinear.

Length one-fifth of an inch.

Head black; *antennæ* brown, base rufous; *labrum* deep piceous; *mandibles* piceous before the tip; *palpi* piceous-black.

Thorax black, slightly cupreous, widest rather before the middle, much contracted behind, lateral groove not dilated, posterior angles very small, base, excepting the angles, hardly wider than the peduncle, basal line rectilinear.

Elytra blackish, or dark piceous slightly glossed with cupreous, with a very indistinct paler posterior margin and tip, striæ impressed, obsolete at tip, lateral ones shortest, punctures very distinct, approximated, interstitial lines flat, third with a puncture before and one behind the middle.

Feet testaceous.

The pale hind margin and tip are usually obsolete, and often almost imperceptible; it varies in extending to the base, but is ordinarily in the form of a very indistinct, subterminal, marginal spot, and an apicial larger one.

6\. B. **niger* purple-black; elytra bronzed, striæ obtuse, obsolete at tip; feet rufous.

Length more than three-twentieths of an inch.

Tachys niger. Melsh. Catal.

Body beneath piceous-black.

Head blackish tinted with purple; *antennæ* fuscous; base and *palpi* rufous.

Thorax black, slightly purpurescent, broadest rather before

the middle, lateral edge slightly excurved near the posterior angles, basal edge slightly oblique each side.
Elytra dark bronzed, striæ obtuse, somewhat canaliculate, obsolete behind, punctures transverse, interstitial lines convex.
Feet rufous.

At once distinguishable from the preceding species by its smaller size.

7. B. **oppositum* black; elytra fuscous, each with two large remote whitish spots.
Length one-eighth of an inch.

Tachys 4-guttatus. Melsh. Catal.

Head black; *antennæ* brown; base and *palpi* testaceous.
Thorax black, somewhat pedunculated, wider before the middle, much contracted behind, posterior angles salient, acute, basal edge oblique each side, and, excluding the angles, hardly wider than the peduncle.
Elytra fuscous or blackish, each with a large, whitish, longitudinally suboval spot attaining the humerus and exterior margin, distant from the suture, and one less than half as large, rounded, placed on the disk behind the middle, striæ obsolete, wanting behind, punctures of the striæ distinct.
Feet testaceous.

Subject to considerable varieties in size and in depth of colouring of the elytra. The term 4-*guttatus* of Mr. Melsheimer is preoccupied.

8. B. **affinis* black; elytra each with two large, distant, obsolete, pale spots, and a smaller one on the humerus before.
Length one-eighth of an inch.
Thorax black, wider before the middle, much contracted behind, posterior angle salient, acute, basal edge oblique

each side, and, excluding the angles, hardly wider than the peduncle.

Elytra blackish, each with obsolete, marginal, pale spots, one placed before the middle not attaining the humerus, one smaller behind the middle attaining the margin, and one smallest before the humerus, striæ impressed, wanting at tip, punctures distinct.

Feet testaceous.

Very similar to the preceding, but may be distinguished by the larger anterior spot being placed considerably behind the humerus and by the more profoundly impressed striæ.

9. B. **inornatum* black; feet piceous; elytral striæ obsolete impunctured.

Length one-tenth of an inch.

Body deep black, polished.

Antennæ brown; base and *palpi* rufous.

Thorax nearly as broad as the elytra, somewhat narrowed behind, lateral edge hardly excurved behind, posterior angles rectangular, basal edge rectilinear.

Elytra black, dorsal striæ obsolete, obtuse, impunctured, lateral striæ wanting.

Feet piceous.

Often under the bark of decaying trees.

10. B. **flavicaudus* piceous; elytra with obsolete, impunctured striæ, and pale at tip.

Length three-fortieths of an inch.

Head blackish; *antennæ*, *labrum*, and *palpi* pale rufous.

Thorax piceous-black, transverse quadrate, broadest in the middle, not contracted behind, posterior angles rectangular, basal edge rectilinear.

Elytra blackish, from near the middle to the tips yellowish white, striæ impunctured, wanting each side and at tip, interstitial lines convex.

Feet pale rufous; *venter* piceous at tip.

Var. a. Entirely testaceous.

These I found very numerous under the bark of decaying trees.

11. B. **proximus.* Head and thorax piceous; elytra testaceous with a blackish common disk, striæ obsolete, impunctured.

Length rather more than one-tenth of an inch.

Head blackish piceous; *antennæ* rufous; base and *palpi* paler; *labrum* rufous.

Thorax piceous, transversely subquadrate, slightly contracted behind, posterior angles rectangular, base much broader than the pedicel, basal line slightly oblique each side, dorsal line distinct, basal ones indented.

Elytra testaceous, a common black spot on the middle hardly attaining the margin, region of the scutel dusky, striæ very obtuse, obsolete, wanting each side and at tip, impunctured, interstitial lines convex.

Pectus and *postpectus* piceous; *feet* testaceous; *venter* blackish, paler at tip.

Approaches the preceding, but, colour apart, it may be known by the thorax being more contracted behind.

12. B. **lævum* piceous; palpi whitish; elytra destitute of striæ.

Length one-twentieth of an inch.

Body piceous tinctured with rufous.

Head rather darker; *antennæ* paler at base; *palpi* whitish.

Thorax transversely subquadrate, broadest before the middle, hardly narrowed behind, lateral edge not excurved behind, posterior angles slightly obtuse angular, basal edge nearly rectilinear, dorsal line obsolete, basal ones wanting.

Elytra impunctured, destitute of striæ, excepting an obsolete sutural one.

Feet testaceous.

I arrange this species with *Bembidium* from the habit, the palpi in the specimen I possess being mutilated.

13. B. **variegatum* black; head and thorax tinged with greenish; elytra varied with testaceous: feet pale piceous.
Length one-fifth of an inch.
Body impunctured, glabrous, beneath black.
Head black slightly bronzed; *antennæ* and *palpi* fuscous, base piceous.
Thorax blackish slightly bronzed, tinged each side with green, broadest in the middle, a little contracted behind, lateral edge a little excurved near the base, posterior angles rectangular, dorsal and basal lines distinct, an elevated acute line at the posterior angles.
Elytra black variegated with testaceous, or testaceous varied with black dots and lines, and with a slight cupreous tinge, striæ punctured, profound, interstitial lines convex, third one with two distant punctures.
Feet fuliginous.

Very closely allied to B. *dorsalis*, which may be a mere variety of this insect. This species is subject to great variety in its elytral markings, the chief colour of the elytra being sometimes black and sometimes pale testaceous, with a greater or less number of lines and spots.

14. B. **tetracolum* greenish-black; feet rufous; elytra each with two rufous spots.
Length nearly one-fourth of an inch.
Head deep greenish; *antennæ* fuscous; base and *palpi* rufous.
Thorax broadest before the middle, contracted behind, lateral edge excurved at base, base punctured.
Elytra blackish, striæ punctured, interstitial lines convex, third one with two distant punctures, a longitudinal, submarginal, rufous spot originating on the humerus, and an oblique, almost common, elongated one behind the middle
Feet rufous.

Genus Trechus. *Clairville.*

Anterior tibia emarginate; anterior and intermediate tarsi of the male dilated; elytra and wings entire; palpi filiform, the last joint of the exterior ones as long or longer than the preceding joint, not narrowed at base, but forming with that joint a fusciform mass.

Species.

1. T. **conjunctus.* Head piceous-black; thorax rufous, impunctured; elytra dusky; feet testaceous.

Length three-twentieths of an inch.

Body impunctured, glabrous.

Head black or deep piceous; *antennæ* brown; base and *palpi* testaceous; *labrum* piceous; *mandibles* rufous at base.

Thorax rufous, rounded behind, dorsal line not deeply impressed, basal lines slightly excavated, base impunctured.

Elytra blackish, margin and suture piceous obscure, striæ impunctured, interstitial lines depressed.

Pectus rufous; *sternum* black; *feet* testaceous; *postpectus* black; *abdomen* black.

Very common. The disk of the thorax is sometimes dusky or blackish.

2. T. **partiarius.* Head black; thorax rufous, rounded behind, punctured at base; elytra pale, disk dusky; feet testaceous.

Length less than three-twentieths of an inch.

Body glabrous, beneath black.

Head black; *antennæ* brown; base and *palpi* testaceous; *nasus* and *labrum* piceous.

Thorax rufous, rounded behind, dorsal line distinct, continued to the base, posterior lines excavated, dilated, and punctured, a few obsolete punctures before.

Elytra pale rufous or testaceous, somewhat darker on the disk, striæ impunctured.

Pectus rufous; *sternum* black; *feet* testaceous; *postpectus* and *abdomen* black.

Very closely allied to the preceding, is less common, and is distinct by the punctures of the thorax, by the less abrupt posterior termination of that part, and by the consequent less obtuse form of the angles.

3. T. **rupestris*. Head black; thorax dark rufous, punctured at base, posterior angles not rounded, beneath black; feet testaceous.

Length nearly one-fifth of an inch.

Body glabrous, beneath black.

Head black; *antennæ* brown; base and *palpi* testaceous: *nasus* and *labrum* deep piceous.

Thorax deep blackish rufous, gradually a little narrowed from before the middle to the hind angles, which are slightly angulated, the edge very slightly excurved at the hind angles.

Elytra with impunctured striæ, disk blackish, margin and suture dark rufous; *pectus* piceous-black; *sternum* black; *feet* testaceous; *postpectus* and *abdomen* black.

Var. a. Length less than one-tenth of an inch.

Strongly resembles the two preceding species, but is sufficiently distinct by the form of the posterior thoracic angles.

It is highly probable that *Var. a.* is in reality a distinct species.

Family III. HYDROCANTHARI.

Genus DYTISCUS. *Lin. Latr.*

Antennæ longer than the head, setaceous; scutel distinct: three basal joints of the anterior tarsi, in the male, dilated, patelliform; palpi filiform.

Species.

1. D. **fimbriolatus* attenuated before, blackish-green above: thorax and elytra yellowish on the outer margin, the latter with three series of punctures.

Dytiscus fimbriolatus. Melsh. Catal.

Length one inch and one-fifth.
Body dark green, beneath piceous-black, impunctured, very distinctly widest behind and narrowed before.
Head smooth, with a slightly impressed spot on each side of the front: *nasus* and *labrum* yellowish, the latter with an impressed transverse puncture each side, the former blackish at base above; *trophi* and *antennæ* rufous; *mandibles* at tip and *labium* black-piceous.
Thorax with numerous, minute, impressed, irregular lines, an anterior, abbreviated, indented, transverse line each side of the obsolete dorsal one, lateral margin yellowish.
Elytra with very numerous, abbreviated, longitudinal, irregular, impressed, unequal lines, which are obsolete near the suture, tip, and on the outer margin, three series of distant punctures slightly villous, lateral one indistinct, costal margin yellowish, which becomes obsoletely semi-deltoid near the tip.
Pectus and *postpectus* piceous-black; *feet* piceous; *femora* and basal joints of the anterior pairs yellowish-rufous; *venter* piceous, three lateral rufous punctures on each side.

A black spot is often present on the middle of the yellow thoracic margin. This species approaches exceedingly near to D. *limbatus* of E. India; but, according to the observations of Dr. J. F. Melsheimer, it is smaller, the colour is less olivaceous, more of a deep green, and the form a rather longer oval.

2. D. **verticalis* suboval, above blackish with greenish reflections; thorax and elytra margined with yellowish, the latter with an oblique subterminal line.

Length one inch and three-tenths.
Body impunctured, above black, with olivaceous green reflections, beneath piceous-black, suboval, very slightly broadest behind and hardly narrowing before.
Head large; *vertex* with an obscure rufous spot, a geminate, impressed, punctured spot near the nasus, numerous super-

ciliary punctures; *nasus* and *labrum* yellowish, the former with an abbreviated impressed line each side before; *antennæ* and *palpi* rufous at base, piceous at tip; *labium* ventricose between the insertion of the palpi, rufous; *labium* and *gula* rufous.

Thorax margined each side with yellowish, a longitudinal impressed line, a transverse, somewhat undulated, submarginal line of impressed punctures each side before, and a more abbreviated sparse one each side behind.

Elytra margined each side with yellowish, which becomes obsolete behind, a yellowish, oblique, subterminal line behind, three very distinct series of punctures, with alternate series of minute remote ones.

Pectus pale rufous; *sternum* black, hardly elevated before; *postpectus* piceous-black; *feet* piceous; *femora* and basal joints of the anterior pairs rufous; *venter* piceous-black, three obsolete, lateral, piceous spots.

Differs much from the preceding species, in being far more robust before, and instead of the semideltoid termination of the yellow margin, there is an oblique subterminal line, as in D. *marginatus*, but it is very distinct from the latter species, by not having the yellowish anterior and posterior thoracic margins.

3. D. **mediatus* blackish, punctured, beneath black; thorax with a yellowish band and margin; elytra fasciate behind.

Length about eleven-twentieths of an inch.

Head rufous-yellow varied with dusky, base black; *front* with sometimes two oblique blackish spots; *nasus* paler; *labrum* whitish, particularly on the anterior margin.

Thorax black, a yellowish margin and abbreviated narrow band which is abruptly dilated backward near the lateral margin, where it becomes confluent with the basal margin; *scutel* black, impunctured.

Elytra blackish-brown varied with yellowish, minute, irregular lines, and as well as the thorax with numerous, minute punctures, a yellowish, narrow, exterior, and subsutural margin, and a common, arquated, somewhat undulated band behind the middle, and a terminal one, obsolete or confounded with the tip.

Anterior *feet* and *sternum* testaceous; posterior *feet* piceous; *thighs* black; *venter*, third, fourth, and fifth segments each with a large, rufous, lateral spot.

The grooves of the elytra in the female of this species are obsolete and abbreviated, and not more distinct than those of the male.

4. D. **tæniolis* blackish; thorax margined each side with rufous; elytra covered with confluent black points, three acute, pale rufous, longitudinal lines on each elytron.

Length rather more than half an inch.

D. *pictus. Melsh. Catal.*

Body oblong-oval, not wider behind, black varied with rufous, beneath piceous-black.

Head with a double, impressed, very distinct line each side before; *antennæ*, *labrum*, and *nasus* rufous, the latter with an impressed line each side.

Thorax with a slightly punctured, transverse line before, and an obscure rufous margin.

Elytra rufo-testaceous, but rendered black by small, dense, confluent punctures, which are entirely confluent near the suture, an immaculate outer margin, and undulated subbasal line, three acute pale rufous lines on each elytron, punctured striæ indistinct, that next the suture more obvious and composed of an interrupted series of minute punctures.

Pectus and *postpectus* piceous-black; *feet* rufo-piceous; *venter* piceous-black, segments piceous at tip.

I have seen but one sex of this species, a female, which was sent to me by Dr. J. F. Melsheimer, under the name which I have adopted; that of *pictus* above quoted having been previously applied to a different insect, although that insect does not belong to this genus in a rigid arrangement.

Genus Colymbetes. *Clairville.*

Antennæ longer than the head, setaceous; scutel distinct: basal joints of the four anterior tarsi of the male almost equally dilated, not patelliform; palpi filiform.

Species.

1. E. **erytropterus* black; elytra dark reddish-brown, margin and base paler; feet towards the tips piceous; body rounded behind.

Length not quite two-fifths of an inch.

Dytiscus erytropterus. Melsh. Catal.

Body black, above divided by minute lines into minute, irregular, longitudinal, or suborbicular spaces.

Head black, two indistinct piceous spots on the vertex, and an abbreviated line and puncture on the front each side; *antennæ* and *palpi* rufous.

Thorax black, dorsal line abbreviated, obsolete, lateral edge arquated; *scutel* black, plain.

Elytra reddish-brown, darker on the posterior disk, immaculate, exterior margin and base paler, rounded behind, inflected margin black.

Pectus and *postpectus* black; *sternum* acutely carinated; *feet* piceous, middle of the thighs black, nails of the anterior pair in one sex dilated in the middle and compressed; *venter* black, segments piceous at tip.

Rather less convex than the succeeding species, and somewhat more dilated. The colour of the head and thorax is manifestly distinct from that of the elytra, and forms a good specific character.

2. C. **fenestralis* black, slightly bronzed; elytra four spotted, anterior spots obsolete, terminal ones distinct, beneath piceous-black.

Length two-fifths of an inch.

Dytiscus fenestralis. Melsh. Catal.

Body black, above slightly bronzed and divided into very minute, suborbicular, depressed granules, beneath piceous-black.

Head with two obsolete piceous spots on the vertex, a definite, impressed, abbreviated, oblique, frontal line, with a smaller oblique one above, each side; *antennæ* and *palpi* piceous.

Thorax, an obsolete, punctiform, central line, often wanting.

Elytra, on each a submarginal, elongated, obsolete, rufous spot behind the middle, and a subtriangular one near the tip.

Pectus and *postpectus* not obviously granulated; *sternum* acutely carinated; *feet* piceous; *venter* with very numerous, oblique, irregular lines.

Var. a. Above dark reddish-brown, margin paler, spots yellow, distinct, beneath piceous; *feet* pale rufous.

My friend Dr. J. F. Melsheimer, in a letter written sometime since, observes that "the two yellowish macula near the apex of the elytra differ oftentimes in depth of colouring and in size. I have several specimens that have the macula of an irregular, others of an oval or elongated form, and the colour of all the different shades from a faint yellow to a light brown. It delights in miry forest springs, where it feeds on tender vegetables and minute insects. If it is caught and pressed between the fingers, it will exudate from the divisional line of the stethidium (*truncus*) and abdomen, a white milky substance. It moves with great activity."

It undoubtedly approaches very closely to C. *fenestratus* of Europe, which insect has the same fenestrate elytral spots; as well as another insect, which is described by Marsham under the name of D. *obscurus*.

3. C. **ambiguus* black; elytra dark reddish-brown; feet rufous; body somewhat acute behind; vertex with obsolete piceous spots.

Length not quite seven-twentieths of an inch.

Body black, above with minute, depressed, irregular granules.

Head black, two indistinct piceous spots on the vertex and an abbreviated frontal line and puncture each side; *antennæ* and *palpi* pale rufous.

Thorax black, dorsal line obsolete; *scutel* black.

Elytra dark reddish-brown, immaculate, margin and base paler, apex acute; *epipleura* black.

Sternum acutely carinated; *feet* pale rufous, posterior ones rufous.

For this insect I am indebted to my friend Dr. J. F. Melsheimer, who sent it to me as a distinct species. It approaches very closely to E. *erytropterus*, but may be distinguished by its smaller size, less dilated form, more gradually attenuated and more acute posterior termination of the body.

4. C. **seriatus* black, immaculate, slightly purple-bronzed; elytra with about three irregular series of punctures on each; lateral edge of the thorax somewhat rectilinear.

Length seven-twentieths of an inch.

Body black, immaculate, above very slightly bronzed, divided into very minute, suborbicular, depressed granules, beneath black.

Head, a transverse frontal puncture each side, with double, parallel, obsolete, smaller ones above; *antennæ* and *palpi* rufous.

Thorax, submargin slightly depressed, dorsal line obsolete, lateral and basal edges nearly rectilinear, posterior angles subacute.

Elytra, on each three irregular series of villous punctures, and a submarginal less distinct one; *epipleura* piceous.

Sternum acutely carinated, depressed behind, slightly elevated, obtuse before; *feet* rufous, posterior pair piceous.

This insect was sent me as distinct by Dr. J. F. Melsheimer. It is very closely allied to C. *nitidus*, but is considerably larger.

5. C. **nitidus* black; elytra with about three irregular series of punctures on each; lateral edge of the thorax arquated each side.

Length three-tenths of an inch.

Dytiscus nitidus. Melsh. Catal.

Body black, immaculate, polished, and divided into very minute, irregularly orbicular granules, beneath black.

Head, a transverse, abbreviated, frontal line each side, superior punctures obsolete or wanting; *antennæ* and *palpi* rufous.

Thorax, dorsal line abbreviated, central, lateral edge arquated, posterior angles subacute.

Elytra with three irregular series of villous punctures, and a submarginal and sutural less distinct one; *epipleura* black.

Sternum acutely carinated, depressed behind; *feet* piceous, anterior ones rufous.

The chief difference between this species and the preceding one appears to rest in the general form and size of the body, the colour and markings being nearly the same; the present is much smaller, of a more rounded oval, and much more obtusely rounded before.

6. C. **bicarinatus* reddish-brown, punctured; sternum bicarinated.

Length rather more than three-tenths of an inch.

Body reddish-brown or ferruginous, oblong-oval, with minute numerous punctures.

Head, lateral frontal line oblique, puncture above wanting.

Thorax, a submarginal slightly rugose line, dorsal line obsolete.

Elytra attenuated behind, rather darker than the thorax, about three obsolete irregular series of punctures.

Sternum bicarinate; *feet*, anterior pairs paler.

7. C. **venustus* pale rufous, beneath testaceous: elytra blackish lineated with whitish.

Length about three-tenths of an inch.
Body pale rufous, minutely punctured, beneath testaceous tinged with reddish, minutely lineated.
Head blackish at base; *antennæ* and *palpi* testaceous.
Thorax at the middle of the base and tip blackish.
Elytra blackish, with very minute, numerous, fenestrate punctures, a submarginal whitish line interrupted at tip, passing round the humerus, and falcate on the base, an abbreviated subsutural one at base, hardly attaining the middle, and two or three smaller obsolete ones near the marginal line.
Sternum acutely carinated.

A remarkably handsome and distinct species. It is not common, and may probably prove to be the *interrogatus* of Fabricius.

8. C. **glyphicus* dark brown or blackish; elytra profoundly striated.
Length one-fifth of an inch.

Dytiscus glyphicus. Melsh. Catal.

Body dark reddish-brown, minutely punctured, beneath blackish, minutely lineated.
Thorax with an anterior, indented, rugous, submarginal line.
Elytra with eleven profoundly impressed striæ, alternately abbreviated towards the tip, the inner ones abbreviated at base, marginal one extending from the middle towards the tip.
Feet rufous.

This insect varies in being of a paler colour. I found it numerous in fresh water ponds on Sullivan's Island, South Carolina.

9. C. **obtusatus* black; elytra four-spotted, punctured.
Length three-tenths of an inch.
Body black.
Head with two obsolete piceous spots on the vertex, a single

impressed. abbreviated, frontal line each side; *antennæ* and *palpi* piceous.

Elytra with two or three distinct series of punctures, somewhat irregular, scattered behind, each elytron with a pale, fenestrate. elongated, submarginal spot behind the middle, and a subtriangular one near the tip.

Feet piceous.

Var. a. Body beneath testaceous; frontal spots obsolete.

This species approaches very near to *fenestralis*, but differs in having the series of large distinct punctures, in being not more than half the size of that insect and more obtuse before. Found on Mr. R. Haines's farm, Germantown.

10. C. **stagninus* oval, black, beneath rufous; vertex with two piceous spots; elytra with a submarginal whitish line behind.

Length less than seven-twentieths of an inch.

Dytiscus stagninus. Melsh. Catal.

Body oval, obtuse behind, black, beneath rufous.

Head with two obscure piceous spots on the vertex, a single, impressed, transverse, abbreviated line and point each side before; *nasus* and *labrum* piceous.

Elytra with three dilated lines of irregular, profound, rather large punctures, becoming confused at tip, an abbreviated, submarginal, whitish line on each elytron, originating near the middle of the tip.

Tergum with a few hairs each side behind.

Genus Laccophilus. *Leach.*

Antennæ setaceous, longer than the head; scutel none; anterior tarsal joints of the male not patelliform; palpi filiform.

Species.

1. L. **maculosus* yellowish-testaceous; elytra blackish, lineated and spotted with white.

Length one-fourth of an inch.

Dytiscus maculosus. Melsh. Catal.

Body yellowish-testaceous, glabrous.

Elytra blackish, three spots or dilated lines at base, of which one is humeral and one subsutural, each emarginate at tip and profoundly so on the inner side, and the third rather shorter, arising from the middle of the base, two marginal spots of which the anterior one is much the largest, a common irregular spot behind the middle, and an apicial common band, white, tip obliquely truncate.

Var. a. Trunk beneath black.

Var. ᵦ. Yellowish-testaceous; elytra with a common black band behind the middle.

Rather a common insect.—The last variety is a remarkable one; but, when closely examined, traces of some of the spots are perceptible upon it.

2. L. **proximus* yellowish-testaceous; elytra blackish obsoletely spotted with dull whitish.

Length three-twentieths of an inch.

Body yellowish-testaceous, paler beneath.

Elytra with spots as in the preceding species, but obsolete, the larger marginal one distinct.

This species I found very numerous in the fresh water marshes of South Carolina. I do not hesitate to give it as distinct from the preceding, although so closely allied to it by the elytral maculæ. It is readily distinguishable by its inferior size.

Genus Hydroporus. *Clairville.*

The four anterior tarsi apparently four-jointed, the fourth joint minute, and with the base of the fifth concealed in a profound fissure of the third joint; body oval, the breadth greater than the height; scutel none

Species.

1. H. **undulatus* ferruginous; elytra trifasciate with black. *Length* about three-twentieths of an inch.

Dytiscus undulatus. Melsh. Catal.

Body ferruginous, very numerous, minute, villous punctures, hairs adpressed to the surface.
Head destitute of large, indented, frontal punctures; *antennæ* and *palpi* paler.
Thorax at base and tip black, lateral edge very slightly arquated.
Elytra, suture and three undulated irregular bands black, of the latter, one is basal, one central, and the other subterminal.

The bands sometimes occur dilated and decurrent, so as to form a common black disk to the elytra.

2. H. **oppositus* blackish; head and base of the thorax ferruginous; elytra with six whitish marginal spots or subfascia.
Length rather less than three-twentieths of an inch.
Body with very numerous, villous, minute punctures, hairs adpressed to the surface.
Head rufous or ferruginous, four or six indented, frontal, distant punctures.
Thorax ferruginous, black at tip, about three indented punctures, placed transversely.
Elytra black, each with an irregular humeral spot, another placed upon the margin behind the middle, and a third apicial one yellowish, edge yellowish.
Postpectus and *venter* blackish or deep piceous; *pectus* and *feet* yellowish-testaceous.

This was sent to me as a distinct species by Dr. J. F. Melsheimer. It is very like *undulatus*.

3. H. **niger* black, villous, obscure, immaculate; head and lateral margins of the thorax and elytra obscure rufous.

Length more than three-twentieths of an inch.

Dytiscus niger. Melsh. Catal.

Body black, obscure, very numerous, minute, villous punctures, hairs adpressed to the surface.
Head obscure rufous, paler beneath, dusky each side of the front, a slightly indented spot each side before instead of the impressed line and punctures; *antennæ* dusky towards the tip of each of the terminal joints; *palpi*, terminal joints blackish.
Thorax black, very obscure rufous on each side, dorsal line none.
Elytra black, very obscure rufous each side near the base. striæ or maculæ none; *epipleura* rufous.
Pectus and *postpectus* black; *feet* rufous; *venter* black, segments slightly piceous at tip.

4. H. **catascopium* black, obsolete, spotted and lineated with rufous; feet rufous.
Length three-twentieths of an inch.
Body black, obscure, with villous punctures, hairs adpressed to the surface.
Head obscure rufous, dilated orbits and base black, indented frontal spots each side instead of impressed lines and punctures; *antennæ,* terminal joints blackish at their tips; *palpi* terminal joint black.
Thorax black, a central longitudinal spot, and irregular submarginal one each side rufous, dorsal impressed line none.
Elytra black, margin rufous, with a transverse irregular process at base, and another at the middle, and common apicial band, a double sutural line, an abbreviated line arising from the middle of the base, and a subsutural spot near the middle, rufous, a distinct sutural stria and an obsolete one near the middle.
Feet rufous.

5. H. **lacustris* rufous, obscure; a common, impressed, lon-

gitudinal line each side on the base of the thorax and elytra.

Length more than one-twentieth of an inch.

Dytiscus lacustris. Melsh. Catal.

Body rufous, obscure, with minute punctures.

Head with slightly impressed frontal spots; *antennæ*, terminal joints tipped with blackish; maxillary *palpi* blackish at tip.

Thorax blackish at base and tip, base each side with an impressed, acute, oblique line not attaining the anterior margin.

Elytra with a blackish suture, base, and submargin, an impressed, acute, longitudinal line as long as the thorax arises from the middle of the base of each elytron, appearing to be a continuation of the lateral thoracic line.

Pectus and *feet* pale rufous; *postpectus* blackish; *venter* pale rufous.

Var. a. Postpectus rufous.

6. H. *affinis* rufous, obscure; a common impressed, longitudinal line each side on the base of the thorax and elytra; elytra varied with longitudinal black lines.

Length more than one-twentieth of an inch.

Body rufous, obscure, punctured.

Thorax blackish at base and in the middle, an impressed, acute line each side at base not attaining the anterior margin.

Elytra with a blackish suture, base, irregular submargin and intervening abbreviated lines, punctures of the disk rather larger, distinct, impressed line of the middle of the base of each elytron much abbreviated, obsolete.

Differs from the preceding, to which it is very similar, in having rather larger punctures on the disk of the elytra, more distinct lines, and in having the impressed ones of the base very short and indistinct.

Genus Hydrocanthus. *Say*.

Antennæ rather longer than the head, somewhat thicker in the middle; scutel none: maxillary palpi filiform: labiales, terminal joint dilated, subovate, compressed, entire; anterior tibia mucronate, tarsal joints of the male not patelliform; a small pectoral scale covering the origin of the posterior feet.

Species.

H. **iricolor* ferruginous; elytra dark reddish-brown, iridescent, attenuated behind.

Length three-twentieths of an inch.

Body pale ferruginous, above glabrous, impunctured, beneath with villous punctures.

Head obtusely rounded before; *eyes* not elevated above the surface; *antennæ* eleven-jointed, originating beneath; *labrum* rather large, abruptly deflected, or somewhat inflected, entire; *palpi* whitish.

Thorax, posterior angles acute; *sternum* not prominent before, behind the origin of the anterior feet dilated, depressed, and connate with the poststernum by a rectilinear suture its whole width; *poststernum* dilated, depressed, equilateral, concealing the origin of the intermediate feet. posterior scales equilateral, obliquely truncate at tip, and concealing the origin of the posterior feet.

Feet, anterior tibia minutely pectinate beneath, and terminated by a robust decurved hook; *tarsi* abbreviated.

Elytra dark reddish-brown, iridescent, destitute of punctures or striæ, and attenuated behind.

This seems to be a rare insect: I have seen but a single specimen. This new genus certainly differs from all the genera of its family by the form of the labial palpi, of the sternum and poststernum, mucronate anterior tibia, &c. It closely approaches the genus *Noterus* by the dilated labial palpi, but differs in having those parts entire. It also has some relation to *Haliplus* by the scales which conceal the origin of the posterior feet. The proper situation of this new genus is between those two genera, but it is unquestionably much more closely allied to the former.

Genus Haliplus. *Latr.*

Antennæ ten-jointed; palpi subulate; scutel none; tarsi filiform, five-jointed, posterior thighs concealed at base by a clypeiform scale; body oval, thick.

Species.

1. H. *12-*punctatus** yellowish; thorax with two black spots at base; elytra punctured and spotted with black.

Length five-fortieths of an inch.

Dytiscus maculatus. Melsh. Catal.

Body pale yellowish, with numerous dilated punctures, rounded behind.

Head immaculate.

Thorax, a distinct black spot each side at base.

Elytra pale, with profoundly punctured striæ, punctures dilated, black, each elytron with six black dots placed 1, 2, 1, 2, the anterior one before the middle, the two succeeding ones on the middle.

The *Dytiscus maculatus* of Fabricius is altogether different from this species; it is a *Colymbetes.* I have, however, thought proper to reject the name *maculatus* as applied to this insect, lest it should be confounded with the Fabrician insect by those who adhere to his system or to that of Linné.

2. H. *triopsis* pale yellowish; thorax with a black spot before; elytra whitish spotted with black.

Length nearly three-twentieths of an inch.

Body pale yellowish, numerous dilated punctures.

Thorax with a large, conspicuous, deep black spot on the anterior margin.

Elytra paler than the body, striæ profoundly punctured, punctures colour of the elytra, suture, base, tip, and six spots on each elytron deep black, spots placed 1, 1, 2, 1, 1, the penultimate one joining the suture, suture at the centre dilated into a spot.

Genus Gyrinus. *Lin.*

Antennæ shorter than the head, second joint with a lateral process; *eyes* apparently four; two posterior pairs of feet dilated, very much compressed.

Species.

1. G. *Americanus* blackish-bronze, beneath piceous: elytra smooth, slightly sinuate at tip.

Length nine-twentieths, breadth more than one-fourth of an inch.

Gyrinus Americanus lævis, ater, opacus, pedibus quatuor posticis testaceis. *Fabr. Syst. Eleut., Pars 1, p. 275.*

G. *Americanus* bronzé; pattes ferrugineuses; élytres simples, presque striées. *Oliv. Ent., III., No. 41, p. 12, pl. 1, fig. 5.*

G. *Americanus. Dr. Forsberg. Trans. Upsal. Society.*

Body oblong-subovate, blackish, slightly tinged with bronze or purplish, beneath piceous.

Head, labrum deeply ciliated with white hair.

Thorax impunctured; *scutel* none.

Elytra with very minute, obsolete, distant punctures, disk plain, each side with four or five obsolete striæ, tip distinctly and very obtusely sinuated, a projecting angle at the sutural tip.

Poststernum with distant profound punctures before; *feet* testaceous, anterior pair rufous and destitute of a femoral spine.

A very common insect. When caught, a lactescent fluid is secreted from the anal segment, that diffuses a strong odor, very similar to that of the flowers of the *Calycanthus.*

2. G. **emarginatus* blackish-bronze, beneath blackish; elytra smooth, each simply rounded at tip.

Length from nine-twentieths to eleven-twentieths of an inch.

Body blackish-green, slightly bronzed, beneath piceous-black or fuliginous.

Head blackish-green; *labrum* at tip and *antennæ* at base ciliated with white hairs.

Thorax impunctured; *scutel* none.

Elytra with very minute, obsolete, distant punctures, striæ seven or eight, more distinct in the male, obsolete, each elytron rounded at tip, not sinuated nor dentated.

Poststernum punctured before, punctures profound and distant; *feet*, posterior pairs testaceous, anterior pair in the male furnished with a prominent angle or obtuse spine near the tip of the anterior edge of the thigh.

The elytra appear emarginated at the tip of the suture when at rest, in consequence of each of them having a rounded termination. This species has been hitherto confounded with the *Americanus* with which it associates indiscriminately, but is sufficiently distinct by the armature of the anterior femora of the male, and by the simply rotund termination of the elytra in both sexes.

3. G. **analis* black slightly bronzed; elytra with punctured striæ; thorax with a transverse indented line.

Length one-fifth of an inch.

Body beneath impunctured and tinged with piceous.

Front between the eyes with two impressed dots; *labrum* at tip and *palpi* at base ciliated with white hairs; *mouth* beneath piceous; labial *palpi* testaceous, blackish at tip.

Thorax with a transverse indented line rather before the middle not attaining to the lateral margins, and a short oblique line on each side behind it curving towards the lateral edge; *scutel* distinct, subtriangular.

Elytra with about eleven distinct narrow striæ of punctures, interstitial lines depressed, each elytron very obtusely rounded at tip.

Poststernum impunctured; *feet* rufous; *caudal segment* testaceous.

Resembles G. *natator*, but that insect is larger; it corresponds in size with the *marinus Gyllenh.*, but the punctures of the elytra are much smaller, and the termination of the elytra is more obtusely rounded.

4. G. **limbatus* black; elytra with punctured striæ: epipleura yellowish.

Length rather more than one-fifth of an inch.

Front bipunctured.

Thorax with an obsolete, transverse, impressed line before the middle, and a short oblique line each side behind the middle.

Elytra striate with small punctures, interstitial lines depressed, each elytron obtusely rounded at tip, beneath rufous; *epipleura* and margin of the *pectus* behind the eye yellowish.

I obtained this species in Georgia and East Florida. It closely resembles the preceding species, but may be at once distinguished from it by the colour of the epipleura and inferior surface of the body.

No. II.

Description and Chemical Analysis of the Retinasphalt, discovered at Cape Sable, Magothy River, Ann Arundel County, Maryland. By G. Troost, M. D.—Read 19th Dec. 1823.

In the American Journal of Sciences and Arts edited by B. Silliman, (Vol. III. p. 8) I published a description of a variety of amber, and of a fossil substance supposed to be a nest of an insect, discovered at Cape Sable, Maryland. This description was the result of only one analysis. It appears now, from subsequent trials, that there occur, at that place, two minerals, which are very similar in their appearance, viz. the true amber, and a resino-bituminous substance known by the name of Retinasphalt. It happened, accidentally, that I selected, for the first analysis, some fragments of the true amber; and in consequence, taking for granted that it was all the same substance, as the hardness, smell when burnt, &c. appeared to be the same, I described it in the above mentioned Journal as amber. Having returned to my former residence, where I have every means to vary my researches, I have submitted this substance again to examination, and have discovered my error, and ascertained that it consists of two, if not of three, others, of somewhat different nature, viz. amber, Retinasphalt, and a substance which corresponds with what Jameson calls fossil copal.

I have now the honour to lay before the Philosophical Society the result of my investigations.

RETINASPHALT.

The *Retinasphalt* is either perfectly opaque, or slightly transparent at the edges: the colour exhibits every shade of a mixture of yellow, grey, and brown, sometimes arranged, in nearly concentric zones, so as to display the beautiful colours admired in the Egyptian jaspers, or disposed in alternate bands, dots, spots, clouds, as in the other agates or jaspers.

It yields with more ease to the knife than amber; breaks easily, exhibiting a perfect conchoidal fracture; and some varieties seem to be of the same hardness with amber, and sufficiently hard and compact to receive a fine polish. Other varieties are porous, having sometimes the appearance of bone which has been long exposed to the action of the sun, and being in that case also of a greyish colour.

In lustre it is inferior to amber, having more of the lustre of the gamboge, than that of copal; and generally it seems to be intermediate between these. Sometimes it is dull, particularly the porous variety. When homogeneous, compact, and polished, it acquires by friction the negative electricity, in the same degree as amber; the porous variety has this property in a feeble degree.

EARTHY RETINASPHALT.

This usually occurs in fragments, or friable porous masses, from the size of a grain of maize and smaller, to that of a walnut; having a dull earthy aspect, intermixed with pyrites. Its solidity does not exceed that of clods of loam or of a stiff soil, with which, externally, it has some resemblance; and like this substance, it crumbles by friction between the fingers. Its colour is grey, or yellowish grey, like ashes. By exposure to heat it melts, and exhibits the properties of the first variety.

The first variety occurs in nodules or irregular masses, from the size of mustard seed to four or five inches in diameter. Its external surface is of a dirty grey colour, covered here and there with pyrites, which substance often penetrates the whole mass, and on the decomposition of which the whole cracks and crumbles to pieces. The surface is a crust which has in some pieces a thickness of one-eighth of an inch, and of whatever colour and lustre the included Retinasphalt may be, is always of a dirty grey and dull.

Its specific gravity varies much, and does not coincide with that given by Hatchet, who states it to be 1.13. I have repeated the experiment several times, and have constantly found that the fragments which did not contain any pyrites, did not exceed 1.04. Some fragments which floated on the surface of the water, I found to be 0.97 and 0.98, and consequently the specific gravity varies from 0.97 to 1.04, and is thus lighter than any of the resinous substances in their unaltered state which are found in the drug shops. These, according to Brisson, vary from 1.0182, as Elemi, to 1.1362 as Labdanum. I found also my supposition as to the great specific gravity, stated in the above mentioned memoir on amber, &c. verified; namely that it was owing to the intermixture of pyrites, which by its decompositions has crumbled several specimens.

CHEMICAL PROPERTIES.

I digested some of it, broken up into small fragments, in pure alcohol. This fluid exhibited some action on the substance even when cold. In less than an hour, some of the colours, particularly the lighter ones, had lost their polish, and seemed to be covered with a dull earthy matter. After it had been exposed for two days to the action of alcohol, the whole of its gloss had disappeared, and though the fragments had retained their former shape, they had nevertheless undergone a change in their constituents: the alcohol had dissolved something which had altered its former nature, and it resembled now, in some measure, the caoutchouc, being somewhat elastic, which elasticity nevertheless is again lost after some time. I then heated the alcohol to boiling, for a quarter of an hour, and after cooling it, decanted it. In this state it exhibited a yellowish colour, not quite as dark as that of madeira wine.

It was during these trials that I discovered that it contained two different substances; as some of the fragments retained all their lustre and were unaltered by the action of alcohol. These I found to resemble, in every case, the true amber of the Baltic sea.

To ascertain the true composition of the substances upon which the alcohol acted, I digested 50 grammes in fine powder, during five days, in pure alcohol, with moderate heat, which gave a tincture of the colour mentioned above. This operation was repeated till the alcohol ceased to act.

All the spirituous solution, after being carefully decanted, was subjected to a slow distillation, which gave a residuum of a brown resin, weighing 20.75 grammes. The residue, which was insoluble in alcohol, was digested in boiling water, but without sensible effect. After it was carefully collected and dried, it weighed 28.25 grammes. It was of a dull ash grey colour, and friable, melting into a black and brilliant mass. When put on hot iron, it melted immediately, emitting much smoke, and at last burnt with a brilliant flame. Its odour is agreeable, approaching in the beginning somewhat that of amber, but soon resembling that of asphalt. A solution of pure potash dissolved upwards of one-fourth of it, which was precipitated by muriatic acid, forming a brown resinous precipitate. It was soluble by heat in fat oil, and had all the qualities of asphalt. After burning, it left 1.75 grammes of an earthy matter, soluble in sulphuric acid, and forming octaedral crystals by the addition of potash, leaving a small residuum of brown uncrystallisable sulphate of iron. So that this earthy matter was alumine and oxide of iron.

From these experiments, it appears, that this mineral is the same as the Retinasphalt, which was first discovered at Borytrace, England, and is composed of

Particular resin	42.5
Bitumen	55.5
Alumine and iron	1.5
Loss	.5
	100.0

The true amber, which occurs at the same place, is usually of a brown colour, and transparent when the piece is not thicker than one-eighth of an inch. Sometimes it is of a honey-yellow, resembling in that case the amber of the Baltic; but this variety is rare. I found pieces at that place of the size of three and four inches. By destructive distillation it gives succinic acid, and has all the other qualities of the amber of the above cited place. This mineral is distinguishable from the Retinasphalt by the action of alcohol upon it. When a piece of the latter is kept for some time in this fluid, it soon loses its lustre, and becomes covered with a dull grey crust; the amber on the contrary retains its lustre, and is not altered.

There occurs also a substance which has much resemblance to the copal; possessing the same colour and transparency. Alcohol seems to have little or no action upon it. It occurs at Cape Sable, only in grains not exceeding the size of a large pea.

It is probable that these vegeto-mineral substances are the products of the same species of trees, and that their peculiar nature is ascribable to local circumstances. They all occur at Cape Sable, in the same formation; but as can be seen in the description which I have published of that place in the above mentioned Journal, this formation is composed of different strata of minerals. The uppermost is a loose sand, the lower part of which is so strongly agglutinated by iron oxide, as to form a coarse ferruginous sandstone. This stone is sometimes so rich in iron as to constitute the compact brown oxide of iron *(dichter brown eisenstein* of Werner.) Below this stratum lies a bed of lignite, from three and a half to four feet in thickness. This bed contains nearly all the varieties of lignite, such as jet, brittle lignite, bituminous wood, and brown lignite, penetrated throughout by pyrites. The junction of this stratum with the above is a mixture of lignite and sand, no abrupt separations being perceptible. It is in this stratum that the Retinasphalt and amber are found; the latter invariably on the very top of the stratum of the lignite; sometimes as much as half a foot above this bed in the sand. The Retinasphalt occurs intermixed with wood and pyrites. This being invariably the case, would induce the belief that they were originally the same vegetable gum or resin, and that the difference which now exists between them is owing to their mineralogical position.

No. III.

Analyses of the Chrysoberyls from Haddam and Brazil. By Henry Seybert.—Read, 5th March, 1824.

In the summer of 1823, I visited Haddam, in the State of Connecticut. Among the various substances there collected, was the Chrysoberyl, a mineral much esteemed on account of its rarity. It occurs disseminated in a coarse grained granite, in which the predominant ingredient is a white feldspar, which Professor Berzelius regards as *Albite*, perfectly resembling that of Finbo. In the same granite this celebrated chemist observed the *Columbite*.* It is also associated with greyish quartz, manganesian garnet of a fine blood red colour, and a yellow granular substance, which some mineralogists supposed to be a variety of the cymophane; but from its inferior hardness and general chemical composition, I recognised it to be common beryl.

For the earliest chemical information concerning the Chrysoberyl, we are indebted to Professor Klaproth. He published his analysis of it in 1795,† and gave the following constituents of it, viz. alumina, 71.50; lime, 6.; oxide of iron, 1.50; silica, 18.; loss, 3. Berzelius presented us with a formula founded on this composition;‡ but from his experiments with the blowpipe he was led to conclude that it contained no lime, and that it was a subsilicate of alumina.§ In this he was apparently confirmed by Professor Thom-

* Essai de' l' Emploi du Chalumeau, p. 243.

† Beitrage, vol. i. p. 97.

‡ Systeme de Mineralogie, p. 219,—C^4S+18A^4S.

§ Essai de' l' Emploi du Chalumeau, p. 325.

son,* who quotes Klaproth's analysis, and states that he examined the mineral some years ago, but having accidentally lost his results, he was unable to publish them. He observes, however, that the only constituents he found were alumina, silica, and oxide of iron. When I was about to prepare the communication which I now have the honour to lay before the Society, a more recent analysis of the Chrysoberyl of Brazil, by M. Augustus Arfwedson, was observed, by me, in Tilloch's Philosophical Magazine.† He confirmed the results of Professor Thomson, and considered the chemical composition of this substance to be—silica, 18.73; and alumina, 81.43, with a trace of oxide of iron.

The cymophane, from Haddam, was sent to M. Hauy by the late Dr. Bruce, in 1810, to have his opinion concerning its nature.‡ Previous to that period, the mineralogists in the United States supposed it to be *Corundum*. The late celebrated crystallographer observes, "La cymophane des Etats Unis a d' abord eté prisè pour une varieté de corindon. Effectivement elle se rapproche de ce mineral par sa dureté, par sa pesanteur specifique, et même par le resultat de son Analyse, qui a donné environ 72 parties d' alumine sur 100, avec 18 de silíce, et 6 de chaux."§ I was anxious to examine the cymophane found at Haddam, especially as M. Hauy does not name the author of the analysis he quotes. The specimen used for my experiments was of a pale green colour. It did not present any of the chatoyant appearance so remarkable in the variety from Brazil, and some specimens from Saratoga in New York, where it was lately discovered by Dr. Steel. Its specific gravity, by two trials, was 3.508 and 3.597. It is not magnetic, and before the blowpipe it is infusible. For a further description of the physical characters of this mineral, I refer to Hauy and Cleaveland.

* Thomson's Chemistry, vol. iii. p. 213.
† No. for November, 1823, p. 357.
‡ Annales du Museum d' Histoire Naturelle, tome xviii. p. 57
§ Traité de Mineralogie, 2me Edition, vol. ii. p. 309.

Three grammes of the mineral were examined under the impression that Professor Klaproth's analysis was accurately made. It was decomposed in the usual manner with four parts of caustic potash, and subsequently treated with diluted muriatic acid; but the solution was imperfect. The insoluble matter was collected on a filter, and it amounted to 25 or 30 per 100. It was repeatedly acted on in the same way, and each time it diminished in quantity, until the fourth experiment. It then weighed about fifteen-hundreths, and thereafter resisted all further efforts to render it soluble by these means. This residue was then boiled in concentrated sulphuric and muriatic acids, but neither of them dissolved more than one-third of it. These solutions were tested by different re-agents, and greatly to my surprise, the addition of subcarbonate of ammonia occasioned a floculent precipitate, which entirely re-dissolved in an excess of the alkaline subcarbonate. I immediately suspected the presence of *Glucina*, but was much at a loss to explain its insolubility, until I observed Berzelius's analysis of the *Euclase*,* in which he met with a compound of glucina and oxide of tin that obstinately resisted acids. He also met with refractory combinations of this earth and the oxides of manganese and cerium. I next endeavoured to dissolve the compound by the acid sulphate of potash; but this method did not succeed. I was not more successful with the nitric and nitromuriatic acids; nor could it be dissolved by means of boric acid. Berzelius having discovered columbium in the gangue of the cymophane from Haddam, the insoluble residue was tested for the oxide of that metal, but all my attempts were fruitless. At length, I supposed, that as barytes could be brought into contact with this substance more conveniently than potash at a high temperature, it might decompose it. With this view, a portion of the insoluble matter was exposed to a strong heat, during one hour with six parts of nitrate of barytes in a platina crucible.

* Nouveau Systeme de Mineralogie, p. 289.

The calcined mass was boiled in nitric acid. In this way nearly two-thirds of the matter that could not be entirely attacked in any other way, were dissolved. The same treatment was repeated, until nearly the whole of it was taken up, which happened after the fourth calcination. It was then no further acted on.

After making numerous experiments on the matter that resisted nitrate of barytes and nitric acid, I ascertained, that it was not acted on by alkalies nor acids when used separately, but after having been previously calcined with caustic potash, it readily dissolved in muriatic acid, yielding a solution of a pale yellow colour, which gave a reddish precipitate with an infusion of galls, a deep green precipitate with the hydrosulphate of potash, and a white precipitate with alkalies. Hence it was oxide of titanium.

After the barytes was separated with sulphuric acid, the nitric solutions were united, and treated with an excess of subcarbonate of ammonia. An abundant precipitate ensued, which entirely re-dissolved in the excess of subcarbonate. By ebullition it was again precipitated, and when calcined, it was in the form of a light white powder, possessing all the properties that characterise *Glucina*. With the sulphuric and muriatic acids it formed very sweet astringent deliquescent salts. By caustic potash it was precipitated from its solutions, and the precipitate re-dissolved in the excess of the alkali. Klaproth and Arfwedson, in their analyses of the Chrysoberyl from Brazil, considered the insoluble matter remaining after they had treated the mineral with potash and muriatic acid, to be *Silica*. This will explain why their results differ so essentially from mine.

After having thus satisfied myself of the composition of the residue above mentioned, I resumed my preliminary experiments, and proceeded to examine the muriatic solution obtained from the treatment of the mineral with potash and muriatic acid. From this solution some silica was separated. A portion of the liquid was treated with caustic ammonia, and then tested for *Lime* with oxalate of potash, but none of it could be detected. To the remaining liquor a considerable excess of subcarbonate of ammonia was added, and the precipitated matter was digested twenty-four hours. It was then separated by filtration, and the fluid was boiled till all the ammonia was expelled. No glucina was thus precipitated. Hence we conclude, that the very small portion of titanium above mentioned, rendered the whole of the glucina so refractory. The alumina precipitated by the subcarbonate of ammonia was mixed with a small quantity of oxide of iron. It was soluble in caustic potash, and with this alkali and sulphuric acid it gave regular octædral crystals of alum. The liquor, when tested with phosphate of soda and ammonia, was found to contain *no Magnesia.*

After the preliminary experiments, I commenced the following

ANALYSIS OF THE CHRYSOBERYL FROM HADDAM.

A. Five grammes of the mineral, reduced to small fragments in an iron mortar, were carefully porphyrised in one of agate, from which it acquired the additional weight of 0.13 grammes. The 5.13 grammes were then exposed to a red heat, and thereby suffered a diminution of 0.40 per 100.

B. The calcined mineral (*A*) was heated, during one hour, in the silver crucible, with caustic potash, and the product was treated with diluted muriatic acid; the solution was of a lemon yellow colour. There remained a white insoluble residue, which after calcination weighed 1.47 grammes. It was repeatedly calcined with caustic potash, and treated with diluted muriatic acid, with the following results:

After the 2d experiment, it weighed	0.97 grammes.
3d	0.89
4th	0.85

By the fifth treatment it was not diminished, and then presented itself in the form of a light white powder, resembling pure silica in appearance.

C. The residue (*B*) was repeatedly strongly calcined with six parts of nitrate of barytes, and subsequently boiled with nitric acid.

After the 1st treatment, there remained	0.43	grammes.
2d	0.15	
3d	0.06	

And by the 4th operation only 0.01 gramme was dissolved.

The remaining 0.05 grammes were essayed in the manner related in the preliminary experiments, and thus proved to be oxide of titanium. Hence we have 1. per 100 of that oxide.

D. The nitric solutions were united and evaporated to dryness, to expel the excess of the acid. The saline mass was dissolved in water, and after the barytes was separated with sulphuric acid, an excess of subcarbonate of ammonia was added to the solution. An abundant precipitate appeared, which entirely re-dissolved. The *Glucina* was precipitated by ebullition. After edulcoration and calcination, it weighed 0.79 grammes, or 15.80 per 100.

E. The several muriatic solutions (*B*) were united and evaporated to a dry mass, which was treated with muriatic acid, and there remained 0.33 grammes of silica, from which deduct 0.13 grammes acquired from the agate mortar; and there will be 0.20 grammes, or 4. per 100 as a constituent of the mineral.

F. After the silica was separated from the liquid (*E*), the alumina and oxide of iron were precipitated by means of a great excess of subcarbonate of ammonia. After twenty-four hours, the liquor was separated from the yellowish precipitate, and was boiled, but no *Glucina* was precipitated from it. The matter precipitated by the subcarbonate of ammonia consisted of 3.68 grammes of alumina, or 73.60 per 100., and 0.19 grammes of peroxide of iron, which, on account of the colour of the mineral, must be estimated as protoxide. The 0.19 grammes of peroxide are equivalent to 0.169 of protoxide, or 3.38 per 100.

THE CONSTITUENTS OF THIS CHRYSOBERYL THEREFORE ARE,

(Per 100 parts)

A.	Moisture	0.40
C.	Oxide of titanium	1.00
D.	Glucina	15.80
E.	Silica	4.00
F.	Alumina	73.60
F.	Protoxide of iron	3.38
		98.18
		100.00
	Loss	1.82

As the preceding results differed so essentially from the analyses of the chrysoberyl from Brazil by Klaproth and Arfwedson, I determined to examine a specimen from that locality. 1.5 grammes were analysed in the manner above mentioned, and the following results were obtained :—

(Per 100 parts)

Water	0.666
Oxide of titanium	2.666
Glucina	16.000
Silica	5.999
Alumina	68.666
Protoxide of iron	4.733
	98.730
	100.000
Loss	1.270

In estimating these constituents according to the electro-chemical theory, I believe that the oxide of titanium, notwithstanding its important agency in the analytical experiments, must be regarded as an accidental ingredient, as well as the oxide of iron, which in some measure may have been derived from the iron mortar. As the cymophane of Brazil appears to be constituted more conformably to the hypothesis of chemical proportions than that of Haddam, the following calculation may be made, founded on its composition, which gives for the essential constituents of Chrysoberyl,

(Per 100 parts)

Silica	6.61	containing Oxygen	3.32
Alumina	75.75		35.38
Glucina	17.64		5.49

and very nearly corresponds with the following mineralogical formula, A^4S+2GA^4.

No. IV.

Geological Account of the Valley of the Ohio: in a Letter from Daniel Drake, M. D. to Joseph Correa de Serra.—Read 7th Nov. 1818.

Cincinnati, Ohio, 1st October, 1817.

Sir,

I fear that you have long since thought me inattentive to your polite request, that I should send you a copy of the *Vertical Chart* which I had sketched of the valley of the Ohio river at this place. But so far from being regardless of your wish, an over anxious desire to gratify it fully has been the cause of my delay. I entertained, till lately, the hope of collecting such facts as would lead to some certain conclusions relative to the epochs and causes of this great excavation; but constant ill health, and an increase of my ordinary engagements, have left me so small a portion of time for research or reflection on extra-professional subjects, that I no longer expect to do more than give you an evidence of my disposition to amuse you.

Notwithstanding the delay of so many months, the graphic execution of the present copy is very little better than the original sketch which you saw in Philadelphia. It is, however, I trust, as accurate a representation as the perforations and admeasurements hitherto made at this place will admit. The elevations and projections are of course on different scales; which gives to the slopes a greater perpendicularity than is correct; but of this, and the other effects produced by combining two proportions in the same delineation, it is superfluous for me to apprise you.

You are, Sir, already apprised, from personal observation, that the alluvial formation of which I have here given you the profile, is divided near its middle by the Ohio river, and extends about a mile from either shore, exclusively of the valley of Licking river to the south, and that of Mill creek to the north-west. When viewed from any of the surrounding hills, this hollow, or expansion, appears nearly of a rhomboidal figure, and its area is equal, by estimation, to eight square miles. I have seen several places, particularly at the junction of other rivers with the Ohio, where its valley is dilated to the same extent; but, in general, it does not exceed half this width; and the current, instead of traversing the alluvial grounds in the centre, meanders from side to side, alternately approaching the hills of Ohio and Kentucky. Thus the earthy plains of one side are generally opposed to the rocky slopes of the other. Many of the former (in our provincial dialect termed *bottoms)* are so low as to suffer frequent inundation; but at Cincinnati and various other places, some of them rise fifty or even a hundred feet above the highest level of the river. The ascent to this elevation is generally over two or three successive terraces, mounting between twenty and fifty feet above each other, so as to exhibit, when viewed from the stream, the elevations of a vast amphitheatre. The alluvial platforms along many of the smaller rivers on the north side of the Ohio, are arranged on the same plan; but the ascent from one to the other is generally less than that stated for the principal valley. Very few of the slopes, or *taluses*, which we see in descending the Ohio, are entirely covered with vegetables, and most of them, towards their summits, exhibit naked perpendicular cliffs, which are yet suffering disintegration, and sufficiently indicate, that the last retreat of the sea was not at a *very* remote period. From an inspection of these precipices, and of the strata which are exposed to view in the bed of the river at low water, it appears probable that the flœts shell limestone of this quarter has experienced no disruption, for it has certainly suffered no elevation nor *bouleversement*. It still retains its horizontal position, or at most, varies from that in too slight a degree to warrant the conclusion, unequivocally, that the valley was formed either by an explosion and consequent rupture of the strata, or by their subsidence. How far their shrinking, from exsiccation, after being laid bare, may have contributed to its formation, I am not prepared to decide.* A hollow produced, however, by any of these causes, except perhaps the last, would, I apprehend, be a deep and irregular fissure, instead of a broad and shallow trench, like that of the Ohio.

To what agent, then, shall we ascribe this great excavation? It is obviously impossible to answer this question with certainty; but it would not perhaps be rash to conclude that, in its formation, there were two or three distinct and successive stages or epochs. Some kind of channel and some degree of declivity must have preceded the commencement of every river; . . . . . but whether this and the other initial excavations were produced by unknown causes which acted on the bottom of the sea, or by a violent elevation of that bottom at the time of its deliverance from the waters, I shall not offer a conjecture. Whatever may have been the *first* agent, the *second* undoubtedly was the vast and resistless currents that must have attended the transportation of the ocean from one bed to another. To these currents, acting upon strata not yet perhaps fully consolidated, and unsupported by the roots of a single plant, we may fairly attribute most of the extent and form of the present vallies.

By supposing the change of place in the sea to have been produced by the elevation of this continent, we can account in some degree for those irregularities of surface which originally directed the retiring waters into their present courses; but the uniform levelness and extensive continuity of our se-

* See Mr. Longmaire's Speculations in the Annals of Philosophy, Vol. 78.

condary formations, the comparative evenness of the surface, and the entire absence of primitive transition and ancient flœtz rocks *in situ*, would seem to render it probable that the retreat of the sea was occasioned by the sinking of another continent, and not by the elevation of this. Which of these alternatives, however, may have occurred, I shall not further attempt to inquire; but assume the hypothesis, that a great convulsion destroyed the relative elevation of this region, and that which is now covered by the Gulph of Mexico and the Carribean sea, from Florida to Cumaria;* in consequence of which the ocean flowed hence into its new bed, in the *direction* of the Mississippi. The valley of that river was of course the first excavation effected by the retiring waters. To this primary canal the others succeeded in the order of their distance from the common *embouchure*. These vast operations continued in all probability for several ages, during which the valleys constantly became deeper, wider, and more symmetrical. Meanwhile the *debris* of the various strata, at that time perhaps more friable than at present, were rolled, polished by attrition, intermixed, and accumulated in the lowest situations.

The currents, which I am supposing to have effected this great work, seem not to have been equally strong over every part of the country. To the south of the river the valleys have less symmetry, exhibit less strikingly the impress of aqueous currents, and contain but few rolled pebbles. On the contrary, we observe in that region numberless excavations which seem not referable to any action of the retiring waters, or of the subsequent rains. In some parts of Kentucky, these hollows, or *ravines*, are from one to two hundred feet in depth, have steep acclivities, and are so narrow at bottom, that their transverse sections would very much resemble in figure and magnitude the same sections of the hills they separate. It is difficult to believe these to have

* We may suppose this to have been either a distinct and limited convulsion, or a part of that general revolution which laid bare the existing continents of the globe.

been cut down by currents, and it would, I think, be more rational to regard them as the signs and products of a forcible elevation of that quarter, or else as cracks from the drying of the strata after being left by the sea, or even as inequalities formed simultaneously with the deposition of the strata where they are found. At some period subsequent to the complete retirement of the waters of the ocean, a third era in the formation of our valleys seems to have commenced. The rivers became much reduced in size, and began to flow in narrow channels, supported by the alluvion which they had previously transported. From this time, they appear to have effected but little horizontal detrition. *They have increased the depth of their beds, but not widened their valleys.* The Ohio, as you may see by a reference to the Chart, has a channel below the bottom of the alluvial deposits, to which it is confined, when not swollen by rains. This, I apprehend, is its own work, and has been effected since the existing state of the surface of the continent was produced. In front of Cincinnati, the depth of this canal is between thirty and forty feet in the centre, and it becomes shallower as we approach either shore, apparently at the same rate at which the velocity of the current decreases, from the middle to the margins of the stream. This bed is doubtless becoming deeper; but the ratio of increase is extremely slow, as no abrasion takes place except when the momentum of the waters is augmented by floods, which are generally transient in their duration. At all other times, the velocity of the current at the bottom is a minimum, or approaching to it. This is obvious in summer and autumn, when the water is so low and transparent, that its bottom may be seen from the surface. It may then be observed, that the bed in many places, from side to side, is covered with rolled pebbles; and that the rocks, where not thus protected, are overspread with minute *algæ musci*, dead leaves, twigs, and other light bodies, which the gentlest current would sweep away. Now where there is no current, it is obvious there can be no detrition.

It is a common opinion of the people on the banks of the Ohio, that its waters were always the same in quantity, and formerly occupied, in succession, various parts of the valley, at much higher levels than at present. By this supposition they attempt to account for the alluvial deposits, which, in many places, arise, as already stated, to the height of several yards above the most elevated high water mark of these times. But the excavation underneath the ancient beds of alluvion is as deep as that beneath the recent ones, and with the exception of the narrow channel in which the river now flows, every part of the valley is equally profound; when therefore the former were accumulated, the waters extended from hill to hill, and constituted a vast river, which must have swollen at times more than a hundred feet above the greatest altitude of the present comparatively diminutive stream. No other supposition, it appears to me, can account for the great elevation of the older alluvial banks. An illustration of this, upon a small scale, is afforded by the little torrents which descend during a shower, from an eminence, along a pre-existing *gully*;* where the declivity is great, and while the mass and motion of the waters are considerable, nothing is deposited; but as they decrease, the pebbles, mud, and light bodies, which are borne along, subside into beds, over which the reduced and narrow rivulet continues feebly to meander. The comparison cannot be extended any further; for a succeeding rain will deluge these little grounds, and perhaps raise them to a still greater height: but the causes which formerly spread the Ohio over the whole valley, have long since ceased to operate; and if its waters be not at this time diminishing, they are certainly not increasing.

I shall conclude this part of my letter with the following observations:—

1. The expansions in some parts of the valley of the Ohio, which I have conjectured were partly produced by

* Used provincially.

causes that acted before the retreat of the sea, or by the convulsion which occasioned that event, must have constituted at one period a series of little lakes, which were gradually, by the action of the waters, formed into the present continued and irregular canal.

2. It has been already stated, that on the south side of the Ohio its tributary streams flow in deeper vallies than on the north. This is obvious from the difference in current, when low, of these two classes of rivers, and from the very different distances at which their waters are rendered stagnant by the floods of the Ohio. When this river is greatly swollen, the current in the Kentucky river is destroyed nearly to Frankfort, a distance of forty miles, while that of the Great Miami in this State, a river of almost the same magnitude, is not suspended for more than twelve or fifteen. The principal vallies of the north are, however, much wider than those of the south. If they were all fissures originally, those of the south were probably the deepest. The present difference in their width has perhaps arisen from the sides of the former being composed of hard limestone, with but thin inter-laminæ of argillaceous matter, while the rocky strata of the latter are widely separated by friable marl and slate clay. It would appear, that to the south the currents had produced more vertical, in the north more horizontal, attrition.

3. In the very extensive artificial excavations made into the old alluvial formation at this place, the only aquatic animal remains, either of the river or the sea, which have been discovered, except those detached from the flœtz rocks, were the shells of a bivalve, which seems to be a species of *Mya*: but whether it inhabited the fresh or salt water, I am unable to decide. Hence it would seem that when these grounds were deposited, the waters had but few inhabitants. Those of the ocean had withdrawn, and those which the river now contains had not yet become its tenants. Whether this be admitted or not, it is certain that the alluvial deposits made at the present day are by no means free from river shells.

4. That the valleys of this quarter are not the work of causes which have acted regularly and unremittingly ever since the recession of the sea, but that there was a particular and distinct period of excavation, is rendered still more probable, by the fact, that their declivities are every where covered with a body of loam and soil: For while the causes which produced these slopes continued to act, it is impossible that mould or any loose matter should have been accumulated upon them.

5. What length of time has elapsed since the final descent of the ocean into its new bed, since the rivers completed the *lateral* excavation of their vallies, were reduced to their present size, and began to deposit the low and recent *bottoms*, I am not in possession any of data for determining. An accurate survey by us of those grounds, of the immediate and rocky channels of the streams, of the incomplete and increasing *taluses* of our hills, and of the vegetable mould which overspreads the face of the country, would furnish to a succeeding generation some important facts for an estimate of this kind. From the rate of advancement of the *downs* and natural sand *level* which border the southern shores of Michigan, and perhaps some of the other lakes, conclusions equally certain will hereafter, in all probability, be drawn.* By a reference to the Chart, you will perceive the lateral extent and various elevations of the alluvial formation at this place. You may suppose the section to be

* I do not know that these *downs* have been mentioned by any traveller or writer. I am informed by my friend Mr. William Harris, who was lately employed under the direction of the Surveyor General of the United States, in running the northern boundary line of this State, that they are found along the south eastern border of the lake for thirty or forty miles. In some places they extend two or three miles from the head. They are very numerous, of various shapes and sizes, and grouped in such a manner as to form basins or concavities, some of which are filled with water. Not a single rivulet flows from among them. There is very little soil spread over any of these hillocks, and part of them are quite destitute of vegetation. Others are thinly covered with small pine and oak trees. It is possible that this formation may have ceased growing, and that it cannot therefore serve as a natural chronometer.

made along Main Street in this town, and through the centre of Covington on the opposite side of the river, a short distance below the mouth of the Licking. It is necessary to consider yourself as placed west of this line, which is nearly on the meridian, with your face directed to the east, or up the river. From this position, it may be seen, that the plain, to the right hand, on the Kentucky side, has an elevation between that, which, in this town, we term the *bottom*, and that which is denominated the hill.

A very small part of the southern or Kentucky plain is liable to inundation, but the lower part of the northern was entirely overflown in the year 1793, and has been partially covered two or three times since.* These three tables differ somewhat in composition, as well as in elevation. That on which the opposite villages of Newport and Covington are built, is little else than a bed of sandy loam, to the greatest depths that it has yet been perforated. The bottom or lower plain on this side, is composed, in its superior parts, chiefly of loam and various coloured clays proper for bricks and coarse earthenware: in its inferior, of beds of strong *debris* consisting chiefly of primitive and transition gravel, which may be seen on the Covington side of the river, at the same depth. The upper table, or *hill*, consists chiefly of sand, gravel, and rolled pebbles, in some parts blended together, in others composing separate beds, the strata of which are either horizontal, or inclined and curved in various directions and degrees. Most of them *dip*, however, to the north and north west. It ought perhaps to be noted, that the sand, when in distinct beds, is generally underneath the pebbles. The greatest collection of the latter is in the upper parts of the table near its southern margin, or that which looks towards the river. Many openings have been made into this part of the plain, and it requires but the slightest inspection to perceive that it contains the wreck of various and very distinct strata. It is indeed an epitome of

* It is proper to observe, that the corporation has lately thrown up a levee that will prevent the future encroachments of the waters.

all the formations of the northern part of the continent, a great natural cabinet at once rich, confused, and instructive. Its multifarious specimens may be arranged in the following manner:

1. Fragments of fossil wood, which have been dug up at various depths, from ten to ninety feet. They are not mineralised, and *appear* to have belonged to trees of the same species with some of those which grow in our existing forests. I have not detected among them any tropical plants.

2. Grey, siliceous, and calcareous sand, which composes a great portion of the plain, and has probably resulted from the destruction of arenaceous limestone rocks, many strata of which exist in this country to the north and east.

3. Veins of blue and yellow clay, afforded no doubt by the marl, which in many parts of the limestone tracts, separate the laminæ of that formation.

4. Rolled and angular fragments of blue shell limestone, detached from the strata of the surrounding hills. Many of these are large tabular masses, and seem to have been brought only a short distance. None of them indeed could have come down the river more than one hundred miles, as this variety does not extend beyond that limit to the east. They are very numerous.

5. Polished *debris* of that kind of grey sandy limestone which the Sciota and Little Miami rivers traverse near their sources, and which have evidently been rolled hither by the copious streams that formerly flowed in the valleys of those rivers. These fragments are as numerous as the last.*

6. Rubble and boulders of grey variegated and micaceous sandstone, with minute fragments of coal, aluminous slate, and shivers, generally rendered smooth by attrition. These are from the country up the Ohio, where such strata are found *in place*. They are not so numerous as the two last.

7. Foreign or adventitious *debris*, consisting of granite of different colours, *gneiss*, *micaslate*, *hornblende*, *sienite*, *wacke*,

* These, on account of the whiteness of the lime into which they burn, are collected and used for that purpose.

porphyry, *trap*, *jasper*, *petrosilex*, *flint*, *agate*, *quartz*, and various other ancient species. These are of every size from small gravel to *boulders* fit for street and court paving. They are not angular, but have suffered attrition, until the distinctive characters of many fragments are almost obliterated, and a fracture must be made before they can be known. They are blended intimately with the other stoney wreck, and have not hitherto been found to occupy any distinct bed. The source of this *debris* of primitive and transition strata can be best ascertained by tracing its distribution over the country. I have observed pebbles of this kind on the Hudson river at West Point, where the plain is composed in part of rolled fragments. But as they are in general larger than those found on the Ohio, less worn and polished, have a greater proportion of mica slate pebbles, which do not seem to bear rolling to a great distance, and are mixed with rubble from the sand stone mountains of Katskill, they should, I think, be considered as being detached from the adjacent primitive rocks. An additional reason for this opinion may be drawn from the silence of our excellent friend Professor Mitchill as to the *debris* of ancient strata among the alluvion of the upper parts of the valley of this river.* It seems probable then that the currents which rolled and polished these fragments, did not extend laterally as far as the basin of the Hudson. We do not however depart from it westwardly but a short distance, before we meet with the ruins of primitive strata. An observing traveller, Mr. J. C. Warren, informs me that he saw them on the Chenongo, a branch of the Susquehanna, and observed them near all the streams in passing thence by the town of Erie on the lake, and along the Allegheny river to Pittsburg. Mr. Thomas Nuttall had previously noted the same thing during a journey in which he visited most of the principal rivers and lakes in the western part of New York. So much for the north-east. To the south-east and south, the valley of the Ohio seems to

* See Medical Repository, Vol. I.

constitute the boundary of this *debris*. Beyond that river, there are indeed but few water worn pebbles of *any* kind; and the narrow alluvions of the streams are generally argillaceous. I have travelled over most of the northern and north-eastern parts of Kentucky, and do not now recollect to have seen any foreign rolled pebbles. Mr. Warren has visited the north-western portions of the same State, and at my request was particularly attentive to this point, but did not discover any. The acute and observing Mr. Nuttall travelled through the centre of the same State from north to south on foot, but after leaving the valley of the Ohio opposite this town, he found none of these fragments until he approached the French Broad, in Tennessee, whose source is in a primordial formation. To the west and south-west, the currents of the great valley have transported the *debris* much farther. Mr. Nuttall has traced it only to the mouth of the river St. Francois; but my late lamented friend Dr. Goforth met with it in the form of gravel, not many miles above Natchez. To the north-west, it was found by Mr. Nuttall on the Missouri, as far as the great bend at the Mandan villages, beyond which he did not ascend. From the mouth of this river to Erie in Pennsylvania, the same persevering naturalist met with it on the shores of all the rivers and lakes which he visited, and from the information which he has kindly afforded me by letter, it appears that this *debris* is larger and in greater quantities in that region than this. Within the limits here sketched, it is found in the vicinity of all the streams, and forms with the ruins of the surrounding strata the bases of all the fertile and level prairies. We are hence, I think, justified in the conclusion, that its origin was in the north, and that it was brought and deposited on the surface of this country by currents which in ancient times flowed from beyond the lakes to the Gulf of Mexico, and of which it may be regarded as the sign and effect.

A more recent formation than many of the alluvial beds contained within the limits just defined, is the stratum of loam spread over the surface of our hills and valleys in an *overlying* position. This appears to be the same that in the north of Europe is denominated *geest*,* and which Mr. De Luc considers as the last deposit made by the sea before its final retreat. Sir Humphry Davy regards the soil or friable argillaceous surface of Great Britain at least, as having resulted from the disintegration of the rocky strata underneath.† There are doubtless but few rocks that would not be mouldered by exposure to the action of the atmosphere, and where the waters, before their final retreat, made no protecting layer, the argillaceous surface may be fairly referred to decomposition. But there is much reason for believing that the greater part of the *geest* of this country has subsided from fresh water, and is a true alluvion. It varies considerably, I acknowledge, in different places, but its essential consituents, clay, sand, and yellow oxide of iron, combined in varying proportions, seem still to be present. It is indeed destitute of the remains of aquatic animals, and might not therefore be supposed to have had the origin here intimated; but the old alluvial beds which have manifestly been accumulated by water, either salt or fresh, are almost equally destitute of aquatic exuviæ. On the other hand, it exhibits, in some places, an obscure stratification, it does not abound particularly in the undecomposed fragments of the rocks over which it is spread, its colour and density are nearly the same from bottom to top, and it envelopes, as we shall presently see, along with more or less gravel, large masses of adventitious rocks, conditions that sufficiently characterise it as a distinct and real *formation*. It has been washed by the rains into the lower parts of the valleys, where becoming blended with the recent alluvion of the streams, it encloses the bones of the arctic elephant, great mastodon, and other extinct quadrupeds. On the south side of the Ohio, it is only from four to eight or twelve feet deep; but to the

* L' Histoire de la Terre et de l' Homme, tome v.

† See his Elements of Agricultural Chemistry.

north of that river, its thickness becomes so great, that the flœtz limestone is but here and there seen projecting through it.

The deposition of the *geest* seems to have been the last operation which the waters of the north performed upon this region; and was of course subsequent to the excavation of the valleys, as no deposit could have remained upon their acclivities, while the agent which formed them continued its action. You are, Sir, already apprised, that to this formation belong the great blocks of foreign primitive, transition, and old flœtz rocks, which have excited in travellers so much astonishment, and which, in one point of resemblance at least, approximate the region south of Erie, Huron, Michigan, and the other lakes, so closely to that which stretches from the southern shores of the Baltic sea.

These masses, in the neighbourhood of this place, are for the most part solitary, but in the interior of the State, it is not uncommon to find them grouped into heaps which are slightly covered with soil; and it is, I suspect, an aggregation of this kind, on one of the islands of Lake Huron, that a British officer mistook for granite *in place*.* The size of these masses extends from that of gravel and pebbles to the diameter of eight or ten feet. The larger blocks are frequently found *upon* the old alluvial plains, but never, that I have understood, *within* them. Their geographical range is over the same region with the smaller foreign *debris* of our valleys, but more limited to the south west. I have never seen a single block on the opposite side of the Ohio, and am not informed that any have been observed lower than the thirty-ninth degree of latitude.

I do not entertain a doubt that these fragments were enveloped in large fields of ice in a region far beyond the lakes, and floated hither by the same inundations that brought down and spread over the surface of this country the *geest* in which they are imbedded. In the southern parts

* See Thompson's Annals of Phil. for March, 1816.

of this formation, they are not found; but this should be attributed to the influence of climate. The ice to which they were attached could not of course pass a certain latitude; and from the great increase of these masses as we advance towards the north, it would seem that many of the ice-bergs suffered dissolution long before they arrived at this *maximum*. Future observers will no doubt trace them to their parent strata in the arctic regions, as Von Buck has traced those which are lodged on the shores of the Baltic. The ice islands of the Atlantic ocean may reasonably be supposed to bring down, and deposit on its bed in the Temperate Zone, primordial masses, similar to those spread over some parts of this and the European continent. These islands are, I believe, not often seen further south than the forty-first degree, near two degrees north of their southern boundary here. This is probably attributable to the gulf stream; but for which, the larger tracts of ice would undoubtedly attain as low a latitude as the southern limits of the primitive blocks in this country: and hence a probable conclusion may be drawn, that the temperature of the northern hemisphere has undergone but little change since the remote epoch when this part of the continent was for the last time subjected to inundation.

I shall, Sir, no longer employ you with my premature, and, I fear, abortive attempts at generalising some of the geological phenomena of this country. I have, indeed, occupied too much of your time in the discussion of points with which perhaps you were already better acquainted than myself.

I have drawn liberally on your patience, because the kindness which you have shown me at various times has inspired a hope, that you will excuse both the tediousness and temerity of my speculations. However this may be, I trust you will at least perceive in them a manifestation of the profound respect with which I have the honour to be,

Sir,

Your obliged friend and servant,

DANIEL DRAKE, M. D.

His Excellency,
The Chevalier Joseph Correa de Serra.
Min. Plenipot. of the
Kingdom of the Brazils.

No. V.

Tables of Observations on the Winds, the Currents, the Gulph Stream, the Comparative Temperature of the Air and Water, &c. made on the North Atlantic Ocean, during Twenty-six Voyages to and from Europe, (principally between Philadelphia and Liverpool,) between the years 1799 *and* 1817, *inclusive. By John Hamilton.*

TABLE I.

Observations on the Winds.

Month	Day	Year	Number of days from the North.	From the Westward.	From the Eastward.	From the Southward	Variations
Jan.	20	1800	2	2	10	3	3
	27	1804	4	13	3	1	6
	29	1809	12	17			
	5	1816			2	3	
	17	1817	2	13		1	1
Days.	98		20	45	15	8	10
Feb.	14	1799	2	6	[illegible]		2
	23	1801	1	15	1	1	5
	28	1803	5	15	5	3	2
	16	1812	1	5	4	6	
	25		3	18	4		
	29	1816	3	10	4	9	3
Days.	135		1.	69	22	19	12
March	21	1799	2	13	1	3	2
	16	1803	2	11		3	
	21	1805	1	15	2	2	1
	31	1806	5	11	11	2	2
	31	1807	1	19	8	1	2
	26	1808	3	13	6	2	2
	11	1812	2	5	1	2	1
	18			12	2		4
	7	1815		1	6		
	6	1816	1	1		4	
	10	1817	5	4	1		
Days.	198		22	105	38	19	14

Month	Day	Year	S.	W	E	N.	Variations.
April	30	1800		25	2	3	
	30	1802		21	1	5	3
	30	1804		27	1	1	1
	30	1805		29	1		
	16	1807		8	3	2	3
	23	1808	2	11		5	5
	13	1812	2	5	2	3	1
	5			3		2	
	27	1815	1	7	7	10	2
	30	1817	6	14	8		2
Days	234		11	150	25	31	17
May	31	1800	2	19	7	2	1
	31	1801	1	17	3	5	5
	23	1802	4	9	5	1	4
	27	1803	3	11	6	6	1
	17	1804		10	4	2	1
	26	1806	2	15	5	3	1
	31	1809	2	18	10	1	
	25	1812	2	14	4	2	3
	13		2	9	1		1
	5	1815			4		1
	26	1816	4	8	8	5	1
	9	1817		2	7		
Days.	264		22	132	64		9

Month	Day	Year	N.	S.	E.	W.	Variations
June	21	1800		1	5	14	1
	23	1801		2	6	12	3
	28	1803	5	1	7	15	
	23	1811	1	14	2	4	4
	20				6	13	1
	30	1815	2	2	1	18	7
	25	1817		3	6	12	4
Days	172		8	23	33	88	20
July	9	1799		3	4		2
	9	1801	1	2		5	1
	12	1802	2	2	8	6	1
	23	1804	1	3	1	18	2
	18	1809	1		5	9	3
	14	1815			1	13	
	31	1816	7	2	2	19	1
Days	125		12	12	21	70	10
Aug	31	1799	4	3	7	11	6
	31	1800		2	3	16	10
	19	1801			2	11	6
	17	1802	7	2		6	2
	31	1806		1	6	23	1
	20	1807		2	4	11	3
	20	1810	3	5	2	9	1
	6					6	
	23	1816	2	1	5	15	
	25	1817	2			21	2
Days	223		18	16	29	129	31
Sept.	7	1799	1	1	4	1	
	14	1801		2	5	6	1
	21	1804	1	2	5	10	3
	28	1807	4	1	4	15	4
	30	1809	2	1	3	22	2
	26		9	1	7	6	3
	7	1815	6				1
	26	1817	5	2		15	4
Days.	159		28	10	28	75	18

Month	Day	Year	N	S	E	W.	Variations
Octob	31	1802	1	2		21	5
	29	1804	2	2		20	3
	31	1810	5			18	3
	31		2	1	16	9	5
	20	1815	4		1	15	
Days	144		14	5	20	83	16
Nov.	4	1799				3	1
	30	1800			11	18	1
	30	1802	1		4	24	1
	21	1806	2	5	6	7	1
	13	1809	3		2	8	
Days.	98		6	5	23	60	4
Dec.	31	1799		7	6	14	4
	23	1800	1	1	4	14	3
	31	1803			14	13	4
	19	1805	1	2	6	9	1
	29	1807		4	2	18	5
	15	1810	3			10	2
	14	1811		2		12	
	6			1	2	3	
	11	1816	4		3	2	2
Days.	179		9	17	37	95	21

January	98 days
February	135
March	198
April	254
May	264
June	172
July	125
August	223
September	159
October	144
November	98
December	179
Total Days	2029

REMARKS.

It appears from the foregoing table, that out of 2029 days, the wind prevailed,

208	days from the	Northward,
167		Southward,
364		Eastward,
1101		Westward.
192	Variable.	
Days 2029		

By the foregoing statement, it will be seen, that very frequently I was at sea only during part of the months.

In the division of the winds, I have called all the points of the compass between NNW. and SSW. *westerly;* those between SSW. and SSE. *southerly;* those between SSE. and NNE. *easterly;* and those between NNE. and NNW. *northerly.* The observations were all made to the northward of the latitude of 33° N. to about 55° N. The SW. winds I consider to predominate, continuing to blow very frequently a week or ten days together. Whereas NW. winds seldom blow more than three days together. Those from SSW. to SSE. for the most part produce rain, and are of short continuance; being superseded by northerly or northwest winds in a few hours.

The wind, according to the above statement, blew more than one half the time from the westward, in the aggregate; and taking the months separately, never less than half, and in some, two-thirds. From the eastward, it blew generally one-fifth or one-sixth of the month.

TABLE II.

Observations on the Currents.

Month	Lat. N.	Lon. W.	Temp. of Air.	Temp of Water.	Direction of Current.	Month	Lat. N.	Lon. W.	Temp. of Air.	Temp of Water.	Direction of Current.
	°	°	°	°			°	°	°	°	
Jan.	48	24	50	55	Northerly.	April.	50	13	49	51	Northerly.
								15	52	50	"
Feb.		17	54	52	Southerl. 20′ per day.			19	53	50	"
		18	48	52	" 15		48	26	46	51	"
	47	25	54	52	" 14			14	56	50	Southerly.
	45	32	53	54	" 15		45	26	52	54	S. W. Strong.
	44	34	54	55	" 17		44	29	54	54	Southerly 21′ sd.
		35	56	56	"		42	22	62	57	"
		37	47	53	" 14						
	42	45	59	62	" 22	May	49	16	55	52	Northerly.
							48	21	50	53	"
March	46	25	59	52	Southerly. Strong.		47	26	57	54	"
		27	61	53	"		45	32	62	58	" 17
	45	29	60	54	"		43	41	65	63	"
	44	33	60	56	"						"
		37	62	57	"						"
	41	40	62	57	"						"

Month	Lat N.	Lon. W.	Temp. of Air.	Temp. of Water.	Direction of Current.
	°	°	°	°	
June	49	22	58	55	SE.
		17	59	50	"
	48	14	56	50	Southerly.
	46	15	59	57	" 27 per day.
	45	18	56	58	" 20
		20	57	59	"
		36	61	63	" 19
	42	22	59	61	" 16
		29	58	61	" 20
		37	66	65	" 25
	41	40	65	63	"
July	50	15	60	59	"
	50	20	60	57	"
	49	12	61	59	"
	49	14	61	59	"
	47	14	60	60	" 18' sd.
	49	17	61	59	"
	44	18	62	62	" 18
	49	19	60	58	"
	44	20	64	65	"
	42	41	75	75	NW.
	43	35	73	71	SW.
	41	30	71	70	"
	41	31	71	71	Southerly.
	41	33	74	72	SW.
	41	38	74	71	Southerly.
	40	42	75	75	SE. Continue in G. S.
Aug.	40	19	61	58	Southerly.
	49	23	60	57	"
	48	20	59	59	"
	47	35	60	59	"
	47	25	56	56	" Strong.
	47	27	58	58	"
	47	15	61	59	" 14'
	46	43	67	61	Northerly.
	46	21	60	60	Southerly.
	46	19	60	59	" 15'
	46	27	61	55	"
	45	30	60	61	"
	44	47	63	58	Northerly.
	44	49	57	58	"
Aug.	44	35	63	62	Southerly. 23' per day.
	43	37	61	62	" Strong.
	45	39	63	64	" 26'
	43	41	67	66	" 14
	45	45	66	68	"
	43	49	56	48	SE. Strong.
	43	23	64	64	Southerly 15'
	45	24	68	66	" 15
	42	50	56	55	"
	42	25	71	67	"
Sept.	49	25	56	55	"
	47	25	56	56	"
	47	33	62	57	Northerly. Strong.
	47	30	65	58	" 15'
	45	38	66	62	Southerly.
	45	39	65	62	"
	45	41	73	71	"
	45	30	63	60	"
	45	34	70	62	"
	45	40	61	60	"
	44	40	68	25	"
	42	44	60	65	"
	41	37	70	70	"
	41	42	67	73	SE. Current 20' sd.
Octob.	49	27	58	56	Northerly. 17'
	49	25	58	58	" 15
	49	19	57	58	"
	48	33	52	58	" 74' in 3 days.
	48	32	58	58	" 14
	47	25	55	56	Southerly 16
	41	36	59	61	" Strong.
	43	47	53	58	Northerly 16'
	45	37	59	61	Southerly. Strong.
	42	39	51	59	"
	49	16	58	57	"
	49	18	58	57	"
	49	20	59	57	"
Nov.					
Dec.	43	49	58	45	Northerly.

REMARKS.

In the month of January I was seldom at sea; and indeed the weather is so boisterous in that as well as the other winter months, that it is difficult, by celestial observations, to detect a current. Nor can sufficient reliance be placed on the steerage of the ship, or courses and distances by log, to be certain of the true cause of any disagreement between the dead reckoning and observations. But when the disagreement happens to be on the same side, not only during several days in succession, but for a number of voyages, there should be no hesitation in giving credit to the existence of a current. I was a long time almost induced to conclude that some of these currents, particularly those which continually prevail between the Grand Bank of Newfoundland and the coast of Europe, were periodical, running one half the year in each direction. And the foregoing Table, with a few exceptions, and those might have been counter currents on the edge of the great stream, for I have invariably found the one always accompanying the other, tends rather to strengthen than to invalidate such an opinion.

In February, as well as March, from latitude 41° to 48° N. the set seems to have been to the southward, without a single exception.

In April, on the parallels of 48° to 50° N. and between the meridians 18° (which is near soundings) and 26° W. its direction was northerly, while at other times, from 48° to 52° N. and from 14° to 29° W. it set to the southward.

In May, between 40° and 48° N. and 16° and 41° W. the current ran invariably to the northward.

In June, always southerly, and for the most part strong.

In July, southerly all the time. And

In August, with only two exceptions.

In September, the same.

In October, sometimes one way and sometimes the other; but throughout the whole, I never knew the current to change from one day to another, only to vary in different years. When that from the northward has prevailed to a great extent, I have always experienced a set in the opposite direction, both in the neighbourhood of the eastern edge of the Bank of Newfoundland and along the west coast of Ireland.

These observations do not extend to the westward of the longitude of 45° W. or to the southward of 41° N. The currents to the southward and westward of these limits belong to the Gulf Stream.

TABLE III.

Observations on the Gulf Stream.

Month.	Lat. N. ° ′	Long. W. ° ′	Temp. of Air. °	Temp. of Water. °	Month.	Lat. N. ° ′	Long. W. ° ′	Temp. of Air. °	Temp. of Water. °
April 21.	32 15	77 18	70	72	June 11.	38 45	61 35	71	71
February 15.	32 40	78 9	65	71	November 1.	38 54	57 46	71	70
April 22.	34 16	75 7	61	71	5.	38 52	52 22	67	68
September 5.	34 42	69 38	79	81	December 1.	38 3	67 17	60	68
6.	35 58	71 5	76	78	October 1.	39 13	58 13	71	76
October 23.	35 38	73 23	65	73	February 21	39 1	53 10	54	64
September 28.	36 50	66 57	67	77	December 28	39 2	57 7	63	66
March 3.	36 40	72 11	69	72	29	39 34	54 46	57	67
May 2.	36 49	71 42	68	74	June 7.	39 37	48 41	69	71
March 29.	37 39	67 29	60	71	July 29.	39 2	66 51	73	70
September 26.	37 42	71 7	67	73	30.	39 12	69 44	75	73
29	37 27	64 2	65	76	31.	39 41	63 39	77	74
May 2.	37 54	68	54	70	October 7.	39 14	48 54	57	67
December 23	37 22	70 10	53	72	March 17.	39 59	58	57	58
24	37 39	69	67	72	May 24.	39 57	61 3	65	68
25.	37 56	67	65	69	November 4.	39 6	52 30	66	68
May 30.	37 36	68 42	71	73	October 2.	40 6	56 37	69	70
December 21.	37 49	63 45	59	63	3.	40 43	56 22	62	70
22.	37 47	60 10	62	63	July 31.	40 39	41 35	75	75
23	37 54	56 15	60	63	August 1.	40 6	42 56	75	77
October 31.	37 34	61 39	71	70	2.	40 15	45 43	76	76
May 5.	37 49	68 58	53	67	3.	40 49	45 5	76	76
6.	37 34	66 59	55	68	1.	40 20	60 32	77	76
7.	37 52	64 24	57	67	2.	40 52	57 19	74	72
March 30.	38 4	64 23	69	70	29.	40 27	64 23	64	73
September 30	38 5	62	69	77	30	40 6	65 3	67	73
May 4.	38 2	61 15	61	69	31.	40 58	65 56	70	70
5.	38 9	57 50	68	69	September 1.	40 33	67 11	69	71
December 26	38 30	64 21	59	70	October 13.	40 46	65 9	55	69
27	38 26	61 33	61	70	14.	40 42	65 2	59	73
June 1.	38 25	62	65	70	July 1.	41 29	57 [illegible]	[illegible]	74
2.	38 20	59 36	64	69	October 4.	41 14	53 5[illegible]	66	71
3.	38 28	58 23	65	72	16.	41 10	41 7	60	65
July 27.	38 30	68 26	72	72	September 16.	41 41	54 51	70	75
June 10.	38 40	65 35	70	73					

REMARKS.

The greater part of these longitudes having been determined by an excellent chronometer, may be depended upon as correct. It must however be evident to every navigator of observation and experience, who has been in the habit of traversing this current, that it is impossible to define, with any degree of accuracy, its precise limits; as it is influenced to a great degree by the wind.

Sometimes you find it spread to a greater breadth than usual, with diminished force and altered directions, (at least of several points,) at other times compressed into a narrow stream, and running with increased rapidity.

However, in the above Table, I have kept nearly in the middle of it, seldom approaching near either limit, or so far to the north or south as I have often experienced its influence.

I have observed, that after it passes the tail of the Grand Bank of Newfoundland, the main stream proceeds in a south-east direction, while several ramifications, generally not very strong in their currents, branch off to the NE. and from that to east, with counter currents in the intermediate spaces.

About two years ago, having been detained several days in that neighbourhood by light baffling winds, I had an opportunity, by my chronometer, and repeated observations through the day, of ascertaining the various directions of the currents, as well as their velocity. On both sides of the Gulf Stream, a counter current, running in the opposite direction, is invariably met with. I have frequently, with a free wind, by often attending to the temperature of the water with the thermometer, succeeded in availing myself of its assistance, so as to have the ship drifted 4° ahead of her reckoning. From the longitude of about 55° to soundings, (in the south side of the Stream) to the northward, the same effects are produced, but I think not quite in so great a degree. In George's Bank, there are regular tides. And the Gulf Stream often trespasses on the soundings to the southward of Nantucket. From thence as far as the capes of the Chesapeake, I have seldom failed to experience a SW. current.

By the frequent use of a thermometer, the navigator may always discover when he touches upon the Gulf Stream; and if he is bound to the eastward, benefit by its current;

or if the contrary, shun its influence. On the north side, the difference of temperature of Gulf and ocean water, is at least 10°, on an average; but greater in the winter than summer season. On the southern side of the Stream, the difference of temperature is never less than 5°. If any one will only be at the pains of trying the water two or three times in the twenty-four hours, he cannot be mistaken on this subject.

In other currents than the Gulf Stream, the water is generally from 2° to 4° warmer than out of the current.

TABLE IV.

Temperature of the Air and Water on Soundings.

Month.	Lat. N.	Temp. of Air.	Temp. of Water.	Depth.
OFF THE CAPES OF DELAWARE.				
	° ′	°	°	
March 26.	Off Capes	48	46	Soundings.
5.	37 45	50	44	50 fathoms.
April 14	37 32	56	41	35
March 25.	Off Capes	49	42	Soundings.
6.	"	48	42	17 fathoms.
8.	"	36	41	20
April 13.	38 34	54	41	22
22.	38 35	52	41	35
23.	"	52	42	20
10.	39 15	56	44	Soundings.
May 1.	Off Dela.	56	50	"
2.	38 12	63	50	38 fathoms.
18.	"	60	52	14
1.	"	52	44	10
July 15.	38 50	76	74	30
14.	39 6	74	71	50
August 20.	39 56	73	68	60
September 8	39 3	67	71	Soundings.
9	38 23	67	65	"
7.	38 57	64	61	"
8	Off Capes.	64	62	16 fathoms.
26.	38 47	71	69	27
27.	39 10	62	61	26
Octobr 20.	Off Capes.	57	61	Soundings.
19.	38 50	57	60	20 fathoms.
20.	38 20	57	61	15
November 1.	39 4	51	53	16
December 21	Off Capes.	40	46	Soundings.
18	"	21	39	15 fathoms.

Month.	Lat. N.	Temp. of Air.	Temp. of Water.	Depth.
GEORGE'S BANK.				
	° ′	°	°	
July 8.		62	54	53 fathoms.
9.	40 15	68	62	60
12.	40 15	71	69	35
August 13.	40 54	69	62	Soundings.
18.	40 20	70	68	60 fathoms.
12.		61	55	55
September 22	40 42	65	61	50
23.	40 13	68	62	53
20	41 23	64	54	40
21	41 7	65	56	45
22	41 12	56	56	41
ON AND NEAR THE GRAND BANK OF NEWFOUNDLAND.				
	° ′	°	°	
March 10.	42 3	52	56	Tail.
13.	42 21	53	36	"
April 5.	41 47	55	32	"
May 16.	42 57	52	41	"
28.	42 44	54	39	"
August 5.	43 28	59	57	30 fathoms.
21.	43 21	56	48	"
September 15	42 10	58	48	Tail.
30	43 57	51	53	Soundings
October 3.	42 23	53	47	Tail.
7.	43 15	58	46	57 fathoms.
D cember 8.	42 54	58	39	Tail.
9	43 31	58	45	Soundings.

Month.	Lat. N.	Temp. of Air.	Temp. of Water.	Depth.
OFF THE BRITISH CHANNELS.				
	° ′	°	°	
January 30.	50 9	50	51	74 fathoms.
February 27.	49 39	48	47	Soundings.
26.	51 19	55	44	65 fathoms.
March 28.	49 18	53	50	Soundings.
27.	50 15	51	48	"
7.	50 29	51	45	67 fathoms.
7.	51 15	51	42	70
April 19.	49 57	50	50	80
22.	49 32	52	49	Soundings.
19.	50 51	50	49	65 fathoms.
22.	50 51	46	48	50
21.	50 33	49	48	Soundings.
May 31.	49 43	57	54	76 fathoms.
30.	50 9	54	53	67
19.	50 28	53	58	85
20.	50 57	54	51	80
29.	51 40	56	53	75
30.	51 3	52	49	65
June 11.	50 49	54	50	70
20.	50 55	60	57	85
21.	50 54	62	58	Cape Clear.
12.	51 47	55	50	40 fathoms.
21.	51 18	63	58	Kinsale.
July 25.	49 9	60	58	Soundings.
24.	50 58	59	57	50 fathoms.
August 15.	50 41	53	53	70
20.	50 54	62	59	60
21	50 22	64	59	80
17.	51 54	69	59	45
19.	51 4	69	60	65
October 18.	50 28	60	58	90
3.	50 52	58	55	Soundings.
1.	51 47	59	57	36 fathoms.
November 22.	50 32	52	48	67
23.	51 6	53	50	55
December 25.	50 40	62	47	80

AVERAGE TEMPERATURE OF THE WATER, OFF THE DELAWARE, IN

	°
March	43
April	43
May	49
July	70
August	70
September	65
October	60
November	53
December	40

ON GEORGE'S BANK.

	°
July	50
August	50
September	50

ON THE COAST OF IRELAND

	°
January and February about	48
March	46
April	49
May	52
June	54
July	57
August	59
October	57
November	50
December	47

REMARKS.

The experiments on George's Bank were too few to be satisfactory. Besides, several of the temperatures in the foregoing Table were not properly on George's Bank, but to the southward of it, where the Gulf Stream often extends, and the water is consequently always much warmer. It will be found to be uniformly the case, that the water is much colder on banks, than on soundings shelving gradually from the land. In summer, the difference of temperature of the water, on and off soundings, on the coast of

America, is not so great, as at other seasons of the year; and on the edge of soundings, it will mostly be found to be colder than in shoaler water. On the other side of the Atlantic, at least in St George's Channel, the reverse is the case.

Off the coast of Ireland, the thermometer is of very little service in indicating soundings; the water seldom falling more than 3°, and sometimes continuing the same as before.

In using the thermometer, I deem it quite unnecessary to take into consideration the relative temperatures of the air and water; as the very great changes which frequently take place in the former, from day to day, have no sensible effect on the latter, which only varies with the varying seasons.

TABLE V.

Mean Temperature of the Air and Water, in the Atlantic Ocean, in different Latitudes, during every Month in the Year.

N. Latitude.	January Air.	January Wat. Ha.	January Wat. Wil.	Febru. Air.	Febru. Wat. Ha.	Febru. Wat. Wil.	March Air.	March Wat. Ha.	March Wat. Wil.	April Air.	April Wat. Ha.	April Wat. Wil.	May Air.	May Wat. Ha.	May Wat. Wil.	June Air.	June Wat. Ha.	June Wat. Wil.	July Air.	July Wat. Ha.	July Wat. Wil.	August Air.	August Wat. Ha.	August Wat. Wil.	Septem. Air.	Septem. Wat. Ha.	Septem. Wat. Wil.	October Air.	October Wat. Ha.	October Wat. Wil.	Novem. Air.	Novem. Wat. Ha.	Novem. Wat. Wil.	Decem. Air.	Decem. Wat. Ha.	Decem. Wat. Wil.
38	53	57	52	50	60	58	57	57	61	60	58	64	61	60	70	66	[illegible]	71	68	68	72			72	67	68	71			62	55	58	58	50	60	56
39	54	55	51	56	57	51	58	57	56	58	59	60	61	60	63	69	65	69	64	63	71	65	69	71	63	63	71	57	61	71			61	60	57	55
40			49	58	58	53	58	56	60	57	57	62	61	58	68	65	62	70			71			71	69	63	70	57	59	60	62	61	56	62	60	54
41	50	61	46	51	54	50	58	54	59	56	56	61	64	60	67	64	61	70	68	68	70	70	69	70	66	66	69	58	59	59			55	54	61	53
42	55	61	46	56	58	49	59	53	58	55	55	60	63	58	66	63	62	69	63	61	70	67	64	70	67	67	68	57	58	58	62	60	54			52
43			46	52	55	48	59	55	56	58	56	59	63	60	65	60	60	68	69	69	69	64	63	69	61	64	66	57	56	57	61	59	53			51
44	50	58	45	59	55	47			55			58			64	62	60	67	64	63	69	63	60	69	63	63	64	58	59	56	59	58	52	59	55	50
45	55	57	45	53	54	46	57	54	54	56	54	57	62	58	63	58	57	66			68			68	63	60	63			55	61	57	51			49
46			44	51	52	46	59	52	54	56	54	56			62	58	57	65			67	62	60	67	63	60	62			54	58	53	50			47
47	49	53	44			46	54	50	55			56			61			64	60	60	60	[illegible]	58	66	56	56	61	55	56	53	58	53	49			47
48	50	53	43	50	49	45	53	50	53	50	50	54			60	58	56	63			65	58	57	65	56	56	60			52	56	51	48			46
49	50	51	43			45	52	50	51	52	50	54	56	53	59	56	53	62	60	58	64			61	56	55	59	53	53	51			47			45
50	50	51	43	53	52	45			50	50	50	53	52	51	58	56	53	61	60	58	63	60	57	63	55	55	58			51	53	51	47			45

Mean Annual Temperature of the Water.

N. Latitude.	Water. Ha.	Water. Wil.
38	61^{64}	64
39	61^{63}	63
40	60^{62}	62
41	61	61
42	60	60
43	59	59
44	59	58
45	56	57
46	56	56
47	55	55
48	53	54
49	53	54
50	54	53

REMARKS.

The second column of Temperature of the Water is taken from a similar Table of General Jonathan Williams in his Treatise on Thermometrical Navigation.

The mean temperature of the water for each distinct month, on a particular parallel of latitude, does not always correspond with J. Williams's Table of the same kind, though the mean annual temperatures in each latitude agree very well as far down as the parallel of 40° N. when a uniformity prevails, as far as I have traced it to the south, viz. 38° N. I can, however, readily account for the water, by my observations, not being so warm, in general, as by his; as in taking the mean, I have never brought into the calculation those made in the Gulf Stream, or any other ascertained currents. Now those parallels embrace the Gulf Stream, for its course of seven or eight hundred miles at least; and you will commonly experience a current in them as far to the eastward as the Western Islands; and it is well known that the water is always warmer in currents than out of them.

My mean, between longitude 15° and 45° west, agrees with Williams's.

I believe the difference of temperature of the water in the Gulf Stream, and its counter currents, to be very small, if there be any at all, and that the breadth of the latter, particularly on the southern edge of the Gulf, is not inconsiderable. For in the early part of my acquaintance with the Gulf, before I had ascertained its limits, various courses, and the influence of the winds on these, I have several times, when steering as I supposed in the very centre of it, from the neighbourhood of the Delaware to the Banks of Newfoundland, afterwards discovered that I had been almost all the time in the counter current. I consider it more difficult, in short, to keep in the easterly current than in the other, as the temperature of the water will always apprise you when in or out of the current; and, with a free wind, a person, bound to the westward, has only to steer out now and then, until the temperature of the water begins to fall, and by that means he will avoid penetrating through into the Gulf. The substance called *Gulf-weed* is no mark by which the stream can be distinguished, as it is met with in great quantities throughout the middle latitudes, to the westward of the Azores, and northward of Bermuda.

TABLE VI.

Mean Temperature of the Air and Water, between the Latitudes of 40° and 50° N. and the Longitudes of 15° and 45° W.

Month.	40°		41°		42°		43°		44°		45°		46°		47°		48°		49°		50°	
	Air.	Wat	Air	Wat	Air.	Wat	Air.	Wat	Air.	Wat	Air.	Wat	Air	Wat	Air.	Wat	Air	Wat	Air.	Wat	Air.	Wat
January.	59	56	55	54	55	61	51	57	50	58	55	$57\frac{3}{8}$	53	55	51	54	50	53	50	51	48	$45\frac{3}{4}$
February	58	59	59	$56\frac{5}{8}$	56	60	52	55	52	54	53	54	51	52	54	52	51	$51\frac{5}{6}$	50	50	50	$47\frac{3}{4}$
March.	58	56	60	$55\frac{5}{7}$	63	55	56	55	60	55	56	54	59	52	54	50	51	49	51	49	53	50
April.	61	$59\frac{5}{8}$	55	$59\frac{5}{7}$	58	55	54	55	60	$54\frac{5}{6}$	55	54	55	53	53	52	48	50	52	52	52	50
May	61	59	65	$64\frac{2}{3}$	63	58	63	60	63	57	62	58	56	53	57	53	52	$52\frac{4}{5}$	55	52	52	51
June.	64	62	61	$63\frac{2}{3}$	61	61	59	60	62	60	58	57	59	56	61	56	60	55	56	53	56	$55\frac{4}{5}$
July	75	75	71	$71\frac{3}{4}$	66	67	71	70	63	62	60	60	60	57	60	60	60	56	60	58	60	58
August.	75	76	68	70	67	$66\frac{1}{3}$	64	$65\frac{3}{4}$	$62\frac{3}{4}$	62	60	61	61	60	59	58	58	57	59	57	60	57
September	70	68	69	$69\frac{1}{3}$	64	67	64	62	63	64	63	60	63	60	57	56	56	56	56	55	55	55
October.	61	60	58	59	60	$56\frac{1}{3}$	61	60	58	59	59	56	60	57	56	56	56	56	58	$57\frac{2}{5}$	56	55
November.	62	61	58	$56\frac{5}{8}$	57	52	61	59	58	59	58	53	58	53	58	53	55	61	60	55	53	51
December.	60	54	55	53	55	58	54	51	59	55	56	50	55	48	54	50	50	48	66	51	59	49

REMARKS.

The figures written across the lines are the mean of the difference (when any difference occurs) between this and Table V. It is very apparent, from these observations, that although you most generally find the water become progressively colder the farther you advance to the northward, or as the season itself becomes colder, yet this does not always happen; so that it is utterly impossible to form, with accuracy, such a Table as the ingenious Mr. Williams has attempted. Yet he is certainly entitled to a great deal of credit for the correctness of many of the deductions in his work on Thermometrical Navigation, considering the limited experiments he had an opportunity of making, in the very few voyages performed by him. He appears to have been so sanguine, as almost to believe that this science might be reduced to such perfection, as to enable the navigator to ascertain thereby the ship's place at sea. Of the fallacy of this hope, the continued experience and unremitted application of more than ten years (to and fro in the same track) have convinced me beyond a doubt. Nevertheless, I shall ever esteem the thermometer as a very important and useful instrument in navigation. Although it is not entitled to that implicit confidence that should induce a person to incur risks in running for the land or soundings in dark nights, or thick foggy weather, yet it may often apprise him of the vicinity of danger, when he does not expect it. In navigating the Atlantic, between the United States and Europe, if bound to the westward, the necessity of shunning the current of the Gulf Stream is obvious to every one, as well as the propriety of making use of its assistance when going in the opposite direction. The irregularity of the courses it pursues, together with its undefined limits, all of which are considerably changed by the prevailing winds.

render it impossible for a person to know when he is in it, by calculation, however well ascertained may be his latitude and longitude. But by the thermometer, if he will only be at the trouble of trying the water once or twice a day, he can never be mistaken in identifying this current. I have been acquainted with many ship masters who were in the habit of carrying this instrument to sea with them, but who never attempted to apply it until they deemed themselves in the neighbourhood of soundings or of the Gulf, and were consequently unqualified properly to appreciate its usefulness. For unless a person will be at the pains of making his thermometrical observations at least once a day, it is impossible he can avail himself of its good offices. It is only from the relative temperatures and changes in them that he can draw his conclusions. The extremes of heat and cold, which are not the same every year, must necessarily give to the water of the ocean a corresponding temperature; so that (as the foregoing Tables plainly shew) in the same season, you will find this temperature very different, in different years.

No. VI.

Observations on the Trap Rocks of the Connewago Hills near Middletown, Dauphin County, and of the Stony Ridge near Carlisle, Cumberland County, Pennsylvania. By the Honorable John B. Gibson.—Read 17th Nov. 1820.

On the Connewago Hills, between Elizabethtown and Middletown, these rocks are found resting on the old red sandstone, which extends from the North River, near New York, to the Rappahannock, near Falmouth in Virginia; and which is here about ten miles broad. They exhibit nothing like stratification, but constitute the summits of the hills; the sandstone preserving a common line of elevation, above which all is either trap rocks, or a grey sandy mould produced from them by decomposition. These rocks are basaltiform greenstone; but they are accompanied by some of the other members of the trap family, such as amygdaloid, wacke, &c. This basalt is of two kinds: The first is of a dark iron grey colour, with a shade of blue, sometimes verging on black; its streak is an ash grey; it is of a compact granular structure, and is chiefly composed of feldspar and augite or hornblende, but as I judge, after an attentive examination with a pretty high magnifying power of the microscope, most probably the latter: it rings when struck; but though extremely hard, gives, with difficulty, a few sparks with steel, and when broken with a hammer, often flies into thin pieces with sharp edges; its fracture is rough.

sometimes inclining to splintery, and sometimes flatly conchoidal; and it is perfectly opake. These rocks have mouldered so much, that their original form cannot be ascertained; the shape in which they now appear undoubtedly being the result of decomposition; but the particular species of which I am now speaking, is usually found in spheroids formed of concentric crusts that fall off in succession as the mass decays. After the first coat is detached, these balls appear perfectly sound; but on being broken, are found to be enveloped with two or three other coats, in a progressive state of preparation for falling off, which decreases towards the centre till the mass becomes thoroughly sound. The outermost crust, by shrinking and chapping, is filled with an infinite number of fissures which cross each other in every direction, and disposed, on being completely detached, to fall into very small pieces, that are soon entirely disintegrated. Within the innermost perceptible layer, the mass, which never contains any foreign body as a nucleus, is equally hard to its centre. In a single instance, I found a quartz pebble, rounded by attrition, embedded in one of these rocks; but they disclose neither organic remains nor vegetable impressions. What shews that the spheroids were not originally formed on a nucleus, or that they did not at first take a figurate form, is, that when, as sometimes happens, they are split by exposure to the weather, each part assumes, in the progress of further decomposition, the form of a distinct sphere, whose crusts take a new point for their common centre, without regard to that by which the general exfoliation before proceeded. In truth, I am of opinion that basalt, or greenstone, is originally always amorphous, and that it takes a determinate form only in a state of decomposition; as is shewn by the columnar basalt of the *Giant's Causeway* in *Ireland*; of the lake of *Bolsonna* in *Italy*; of *Halleberg* and *Hunneberg* in *Sweden*; and other places; which exhibits regular prismatic forms only when it has long been exposed to the action of the atmosphere; for whenever a part of the surface has been removed, the interior has exhibited only the incipient appearance of regular forms; and doubtless every rock of the kind would, if penetrated to a sufficient depth, be found to be a solid mass. Humboldt, it is true, in his account of the breaking out of the volcano of Jorullo in the intendancy of Valladolid in Mexico, says that strata of clay, enveloping balls of decomposed basalt *in concentric layers*, were thrown out: but these, although actually ejected in a figurate shape, it clearly appears, were not then recently formed, but were the product of anterior convulsions, and had long lain in the ground in a state of decay. But the crystalline form of basalt has, at all events, received an importance with respect to the question of origin, which it by no means deserves: for although it is conceded that columnar and other figurate forms exist in rocks of aqueous origin, it has been proved, by the well known experiments of Mr. Gregory Watt, that both the columnar and globular structure *may* be produced by the slow refrigeration of a mass of melted basalt; and lava has been found in Filicuda, one of the Lepari islands, in perfect columns, and imperfectly columnar in the island of Ponga.

The second species is soft and friable throughout, usually amorphous, and of every intermediate shade between a dark and an ash grey; but most frequently of the latter. It is of a coarse open structure, and so soft, that some specimens may be crumbled between the fingers. It is not incrustated; but the whole mass, when disintegrated, falls into a coarse sand with a rather slight intermixture of clay. It is not very abundant, and is used with advantage in giving a smooth surface to the turnpike road which leads from Lancaster to Harrisburg; the body of which is constructed of the harder species, which is also sometimes amorphous.

Both kinds, when exposed to constant moisture, are covered with a reddish brown, whose depth of colour is in proportion to their hardness: hence the harder masses contain more iron. These rocks correspond, in almost every particular, with the descriptions we have of the incrustated basalts of Europe, except that they, as well as those of the Stony Ridge, of which I shall presently speak, are decomposed much more readily below the surface of the ground than when subjected to the action of the weather. As oxygen is the chief, perhaps the only agent in dissolving them, their iron must be in the lowest state of oxidation; and their decomposition is therefore accelerated by a position, which by constantly exposing them to moisture, quickens the change of their iron in its passage into a peroxide. But it is by no means certain that their decomposition is effected exclusively by means of the iron they contain; for the feldspar which is one of their constituents, may, by being decomposed, also contribute to effect a decomposition of the whole rock. When the ground is penetrated where the rocks are most abundant on the surface, nothing is usually found but a yellowish sand mixed with a portion of aluminous clay, and forming a cold meagre mould of little value for purposes of husbandry. Hence it is a practice with the owners of the land, who have of late begun to clear some parts of it, to bury the rocks where they lie; and it succeeds very well.

The question respecting the origin of trap rocks has engaged the attention of the most celebrated geologists, and it would therefore be presumptuous in a sciolist to attempt to discuss it further than as it is directly involved in the subject on which he professes to treat. I may however be permitted to remark, that there is nothing in the position of the trap of the Conewago Hills, to indicate its being ignigenous. The common answer to arguments drawn from the absence of all the characteristics of a volcanic mountain, to wit that the basalt was formed on the bosom of the mountain itself, and afterwards denuded by the removal of the superincumbent mass, cannot be admitted here; because in that case we ought not to expect to find it resting on even the oldest of the secondary rocks. That it may have been deposited on the sandstone by a volcano, before the present continent was elevated above the level of the sea, would be a more plausible supposition; but it would be altogether gratuitous. Perhaps the Plutonists and Neptunists have both been wrong in refusing to admit of exceptions to their respective theories; and particularly with respect to the formation of trap rocks, which probably ought not to be exclusively referred to the agency of either fire or water.

But the Stony Ridge near Carlisle presents appearances more decisively volcanic. In structure, the trap of which its rocks are composed, differs but little from that of the Connewago Hills, except that it is somewhat harder, of a finer granulation, and a darker colour; but it is decomposed in the same way, is covered by the same ferruginous coat, and would, on being analysed, probably exhibit but little difference of result in the relative quantity of its constituent parts. The rocks differ more in size and shape, those of the Stony Ridge being smaller, and very rarely globular. They present no columnar appearance, but at the Carlisle Ironworks, where the ridge has been penetrated, I have observed something like arrangement in their position, although I cannot say they were of a crystalline form. It is however not so much in the structure of its rocks, as in the position of the ridge itself, that the evidence of its igneous origin is found. The valley is here about twelve miles wide. Its bottom is formed of an extremely compact transition limestone, which, dipping at an angle of from thirty to forty degrees, presents the broken edges of its strata, and forms a pretty uneven surface. Between the Conodoquinnet creek and the North, or as it is here called, the Blue Mountain, the limestone is covered by schistus, and between the Yellow Breeches creek and the South Mountain by gravel. This limestone formation, though it occupies the valley in nearly its whole extent, certainly for a distance of five hundred miles, is not exclusively confined to it, but appears at the same level to the south of the South Mountain, and forms the soil of Frederick county in Maryland, of a great part of York, and of the whole of Lancaster counties in Pennsylvania. The North and South Mountains are composed of quartzose masses, of grey wacke, and of a puddingstone, which sometimes contains marine shells. The ridge in question then, four miles east of Carlisle and distant twenty-four miles from the basalt of the Connewago Hills, stretches, by a course somewhat meandrous, from the foot of the North Mountain, across the valley, till it arrives at within two miles of the South Mountain, where it terminates abruptly, filling the cavities of the bottom of the valley, and forming an overlying unconformable mass of the newest flœtz trap of Werner, so unlike every other rock in the neighbourhood, as to arrest the attention of the inhabitants. Its base is about three hundred yards broad, and its height from twenty to thirty, its summit being nearly a dead line. The transverse direction and want of conformity to the stratification of the limestone, as well as the isolated situation of the ridge, give it a strong appearance of having originally been a stream of lava: to convince one of which, nothing is wanting but an extinguished crater in the North Mountain. But I by no means consider its absence a decisive objection; for rocks undoubtedly volcanic are found, where all vestiges of a crater have long been obliterated. But in the present instance I see no necessity for one having ever existed. If there is any position in geology thoroughly established, it is that the crust of the earth has undergone a series of great and sudden revolutions, which have buried all the countries that were before inhabited. From the animal and marine organic remains alternately imbedded in the different strata of transition and secondary rocks, it is demonstrated by M. Cuvier, that every part of the surface of the globe has, by subsidence or upheaving, alternately been the bottom of the sea and dry land. To what cause but subterraneous fire can effects such as these be attributed? It is idle to talk of the motion of the sea from east to west, of the action of the tides, or deposits of sediment: unless we return to the exploded notion of the earth having suffered violence from the oblique stroke of a comet, we shall be unable to imagine any possible force applied *ab extra*, that is competent to produce them. Electricity must also be rejected; for the whole quantity of that fluid which exists in the universe would be insufficient to charge the earth so highly, as to produce by its discharge the immersion of continents and the elevation of the bottom of the sea above the level of its surface. Although there are non-conducting bodies in the earth; yet as water, which at every temperature between ice and vapour is an excellent conductor, pervades every part of it, it would be impossible to confine the fluid to any particular place, and the whole globe would have to be charged. But the clouds and every thing coming into contact with the surface, would abstract at least a portion of it. Every one who has experienced the difficulty of confining this fluid by the best insulation of glass or resins, will readily acknowledge this. Then to collect a sufficient quantity of fluid, would require over the whole surface of the earth an uninterrupted continuance of a state of things favourable to such a result for a longer period than can, in the nature of things, be expected ever to have taken place. Besides, only dry earth is an electric *per se;* for when it is mixed with water, in which state only it is a constituent part of the globe, its power of being electrically excited is proportionally decreased; so that the solid parts of the globe would, independently of the effects produced on them by the contact of seas and rivers, be capable of excitement in a degree so very low, as to render them inadequate under any circumstances to collect the quantity of fluid required: but when to this is added the contact of lakes, rivers, and seas, we shall find that the globe is altogether incapable of being electrically excited. In Werner's theory, the alternate submersion and emergence of the different portions of the earth's surface is not a postulate, and of course he does not pretend to account for it. His notion that the waters originally covered the whole surface, and that they gradually, and at length finally, retired into caverns at the earth's centre, left empty at the creation for their reception, having first deposited the strata in the broken state, and inclined positions in which we now find them, is hostile to every thing like fair induction from facts and propositions conceded on all hands. Then to assign an adequate cause for the effects discoverable in the disjointed and scattered condition of the earth's crust, we are driven by necessity to have recourse to the theory of Dr. Hutton.* which, although we may not choose to adopt it in its full extent, alone affords a rational solution of the difficulties that embarrass the subject. While I acknowledge that his theory of the consolidation of the strata by means of heat at the bottom of the sea, appears to be altogether unnecessary and beset with insuperable difficulties, I am compelled by the want of any other adequate agent to assent to his doctrine that the changes between oceans and continents are due to the expansive power of heat from below. Earthquakes are doubtless the more languid efforts of the same power; and when during these, we behold the surface of the earth tossing like a sea, while mountains are raised or districts of country swallowed up, we may judge of what it is capable of effecting, when roused into full activity. In earthquakes as well as volcanoes, electricity acts an efficient but subordinate part; for during an eruption, vivid flashes of lightning issue from the clouds of pumice and ashes sent up, and shocks of earthquakes are frequent and violent. Mountains are nothing but dislocated portions of the earth's crust, and must therefore owe their formation to the same general cause that effected the other parts of the grand revolution. Else how could granite, the lowest of the known formations,

* The changes that have taken place on the earth's surface, were, it seems, at a very early period ascribed by Xanthus to earthquakes and subterraneous fires, which, at the deluge, elevated some portions of the bed of the sea, as well as depressed others, and produced the inequalities of the solid parts of the globe. This opinion was afterwards, in 1692, in substance adopted by an English geologist of the name of Ray; and also in 1740 by an Italian called Lazaro Moro. Their writings may have suggested to Dr. Hutton a distinguishing feature of his theory: but none of them appear to have suspected what he has, I think, established, a succession of continents which he calls a succession of worlds.

be found constituting the summits of the highest peaks: Every appearance connected with the structure of Alpine mountains irresistibly tends to one conclusion, that they have been pushed up through the superincumbent strata, whose *debris* are found resting at their bases, or on their flanks. In truth there is such an apparent mutual and intimate connexion between those mountainous elevations of the crust, and volcanoes and earthquakes, that it is impossible to regard them as distinct phenomena. Earthquakes are more frequent and violent in volcanic countries, and the mountains become more gigantic as we approach the torrid zone, the peculiar seat of volcanic action; and in Europe, let me add, earthquakes are more frequent in the vicinity of trap formations than elsewhere. From all this there is reason to conclude, that there are long ranges of subterraneous fire at an immense depth, and that volcanoes are merely the vents through which, as a safety valve, are discharged the elastic vapour and other substances, which, when confined, are the cause of earthquakes, and of the upheaving of mountains or even continents.

But to return from this digression. Would it be surprising, if, during a convulsion capable of producing results so tremendous as the breaking up of the earth's crust, a stream of lava should escape through a lateral opening at the base of a mountain newly formed, or that had been thrown up by a previous effort of the same power? A crater is formed by the gradual accumulation of pumice and ashes ejected by an established volcano; but I see no reason to doubt that a single eruption might take place in the manner suggested, which would be sufficient to account for the absence of all traces of a crater and the want of that conical shape so observable in the mountains of volcanic countries. But that conic shape so decisively volcanic, furnishes no argument that the power which caused it might not, by a different mode of operation, produce those long uniform ridges which constitute the chains of mountains in North America. Humboldt describes Antisan and Pichinca, two volcanoes in the province of

Quito, as each having no cone at all; but as being in one direction a lengthened ridge, sometimes smooth and sometimes rough, with pointed rocks. In Europe and Asia, no active volcano is situated in a chain of mountains; but in America, in a range of from four to five thousand miles north and south, the most stupendous volcanoes form a part of the Cordilleras; and this range of subterraneous fire is crossed between the eighteenth and nineteenth degrees of north latitude, by another extending from the Gulf of Mexico to the Pacific Ocean. Humboldt considers the whole province of Quito as a volcanic abyss covered with a crust whose craters are different vents to one continuous mass of fire. When we consider the influence which distant volcanoes are known to have on each other, we cannot doubt the existence of a range of subterraneous fire serving to connect them; and when we see a line of volcanoes coinciding with the course of the longest chain of mountains in the world, we are forced to believe that, as the mountains could not have produced the volcanoes, the volcanoes must have had some concern in producing the mountains. It is not an extravagant theory, then, that all chains of mountains have been produced by volcanic fire, acting either generally and raising above the surface of the sea the immense edges of the earth's crust as the original framework of a continent, or in veins at an immense depth below the surface of land already elevated, without, except in a few instances, breaking through the crust acted on; and that masses of overlying trap may be volcanic products, emitted, in either case, through accidental openings, where no remains of a crater appear. I know not whether this idea is in any respect new; but I acknowledge that many of the arguments I have employed are not new; but as they were those which naturally and powerfully resulted from established facts, I thought myself justified in appropriating them to the support of my hypothesis.

It may be objected, that from the vicinity of the Conewago Hills to the Stony Ridge, it ought to be presumed that the trap of both places had a common origin. But to those who require that a theory should explain and reconcile all the phenomena connected with its subject, it may be answered, that it is conceded by many advocates of the Huttonian system, that some basaltic rocks may have been formed in the humid way from eruptions of mud such as issue from some volcanoes in South America: not those that are properly called *mud* volcanoes, which are destitute of heat, and whose eruptions are produced by a fermentation in which common salt is supposed to be concerned; but actual fire volcanoes into which water has found its way. In this manner a different origin may consistently be attributed to the rocks of both places. But I do not say that the trap of the Connewago Hills is not a volcanic product, but only that it exhibits no *peculiar indicia* of igneous origin.

In conclusion, however, it must be acknowledged that the footsteps of the agent employed to work those grand changes of which we every where see such convincing proofs, are so intricate and confused, that we never can expect with absolute certainty to trace them home. The Huttonian system, though open in some of its parts to strong objection, affords the most rational solution of the most important phenomena of the earth, and must eventually gain ground. Connected with this subject there are few facts so devoid of interest as to be unworthy of being communicated; and the author of these observations therefore trusts he will not be considered a trespasser on public attention, by having given them publicity.

No. VII.

An Account of two North American Species of Cyperus, discovered in the State of Georgia: to which is added four Species of Kyllingia, found on the Brazilian coast, and on the Rio de la Plata in South America. By William Baldwin, M. D.—Read 16th April, 1819.

Culmo triquetro. Spiculis terminalibus capitulis.

Cyperus sparsiflorus.

CULMO subnudo, *erecto:* foliis canaliculatis, nervosis, scabris: *capitulo* globoso: involucro 3—4-phyllo, foliolis canaliculatis scabris: spiculis lanceolatis, acutis, 4—7-floris: squamis *remotis*, ovatis, obtusis: semine triquetro, basi attenuato. Pistillum trifidum.

Root tuberous. *Culm* 6—12 inches high, somewhat 3-angled, and always erect. *Leaves* narrow, channelled, with setaceous points, shorter than the culm. *Sheaths* open, tinged with purple at base. Leaves of the *involucre* 3—4, *rarely* 5, one or more much longer than the head. *Heads always solitary. Spikelets* generally very numerous and compact, varying considerably in length and appearance. *Scales* generally *remote*, but sometimes close. *Keels* green, the margins a yellowish brown colour.

Inhabits pine barrens in the vicinity of Savannah and St. Mary's Georgia. Flowers, *May—October.*

Observations.

Specimens of this plant were transmitted to Dr. Muhlenberg, in 1813. Although he referred it to his *Scirpus cyperiformis*, it is sufficiently distinct. It differs principally by its *erect* culm, *solitary* head, and its *shorter, narrower*, and *coloured* spikelets.

Cyperus ovatus.

Culmo subnudo: foliis linearibus: involucro subtetraphyllo: capitulis *ovatis*, obtusis, sessilibus, et pedunculatis: pedunculis subteretibus, striatis, brevibus: ocreis obtusis: spiculis linearibus, 4—6-floris, bibracteatis: squamis ovatis, subacutis, remotiusculis: semine triquetro, nigro. Pistillum trifidum.

Root fibrous. Culm about one foot high, acutely triquetrous. *Leaves* shorter than the culm, the sheaths open, and purplish at base. Leaves of the *involucre* resembling those of the culm, slightly scabrous on the margins. The *heads*, as far as I have seen, are *four* in number, pedunculate, and sessile. *Spikelets* generally 6-flowered, the superior flower abortive. From one to two very small, obtuse, empty scales are sometimes found beneath.

Inhabits low moist situations near St. Mary's in Georgia. And appears to flower throughout the summer.

Observations.

There are still a considerable number of new or doubtful species of *Cyperus* in the United States; and I have several belonging to this division of the genus from South America. An account of which, with observations on the *essential* character of the genus, I reserve for a future occasion.

An Account of four Species of Kyllingia, &c.

Calyx 2-valvis. Corolla nulla.

Kyllingia tenuis.

Culmo triquetro, *tenui*, basi folioso: foliis angusto-lanceolatis acutis; involucro triphyllo; capitulo globoso, minimo:

glumis inequalibus, membranaceis, acutis, carinis albidis, glabris: semine ovale, compresso. *Floribus triandris. Pistillum bifidum.*

Root creeping, perennial. *Culm* 3—10 inches high. *Leaves* 1—3, much shorter than the culm, and entirely smooth. *Sheaths* closed. Two or three acute pointed *sheaths*, independent of the leaves, are frequently found at the base of the culm. Leaves of the *involucre* generally vertical, with a few scattering spines on the margin. *Heads* very small, and always solitary.

Inhabits damp close soils on the shores of the Rio de la Plata, in the vicinity of Buenos Ayres. Flowers, *February—April.*

Kyllingia rigida.

Culmo triquetro: foliis linearibus, brevissimis, abruptè acutis: involucro triphyllo, brevi, acuto: capitulo ovato, obtuso: glumis inequalibus, membranaceis, obtusis, carinis viridibus, glabris: semine oblongo, subtriquetro. *Pistillum bifidum. Planta rigida.*

Root creeping, perennial. *Culm* 4—15 inches high. *Leaves* very short, and rarely more than one exclusive of the sheaths, of which there are two or three at the base of the culm, closed, and acute. Leaves of the *involucre* generally expanded, and sometimes shorter than the head. *Head* generally ovate, but varies from globose to cylindrical. The flowers appear to be *diandrous.*

Inhabits low moist situations near Rio de Janeiro, and also near Maldenado, on the Rio de la Plata, in the Banda Oriental. Flowers, *January—April.*

Observation.

This plant appears to be allied to the K. *brevifolia* of Rottboll, but differs in the culm. Vide *Willd.* Sp. pl. v. 1, p. 256.

Kyllingia leucocephala.

Culmo subtriquetro, sulcato: foliis angustis, acutis: involucro triphyllo: capitulis 1—3-glomeratis, albis, subcylindricis: glumis subæqualibus, membranaceis, obtusis, carinis palidè viridibus: semine obovato, compresso, marginato: *floribus monandris, bibracteatis, bracteis inequalibus, membranaceis, obtusis, corolla multo brevioribus: pistillum bifidum.*

Root fibrous. *Culm* 3—8 inches high. *Leaves* rather shorter than the culm, with sheaths *open* at base, and scabrous towards the summit. *Involucre* from one to four leaved, but generally three, reflexed, and scabrous on the margins. *Heads* solitary or in threes, the middle one much the largest, vertical, and cylindrical; the others are placed opposite at its base, horizontal, and of a globular form. They are at first white, but generally change on drying to a pale yellow.

There is sometimes found in this species, besides the bracteas, a minute, ovate, obtuse scale, situated at the base of the calyx.

Common in both high and low situations, at Rio de Janeiro and at Bahia in the Brazils, and also at the Banda Oriental on the Rio de la Plata, where I met with it in March. 1818.

Kyllingia squarrosa.

Culmo exacte triquetro: foliis angusto-lanceolatis: involucro 3—6-phyllo, longissimo: capitulis 5—7-glomeratis, *subsquarrosis*, cylindricis, uno in medio verticali: glumis subæqualibus, obtusis, carinis viridibus: *floribus triandris. bibracteatis, bracteis inæqualibus, calyce brevioribus: pistillum trifidum.*

Root tuberous. *Culm* 6—18 inches high. *Leaves* shorter than the culm, with closed *sheaths*, and the margins scabrous. Leaves of the *involucre* similar to those at the base of the culm, and sometimes very long, expanded or reflexed. *Heads* sometimes an inch in length, and of a brown colour. The exterior bract is ovate, acute, and longer than the interior, which is much broader, and obtuse.

There is a small variety from 3 to 6 inches high, with heads from 2 to 3, not differing materially in other respects.

Common at Rio de Janeiro, and also in the Banda Oriental on the Rio de la Plata. Flowers, *January—April.*

Observations.

The genus *Kyllingia* appears to abound beyond the southern tropic, on the American continent. But *three* species are yet known within the limits of the United States. Neither of these agree exactly with the generic character given to the genus. The K. *monocephala* of Muhlenberg, and the *pumila* of Michaux, have neither *bracteas* nor *corollas*.* The flowers of the K *maculata* of Michaux are furnished with a single *bractea*, which has been called a 1-*valved calyx* by Mr. Elliott. The flowers of the K. *leucocephala* and *squarrosa* have each *two* bracteas. Perhaps the flowers of the foreign species which have been described as furnished with both *calyx* and *corolla*, *may merely be bracteated*. The *bracteas* are so situated as to appear like a 2-valved calyx; but on examination, they will be found in the species I have examined, unconnected with the fructification, and remain, after the seed with its two glumes falls off, attached to the rachis.

* It will be perceived that I have adopted *calyx* instead of *corolla* in those species, I have described, which are not furnished with both.

No. VIII.

Catalogue of Plants collected during a Journey to and from the Rocky Mountains, during the summer of 1820. By E. P. James, attached to the Exploring Expedition commanded by Major S. H. Long, of the United States Engineers. And by the Major communicated to the Society, with the permission of the Hon. J. C. Calhoun, Secretary of War.

The Collection of Plants made during the excursion of the exploring party commanded by Major Long, in the summer of 1820, contains a considerable number of species not enumerated in this Catalogue.

These have been necessarily withheld, for want of opportunity to make the requisite comparisons. Such only are given, with a few exceptions, as have already been ascertained to belong to the Flora of North America.

In the arrangement and nomenclature, Nuttall's "Genera of North American Plants" has been principally followed.

E. P. JAMES.

CLASS I.—*Order* 1.

Hippuris vulgaris. *Linn.*

Order 2.

Callitriche verna. *Willd.* C. autumnalis.
Corispermum hyssopifolium. On the Missouri.
Blitum chenopodioides. *Nutt.* On the Platte and Arkansaw, on arid and saline soils.

CLASS II.—*Order* 1.

VERONICA officinalis. *Linn.* V. serpyllifolia. V. agrestis. V. arvensis. V. peregrina. These five species are naturalised and common throughout the middle States. V. beccabunga. In small streams throughout the northern and middle States, and in Upper Louisiana. V. scutellata. V. anagallis. On the Platte. V. plantaginea. N. S.? Flowers spiked, unibracteate. Capsule nearly orbicular, dehiscent at the margin. Radical leaves numerous and large, oval-lanceolate, stiped. Margin crenate. Those of the scape few, sessile, and alternate. Spike long, dense-flowered.

This plant, so unlike in habit and appearance to the American Species of Veronica, seems referable to no other Genus among the Pediculariæ of *Jussieu*, to which it is manifestly nearly allied. Habitat on open plains within the Rocky Mountains; flowering in June and July.

LEPTANDRA virginica. *Nutt.* On the Arkansaw.

GRATIOLA aurea. G. virginica. G. aluminata. G. fontinalis, N. S.? On the Missouri.

LINDERNIA dilatata. *Muhlenberg.* L. attenuata. On the Canadian fork of the Arkansaw.

BIGNONIA catalpa. At Old Smithland, near the mouth of the Tennessee river.

JUSTICIA peduncolosa. *Pursh.*

UTRICULARIA fibrosa. *Walter.* U. longirostris. *Le Conte.* U. gibba. U. cornuta.

PINGUICULA acutifolia.

LYCOPUS vulgaris. L. virginicus. L. obtusifolius.

CUNILA mariana.

HEDEOMA glabra: (Cunila glabella. *Muhl. Cat.*) H. pulegioides. H. hirta of *Nuttall* about the Paunee Villages.

MONARDA fistulosa. Ohio. M. purpurea. M. punctata. M. rugosa. M. clinipodia.

SALVIA trichostemoides. On the Missouri.

COLLINSONIA canadensis. C. ovalis.

CIRCAEA lutetiana C. alpina.

LEMNA polyrhiza. L. minor.

CLASS III.—*Order* 1.

VALERIANA pauciflora.

FEDIA radiata.

IRIS cristata. I. versicolor. I. tripetala.

SISYRINCHIUM anceps. S. mucronatum. *Nutt.* On the Platte.

CALYMENIA nyctaginea. *Mich.* C. albida. C. angustifolia. Platte.

COMMELINA communis. C. erecta.

LEPTANTHUS ovalis. New York.

POLYCNEMUM americanum. *Nutt.* On the Platte.

XYRIS anceps.

SCIRPUS acicularis. S. capillaceus. S. trichodes. S. simplex. S. filiformis. S. palustris. S. quadrangulatus. S. mucronatus. S. lacustris. S. debilis. S. autumnalis. S. coarctatus. S. sulcatus. S. exaltatus. S. divaricatus. S. polyphyllus. S. puberulus (Fimbristylis puberulum. *Nutt.*)

S. retrofractus. S. cyperiformis. S. macrostachyos. S. brunneus. S. atrovirens. S. pendulus.
Rhyncospora alba.
Schoenus setaceus.
Cyperus fasciculatus. C. poæformis and uncinatus of *Pursh*. On the Canadian. C. autumnalis. C. compressus. C. filiculmis. C. flavescens. C. gracilis. C. tenuiflorus. C. strigosus. C. tetragonus. C. flavicomus.
Dulichium spathaceum.
Trichophorum cyperinum.
Eriophorum cæspitosum. E. polystachium. E. angustifolium. E. virginicum
Cenchrus echinatus. Very abundant in the sandy soils on the Canadian.
Limnetis glabra. On the Missouri and La Platte.
Nardus stricta.
Miegia macrosperma. *Persoon*. Cane. Commencing on the Ohio near Louisville, and found on all the rivers to the south.
Oryzopsis asperifolia. *Mich*. New York and Pennsylvania.
Eriocoma cuspidata. *Nutt*. (Stipa membranacea. *Pursh*.) On the Platte.

Order 2.—Proper Grasses.

Muhlenbergia diffusa. *Schreber*. Common. M. erecta.
Trichodium laxiflorum. *Muhl*. T. decumbens. *Muhl*.
Leersia virginica. *Pursh*. Ricegrass. L. oryzoides. L. lenticularis.
Agrostis tenuiflora. A. spica venti. A. pauciflora. A. setosa. In mountain marshes. A. stricta. A. canina. A. sericea. A. decumbens. A. vulgaris. A. aspera. A. clandestina.
Calamagrostis mexicana. *Nutt*. (Arundo agrostoides. *Pursh*.) C. canadensis.
Anthoxanthum odoratum.
Beckmannia erucæformis. On the Platte.
Crypsis squarrosa. *Nutt*. Near the Rocky Mountains.
Phleum pratense.
Polypogon ramosum. *Nutt*. Agrostis racemosa. *Mich*. On the Missouri.
Alopecurus geniculatus. A. pratensis.
Panicum crus-galli. P. Walteri. P. virgatum. P. nitidum. P. dichotomum. P. capillare. P. latifolium. P. scoparium. P. pauciflorum. P. scabriusculum. P. nervosum. P. villosum. P. barbulatum. P. angustifolium. P. divergens. P. elongatum.
Pennisetum glaucum. P. viride. P. verticillatum. P. italicum.
Digitaria sanguinalis. P. villosa. P. paspalodes.
Paspalum purpurascens. P. vaginatum.
Aristida oligantha. A. dichotoma. A. pallens. On the Platte.
Stipa avenacea. S. canadensis. S. sericea. Very common and troublesome on the Missouri and Platte. The pungent stipe of the seed penetrating the firmest cloathing. The long awn is hygrometric. S. bicolor. S. stricta. S. parviflora. *Nutt*.
Andropogon nutans. A. avenaceum. A. macrourum. A. virginicum. A. tetrastachium. *Elliott*. A. furcatum.
Aira aquatica. A. obtusata. A. cæspitosa. A. mollis.
Holcus lanatus.
Sesleria dactyloides. *Nutt*. On the Platte.

Poa trivialis. P. pratensis. P. viridis. P. nemoralis. P. annua P. compressa. P. nervata. P. parviflora. P. tenella. P. eragrostis. P. reptans. On the Mississippi.
Uniola spicata. U. paniculata. U. latifolia.
Windsoria poæformis. *Nutt.* W. ambigua.
Danthonia spicata. *Nutt.*
Festuca tenella. F. elatior. F. polystachya. F. diandra. F. fluctans. F. nutans. F. spicata. On the Missouri.
Bromus secalinus. B. mollis. B. purgans. B. ciliatus. B. altissimus.
Koeleria cristata. K. nitida. On the Missouri.
Arundo cinnoides.
Atheropogon apludioides. A. oligostachium. *Nutt.*
Lepturus paniculatus. *Nutt.* On the Platte.
Anthopogon lepturoides. *Nutt.*
Ægilops hystrix. *Nutt.* On the Missouri and La Platte.
Elymus canadensis. E. villosus. E. striatus. E. hystrix.
Hordeum jubatum. (Wild Barley.) H. pusillum. *Nutt.* On the Missouri.

Order 3.

Mollugo verticillata.
Lechea major. L. minor. L. thymifolia. L. tenuifolia.
Proserpinaca palustris. P. pectinacea.

CLASS IV.—*Order* 1.

Cephalanthus occidentalis.
Dipsacus sylvestris.
Galium trifidum. G. latifolium. G. tinctorium. G. asprellum. G. triflorum. G. hispidulum. G. circæzans. G. boreale.
Diodia virginica. On the Canadian.
Houstonia cærulea. H. tenella. H. serpyllifolia. H. angustifolia.
Mitchella repens.
Elæagnus argentea.
Ludwigia sphærocarpa. E. lanceolata.
Isnardia palustris.
Cornus florida. C. circinata. C. sericea. C. asperifolia. C. stricta. C. sanguinea. C. alba. C. paniculata. C. alternifolia.
Centunculus lanceolata.
Plantago major. P. lanceolata. P. cordata. P. cucullata. P. interrupta. P. virginica. P. lagopus* of *Pursh.* (P. gnaphaloides of *Nuttall.*) This species constitutes almost the only vegetation in extensive tracts of the gravelly plains on the upper part of the Platte. P. pusilla. *Nutt.* Collected by Dr. *L. C. Beck* on the Illinois river. P. glabra. *Nutt.* In moist soils and on the upper part of the Platte.
Centaurella paniculata.
Frasera Waltheri. Near the Rocky Mountains, on the Arkansaw.
Ammannia ramosior. A. humilis.
Symplocarpos fœtida.

* This name has been previously employed for another species.

Order 2.

Hamamelis virginica. A variety, or perhaps a distinct species, is found about the Hot Springs of the Washita.
Sanguisorba canadensis.

Order 4.

Myginda myrtifolia. *Nutt.* On the Rocky Mountains, about the high peak.
Ilex opaca. On the Washita, Ohio, Cumberland, &c. I. vomitoria. On the Washita, where the leaves are much used as a substitute for tea. I. prinoides. I. canadensis.
Sagina procumbens.
Potamogeton natans. P. fluitans. P. heterophyllum. P. setaceum. P. perfoliatum. P. lucens. P. crispum. P. gramineum. P. pectinatum.

CLASS V.—*Order* 1.

Myosotis scorpioides. M. arvensis. M. virginiana. M. lappula. M. glomerata. *Nutt.*
Lithospermum arvense. L. latifolium. L. angustifolium. L. apulum.
Batschia Gmelini. B canescens. B. longiflora. B. decumbens. *Nutt.*
Cynogloseum officinale. C. amplexicaule.
Pulmonaria virginica. P. ciliata. N. S.? In the crevices of rocks along the streams within the Rocky Mountains.
Onosmodium hispidum. O. molle.
Lycopsis arvensis.
Phacelia bipinnatifida. P. fimbriata. P. parviflora.
Hydrophyllum appendiculatum. H virginicum. H. canadense.
Androsace occidentalis On the Platte
Dodecatheon meadia D integrifolium.
Menyanthes trifoliata
Samolus valerandi On the Canadian, and near Lake Champlain.
Lysimachia angustifolia. L. racemosa L quadrifoiia L ciliata. L. hybrida L thyrsiflora
Diapensia lapponica D barbulata On the gravelly plains of the Platte.
Convolvulus trichosanthes *Mich.* C. sæpium. C stans. C. obtusifolius. C panduratus.
Ipomaea coccinea.
Cantua coronopifolia C. aggregata. On the Canadian
Phlox acuminata P pilosa P. undulata P. subulata? On the upper part of the Platte
Collomia linearis *Nutt.* Near the Rocky Mountains.
Polemonium reptans
Solanum nigrum S dulcamara. S. virginicum S carolinense. S. triflorum? S hirsutum This plant appears to be distinct from the S triflorum of *Nuttall.* Stem hirsute, as are also the leaves; peduncles about 3-flowered, alternating with the leaves Habitat on the Platte, commencing near the Paunee Villages, and continuing to the mountains. I have never seen it, except immediately about the burrowing places of the marmots or prairie dogs, where it is almost constantly found.

Androcera lobata *Nutt.* (Solanum heterandrum *Ph.)* Common throughout all the country on the Platte, and the upper part of the Arkansaw.
Physalis viscosa P. pennsylvanica P obscura
Datura stramonium. Hyoscyamus niger. Both naturalised.
Verbascum thapsus. V. blattaria. V. lychnites.
Spigelia marylandica. In Kentucky and the Arkansaw Territory.
Sabbatia angulosa. S. gracilis.
Azalea nudiflora. A. canescens. A. bicolor.
Bumelia oblongifolia. *Nutt.* On the Mississippi.
Campanula decipiens. *Persoon.* C. divaricata. C americana. C. erinoides. C. amplexicaulis. C. uniflora of *Persoon?* A small but beautiful species with a single terminal flower. Habitat in the grassy plains about the head waters of the Arkansaw.
Caprifolium sempervirens. C. parviflorum. On the Mississippi.
Xylosteum ciliatum.
Symphoria glomerata. S. racemosa.
Diervilla Tournefortii. About the Rocky Mountains.
Triosteum perfoliatum. T. parviflorum.
Ribes albinervium. R. rigens. R. resinosum. R. sanguineum. R. aureum. R. recurvatum. R. pennsylvanicum. R. nigrum. R. hirtellum. R. gracile. R. triflorum.
Drosera rotundifolia. D. longifolia.
Vitis labrusca. V. æstivalis. V. cordifolia. V. riparia. V. rotundifolia. A new Species of Vitis is found on the Arkansaw, which having not seen in flower, I must omit.
Cissus ampelopsis. C. hederacea. C. bipinnata. On the Canadian.
Impatiens fulva. I. pallida. *Nutt.*
Viola pedata. V. palmata. V. sagittata. V primulifolia. *Ph.* V. cucullata. V. asarifolia. *Ph.* V. blanda. V. lanceolata. V. canadensis. V. stricta. V. debilis. V. rostrata. V. pubescens. V. Nuttalli. V. concolor.
Claytonia virginica. C. spathulæfolia. C. alsinoides.
Rhamnus alnifolius.
Zizyphus volubilis.
Ceanothus americanus. C. intermedius. Missouri. C. sanguineus.
Euonymus americanus. E. angustifolius.
Celastrus scandens.
Thesium umbellatum. *Linn.* (Comandra umbellata. *Nutt.)*
Queria canadensis.

Order 2.

Echites difformis.
Apocynum cannabinum. A. androsæmifolium. A. hypericifolium.
Gonolobus macrophyllus. G. viridiflorus.
Asclepias syriaca. A. phytolaccoides. On the Platte. A. parviflora. A. incarnata. A. obtusifolia. A. amplexicaulis. A. viridis. A. cinerea. A. verticillata. A. longifolia. A. lanuginosa. *Nutt.* A tuberosa.*
Gentiana crinita. G. pneumonanthe. G. saponaria. G. ochroleuca. G. alba. G. angustifolia.

* All these species, except A. *viridis*, *tuberosa*, and *lanuginosa*, I have seen on the Platte or Arkansaw, and the latter species on the Canadian.

Evolvulus argenteus. *Nutt.*
Heuchera villosa.
Panax trifolium. P. quinquefolium.
Sanicula marylandica. S. canadensis.
Ammi capillaceum.
Conium maculatum?
Selinum canadense. (Ferula canadensis? *Linn.)*
Heracleum lanatum. H. sphondylium. On the Missouri.
Ferula villosa. *Nutt.* F. fœnicularia. *Nutt.* On the prairies of Grand River.
Angelica triquinata. A. atropurpurea. A. lucida.
Sium latifolium. S. lineare.
Erigenia bulbosa. *Nutt.* (Hydrocotyle bipinnata. *Muhl.)* On the Ohio.
Cicuta maculata. C. bulbifera.
Myrrhis canadensis. (Sison canadense.)
Ursapermum Claytoni. *Nutt.*
Chaerophyllum procumbens.
Seseli divaricatum.
Smyrnium integerrimum. S trifoliatum. (S. cordatum. *Pursh.)* S. aureum.
Atriplex canescens. A. argentea. *Nutt.* On the Platte.
Chenopodium album. C. hybridum. C. Botrys. C. ambrosioides. C. anthelminticum. C. subspicatum.
Salsola salsa. On the upper part of the Canadian.
Kochia dioica. *Nutt.* On the Platte.
Ulmus americana. U. nemoralis. U. fulva. U. alata? Very common in the Arkansaw Territory, and in Missouri.
Planera aquatica.
Celtis occidentalis, var. integrifolia. *Nutt.* C. tenuifolia.

Order 3—4.

Viburnum prunifolium. V. pyrifolium. V. lentago. V. nudum. V. dentatum. V. pubescens. V. lantanoides. V. accrifolium. V. oxycoccus.
Sambucus canadensis S pubescens.
Rhus typhinum R glabrum R viridiflorum. R. vernix. R. toxicodendron R radicans. R. aromaticum.
Staphylea trifoliata.
Sarothra hypericoides. *Nutt.* (S. gentianoides. *Ph.)*
Parnassia palustris. P. caroliniana. P asarifolia.

Order 5—6.

Aralia nudicaulis. A. racemosa. A. hispida. A. spinosa
Linum Lewisii. *Ph.* L virginicum. L. rigidum.
Zanthorrhiza apiifolia.

CLASS VI.—*Order* 1.

Tradescantia virginica. T. rosea.
Caulophyllum thalictroides.
Mahonia aquifolia. *Nutt.* (Berberis aquifolium. *Ph.)* On the Rocky Mountains.
Prinos verticillatus. P. ambiguus. P. lævigatus. P. lanceolatus.

PANCRATIUM mexicanum. P. rotatum
ALLIUM fragrans A striatum. A angulosum. A. stellatum. A. triflorum A canadense.
BRODIAEA grandiflora. On the Missouri.
HYPOXIS erecta. H. graminea.
YUCCA angustifolia. *Nutt.*
AGAVE virginica.
PHALANGIUM esculentum. (P. quamash. *Pursh.*) On the Ohio and Arkansaw, &c.
NARTHECIUM americanum.
LILIUM pennsylvanicum. L. canadense. L. philadelphicum.
ERYTHRONIUM lanceolatum. *Ph.* E. albidum. *Nutt.*
UVULARIA perfoliata. U. flava. U. grandiflora. U. sessilifolia.
STREPTOPUS distortus. S. roseus.
SMILACINA umbellata. S. stellata. S racemosa.
POLYGONATUM canaliculatum. P. multiflorum. P. latifolium.
ORONTIUM aquaticum.
ACORUS calamus.
JUNCUS acutus. J. glomeratus. J. effusus. J. filiformis. J. setaceus. J. marginatus. J. nodosus. J. polycephalus. J. sylvaticus. J. acuminatus. J. aristatus. J. bulbosus. J. tenuis. J. bufonius. J. compestris. J. melanocarpus.
FLOERKIA proserpinacoides. *Willd.* Very common about Franklin.

Order 3.

CALOCHORTUS elegans. *Ph.* Within the Rocky Mountains.
MELANTHIUM hybridum. On the Missouri.
VERATRUM viride. V parviflorum. V. angustifolium.
HELONIAS erythrosperma.
SCHEUCHZERIA palustris
GYROMIA virginica. *Nutt.* (Medeola. *Linn.*) G. picta ? *Nutt.*
TRILLIUM sessile. T. cernuum. T. pictum. (T. erythrocarpum. *Mich. Nutt.*) T. erectum.
RUMEX sanguineus. R. crispus. R. verticillatus. R. britannicus. R. crispatulus. R. aquaticus. R. acetosella. (Lapathum acetosellum.) R. venosus.

Order 6.

ALISMA plantago.

CLASS VII.—*Order* 1.

TRIENTALIS americana. A variety of T. europea.
ÆSCULUS Pavia. Æ. discolor. Æ flava. Æ. macrostachya

CLASS VIII.—*Order* 1.

RHEXIA virginica. R. ciliosa.
ŒNOTHERA biennis. Œ. muricata. Œ. parviflora. Œ. grandiflora. Œ. sinuata. Œ. albicaulis. *Nutt.* On the Platte. Œ. pinnatifida. *Nutt*

Œ. cæspitosa. *Nutt.* Œ. serrulata. *Nutt.* Œ. fruticosa. Œ. alata. *Nutt.* (Œ. macrocarpa. *Ph.)* On the Canadian.

Gaura biennis. G. angustifolia. G. coccinea. Two other Species apparently undescribed are met with about the south-west branches of the Arkansaw.

Epilobium spicatum. E. tetragonum. E. coloratum. E. palustre. E. alpinum.

Oxycoccus macrocarpus. O. hispidulus. (Gaultheria hispidula. *Ph.)*

Acer rubrum. A. dasycarpum. Common on the Ohio, Cumberland, &c. A barbatum. A saccharinum. A. nigrum. A. striatum. (Moose wood.) A. montanum. A. negundo. (Negundo fraxinifolium of *Nuttall.)* This last species extends westward to the valleys within the Rocky mountains.

Dirca palustris. Most common in the northern States.

Jeffersonia diphylla. On the Ohio.

Order 2.

Chrysosplenium oppositifolium.

Order 3.

Polygonum aviculare. Common on the Platte and Arkansaw, near the mountains. (P. glaucum? *Nutt.)* P. tenue. P. hydropiperoides. *Mich.* (punctatum. *Elliott.)* P. mite. P. hirsutum. P. virginianum. P. coccineum P. pennsylvanicum. P. persicaria. P. sagittatum. P. arifolium. P. cilinode. P. scandens. P. articulatum.

Cardiospermum helicacabum. Very abundant on the Canadian, two hundred miles above its confluence with the Arkansaw. Undoubtedly a native.

CLASS IX.—*Order* 1.

Laurus benzoin. L. sassafras.

Eriogonum tomentosum. *Ph.* E. flavum. *Nutt.* E. parviflorum. *Nutt.* This genus abounds near the Rocky Mountains.

CLASS X.—*Order* 1.

Arbutus uva-ursi. On the Rocky Mountains.

Gaultheria procumbens.

Vaccineum stamineum. V. album. V. dumosum. V. frondosum. V. resinosum. V. corymbosum. V. nitidum. I have seen none of this Genus on or about the Rocky Mountains. Many of them are found in the Mas- sernes.

Andromeda polyfolia. A. calyculata. A. angustifolia. A. spinulosa. *Ph.* A. racemosa.

Kalmia latifolia. K. angustifolia. K. glauca.

Rhododendrum maximum.

Epigaea repens.

Pterospora andromedea. *Nutt.* At Albany and Greenbush, N. Y.

Monotropa lanuginosa. (Hypopithys lanuginosa. *Nutt.)* M. uniflora.

Pyrola uniflora. P. minor. P. secunda. P. rotundifolia. P. chlorantha. (P. asarifolia. *Mich.*

CHIMAPHILA maculata. C. umbellata.
LEDUM latifolium. In sphagnose swamps.
CLETHRA tomentosa. C. alnifolia.
MELIA azederach? Indigenous on the Canadian.
JUSSIEUA leptocarpa. *Nutt.*
CASSIA ligustrina. C. linearis. C. marylandica. C. fasciculata. C. nictitans. C. chamæchrista.
SOPHORA sericea. *Nutt.* On the Platte.
BAPTISIA leucophæa. *Nutt.* On the Missouri. B. cœrulea. B. mollis. B. tinctoria.
THERMIA rhombifolia. *Nutt.* On the Platte.
CERCIS canadensis.

Order ..

SAXIFRAGA nivalis. Flowering in July among the snows of the Rocky Mountains. S. virginica. S. pennsylvanica.
TIARELLA cordifolia. T. trifoliata.
MITELLA diphylla. M. cordifolia. M. reniformis
SAPONARIA officinalis.
SCLERANTHUS annuus.

Order 3.

CUCUBULUS stellatus.
SILENE quinquevulnera. S. pennsylvanica. S. virginica. S. regia. S. rotundifolia. *Nutt.*
STELLARIA pubera. S. media. S graminea. S. uliginosa
ARENARIA latifolia. A serpyllifolia A thymifolia. A juniperina
MICROPETALON lanceolatum. M gramineum. M. lanuginosum.

Order 5.

SPERGULA arvensis. S. saginoides.
CERASTIUM vulgatum C. viscosum. C. semidecandrum. C. glutinosum *Nutt.* (C nutans? *Rafinesque.*) C arvense C tenuifolium C elongatum One or two species, apparently undescribed, are found about the Rocky Mountains.
AGROSTEMMA githago.
OXALIS acetosella O violacea. O. corniculata. O stricta. O. Dillenii.
PENTHORUM sedoides.
SEDUM pulchellum. S. ternatum. S. stenopetalum. *Pursh.* On the Rocky Mountains.

Order 6.

PHYTOLACCA decandra.

CLASS XI.—*Order* 1.

CACTUS mammillaris. C viviparus *Nutt* C ferox. C. fragilis.
These four Species of Cactus are very common on the arid plains of the Platte and Arkansaw, near the mountains. C. ferox I have seen growing

at a great elevation upon the sides of the Rocky Mountains. C. cylindricus? Arborescent, rising to a height of eight or ten feet and much branched. Habitat about the head waters of the Arkansaw and Canadian, where are also two other shrubby Species.

BARTONIA nuda. B. ornata.

MENTZELIA aurea. *Nutt.*

PRUNUS virginiana. P. serotina. P. canadensis. P. borealis. P. pennsylvanica. P. nigra. P. pygmæa. P. pumila. P. depressa. P. chicasa. Common and certainly indigenous on the Arkansaw.

LYTHRUM verticillatum. L. salicaria. L. virgatum.

CUPHEA viscosissima.

Order 2.

AGRIMONIA eupatoria. A. parviflora. A. striata.

CRATAEGUS apiifolia. C. spathulata. C. coccinea. C. pyrifolia. C. elliptica. C. flava. C. punctata. C. crus-galli.

Order 4.

ARONIA arbutifolia. *Nutt.* A. melanocarpa. A. botryapium. A. ovalis. A. sanguinea.

PYRUS coronaria. P. angustifolia.

SPIRAEA salicifolia. S. tomentosa. S. hypericifolia. S. opulifolia. S. aruncus.

GILLENIA trifoliata. G. stipulacea.

Order 5.

ROSA blanda. R. parviflora. R. nitida. R. gemella. R. carolina. R. rubifolia.

RUBUS occidentalis. R. villosus. R. strigosus. R. canadensis. R. cuneifolius. R. hispidus. R. trivialis. R. inermis. R. odoratus. R. spectabilis?

DALIBARDA repens. D. fragarioides. Found mostly about mountains.

DRYAS octopetala? On the Rocky Mountains.

GEUM strictum. G. agrimonioides. G. album. G. virginianum. G. geniculatum. G. rivale. G. anemonoides.

POTENTILLA tridentata. P. emarginata. P. norwegica. P. recta. P. pumila. P. canadensis. P. simplex. P. argentea. P. humifusa. *Nutt.* On the Missouri. P. fruticosa. On the Rocky Mountains. P. anserina. P. pennsylvanica. P. supina. On the Mississippi.

COMARUM palustre.

FRAGARIA canadensis. F. virginica.

CLASS XII.—*Order 1.*

TILIA glabra. T. pubescens. T. heterophylla.

HELIANTHEMUM canadense. (Cistus canadensis.) H. ericoides.

PORTULACCA oleracea. Very common near the Rocky Mountains.

TALINUM teretifolium. *Pursh.*

CHELEDONIUM majus.

STYLOPHORUM diphyllum. *Nutt.* S. petiolatum. *Nutt.*
ARGEMONE mexicana? Flower very large, and invariably white. On the Platte
SANGUINARIA canadensis.
PODOPHYLLUM peltatum.
ACTAEA rubra. A. alba. *Bigelow.*
SARRACENIA purpurea.
NUPHAR lutea. N. Kalmiana. N. advena.
NYMPHAEA odorata.
DELPHINIUM azureum. D. exaltatum. D. virescens. *Nutt.*
AQUILEGIA canadensis. Another most beautiful species is found growing near the limits of phænogamous vegetation, on the Rocky Mountains.
CIMICIFUGA racemosa. C. americana.
HYPERICUM pyramidatum. H. ascyroides. H. fasciculatum. H. tenuifolium. H. perforatum. H. corymbosum. H. parviflorum. H. angulosum. H. canadense.
ELODEA virginica.
LIRIODENDRON tulipifera.
PORCELIA triloba. P. parviflora.
ATRAGENE americana.
CLEMATIS virginica. C. cordata. C. holosericea.
ANEMONE ludoviciana. *Nutt.* About Council Bluffs. A. nemorosa. A. cuneifolia. A. tenella. On the Platte. A. thalictroides. A. pennsylvanica. A. dichotoma. A virginiana.
THALICTRUM cornuti. T. dioicum. T. rugosum. T. pubescens. T. purpurascens. T. ranunculinum.
HYDRASTIS canadensis. On the Missouri.
CALTHA palustris. A second Species with white flowers is found in swampy places, about the upper parts of the Rocky Mountains.
COPTIS trifolia.
HEPATICA triloba.
RANUNCULUS flammula. R. lingua. R. pusillus. R. cymbalaria. R. abortivus. R. nitidus. R. sceleratus. R. auricomus. R. pygmaeus. R. pennsylvanicus. R. bulbosus. R. philonotis. R. repens. R. acris. R. marylandicus. R. recurvatus. R. fluviatilis. R. amphibius. N. S.? Inhabiting stagnant waters and marshy places near the Rocky Mountains. R. intermedius? *Smith, in Rees's Encycl.* Habitat in marshy grounds, near the confluence of the Ohio and Mississippi. Flowering in January. R. ———. N. S.? Approaching R. abortivus, but much smaller. Calix and corolla very minute, scarcely visible without a magnifier. Habitat on inundated ground on the Cumberland and Tennessee Rivers, flowering in February.
BRASENIA peltata. (Hydropeltis purpurea.)
CYAMUS luteus. On the Missouri and Arkansaw, in stagnant waters.

CLASS XIII.—*Order* 1.

TEUCRIUM canadense. T. virginicum.
MENTHA borealis. M. canadensis. M. tenuis
ISANTHUS caeruleus.
HYSSOPUS nepetoides. H. scrophulariaefolius.
GALEOPSIS tetrahit.

SYNANDRA grandiflora. *Nutt.*
STACHYS aspera. S. hyssopifolia. S. hispida. S. sylvatica.
LEONURUS cardiaca.
GLECHOMA hederacea.
HYPTIS capitata. H. radiata.
PYCNANTHEMUM incanum. P. aristatum. P. virginicum. P. muticum.
CLINOPODIUM vulgare.
ORIGANUM vulgare.
DRACOCEPHALUM variegatum. D. virginianum. D. denticulatum. D. parviflorum. *Nutt.* On the upper part of the Platte.
PRUNELLA pennsylvanica.
SCUTELLARIA galericulata. S. laterillora. S. integrifolia. S. pilosa. S. canescens.
TRICHOSTEMA dichotoma.
PHRYMA leptostachya.

Order 2.

VERBENA aubletia. V. spuria. V. hastata. V. urticifolia. V. diffusa. V stricta.
ZAPANIA nodiflora.
CAPRARIA multifida.
HERPESTIS? micrantha.
SCROPHULARIA marylandica. S. lanceolata.
BIGNONIA radicans.
BUCHNERA americana.
ANTIRRHINUM elatine. A. linaria. A. canadense.
COLLINSONIA verna. *Nutt.* Common in Missouri.
GERARDIA purpurea. G. tenuifolia. G. flava. G. quercifolia. G. pedicularia, var. pectinata. On the Washita.
PEDICULARIA pallida. P. canadensis. P. flammea. On the Rocky Mountains.
MIMULUS ringens. M. alatus. M. luteus.
CHELONE glabra. C. obliqua.
PENTSTEMON lævigatum. P. pubescens. P. gracile. *Nutt.* P. cristatum. *Nutt.* P. erianthera. *Nutt.* P. cæruleum. *Nutt.* P. albidum. *Nutt.* P grandiflorum. *Nutt.* (P. Bradburii. *Pursh.)* P. coccineum. N. S.? This last plant, though closely allied, is scarcely a congener to the other Species, and may probably be referred to some other Genus. Habitat on the declivities of the Rocky Mountains. Plants of the Genus Pentstemon abound in the vicinity of the Rocky Mountains; and some of the Species extend on their sides to the extreme limits of phænogamous vegetation.
MARTYNIA proboscidea. Common throughout Upper Louisiana to the mountains.
EUCHROMA coccinea. *Nutt.* E. grandiflora. *Nutt.* (Castilleja sessiliflora.) At Council Bluffs.
BARTSIA alpina.
MELAMPYRUM lineare.
OROBANCHE americana. O. ludoviciana. O. fasciculata. On the Canadian. O. uniflora. O. virginiana. (Epifagus americanus. *Nutt.*)

CLASS XIV.—*Order* 1.

DRABA verna. D. nivalis. D. nemoralis.
ALYSSUM ludovicianum. *Nutt.* (Myagrum argenteum. *Pursh.*)
CORONOPUS didymus.
LEPIDIUM virginicum. Common in the most remote parts of Louisiana.
THLASPI arvense. T. alliaceum. T. bursa pastoris.

Order 2.

DENTARIA laciniata. D. diphylla. D. heterophylla. D. multifida.
CARDAMINE spathulata. C. teres. C. virginica. C. pennsylvanica.
BARBAREA vulgaris.
SISYMBRIUM amphibium. S. palustre.
ERYSIMUM officinale. E. parviflorum.
CHEIRANTHUS asper. *Nutt.* On the Platte.
HESPERIS pinnatifida.
ARABIS alpina. A. thaliana. A. lyrata. A. canadensis. A. pendula. A. hirsuta.
STANLEYA pinnatifida. *Nutt.* S. integrifolia. N. S.? On the upper part of the Arkansaw, with the preceding.
CLEOME pentaphylla. C. dodecandra. C. serrulata. *Ph.* (Atalanta serrulata. *Nutt.*) On the Platte. Common.

CLASS XV.—*Order* 1.

LOBELIA Dortmanna. Habitat in New York and Pennsylvania. L. amœna. L. Kalmii. Common in New York and New England. L. inflata. L. siphilitica. L. cardinalis.
PASSIFLORA lutea? On the Arkansaw.

Order 3.

GERANIUM maculatum. G. robertianum. G. ———. N. S.? On the Rocky Mountains.
SCHRANKIA uncinata? Apparently a second Species, with white flowers, is found on the Canadian.

Order 4.

SIDA hispida. S. abutilon. S. alceoides. S. ———? S. ———? Two species on the Platte.
MALVA rotundifolia. M. coccinea. *Nutt.*
HIBISCUS grandiflorus. In the Arkansaw Territory. H. militaris. H. virginicus.

CLASS XVI.—*Order* 1.

PETALOSTEMUM candidum. P. violaceum. P. villosum.

Order 2.

CORYDALIS cucullaria. C. formosa. C. fungosa. C. glauca. C. aurea.

POLYGALA incarnata. P. paucifolia. P. senega. P. alba. On the Missouri. P. sanguinea. P. verticillata. P. brevifolia. *Nutt.*

Order 4.

AMORPHA canescens. *Nutt.* A. nana. *Nutt.* A. fruticosa. This is almost the only woody plant which is found on many extensive tracts of the plain country about the river Platte.

LUPINUS perennis. L. argenteus. L. pusillus. A suffruticose species, very large and beautiful, is found near the sources of the Canadian.

OROBUS dispar. *Nutt.* O. longifolius. *Nutt.*

LATHYRUS myrtifolius. L. venosus. L. polymorphus. *Nutt.*

VICIA americana. V. sylvatica.

PHACA villosa. V. cæspitosa. *Nutt.*

OXYTROPIS Lambertii. On the Platte.

ASTRAGALUS canadensis. Near Franklin Mountain. A. carolinensis. A. missouriensis. A. hypoglottis. A. Laxmanni. A. carnosus. A. galegoides. A. gracilis. *Nutt.* This Genus is abundant in the woodless plains of the Missouri to the mountains.

DALEA alopecuroides. D. aurea. D. laxiflora.

PSORALEA canescens. *Nutt.* P. cuspidata. *Nutt.* P. esculenta. *Nutt.* (Pomme blanche) used as food by the Paunees and Canadian traders. P. incana. *Nutt.* P. tenuiflora. P. arenaria. *Nutt.* Most of these species are found in the sandy plains of the Platte and Arkansaw. P. onobrychis. *Nutt.* P. ———. N. S.?

MELILOTUS officinalis. M. psoraloides. *Nutt.* Ohio.

TRIFOLIUM reflexum. T. repens. T. pratense. T. arvense. T. stoloniferum. *Muhl.*

STYLOSANTHES elatior.

GLYCIRRHIZA lepidota. *Nutt.* *Hab.* from St. Louis to the Rocky Mountains.

LESPEDEZA sessiliflora. L. capitata. L. polystachya. L. violacea. L. procumbens.

HEDYSARUM canadense. H. canescens. H. marylandicum. H. ciliare. H. viridiflorum. H. cuspidatum. H. paniculatum. H. glutinosum. H. viridiflorum. H. pauciflorum. H. boreale.

PHASEOLUS perennis.

APIOS tuberosa.

AMPHICARPA monoica. *Elliott.*

GALACTEA glabella.

CLITORIA virginiana.

ROBINIA pseudacacia. R. hispida.

TEPHROSIA virginiana.

TRIGONELLA americana. *Nutt.* On the Platte.

PRENANTHES altissima P. cordata P virgata. P. alba. P. racemosa. P. illinoensis P juncea. P. runcinata? *Hab.* about the Rocky Mountains.

LACTUCA elongata L integrifolia

SONCHUS macrophyllus S leucophæus. S. pallidus. S. arvensis. S. oleraceus S ludovicianus *Nutt.* On the Platte.

HIERACIUM venosum H paniculatum H marianum H runcinatum

KRIGIA virginica K. amplexicaulis *Nutt* (Hyoseris amplexicaulis. *Mich.*)

TROXIMON glaucum. T. marginatum. Near the Rocky Mountains.

CNICUS lanceolatus. C. altissimus. C. arvensis. Not yet naturalised in the western States. C. discolor. C. horridulus. C. undulatus. *Nutt.*
LIATRIS spicata. L. graminifolia. L. cylindracea. L. squarrosa.
VERNONIA noveboracensis. V. præalta. V. altissima. *Nutt.* V. angustifolia.
EUPATORIUM sessilifolium. E. lanceolatum. E. ceanothifolium. E. purpureum. E. maculatum. E. punctatum. E. verticillatum. E. perfoliatum. E. ageratoides. E. cœlestinum.
CHRYSOCOMA graveolens. *Nutt.* C. nauseosa. On the Missouri.
CACALIA tuberosa.
HYMENOPAPPUS tenuifolius.
SANTOLINA ? suaveolens. About the Rocky Mountains.

Order 2.

ARTEMISIA longifolia. *Nutt.* A. serrata. *Nutt.* A. columbiensis. *Nutt.* A. gnaphaloides. *Nutt.* A. ludoviciana. *Nutt.* A. cernua. *Nutt.* (A. dracunculoides. *Pursh.*) A. sericea. A. biennis. A. canadensis. Most of these species are found on the Platte.
BACCHARIS ? angustifolia. A shrub on the Arkansaw.
GNAPHALIUM margaritaceum. G. polycephalum. G. purpureum. G. plantagineum. G. americanum. G. uliginosum.
ERIGERON pumilum. *Nutt.* On the Platte. E. asperum. *Nutt.* E. glabellum. *Nutt* E. bellidifolium. E. purpureum. E. philadelphicum. E. strigosum. E. heterophyllum. E. canadense.
INULA Helenium. I. mariana. I. villosa. I. linarifolia. I. linifolia. I. alba.
ASTER hyssopifolius. A. tortifolius. A. nemoralis. A. paucifiorus. On the Platte. A. pilosus. A. biennis. A. multiflorus. A. sparsiflorus. A. squarrosus. A. concolor. A. sericeus. A. novæ angliæ. A. cyaneus. A. oblongifolius. *Nutt.* A. undulatus. A. cordifolius. A. corymbosus. A. macrophyllus. A. spectabilis. A. gracilis. A. puniceus. A. novibelgii. A. acuminatus. A. lævigatus. A. eminens. A. junceus. A. miser. A. divergens.
SOLIDAGO canadensis. S. procera. S. serotina. S. ciliaris. S. reflexa. S. lateriflora. S. aspera. S. altissima. S. juncea. S. arguta. S. bicolor. S. petiolaris. S. livida. S. cæsia. S. flexicaulis. S. macrophylla. S. viminea. S. graminifolia. S. tenuifolia.
BRACHYRIS Euthamiæ. *Nutt.*
DONIA squarrosa.
ARNICA montana. About the Rocky Mountains.
SENECIO hieracifolius. S. elongatus. S. obovatus. S. balsamitæ. S. lobatus.
BOEBERA glandulosa.
TRICHOPHYLLUM oppositifolium. *Nutt* On the Platte. T. ———. N. S. ?
STARKEA pinnata. *Nutt* On the Missouri, Platte, &c.
ACHILLEA tomentosa. A. millefolium.
HELIOPSIS lævis.
HELENIUM autumnale.
ACTINELLA acaulis. *Nutt*

Order 3.

Galardia bicolor. *Hab.* on the grassy hills of the Platte.
Helianthus tubæformis. H. atrorubens. H. divaricatus. H. frondosus. H. trachelifolius. H. giganteus. H. altissimus. H. multiflorus. H. decapetalus.
Rudbeckia purpurea. R. gracilis. R. columnaris. R. laciniata. R. digitata. R. pinnata. R. ramosa. N. S. *Hab.* on the Canadian.
Bidens cernua. B. chrysanthemoides. B. connata. B. frondosa. B. pilosa. B. bipinnata.
Coreopsis lanceolata. C. trichosperma. C. tripteris. C. palmata. *Nutt.*
Actinomeris helianthoides. *Nutt.* A. alata.
Silphium laciniatum. S. compositum. S. terebinthinaceum. S. lævigatum. S. trifoliatum. S. triternatum. S. atropurpureum.
Polymnia canadensis. P. uvedalia.
Parthenium integrifolium.
Iva xanthifolia. *Nutt.* I. axillaris.
Ambrosia trifida. A. elatior. A. artemisifolia. A. paniculata. A. tomentosa.
Xanthium strumarium.

CLASS XVIII.—*Order* 1.

Orchis ciliaris. O. blephariglottis. O. cristata. O. psycodes. O. spectabilis. O. rotundifolia. O. dilatata. Near the Rocky Mountains. O. fimbriata. O. orbicularis. O. incisa.
Goodyera pubescens. (Neottia pubescens. *Willd.*)
Neottia tortilis. N. cernua.
Pogonia ophioglossoides. P. divaricata.
Triphora pendula. *Nutt.*
Calopogon pulchellus.
Arethusa bulbosa.
Malaxis ophioglossoides. M. liliifolia.
Corallorhiza innata. C. odontorhiza. C. hyemalis.

Order 2.

Cypripedium candidum. C. parviflorum. C. pubescens. C. spectabile.
Asarum canadense.

CLASS XIX.—*Order* 1.

Caulinia fragilis. C. flexilis.
Podostemum ceratophyllum.
Typha latifolia. T. angustifolia.
Sparganium ramosum. S. americanum.
Carex scirpoidea. C. sterilis. C. squamosa. C. arenaria. C. bromoides. C. retroflexa. C. stipata. C. muricata. C. multiflora. C. leporina. C. scirpoides. C. lagopodioides. C. ovalis. C scoparia. C. crinita. C. acuta. C. pedunculata. C. ovata. C. varia. C. subulata. C. margi-

nata. C. vestita. C tentaculata. C miliaris. C. lupulina. C. plantaginea C anceps. C granularis. C miliacea. C. pseudo-cyperus C. recurva. C pellita. C lacustris. C. vessicaria.
SCLERIA triglomerata.

Order 4.

ALNUS serrulata. A. crispa?
DIOTIS lanata.
URTICA pumila. U. urens U. dioica U procera. U. chamaidroides. U. capitata U divaricata. U. canadensis.
MORUS rubra M scabra
AMARANTHUS albus. A græcizans A lividus. A. hybridus. A. paniculatus A sanguineus A retroflexus.
MYRIOPHYLLUM spicatum M verticillatum
SAGITTARIA sagittifolia. S obtusa. S hastata. S. heterophylla. S. lancifolia S graminea S natans
QUERCUS phellos (Willow oak) *Hab* on the Arkansaw, &c. Q imbricaria. (Burriers oak) Q. heterophylla Q monticola Q prinoides. Q castanea. Q bicolor. Q nigra Q falcata Q tinctoria Q discolor Q. rubra. Q coccinea Q Catesbæi Q palustris. Q. ilicifolia. Q. alba. Q stellata Q macrocarpa. Q lyrata.
CARPINUS americana.
OSTRYA virginica.
CORYLUS americana. C. rostrata.
FAGUS sylvatica. F ferruginea.
CASTANEA americana. C. pumila.
BETULA populifolia. B. excelsa. B. nigra. B. papyracea. B. lenta. B. glandulosa
PLATANUS occidentalis.
LIQUIDAMBER styraciflua.
JUGLANS nigra J cinerea. *(Carya.)* J olivæformis. J. sulcata. J. alba. J tomentosa. J amara. J porcina.
ARUM dracontium. A triphyllum. A. virginicum.
CALLA palustris.

Order 8.

PINUS resinosa. P rigida P serotina. P. strobus. P. larix. P. microcarpa P flexilis N S?
ABIES canadensis A. balsamea. A. nigra. A rubra. A. alba.
THUIA occidentalis.
CUPRESSUS disticha.
ACALYPHA virginica.
CROTON ellipticum C. capitatum C. glandulosum.
IATROPHA stimulosa On the Canadian.
EUPHORBIA hypericifolia E maculata E polygonifolia E. ipecacuanha. E peplus E. dentata. E. thymifolia. E marginata.
MELOTHRIA pendula
MOMORDICA echinata.
SYCIOS angulata
CUCUMIS? ——— *Hab* on the Arkansaw. C. pepo. The size of a large orange

CLASS XX.—*Order* 2.

VALISNERIA spiralis.
SALIX nigra S discolor. S. myricoides. S. cordata. S. rigida. S lucida. S planifolia. S rosmarinifolia. S fuscata S conifera. S longifolia. S. angustata. *Hab.* westward to the Rocky Mountains. S nigra. S. grisea.
FRAXINUS sambucifolia. F. quadrangulata. F. epiptera. F. acuminata. F. pubescens
MACLURA aurantiaca. *Nutt.* (Bow wood) On the Arkansaw and Canadian.
VISCUM rubrum V purpureum. V. verticillatum.
NYSSA villosa N biflora. N. tomentosa. N. denticulata.
ZANTHOXYLUM fraxineum.
ACNIDA cannabina. A. rusocarpa.
HUMULUS lupulus. Within the Rocky Mountains.

Order 6.

SMILAX hastata. S. bona nox. S. sarsaparilla. S. rotundifolia. S. caduca. S. laurifolia. S. peduncularis. S. herbacea.
DIOSCOREA villosa.
GLEDITSCHIA triacanthos.

Order 8.

POPULUS balsamifera. P. candicans. P. trepida. P. hudsonica. P. grandidentata. P angulata. (Cotton wood) To the Rocky Mountains.
DIOSPYROS virginiana.
SHEPHERDIA argentea *Nutt.* On the Platte.
UDORA canadensis. *Nutt.* (Elodea canadensis. *Mich.)*
GYMNOCLADUS canadensis.
MENISPERMUM canadense. M. virginicum. M. Lyoni.
JUNIPERUS communis. J. virginiana.
TAXUS canadensis.

No. IX.

Remarks on the Sandstone and Flœtz Trap Formations of the Western Part of the Valley of the Mississippi. By E. P. James, attached to the Exploring Expedition commanded by Major S. H. Long, of the United States Engineers. And by the Major communicated to the Society, with the permission of the Hon. J. C. Calhoun, Secretary of War.—Read (in conjunction with the preceding Number) on the 17th of August, 1821.

The district of country contemplated in the following Essay, lies on the south western margin of that great valley which is watered by the Mississippi and its numerous tributaries. We have confined our attention to that tract which lies south of the river Platte, and west of a meridian line intersecting the Arkansaw at the confluence of the Negracka.

Towards the West, our examinations have been terminated by the first ranges of the Rocky Mountains; and by Red River on the south.

E. P. JAMES.

Smithland, Kentucky, 12th April, 1821.

It is remarked by Maclure and others, who have made the requisite comparisons, that the rocky formations of North America appear less disturbed and confused than those of Europe. If this be the case with that part of the country which has been examined by the above mentioned philosopher, it is perhaps more so with a large and interesting portion of it hitherto little known to the geologists of Europe or America. I refer to that extensive plain, a part of which contains the bed of the Mississippi and its tributaries, and to the stupendous range of mountains which constitute its western boundary.

These mountains have by some been considered as a continuation of the great chain of the Andes; and in conformity to this opinion, the name has been extended to them. It is to be regretted, that common consent has not as yet estalished a distinctive appellation for this important range. Snowy, Rocky, Shining, Chippewan, Sandy, Missouri, Caous, and Mexican, are a few among the attributives hitherto bestowed upon it. It is to be hoped that one of these, or some other, may finally gain the ascendancy, and it is of little importance which it shall be.

The general direction of the range is from north west to south east. It extends from near the Gulf of Mexico on the south east to the Northern Ocean at the mouth of Mackenzies River on the north west.

It will be proper first to direct our attention to the great plain, or, as it has been called, the Valley, of the Mississippi, which must be considered as commencing near the summit of the Alleghany Mountains, and stretching westward to the feet of the northern Andes. In this region, the observer discovers few traces of those tremendous upturnings and commotions whose history is so plainly written on the rocky strata in the eastern part of the continent. Until he arrives within a few leagues of the Rocky Mountains, he finds all the materials constituting the surface resting undisturbed in their original position. The rocks are almost universally stratified, and their stratifications commonly maintain a parallelism with the horizon. The slight inequalities of the surface are often manifestly the effects of water, which running for ages over a light and loose soil, have hollowed for themselves channels and valleys proportioned to their size and velocity. Wherever these currents, or other causes, have laid bare the rocky substrata of the soil, the remains of marine animals are found incorporated in the body of the rock. They are also met with in most perfect preservation in the soil.

These appearances afford sufficient evidence, that at some remote period the waters of the ocean rested upon this extensive region.

Proceeding westward from the Mississippi, the surface rises gradually, having however inclination sufficient to give to many of the streams which traverse that part of the country a velocity of near six miles per hour. This inclination seems to be greatest in the neighbourhood of the Missouri, as that river, the Quicurre, Platte, &c. have a much more rapid current than the Arkansaw and the south western tributaries of the Mississippi. The country bordering on the Mississippi is for the most part deeply covered with soil, which supports a profuse vegetation. To the north and west it differs little from one extensive savanna. The traveller journeys, for weeks in succession, over a dreary and monotonous plain, sparingly skirted and striped with narrow undulating lines of timber, which grow only along the margins of considerable streams of water. In these boundless oceans of grass, his sensations are not unlike those of the mariner, who beholds around him only the expanse of the sky and the waste of waters.

The Missouri, between the Mississippi and the mouth of the Platte, passes through some considerably extensive fields of compact limestone, sandstone, and other horizontally stratified rocks. On the Platte, no rocky formations appear within about four hundred miles from its confluence with the Missouri. At about this distance, some inconsiderable ridges of coarse friable sandstone occur. These hills, though irregular in direction, appear to range from north to south. They may perhaps be a continuation from the Côtes Noires, or Black Hills, which are situated farther to the north, and are said to contain the sources of the Shian, the Little Missouri, and some branches of the Yellowstone. *Lewis and Clark's Hist. Vol. I. p.* 183. The strata which compose these hills are not inclined, and their appearance indicates recent marine origin. The only rock which I have met with here is sandstone, of a kind not unlike that which usually accompanies coal. This inconsiderable tract being passed, the surface again subsides to a plain; but is more barren and gravelly than before. Instead of the fine and somewhat fertile sand which prevails to the east of the above mentioned ridge, the surface is here almost entirely made up of small pebbles and gravel. The soil is of course barren.

From this plain the Rocky Mountains are first seen at a distance, in some states of the atmosphere, exceeding one hundred miles. They first discover themselves, not by emerging from below the sensible horizon, but become distinguishable from the clouds and the sky above it. Their snowy and shining summits, when first seen, were mistaken for clouds by almost every individual of our party. On approaching such considerable elevations, it is not uncommon to look for great changes in the structure and materials of the surface. But here none such are seen until you arrive at the very foot of the mountain. Where the Platte first enters the plains, the horizontal strata of sandstone extend to within five miles of the commencement of the high granitic ridge which forms the first barrier of the Rocky Mountains. On the Cannon-ball River, eight miles above its confluence with the Platte, and less than one-third of that distance from the granitic ridge just mentioned, are several ranges of small hills running parallel to the general direction of the mountain, and extending to the northward for a considerable distance. Where these have been cut through by the bed of the river, they are found to consist of a soft horizontal sandstone abounding in mica.

In a somewhat elevated district, a little to the south of the immediate valley of the Platte, similar ridges occur, at a greater distance from the primitive mountains.

After passing numerous small and rounded hills, whose surface is chiefly composed of gravel, sometimes intermixed with rolled masses of granite and other similar rocks, there is seen a range of naked perpendicular and lofty rocks, rising from the naked plain at the very foot of the mountain, and presenting to the eye the forms of walls, columns, pyramids, &c. These, when minutely examined, appear to be of the same sand rock found so abundantly in the plains differing from it however in the particular of that great inclination which its strata in this instance possess. These ranges appear to be formed by the margin of the strata of sandstone which occupy the plain; this margin, by the violent operation of some unknown cause, having been broken off from the body of the stratum and thrown into the perpendicular position in which it is now seen. Climbing to the summits of these ridges, and crossing their stratifications in a direction towards the primitive, appearances occur similar to what are seen in the same rocks remaining in their original position, when circumstances enable us to push our inquiries at any considerable distance below the surface. Having crossed the upturned margin of the whole secondary formation which occupies the plains, and arriving at the primitive, an unexperienced geologist will perhaps be surprised to find these rocks, so evidently of recent marine origin, reposing immediately against the granite. Previously formed opinions may have induced him to expect appearances which he will not here find. He will search in vain for any traces of those rocks which occupy so conspicuous a place in the works of systematic geologists, denominated rocks of transition. He may also be surprised at the total absence of those primitive strata which the theory of universal formations may have taught him to look for above the granite. He will find recent marine sandstone abounding in organised remains, with its stratifications nearly perpendicular, and in immediate contact with the side of a granitic mountain of vast magnitude and elevation, and of a character most manifestly and highly primitive. The inclination of the strata of this sandstone varies within a short distance from horizontal to an angle of more than sixty degrees. It is sometimes difficult to determine, by the eye alone, which way it varies from an exact perpendicular. Those laminæ or strata of it, which are most distant from the primitive occupying the eastern ridges of its first elevations, have the least inclination, and may with propriety be denominated the uppermost. At the level of the surface of the great plain they sink beneath the alluvial, and in the immediate neighbourhood of the river Platte they are no more seen. The uppermost are of a yellowish grey colour, moderately fine, compact, and hard, constantly varying however at different points in colour, as well as most other characters. The light coloured varieties frequently contain numerous small round masses of about the size of a musket ball, which are more friable than the rock in which they are imbedded, and from which they are easily detached, leaving cavities corresponding to their own shape and dimensions. They are commonly of a dark brown colour, and of a coarser sand than that which enters into the composition of the rock itself. Mr. Say informed me that their appearance was not unlike that of certain organic remains of the Genus Ovulite. Where these are found, I could never discover any of those numerous animal relicts which are so common in many of the secondary rocks of this district.

Crossing the edge of these strata of sandstone, the character of the rock is found to change, on coming nearer to the primitive. The rock becomes more coarse and friable, its colour inclining more to several shades of red and brown. This variety contains numerous masses of iron ore, and does not appear to abound in the remains or impressions of organised beings. It is also less distinctly stratified than the variety before mentioned, and contains many beds of puddingstone (le poudingue of Brochant.) These beds are sometimes of great extent, but certainly cannot be considered as constituting a stratum distinct from the sandrock. This tract of inclined sandstone, which skirts the eastern boundary of the Rocky Mountains, and which we have considered as constituting a part of that immense formation of secondary which occupies the valley of the Mississippi, abounds in scenery of a grand and interesting character. The great inclination of the strata we have before noticed. That side of the ridges which is nearest the primitive, appears as if broken off from a part of the stratum beyond, and is usually an abrupt perpendicular precipice, sometimes overhanging and sheltering a considerable extent of surface. The upper part of the stratum, or that surface which is most distant from the primitive, is usually smooth and hard, and both sides are alike destitute of soil and verdure. Elevations of this sort are met with varying from twenty to several thousand feet in thickness. Nor are they by any means uniform in height. Some of them rise probably three or four hundred feet, and considering their singular character, would be high, were they not subjected to an immediate and disadvantageous comparison with the towering Andes at whose feet they are placed. Their summits, which in some instances are regular and horizontal, are crowned with a scanty growth of cedars and pines. Where the cement, and most of the materials which constitute the sandstone, are silicious, the rock evinces a tendency to separate in fragments of a rhombic form: and in this instance the elevated edge often presents a notched or serrated surface. Those sandstones which consist of silex with the least intermixture of foreign ingredients are the most durable. But in the region which we are now considering, the variations in the composition, character, and cement of the sandrock, are innumerable. Clay and oxide of iron abound principally in those varieties nearest the granite, which are usually of a reddish colour. When these enter into the composition of the rock in certain proportions, they seem to disqualify it for withstanding the attacks of the various agents, whose effect is to hasten dissolution and decay. Highly elevated rocks of this description may well be supposed in a state of rapid and perceptible change. The sharp angles and asperities of surface which they may have originally presented, are soon worn away. The matter which is constantly removed, by the agency of water, from their sides and summits, is deposited at their feet; their elevation gradually diminishes, and even the inclination of their strata becomes obscure, or is rendered wholly undiscoverable. A soil is at length formed over the whole surface, which gives support to a covering of vegetables. This is probably the process by which have been formed the numerous conic hills and mounds, that are now seen interspersed among the highly inclined naked rocks of which I have been speaking. These hills, often clothed with considerable verdure to their very summits, add greatly to the beauty of the surrounding scenery. The contrast of colours which is here seen, often produces the most brilliant and grateful effects. The deep green of the small procumbent cedars and junipers, with the less intense colours of various kinds of deciduous foliage, acquire new beauty by being placed as a margin to the glowing red and yellow which is seen on the surface of many of the rocks. In the narrow but verdant valleys, small pyramids and columns of the purest white are met with, standing solitary and detached from any surrounding rocks.

The district of country of which we have now been speaking may, without impropriety, be denominated the valley of the Platte, as the waters which flow from it are discharged into that river.

Near the summit of the small ridge which, running east from the Rocky Mountains, divides the waters of the Platte from those of the Arkansaw, the sandstone district presents the following appearances, in traversing it from the east toward the primitive:

1. Compact, hard, yellowish grey sandstone, containing organised remains, but not in great abundance. This rock is inclined to the west, at an angle of about twenty degrees. It forms an inconsiderable, but continuous elevation, stretching along the foot of the mountains, from north to south, its western side exhibiting a perpendicular precipice.

2. In the valley between the last mentioned and the succeeding ridge, are several detached columns, of great height and thickness, standing perpendicular, and being irregularly dispersed through the narrow but woodless valley. These masses are usually of a deep red colour. They consist of sandstone of various degrees of fineness, the particles of which are held together by a cement of clay and oxide of iron. They have an irregular surface, which evidently owes its present form to the action of water; and their summits are usually sharp. Several of them, though of great height and covering a considerable extent of surface, are so naked and steep on all sides, as to bid defiance to all attempts at climbing them.

At a short distance beyond these, is the commencement of the high primitive mountain. The beginning of the ascent upon this is covered by a thick bed of white puddingstone, rising upon the side of the granite to an elevation of about two hundred feet above the little plain just mentioned. This rock, though commonly very coarse, contains small beds and stripes of the fineness of ordinary sandstone, in which there occur several small oval masses of yellowish and blueish white hornstone. On the surface of these masses, are the relicta of marine animals, mostly bivalves, in beautiful preservation. This rock also abounds in ironstone. From its eastern declivity about two hundred yards from the point at which the granite emerges, there issues a considerable spring of water, highly impregnated with muriate of soda. The granite which here rises from beneath the secondary strata, is coarse, consisting of a large proportion of reddish brown feldspar in imperfect crystalline masses. The mica is black, and in small proportion. The granite is not compact, and decays rapidly. Being separated probably by the frost, it crumbles into small fragments, which roll down from its steep declivities and accumulate in great quantities in the small hollows and in the beds of streams. This rock rises abruptly to a vast elevation, and probably extends far to the west.

These appearances are found on the southernmost of those branches of the Platte which descend from the mountains before their junction with that river. Proceeding still southward, the sandstone ridges nearly disappear in the elevated tract which divides the waters of the Platte from those of the Arkansaw. The smooth and grassy plain is here terminated by brown and naked piles of granite, which rise almost perpendicularly into the regions of perpetual frost.

The secondary district which lies beyond this ridge, has a surface slightly inclined towards the north east, discharging in a contrary direction several small streams into the Arkansaw. The most striking feature of this region is constituted by certain moderately elevated tabular hills, with perpendicular sides and level summits, which are scattered irregularly about the country, adding greatly to its beauty. In ascending these hills, their sides are almost invariably found to be of coarse friable sandrock and loosely cemented, conglomerate. Above these, and forming the top of the hill, is usually a stratum of fine compact sandstone. It is also obvious, on the slightest examination, that in the sides of those hills which stand near each other, there are, at equal heights on each, corresponding stripes and beds similar in colour and other particulars. These appearances are so constant as to leave little doubt that the hills in question are the remains of a formation of coarse sandstone which may formerly have covered a great extent of the plain country bordering on the mountains. From the nature of the cement, the fineness of the sand, or from other causes, insulated portions of the upper part of this formation have resisted the action of the water, and of the various agents which have broken down and removed the adjacent parts. These portions have protected and preserved entire the columns of loose sandstone on which they rested. One of these singular hills, called the Castle Rock, of which Mr. Seymour has preserved a sketch, when seen from a little distance, presents the appearance of columns, porticos, arches, &c., having a most striking resemblance to an architectural ruin.

One of the first considerable tributaries which the Arkansaw receives from the north, after it enters the plains, is called the Boiling-spring Fork. It has received this name from a large and uncommonly beautiful spring of water, situated upon it immediately at the foot of the mountain. This spring is but a few rods from the commencement of the granite, which there rises into what is called by Pike the "highest peak," and issues from a chasm in a stratum of fine compact sandstone of a deep red colour, which reposes against the granite at an angle of near forty degrees. A short distance to the right, this sandstone is succeeded by an extensive bed of silicious breccia resting against the granite in a similar manner. This aggregate consists of coarse angular fragments of hornstone, jasper, and other silicious minerals, firmly cemented. It is also of a red colour, and abounds in iron.

The spring above mentioned throws out a considerable quantity of water, perhaps fifty gallons per minute, and also about an equal volume of an aeriform fluid. The water is limpid and colourless, and when freed by boiling from the carbonic acid which it contains, is entirely without taste. Immediately on coming in contact with the air, it is covered with a pellicle of carbonate of lime, which substance has been so copiously deposited as to form a capacious bason overhanging a considerable stream of water, and looks as if chiselled from the whitest marble. The rising of the air through the water of this bason produces a constant and violent agitation similar to boiling.

When fresh from the spring, the water has the taste and appearance of the common soda water, and is, I believe, as highly impregnated with carbonic acid as it could be by the most powerful artificial means. It is extremely agreeable to the taste, and when drunk in the quantity of several pints, is followed by no sensible effects except a very considerable degree of exhilaration, which is immediate.

The general direction of the first ridge of the Rocky Mountains, from beyond the Platte to the Peak, is from north to south. A few miles south of the peak, this ridge abruptly terminates, sending out, in a south eastern direction a long range of low secondary hills. Crossing these in a south west direction, we found, that though broken and elevated, they consist almost entirely of horizontal sandstone. This rock is of a yellowish white or light grey colour, of an uncommonly slaty structure, and evidently contains a large proportion of clay. Organised remains are to be seen in it, but these are not numerous or conspicuous. It is traversed by narrow upright veins of carbonate of lime, in crystals. It contains horizontal beds of bituminous shale; and selenite is sparingly scattered over the surface. This formation of argillaceous sandstone extends far to the south and south west; it also occupies the large amphitheatre or bay which is formed between the main range of the mountains and the projecting spire which contains the high peak. At the extremity of this bay, the sandstone is red and highly inclined, similar to that on the Boiling-spring Fork; but this appears to dip under the argillaceous sandstone above mentioned. At the place where the red sandstone ridge is divided by the bed of the Arkansaw, are several springs highly impregnated with muriate of soda, sulphate of magnesia, and probably several other soluble salts. They also emit carbonic acid and sulphuretted hydrogen gases. The water of these springs, except one, is nauseous to the taste, and their disagreeable smell is perceptible at some distance. They are not like most of the saline springs frequented by herbivorous animals. They are six or seven in number, and all rise within a few yards of each other. The mineral substances which they hold in solution are probably nearly the same in each ; but the water of one of them is highly charged with fixed air, and for this reason is more agreeable to the taste. Their temperature appears to be that of the earth at a small distance below the surface. In the middle of July, the medium temperature of these springs, as well as of the great one at the foot of the peak abovementioned, appeared by several trials, to be about sixty-two degrees of *Fahr.* In the air the thermometer ranged from fifty to one hundred and four degrees. These springs have been called Bell's Springs, in compliment to captain John R. Bell, who visited them on the 18th of July, 1820. The sandrock from which they issue is rapidly succeeded by one still more fine and hard, and of a browner colour, alternating with each other, and resting against the perpendicular gneiss rock which there forms the commencement of the primitive, and beyond which it seems almost impossible to penetrate. It appears, however, from the Journal of that enterprising traveller, the late General Pike, that he entered the mountains at this place. The Arkansaw rushes with great violence of current from a narrow gap in this gneiss rock, and is then for a considerable distance confined to a narrow and deep valley bounded on both sides by precipitous walls of sandstone rising from one hundred to one hundred and fifty feet to the level of the great plain. These rocky banks are of the argillaceous sandstone before mentioned, and appear to extend sixty or seventy miles from the mountain. Where the exploring party forded the Arkansaw, about one hundred miles from the mountain, the country is not rocky, but rises very gradually from the river, till at the distance of six or eight miles it is broken by a few inconsiderable gravelly hills. A little distance from the considerable streams, it varies but little from the country about the river Platte, which is an arid and sterile plain of sand and gravel.

From the Arkansaw to the sources of its longest tributary, the Canadian, is a distance of about one hundred and fifty miles in a direction nearly south. The district between these two rivers is nearly plain, but the small streams which traverse it are sunk in deep and narrow valleys terminated by precipices of sandstone similar to the valley of the Arkansaw. In the sides of these deep canals the rocks are so exposed as to afford convenient opportunities for examining a short distance into the internal structure of the plain. Here as in the other districts which we have mentioned, the lowest and almost the only rock found in the plains is sandstone. This we shall consider as of two varieties, though we do not doubt that those who are fond of system and of calling by different names things which are essentially the same, would be at no loss to discover here every variety of sandstone hitherto described, and perhaps many more.

1. Red sandstone. This rock which is the lowest of the horizontal or secondary rocks here met with, is very abundant in all that part of the plain immediately subjacent to the Rocky Mountains which we have had the opportunity to examine. A similar rock is met with in the eastern part of the State of New York, and is there, as in the instance of which we are speaking, placed near the borders of this great secondary formation. I have never met with it in the eastern part of the Mississippi valley. It occupies the country about the Canadian River, occurring on both sides most of the way from its sources to its confluence with the Arkansaw. It appears at intervals along the feet of the Rocky Mountains, reposing against the primitive in a highly inclined position. It varies in colour from vermilion red to dark brown, and sometimes to various shades of yellow and grey. Its cement is however almost invariably ferruginous, and the predominance of red in the colouring certainly entitles it to the distinctive appellation of red sandstone. The lowest

part of the stratum has frequently least colour, and is also most compact and hard. This is not however invariably the case: for about the Platte, that part of it which lies immediately upon the granite is white, and contains numerous and extensive beds of coarse puddingstone. About the Canadian, and in other places where this rock still lies in its original horizontal position, the upper part of the stratum is soft, and pretty uniformly of a red or yellowish brown colour. It is disposed in immense horizontal strata or laminæ, which when broken, transversely exhibit some tendency to separate into fragments of a cubic or rhombic form. In the face of the high precipices, are often seen broad stripes or belts of a lighter colour, conspicuously marked with reticular yellowish veins, which are of a substance similar to hornstone. The cross fracture of the rock of course varies with the fineness of the particles of sand of which it is composed. It is often even, and sometimes approaching to splintery. When divided in a direction parallel to the stratifications, it frequently exhibits small scales of mica; but these are not numerous. Specimens from many parts of this stratum are entirely similar to that which is quarried in New Jersey, and used in great quantities in the cities of New York, Albany, &c. for building. That of the Rocky Mountains usually contains less mica and in smaller scales: but in other respects is similar. The cement of this rock is sometimes argillaceous; but I believe this is by no means universal. Whether this sandstone is in all respects similar to the "Old Red Sandstone" of Werner,* which makes so conspicuous a figure in the systems of certain geologists, we are not able to say. It however certainly occupies a place similar to the one which has been assigned to that rock. It is the lowest of the flœtz or horizontally stratified rocks. and it is perhaps not improbable that it may extend under a great part of the

* This red sandstone is first found on the waters of the lakes on the strait between Lake Huron and Lake Superior, and forms the fall called the Saut de St. Marie. Below that point of the tide water, it is generally limestone.

formation of secondary which we are now considering. We have already mentioned that in an horizontal position it covers a very extensive tract to the south west of the Arkansaw, that it skirts the eastern side of the Rocky Mountains, rising at a great angle from beneath the superimposed strata. It also occurs in the Catskill Mountains, and in the Salt District in the western part of the State of New York, having a similar relation to the secondary rocks in that quarter. The old red sandstone of Werner has by some been referred to the rocks of transition, and considered as the most recent member of that class; others have considered it as the oldest of the secondary. But it seems to have happened here, as in other parts of this yet imperfect science, that distinctions have been made, for which there is really no foundation in nature. The red sandrock now under consideration appears at one place with every character requisite to place it among the rocks of transition, at another it is manifestly secondary; yet its continuity may be traced through minute shades of gradation, or by a sudden transition from one of these points to the other.

Immediately above the red sandstone, when any rock rests upon it, I have commonly found a greyish or yellowish white sandstone which may perhaps be with some propriety distinguished as the second variety. It commonly contains a greater or less proportion of clay in the cement, and has a somewhat slaty structure. Hence it may properly be called argillaceous sandstone, though in some respects it may differ from the rock known to many by that name.

2. Argillaceous sandstone. This variety being uppermost in actual position, is perhaps more frequently seen on the surface than the other; while at the same time it is probably less abundant. The line of separation betwixt the two is often manifest and well defined, and in other instances they pass by imperceptible gradations into each other. The upper or argillaceous sandstone is usually more compact and more homogeneous in its composition than the red. It is also of a close texture and a fine grain, embracing few

foreign substances, and I believe in some rare instances, passing into a coarse or conglomerate puddingstone. It sometimes breaks into large rhombic masses (though in this case it must be acknowledged that it contains little or no clay,) and these, on account of a more compact texture, retain their form longer than similar masses of the other. The precipices formed by both are frequently lofty and perpendicular, but the projections and angles of the red are more worn and rounded than those of the variety now under consideration. The narrow defiles and ravines which the streams of water have excavated, are less tortuous as well as narrower, when made entirely in this rock, than in other instances. The springs of water which it affords are sometimes saline, but more commonly free from mineral impregnations than such as are found issuing from the other variety. It sometimes consists of glittering crystalline particles, but does not in this case appear to be a chemical deposit. In fine, it appears under an almost endless variety of characters, which it would be in vain to attempt to enumerate. Though not invariably distinguished by the presence of an argillaceous ingredient, yet this is often the case, and it is constantly found accompanying the beds of soft clay slate or bituminous shale, whenever these occur. Whether coal accompanies these beds in the neighbourhood of the Rocky Mountains, as it usually does in other places, we are unable to say. It is however certain that they contain similar impressions of vegetables, and in other respects closely resemble the bituminous shale of many coal districts. About the sources of the Canadian, this shale occurs in very narrow horizontal beds, and contains charred vegetable matter which could not readily be distinguished from common charcoal.

If this formation of sandstone, consisting of the two varieties just mentioned, ever extended across the valley of the Mississippi to the Alleghany Mountains, as some might be disposed to imagine, I cannot pretend to determine what was the position it occupied relative to the immense masses of flœtz limestone and other secondary rocks which are now found in that valley.

But as the red variety is still extensively disseminated, and usually accompanied by those valuable substances, salt and plaister, (sulphate of lime) it may not be amiss to trace, as far as our examinations have enabled us to do it, the outline of the region it occupies.

As we have before mentioned, it is found in the vicinity of the river Platte, in a highly inclined position, covering a narrow margin, immediately at the foot of the Rocky Mountains. From the account of Lewis and Clarke, we are disposed to believe that it exists under similar circumstances near the falls of the Missouri. On the Canadian, it is constantly met with from the sources of that river, which are on the borders of New Mexico in west longitude about 106 degrees, nearly to its confluence with the Arkansaw, in 97 degrees. The waters of the Canadian, from flowing over the sandstone in question, acquire an intense red colour, and are so impregnated with muriate of soda and other soluble salts, as to be unfit for the uses to which common water is applied. This, it is well known, is also the case with the waters of the three small rivers tributary to the Arkansaw, above the Canadian, on the same side also with the waters of Red River. Hence the conclusion appears to be justified, that this rock extends from near the Arkansaw on the north to a point beyond Red River on the south, and from near the mouth of the Canadian an unknown distance to the west beyond the remotest sources of that river. It is not unlikely that it exists about the sources and upper branches of the Rio Colorado of California, though we must acknowledge that the name of that river is the only foundation we are acquainted with for such an opinion.

Near the mountains at the head of the Platte, and for a great distance to the south and east of the high peak, the red sandrock is covered by the stratum of argillaceous sandstone already mentioned. It has, however, in many instances, been laid bare by the action of water, which has worn away the superincumbent stratum, as is the case on the Vermilion River, a branch of the Platte which rises in the plains at a considerable distance to the east from the peak. This argillaceous or grey sandstone is the uppermost of those horizontally stratified rocks which are seen in this region, possessing within themselves convincing evidence of their having been formed by deposition from the waters of the ocean.

Another family of rocks of recent, but doubtful, origin, which are usually found resting on the sandstone last mentioned, remains to be considered. These are rocks of basaltic or trappean conformation, by some geologists denominated superincumbent rocks, and by many supposed to be of volcanic origin.

They present a striking contrast by their dark colour, and the vastness and irregularity of their masses, to the smooth, light, and fissile sandstone on which they rest. In their texture and external conformation they often make a nearer approach to the primitive rocks than to those denominated secondary among which they occur. Their appearance and position are such as to lead almost involuntarily those least attached to visionary theories into speculations concerning their origin. Sometimes they are observed compact and apparently homogenous in their composition, presenting a crystalline rather than a stratiform appearance, and in many particulars of structure, form, hardness, colour, &c. seeming closely allied to the rocks of primitive formation. In other instances, black and semivitrified substances are seen scattered about the plains, or heaped in conic masses, but never approaching in character the rocks on which they rest. Most of the rocks of this sort which were observed, are found in the country about the sources of the Canadian River. Among them may be distinguished two kinds referable to two divisions of the class called by Werner superincumbent rocks, viz. greenstone and amygdaloid.

1. Greenstone. Grünstein. *Wern.* Roche amphibo-

lique, *Haüy*. It appears, in the limited district which we examined, under almost every variety of form and character ever noticed by geologists. Sometimes it is nearly free from any intermixture of hornblende, and is of a fine dark green colour, nearly resembling some varieties of serpentine.

Its minute structure is often manifestly crystalline; in which case its fracture is granular. In other instances its particles are not perceptibly crystalline, and the fracture is earthy. Sometimes its colour is a dull grey, graduating into brown and black of various shades and intensities. This rock forms numerous conic hills of considerable elevation, which are irregular in height, and scattered without order in various parts of the plain. These hills are usually of a regular and beautiful form. The great plain in which they stand is elevated, and destitute of timber or water, but ornamented with a thick and verdant carpet of grasses and other herbacious plants. The hills, though steep and high, are smooth and green to the summit, their surface being nearly unbroken by rocks, and covered with thick turf. The whole forms a scene of singular beauty. During our journey across that district of country which is based upon the rocks now under consideration, we had constant occasion to admire the exuberance and freshness of vegetation. The plains of the Platte and Arkansaw we had seen brown and desolate as if recently ravaged by fire, yet here we passed elevated tracts having a scanty soil, and scarcely affording water for our necessities, yet the vegetation possessed the freshness of spring in the most fertile regions.

The conic hills above mentioned are not the only nor indeed the most common form under which the greenstone appears. It sometimes forms low ridges extending a considerable distance, and sloping gradually on both sides into the level of the plain. In the narrow channels which the streams of water have sunk in it may be seen perpendicular precipices of considerable elevation; but the valleys are usually much obstructed by large broken masses of the rock which sometimes exhibit a prismatic form. It falls readily into large angular fragments, but seems strongly to resist that progress of disintegration which it must undergo before it can be removed by the water. The face of the perpendicular precipices which it forms is often marked by large parallel vertical seams. Following the water courses, which are sunk a considerable distance below the surface, the line of separation from the sandstone on which the greenstone rests at length becomes visible. The sandrock in these places has its strata nearly or quite horizontal, and in all other characters is similar to what we have formerly mentioned.

2. Amygdaloid. *Kirwan.* Mandelstein, *Werner.* Roche amygdalöide. *Brochant.*

We apply this name to a porous or vesicular rock of a very dark grey, greenish, or black colour, usually accompanying the greenstone, and sometimes in connection with the sandstone. In its ultimate composition it resembles greenstone, but I have never seen in it such large fragments of feldspar and scales of mica as are observed in that rock. The cavities which occur in every part of the substance of this rock are of various sizes, some of them having the appearance of bubbles which had been formed in a semifluid mass and afterwards lengthened and variously distorted by the motions of the contiguous matter. Near the surface they contain a soft white or yellowish carbonate of lime nearly filling the cavity and giving to the recent surface a variegated or spotted appearance. In surfaces which have for some time been exposed to the air, this soft substance has been removed, and the little cavities are found empty.

Amygdaloid does not appear to occupy any great extent of the country near the Rocky Mountains. I have not met with it imbedded in, or surmounted by, any other rock. It forms conic hills like the greenstone before mentioned, and these sometimes occur in deep waterworn valleys bounded on both sides by precipices of sandrock rising much above the elevation of the amygdaloid. It is likewise seen in the high plains, sometimes in narrow and crooked ridges, as if following the direction of what were formerly the beds of small brooks. This appearance was in one instance so striking, that several of the party who saw it were induced to believe that the materials which constituted the ridge had formerly been ejected in a fluid state from beneath the surface. We had not an opportunity to examine the surrounding country with sufficient minuteness to enable us to form a conjecture concerning the accuracy of this opinion. Some high and sharp conic hills were visible to the westward, but at a great distance. Two of this kind, which stand near each other and appear to be detached from the primitive mountain, are called the Spanish Peaks, and at the end of July, snow was still to be seen on them.

Where either of the two rocks last mentioned occur, it is not uncommon to meet with detached masses of a substance greatly resembling the pumice stone, which is an article of commerce, and entirely similar to that which is often seen floating down the Missouri. It is usually of a faint red or dirty yellow colour, but sometimes brown or nearly black. It feels less harsh than common pumice stone, and is composed almost wholly of clay.

With regard to the alluvial formations of the portion of country of which we have been speaking, little need be said. The trap rocks are often covered with a scanty dark coloured soil, free from pebbles or waterworn masses, and of considerable fertility.

The sandstone districts are often covered to a great depth with rounded fragments and particles of rocks similar to those of the primitive mountains. The fineness of this soil bears a pretty constant proportion to the distance from the mountain at which it is examined. On the lower part of the Platte scarce a stone or a pebble is to be seen. At a distance of two hundred miles from the mountain the surface is often like a gravelled walk or a street paved with pebbles, and near the foot of the mountain it is covered with large boulders. The soil is almost invariably arid and barren. The total absence of any formation of limestone in the district of country under consideration, will not fail to be remarked, but I believe is also common to several other similar districts. A traveller to the upper part of the Missouri mentions "calcarious and petrosilicious hills" as existing in the coal formations on that river. But in ascending the Platte from its confluence with the Missouri, not a fragment of limestone or petrosilex is to be seen. Small veins of carbonate of lime, crystallised in the usual form, are found in the argillaceous sandstone of the Arkansaw. Also the sulphate in small quantities. Gypsum is very abundant on the Canadian River at the distance of three or four hundred miles from its sources. It is disseminated in veins and in thick horizontal beds in red sandstone. The extent and thickness of these horizontal beds are perhaps such as would justify the appellation of stratum, but as it is not met with in great quantities, except in connection with this sandstone, with which it often alternates, it may with propriety be considered as a subordinate rock.

Rock salt. It has been often and confidently asserted, that this substance exists in some part of Upper Louisiana in the form of an extensive stratum.

I have met with it among the natives in masses of twenty or thirty pounds weight. These, of which I have seen only two, were about six inches in thickness and eighteen or twenty in diameter. They were in the possession of an Arikara who lives among the Paunees of the Loup Fork, and when we saw him, was on his return from an excursion to the Arkansaw. The interior of these masses, when broken, presented a crystalline structure, being made up of incomplete cubic crystals variously grouped together. On one of the surfaces of the mass, which had probably been the one in contact with the ground or rock on which the salt had rested, a considerable mixture of red sand was discoverable. These masses, it is highly probable, had been produced by the evaporation, during the dry season, of the waters of some small lake. The Indians who wander near the mountains had considerable quantities of salt, which was in the form of large detached crystals, and seemed to have been formed in the same manner as the other. They said it came from the south west, and as we understood them, from some of the upper branches of Red River.

The whole country near the mountains abounds in licks, brine springs, and saline efflorescences; but it is in the neighbourhood of the red sandrock that salt is met with in the greatest abundance and purity.

The immediate valley of the Canadian River, in the upper part of its course, varies in width from a few rods to three or four miles, but is almost invariably bounded by precipices of red sandrock, forming what are called the river bluffs. On the valley between, these incrustations of nearly pure salt are often found covering a considerable extent of surface, in the manner of a thin ice, and causing it to appear when seen from a distance, as if covered with snow.

Most of the remarkable formations of rock salt hitherto known in various parts of the world are contained in what is denominated the lowest red sandstone which appears to correspond in character, position, &c. with the sandrock above mentioned. In this connection it is found in Cheshire, at Northwich and Droitwich in England, at the feet of the Carpathian Mountains in Poland, and in Peru. Accident, or further examination, it is probable, may hereafter bring to light those extensive beds of this substance which there is every reason to believe exist in the neighbourhood of the Rocky Mountains.

The briny character of those two great streams, the Arkansaw and Red River, flowing from this district of country, scarcely permits us to call in question the existence of such repositories; and the greatness of the quantity of salt which those rivers have for ages been washing away, would lead us to conclude that its beds must be of great extent. Analogy would teach us to look for them in depressed situations and in bason-shaped concavities, whose contents had not yet been worn down and removed by currents of water.

Other rocks of secondary formation are found in the great valley of the Mississippi, but have not been observed in that portion of it of which we have been speaking. These will be noticed at another time.

No. X.

Some Observations on the Anatomy and Physiology of the Alligator of North America. Lacerta Alligator, Gmel. Crocodilus Lucius, Cuvier. Communicated to the American Philosophical Society by N. M. Hentz, Member of the Academy of Natural Sciences of Philadelphia.—Read 21st July, 1820.

I WAS first induced to write the remarks which I have made on the anatomy of this animal, from observing the *singular structure of the organs of circulation*, presented on dissection; which I believe have hitherto been inaccurately described. I frequently repeated my dissections, and always found the same organisation of those parts, and have concluded to lay my observations before the Society.

It is not my intention to give the whole anatomy of the animal; such an attempt would be not only useless but altogether out of my power, under present circumstances; and its osteology has already been ably described by M. Cuvier in the *Annales du Museum.* It is highly probable, however, that in Europe the examination of the viscera has been confined to very young subjects.

M. Correa de Serra had the goodness to inform me that a traveller in the West Indies, Descourtils, had written a dissertation upon the anatomy of this animal. M. Cuvier, in the tenth volume of the *Annales du Museum* mentions his name, and says that he had dissected thirty or forty alligators. The work of this author I have not been able to procure; and I think it is not to be obtained in this country. Strongly impressed with the remarks of M. Correa de Serra, I had relinquished the idea of giving publicity to my remarks, believing that the subject had been treated accurately by able anatomists; but reflecting that this traveller wrote in 1806 or 1807,—that in the *Regne Animal*, published in 1817, at least ten years after, M. Cuvier describes the circulation in the crocodiles, as similar to that in the cheloniens or turtles,—and that the result of my dissections is far from coinciding with that description, I concluded that an error must still exist in regard to that important point of anatomy and physiology.

I now therefore lay before the American Philosophical Society my notes, illustrated by several drawings of the heart, and leave them to judge of the correctness of my observations.

I thought proper to add the drawing of the alligator, which I have taken from the recent subject, because in the new *Dictionnaire d' Histoire Naturelle* I find that no correct representation of this animal has yet been made.

The circulation being the most important point, I shall begin with the description of the heart, and shall first give the descriptions and opinions of M. Cuvier.

In the *cheloniens* or turtles, it appears that the heart is composed of two auricles and one ventricle, sometimes partly divided into two cells, which always communicate. It results from this organisation, that the blood returning from the different parts of the body, is partly propelled through the aorta; and that a portion of the blood brought to the heart by the pulmonary veins, flows again by the pulmonary artery into the lungs. M. Cuvier thinks that the circulation is the same in the *Sauriens*, which order includes the genus *Lacerta* of Linnaeus, to which the alligator belongs. In his *Regne Animal*, M. Cuvier merely expresses this opinion, but gives no particular description: in his *Comparative Anatomy*, however, he describes the structure of the heart in the crocodile. I shall here subjoin a literal translation of this passage, which must be compared with my observations: —

"*Heart of Reptiles.*

"We shall first describe the heart of crocodiles, because it furnishes us with an example of the most complicated structure that we have observed in animals of this order, or indeed in the whole class of reptiles.

"The pericardium adheres, as in the *cheloniens*, to the peritonæum, which covers the convex surface of the liver, and its point is retained by a very strong tendinous chord to the free portion of the sack, which is extremely thick, and exteriorly of a fibrous structure. It is fixed on one direction between the two lobes of this viscus; on the other, between the two lungs. The auricles, a little smaller than those of the cheloniens, have however the same relations, thick parietes, closed by strong fleshy columns, crossing in different directions. The ventricle, properly so called, presents an oval form, and very thick parietes; its cavity is *divided into three cells, communicating with each other by many orifices*, but giving, nevertheless, to the blood which they receive a sufficiently determinate course. One of these cells is inferior, and on the right: the auricle of the same side pours out the blood which it receives from the veins of the body by a large opening, bordered with two valves and placed at the most advanced part of this cell: upon the left side of this same cell, but still before, we find the opening of the left descending aorta; and behind this opening, an orifice which leads to the smallest of the three cells, placed at the middle part of the base of the heart, and into which opens the common trunk of the pulmonary artery.

"Consequently, the blood which arrives from the right auricle into the cell of the same side, has two courses to take :—1. That of the left desending aorta ; and 2. That of the pulmonary cell which forces it into the artery of the same name ; it may even take a *third* route, in filtrating through *numerous canals* that traverse the partitions which separate the two preceding,—the left and superior cell. The left auricle propels into this the blood which it has received from the pulmonary vessels. Its opening is bordered on the right side with a membranous valve, to the right of which opens the common trunk of the right descending aorta, the carotids, and the axillaries : which blood, passing into this trunk, is distributed particularly to the head and to the extremities ; or it filtrates through the intervals of the fleshy columns of this cell, and penetrates into the two others. It results from this, that the carotids and the axillaries carry to the anterior portion of the body, the iliacs to the posterior portions, and the median sacral to the tail, the blood which comes almost entirely immediately from the lungs ; whilst a portion of that which takes its course for the viscera (by the left aorta) comes from the right cell, and from the auricle of the same side ; and consequently has not traversed the lungs in order to be modified by the surrounding element. The pulmonary blood does not mix then so well with that of the body, as in the cheloniens. Such is the structure of the heart in the crocodile of the Nile and the Caïman." *Cuv. Anat. Comp. Vol. IV.*, *p.* 221.

I shall now give the result of my dissection, which differs very much from the preceding description :—

The heart, in the alligator, is placed in the centre of the thorax, exactly under the middle of the sternum ; it occupies a large space between the two lobes of the liver and the lungs. The heart itself however is not as large as might be expected from the mere inspection of it, when contained in the pericardium: the arterial tubes, nearly as bulky as the auricles and ventricles together, fill a great space in the pericardium, which contains besides a large quantity of lubricating fluid. The parts composing this organ are two auricles, two very distinct ventricles, a set of veins from the body, the pulmonary artery, two veins of the same name, a branch for the aorta on the left, another for the right side, the right subclavian, and the carotid artery. I shall now describe these parts, beginning with the veins returning from the body:

The vena cava descendens follows for a time the right subclavian artery; it enters the upper part of the pericardium, and is attached to the inner coat of this membrane until it joins the vena cava ascendens, opposite to the right auricle, where they unite. This vein runs along the right side of the vertebræ, until it reaches the inner and lower part of the large lobe of the liver; there it enters this organ, running in a perfectly straight channel, formed near the edge of this viscus, receiving from it a great number of veins, and comes out a little above the gall-bladder, where, along with four or five *venæ hepaticæ*, it enters directly the pericardium. This is closely attached to the liver, as M. Cuvier observes, but more so in that part than any other. There is another vein bringing the blood from the left axilla, which pierces the pericardium near and above the left pulmonary vein, and enters the *sinus venosus*. This vein is analogous to the left subclavian (of the human subject.) differing only from this, in its entering the right auricle *separately*: this, and several important observations, I owe to Dr. Harlan, who has examined the heart with me. These three veins empty themselves into the right auricle, which, rather larger than the left, is situated above and on the right side of the heart. The right ventricle, very muscular, has, like the left, thick parietes; it extends a little lower than the other, and is rather more spacious; it is furnished with two large valves situated near the orifice of the auricle to prevent the return of the blood. This ventricle has an opening into two arterial tubes; one on the left and superior part is furnished with two semilunar valves opposed to each other, and opens into the splanchnic or left aorta. At this place, the partition between the two ventricles is not as thick as below, but there is a cartilaginous septum, which is so placed as to divide and give elasticity to the orifice of the pulmonary artery, and the splanchnic or left aorta. I have endeavoured in vain to find here a direct communication with the left ventricle. The pulmonary veins pass under the *bronchia*, and pierce the pericardium behind; they then unite, and enter the left auricle, which is placed on the upper and posterior part of the base of the heart. The left ventricle is situated partly behind the other; it extends a little higher, and seems to be rather smaller; it is furnished, like the other, with two valves, placed before the orifice of the auricle; it has also an opening into two arterial tubes; the first leads into the left or splanchnic aorta, and is only separated from the orifice of the right ventricle into the same artery by the cartilaginous partition: it is bordered by a valve, which nearly closes it, so that a very small quantity of blood only is allowed to pass from this ventricle through the opening. The other passage for the blood is placed above; this arterial tube divides into *three* branches—one which forms the right or systemic aorta, another forming the right subclavian, and a third the carotid artery, which at first inclines on the left side, sends a branch which is the left subclavian, and previous to its entering the cranium, divides into two branches. This common tube, together with the left aorta, and the canal for the pulmonary arteries, is united, and forms a large arterial sack, situated above the heart, which is inclosed within the pericardium: the arteries divide into branches as they pierce through this sack. These three canals, above the ventricles, and before leaving the pericardium, are extremely enlarged, and form wide bags, capable of containing more blood than all the cavities of the heart together. Such I always found the structure of the heart in the alligator.

Thus the blood coming from the body is introduced into the right auricle: from this cell it flows into the right ventricle, which propels it into the pulmonary artery, and partly into the left aorta. On the other side, the pulmonary veins bring the blood from the lungs into the left auricle, which discharges it into the ventricle of the same side; from thence it is propelled into the right aorta, the right subclavian, and the carotid artery. It appears, that the circulation goes on in this manner whilst the animal is allowed to breathe; but when it is confined under water, when the lungs have ceased in part to perform their office, the right ventricle must send a greater quantity of blood into the left aorta, which becomes filled with an increase of the fluid; the weight and pressure must act on the valve, which, as I have already observed, allows but a very small quantity (if any) of the blood coming from the left ventricle to penetrate into the left aorta.

M. Cuvier describes the ventricle as being *divided into three cells, communicating with each other by many orifices.* I have proved, if my observations are correct, that there are two ventricles, very distinct, and having no manner of communication from one to the other through their partition: only nature has placed a large arterial tube (the left or splanchnic aorta,) which has a communication with the right or systemic aorta, and which being capable of great distention, when filled with the fluid, empties part of its contents into the right aorta.

This structure which M. Cuvier thinks analogous to that in the cheloniens, differs essentially from it. In turtles, a mixture of arterial and venous blood takes place in the ventricle: whilst in the alligator, when the left aorta becomes much distended with blood, which must be the case when the animal is under water, this artery may supply the left ventricle with part of its contents, but the two semilunar valves placed at the orifice of the right ventricle into this tube prevent the introduction of any part of the fluid into it from the arterial canal, so that the lungs never receive blood which has not passed through the system. Moreover, when the animal is exposed to the atmosphere, when the lungs receiving the regenerating element, allow the venous blood to flow towards these organs, both ventricles must receive an equal proportion of the fluid; the right aorta receives a greater quantity, and the left aorta must cease to be distended with a surplus of blood, whilst that part of it contained in the left ventricle must act upon the valve placed before the orifice leading to this same left aorta, and thus prevent the flowing of the blood from that artery. In this state, the other arteries are supplied with nearly pure blood. Such is the result of my observations. It appears that M. Cuvier, whose anatomical knowledge is well known, has dissected only a small alligator which was sent alive from the West Indies, which, though it died on the passage, arrived in time to be examined. Youth, disease, and several other causes, may have rendered this body an unfit subject to examine with certainty those organs; which I have dissected several times in large animals, soon after their being deprived of life.

In the alligator, the muscles are not very numerous, but extremely large in general, and strong; those of an animal killed as it has just left its winter retreat, are white and flaccid; they stand several days in the open air without any alteration, whilst the muscles of one killed in the summer are red, more firm, and resemble those of any animal with double circulation, except in their great contractile power after apparent death. I shall enumerate those muscles which are most conspicuous. On the thorax, there is an extensive pectoral muscle, covering nearly all the ribs, and inserted on the humerus; there is above, a flat and long muscle extending from the sternum to the lower jaw by one fasciculus, and to the larynx by another; one extending from the clavicle to the larynx: another arising from the *os hyoides*, covering the larynx, and ending at the point of the tongue; and a last smaller muscle, arising from the *os hyoides*, and attached to the lower jaw. These muscles having connections with the throat, bring down the larynx and the tongue, and probably assist deglutition. The most important muscle of the abdomen is one that arises from the *os pubis*; it passes under the abdominal ribs which have been described by M.

Cuvier, and is attached very closely on the anterior surface of the two lobes of the liver; a thin aponeurosis extends farther and nearly surrounds this organ; the contraction of this muscle must move down the liver, the heart itself, and indeed most of the viscera contained in the abdomen. Fibres from the above mentioned aponeurosis are attached behind the liver to the ribs, forming a sort of diaphragm, or a partition which divides the thoracic from the abdominal viscera. The last which I shall mention, remarkable for its size, arises from the first inferior process of the vertebra over the lungs; as it comes out of the thorax, it all at once grows very thick, and sends on each side a tendon which is attached to the first rib; it tapers gradually above, and is inserted into the sphenoid bone; it appears to me to be an antagonist to the muscles of the neck. The lower muscle of the tail is inserted on the pelvis, and to the femur by a tendon on each side. The *intestinal canal* is not very large; the œsophagus is extremely thick, and capable of great distention; the stomach has a rounded oblong form; on the right side, close by the orifice of the œsophagus, is that of the duodenum. This intestine, near the end of its second turn, receives the duct of the gall bladder. Near the end of the rectum, on each side, are two *intestina cœca;* they at first take a direct course upwards; above they lie in a vermiform position, fixed by a folding of the mesentery.

I always found the stomach empty, with the exception of some gravel and a few small pieces of wood. It is generally believed in Carolina, that the alligators swallow a piece of the resinous knot of the pine tree, before they retire to their winter retreat. A glass stopper has been found in the stomach of one, which had assumed a round form.

On each side of the anus there is a gland, which contains a thick yellow fluid having a strong smell of musk; but this smell is perceptible in every part of the body in old animals. M. Cuvier *(Règne Animal)* states, that on each side of the throat there is the orifice of such a gland: on dissecting this part, I found a small bag having an opening near the lower jaw; it contained some particles of sand; towards the bottom of this bag there is a white glandular substance, which, when opened, presents no cavity discernible by the naked eye, and is destitute of smell; the fore extremity of this is terminated by a similar substance, in the form of a cord, which is attached to the extremity of the cornu of the *os hyoides*. Several gentlemen informed me that when the animal is wounded or angry, he contracts the lower muscles of his neck, and the two bags protrude. I have not been able to discover the use of these organs. It has been said, that in the alligators and turtles, the heart beats for a long period after being extracted from the body; for my part, although I dissected the animals immediately after they were killed, nay whilst their limbs still preserved a sort of involuntary motion, I always found that the heart had entirely ceased to contract.

I cannot close my remarks without mentioning a circumstance which I am unable to explain: Whilst dissecting these animals, I often found small bags, apparently formed by the cellular substance; they contained a black residuum, and some fine gravel: in one of them I discovered the elytrum of an insect of the genus *Dytiscus*, well preserved. There was no connection with the surrounding parts, and no cicatrix could be perceived in the skin near them. I even found one of these bags under the sternum. I leave it to future observation to explain how they are formed.

This is the amount of my observations on this singular animal during my residence in South Carolina. I regret that it is not more complete. I have endeavoured however to make known such facts only as appeared to me to be new, omitting those which are already known.

Since writing the above, I have had an opportunity, in conjunction with Dr. Harlan, of minutely dissecting a young alligator. The animal being injected, furnished clearer demonstrations of the correctness of my remarks.

The following is a brief exposition of the result. The mucous coat of the stomach is smooth, without rugæ. About one inch from the pylorus, there is a constriction of the duodenum, forming another pylorus; immediately beyond this, the duodenum forms a loop, in which is found the *pancreas;* through this gland passes the gall duct. There is not the least vestige of the valvulæ conniventes throughout the intestines; but in place of them are transverse constrictions forming the alimentary canal into numerous cells, which must necessarily impede the progress of the contents. There was no blind gut in this animal.

In this subject, which was three feet ten inches long, the intestines were five feet in length.

The spleen lies beneath the duodenum, above the vertebræ. The left aorta, in the abdominal cavity, previous to its visceral divisions, gives off a considerable branch, which communicates with the right descending aorta; the rest divides into several branches distributed to the abdominal viscera.

The bag under the throat, in this young animal, contains a musky substance.

Letter from Dr. Harlan to N. M. Hentz, Esq. containing some further Observations on the Physiology of the Alligator.

Philadelphia, 19*th May*, 1824.

Dear Sir,

Since I had last the satisfaction of communicating with you, I have enjoyed another opportunity of dissecting an alligator, three feet in length, which had lived several months in the Philadelphia Museum. As the following facts tend to confirm the observations we made some time ago, on three individuals, I hasten to communicate them, in order to give you an opportunity of adding them to your paper, which I understand will soon be published. This dissection was performed on the 6th of January, 1824.

1. I forced air into the vena cava ascendens, which injected the right auricle and ventricle, passed into the lungs through the pulmonary artery, and into the splanchnic aorta, also into the systemic aorta through the valvular opening at the base of the former.

2. I forced air into one of the pulmonary veins, which inflated the left auricle and ventricle, passed into the systemic aorta and the subclavian trunks which leave the supercordal sack.

The apex cordis was not attached to the pericardium, as is usually the case.

The circulation of these animals is briefly as follows:

The blood passes from the right auricle into the ventricle of the same side. From this cavity there are three openings:—1. One into the systemic aorta, by a valvular communication at its base, which allows the continuation of the circulation, when the progress of the blood through the lungs is impeded by expiration.—2. One into the pulmonary artery —3. And one into the splanchnic aorta, carrying black blood to the viscera. During expiration, there is still some pulmonic circulation; a small quantity of blood passing from the lungs into the left auricle to the ventricle of the same side, from whence it has a direct passage into the systemic aorta. The valve at its base will not permit even wind to pass into the right side; nor will the semilunar valves of the aorta permit regurgitation; so that the only mixture of the black and red blood takes place in the systemic aorta, during expiration or collapse of the lungs.

With sentiments of respect,

I remain your friend, &c.

R. HARLAN.

N. M. Hentz, Esq.

EXPLANATION OF PLATE II.

Figure 1.*

a The heart contained in the pericardium.
b—b The vena cava descendens.
c—c The pulmonary arteries.
d—d Left axillary vein, or subclavian.
e—e Pulmonary veins.
f—f Left or splanchnic aorta.
g—g Right or systemic aorta.
h—h Carotid artery.
j—j Right subclavian artery.
i Trachea.
k Bronchia.
l The lungs.
m The liver.
n Muscle covering the liver.
o Œsophagus.

Figure 2.

This figure represents the heart, the pericardium being opened; and a section of the right ventricle and the left aorta.

1. Sinus venosus.
2. Right auricle.
3. Orifice of the right auricle into the ventricle of the same side with the valves.
4. The right ventricle cut open.
5. Orifice of the pulmonary artery.
6. Pulmonary artery, which being situated behind, is merely indicated.
7. Left aorta cut open.
8. Semilunar valves.
9. Cartilaginous septum.
10. The whole arterial trunk.
11. Part of the left auricle.
12. Attachment of the ventricles to the pericardium which is mentioned by M. Cuvier.

Figure 3.

This represents the heart viewed behind.

1. The left ventricle cut open.
2. The orifice of the left auricle, with the valves.
3. The opening into the left aorta nearly closed by the valve.
4. The common tube for the right aorta, partly cut open.

* The *latter* of the *double letters* in Figure 1, have reference to Figure 2, in the Plate.

No. XI.

Analysis of the Hydraulic Lime used in constructing the Erie Canal in the State of New York. By Henry Seybert.—Communicated on the 19th of July, 1822.

Philadelphia, 10th July, 1822.

Dear Sir,

Agreeably to your request, I examined the Hydraulic Lime which you presented to me, and herewith transmit to you the detail of my experiments. In Professor Silliman's Journal, Vol. III. No. 2, p. 231, we have a statement of Dr. Hadley's analysis of this substance, viz. carbonic acid, 35.05; lime, 25; silex, 15.05; alumine, 16.05; water, 5.03; oxide of iron, 2.02;=98.20. On examining these results, it was evident that the proportion of carbonic acid was too great for the lime: from my analysis, it appears that he overlooked the *magnesia*, which forms an essential constituent of this mineral.

I am,

Very respectfully,

Your obedient servant,

H. SEYBERT.

Dr. James Mease.

Analysis of the Hydraulic Lime used in constructing the Erie Canal in the State of New York.

This mineral is greyish both in mass and powder. It is without lustre. Opaque. Amorphous. Fracture irregular. Fragments indeterminate. Yields readily to the knife, and is easily frangible. Fine grained; presenting an earthy aspect. Its specific gravity is 2.753.

Analysis.

A. Three grammes of the mineral, finely pulverised. were digested in a phial containing a determined weight of diluted muriatic acid. The addition of the acid to the mineral occasioned an immediate and violent effervescence. After three or four hours, when the carbonic acid was supposed to have been entirely disengaged, it was ascertained that the diminution of weight amounted to 1.18 grammes. Hence we have 39.333 per 100 of carbonic acid.

B. The mixture *(A)* was then submitted to ebullition. When all the soluble matter appeared to have been taken up by the acid, the whole was evaporated to dryness. The residue was treated with water acidulated with muriatic acid, and again moderately evaporated. It was then treated with more water, and filtered. The residue on the filter was nearly colourless; and after calcination it weighed 0.435 grammes. This residue was calcined with three parts of caustic potash in a silver crucible, and dissolved in an excess of diluted muriatic acid. By subsequent evaporation of the liquor, &c. it was found to consist of 0.353 grammes of silica on three grammes, or 11.766 per 100; and 0.82 grammes of alumina on three grammes, or 2.733 per 100.

C. The excess of acid of the liquor *(B)* was neutralised with caustic potash. On adding hydrosulphate of potash, there was produced a black precipitate, which, after being roasted and calcined with a little nitric acid, yielded 0.45 grammes of peroxide of iron on three grammes, or 1.5 per 100.

D. After the separation of the ferruginous precipitate from the liquor *(C)* it was treated with oxalate of potash, which occasioned a voluminous white precipitate. This precipitate, after exposure to a high temperature, afforded 0.75 grammes of lime on three grammes, or 25.0 per 100.

E. The magnesia precipitated from the liquor *(D)* by an excess of caustic potash, after edulcoration and strong calcination, weighed 0.535 grammes on three grammes, or 17.833 per 100.

F. Three grammes of the pulverised mineral were submitted to a strong calcination. The diminution of weight occasioned by this treatment was 1.225 grammes. Now in deducting 1.18 grammes of carbonic acid *(A)* we have 0.045 grammes of moisture on three grammes, or 1.5 per 100.

We then have the following results, as the products of the preceding experiments, viz.:

(Per 100 parts.)

A.	Carbonic acid	39.333
B.	Silica	11.766
B.	Alumina	02.733
C.	Peroxide of iron	01.500
D.	Lime	25.000
E.	Magnesia	17.833
F.	Moisture	01.500
		99.665
		100.000
	Loss	000.335

No. XII.

Papers on Various Subjects connected with the Survey of the Coast of the United States. By F. R. Hassler.—Communicated 3d March, 1820.

CIRCULAR LETTER.

Treasury Department,
25th March, 1807.

Sir,

The President of the United States being authorised by an Act of the last Session to cause the whole of the coast of the said States, together with the adjacent shoals and soundings to be surveyed, it is his intention that the work should be executed with as much correctness as can be obtained within a reasonable time; and he has directed me to apply to you, requesting that you would have the goodness to suggest the outlines of such a plan as may, in your opinion, unite correctness and practicability.

As each nautical survey of the shoals and soundings, presupposes a knowledge of the position of certain points of the coast, it seems to me that the work should consist of three distinct parts, viz.:

1. The ascertainment, by a series of astronomical observations, of the true position of a few remarkable points on

the coast; and some of the light houses, placed on the principal capes or at the entrance of the principal harbours, appear to be the most eligible places for that purpose, as being objects particularly interesting to navigators, visible at a great distance, and generally erected on spots on which similar buildings will be continued so long as navigation exists.

2. A trigonometrical survey of the coast between those points of which the position shall have been astronomically ascertained; in the execution of which survey, the position of every distinguishable permanent object should be carefully designated, and temporary beacons be erected at proper distances on those parts of the coast on which such objects are rarely found.

3. A nautical survey of the shoals and soundings of the coast, of which the trigonometrical survey of the coast itself, and the ascertained position of the light houses and other distinguishable objects would be the bases; and which would therefore depend but little on any astronomical observations made on board the vessels employed on that part of the work.

But this is submitted to your consideration not for the purpose of pointing out any plan in preference to another, but only in order to shew the view which we have taken of the subject, and the degree of accuracy which we are desirous of obtaining.

I will only add, that the greatest practical difficulties which have heretofore occurred, relate to what I call the nautical survey; and on that part of the subject the following inquiries have arisen:—Can a correct survey be taken with one vessel alone? Can angles be taken with sufficient correctness from on board a vessel, so as to ascertain its position in relation to three visible objects on shore? Or is it necessary that the vessel's position, at the time of taking any particular sounding, should be ascertained by observers on shore? And many others which an examination of the subject will naturally suggest to you.

Permit me also to ask, whether you know any person whom you might recommend as capable of acting in the different parts of the work.

I have the honour to be
Respectfully,
Your obedient servant,
(Signed) ALBERT GALLATIN.

Mr. Hassler,
Philadelphia.

Philadelphie, 2 Avril, 1807.

MONSIEUR,

Honoré de votre lettre du 25 Mars passé, je prends la liberté de répondre à la confiance que vous voulez bien me montrer, et de vous communiquer mes idées sur les meilleures méthodes à suivre pour la levée des côtes, desirée par le gouvernement.

La marche que vous avez tracée à cet ouvrage dans votre lettre est très juste, et en contient les veritables principes ; permettez moi de les étendre seulement, en y appliquant quelques considérations plus détaillées.

Pour faire cette levée avec toute l'exactitude possible, la marche à suivre seroit la suivante :

De mesurer par toute l'étendue des côtes avec un cercle répétiteur à deux lunettes, d'un pied de diamètre (ou à son défaut, avec un theodolite anglois de même diamètre au moins, et susceptible de multiplier les angles) une chaîne de triangles d'environ 60 à 100 mille pieds de côte, fondée sur deux ou plusieurs bases mesurées, avec les moyens d'exactitude connus. Toutes les observations et déterminations astronomiques, que les circonstances permettront, ou qui peuvent être exigées, doivent être faites dans le cours de cet ouvrage, aux points convenables, tant pour déterminer les longitudes et latitudes des points, que les azimuths des côtés des triangles; se servant principalement du soleil et de l'étoile polaire pour les dernières déterminations et de signaux instantanés (p. ex. fusées volantes ou décharges d'armes à feu) données d'un point intermédiaire entre deux observateurs. On doit déterminer en même tems autant de points secondaires, et même autant de simples directions, qu'il sera possible, sans entraver le but principal. Cette mesure déterminerait, ainsi que vous l'avez observé, les fanaux, villes, villages, et autres points principaux des côtes, avec un nombre suffisant de signaux, érigés dans les lieux convenables pour la continuation des levées au détail. Les résultats seraient portés, d' après les différences des méridiens et parallèles, calculées pour le sphéroide terrestre, sur des grands papiers divisés en planches, d' après la convenance, accompagnés d'un tableau des longitudes, latitudes, distances, et azimuths.

Il serait avantageux de réunir toujours deux observateurs et une personne entendue pour signaler, &c.: il faut les subordonner, pour éviter les retards possibles d'une différence d'opinion sur les opérations. Il serait utile de former un centre pour tout l'ouvrage, sous un homme qui réunirait aux connaissances mathématiques celles de la géographie du pays ; chez lui seraient les calculs et la réduction de la grande mesure, la distribution, vérification, et rassemblement des ouvrages de détail.

Les journaux doivent être tenus avec une telle clarté que les observateurs, après leur retour, puissent les donner à toute autre personne entendue en tels ouvrages, pour en tirer les résultats. Ils doivent être in folio, et l'opposée de chaque page d' observation entièrement destinée aux remarques, dessins, descriptions des stations, même notice du tems, et autres. Une bonne methode de signalisation est trèimportante pour la vision distincte et certaine, et par conséquent pour l'exactitude et l'économie du tems.

Les signaux de la chaîne de triangles doivent être des pyramides triangulaires équilaterales de 10 a 30 pieds de haut, à base proportionnée selon l'exigence des localités, formés de trois sapins fixés en terre et réunis au haut, surmontés d'une forte perche, portant une boule de poterie, avec un fort bon vernis jaune, d'un pied de diamètre, soit de toute autre matière qui formerait un point réfléchissant, ou bien d'une sphère de 1½ à 2 pieds de diamètre, formée de cercles de barils, recouverte de toile blanche ou noire, selon que leur projection relativement à l'observateur tombe sur des objets terrestres, ou bien dans l'air ou la mer. Pour les signaux de nuit, des lampes d'Argand, à grandes mèches, de six pouces et même plus, de diamètre suivant les distances, peuvent être fixées sur ces signaux. Dans les basses terres ou les marais, les signaux élevés seraient indispensables. Au centre de la pyramide, pourrait être placé un appareil, d'un transport facile, pour supporter les instruments et les observateurs séparément. De cette manière, on pourrait observer avec une stabilité suffisante sur les terrains marécageux; surtout si l'on doit se servir du cercle répétiteur à deux lunettes.

Dans les bois, les signaux peuvent être érigés sur quelque point un peu plus élevé, ou unis à des arbres d'une hauteur prédominante. Ils pourraient être arrangés de manière qu' un observateur pût monter dessus, pour prendre les angles avec un instrument à reflexion, supposé que leur mesure ne pût être suppléée par celle des autres angles du triangle, avec le grand instrument.

Les géomètres chargés de la levée du détail, auxquels les planches et tableaux susmentionés seraient distribués, doivent baser sur ces points donnés, pour faire tous les remplissages qui peuvent être desirés, soit avec de petits théodolites, la planchette, la boussole, le sextant, &c. suivant la convenance des localités et les moyens dont ils pourront disposer. Il pourrait être réservé des déterminations moins essentielles, qui ne leur seraient pas communiquées pour servir ensuite à vérifier leur ouvrage.

Les sondes seraient levées par un petit bâtiment (p. ex. un *pilot boat)* avec un observateur à bord, suivant et secondant le géomètre levant les côtes. Il devroit être accompagné de deux chaloupes, pour la convenance des observateurs, pour servir de signaux, &c. Le bâtiment s'arrêtant chaque fois qu'il changerait de direction ou prendrait quelque sonde remarquable, l'observateur à bord mesurerait avec un sextant l'angle entre la station de l'observateur et la côte, (auquel il donne un signal) et quelqu' autre point convenable: en même tems l'angle entre le bâtiment et quelque point convenable, doit être observé sur la côte. La route du bâtiment ainsi levée, indépendamment des déterminations de loc et boussole, qui seraient néanmoins faites, découvrirait les courants (s'il y en a) par leur différence.

La levée nautique serait par là évitée, ou en cas de besoin substituée, lorsque celle aux côtes ne pourrait avoir lieu, suivant la convenance, et pourrait toujours être basée sur cette dernière. Il conviendrait que ces géomètres fussent secondés par un pilote, ou à son défaut par une autre personne connaissant bien les cotes, pour leur faire connaitre les objets remarquables, les noms, &c.

Dans ces levées, le problème des trois points, dont vous avez fait mention, trouverait souvent son application, mais étant sujet à une erreur d'autant plus grande, (en supposant quelque erreur d'observation ailleurs sans conséquence) que le point à trouver s'approche plus du cercle qui passe par les trois points donnés, au quel cas il devient indéterminé, il ne peut être donné en instruction generale. L'observateur doit donc, avant de s'y fier, s'assurer parfaitement que, dans le cas où il se trouve, l'usage lui en convient.

Le lieu d'un observateur peut aussi être déterminé par une seule ligne, donnée en longueur et direction avec le méridien, sous les latitudes donnees, par la mesure de leur angle au point cherché, et d'un azimuth.

Pour toute détermination d'azimuth, il faut faire usage des observations du soleil et des étoiles, surtout de l'étoile polaire. Il serait avantageux pour les géomètres occupés au détail de faire une instruction des problêmes de cette espèce, qui montrât dans quel cas l'application de l'un ou de l' autre est favorable ou non, avec les meilleures méthodes d'en faire l'observation. le calcul, la construction, &c. le tout adapté au mode de levée qui sera mis en usage, peut être même on pourrait y joindre des tables.

Un tel systême d'opération étant susceptible de tous les degrés d'exactitude qu'on peut désirer, (dans les grands triangles elle peut être à $\frac{1}{30000}$) et portant avec lui sa propre vérification, donnerait des résultats à tout usage, et permettrait de travailler hardiment dans les levées de détail, par les occasions fréquentes de vérifier l'ouvrage ; cette partie tire sans cela toujours beaucoup plus en longueur qu'on ne pense d'abord. Plus le systême adopté s'approchera de celui que j'indique, plus il donnera d'exactitude et d'utilité dans les résultats.

Si un tel plan d'opération était regardé comme d'une exécution trop entravée par les localités, il faudrait y substituer le suivant, qui serait :

De suppléer la mesure triangulaire par les déterminations de longitude et latitude, avec des chronomètres et des sextants ou cercles de reflexion, qui doivent dans ces cas être de première qualité, et les chronomètres toujours. 2. Une série de points et signaux, systêmatiquement placés et distribués, doivent par là être déterminés, de même que les triangles de la méthode precedente ; des déterminations d'azimuths et même des lignes mesurées et des triangles levés avec les instruments à reflexion, devraient y être joints, lorsque l'occasion s'en présenterait, tant pour multiplier le nombre des points déterminés que pour vérifier les déterminations astronomiques, l'une par l'autre mutuellement. Pour suppléer au défaut de pouvoir observer la double hauteur méridienne du soleil en été, il faudrait se servir d'étoiles bien déterminées, surtout de l'étoile polaire.

Aux endroits convenables et d' un interêt majeur, il faudrait, par la multiplication et variation des observations, suppléer par la jonction des observations astronomiques aux mesures des triangles mentionnés dans le système précédent.

Cette méthode, quoiqu' elle ne soit pas susceptible de toute l'exactitude de la précédente, est cependant exempte du défaut d'accumulation d'erreurs, parceque les déterminations sont indépendantes les unes des autres (on peut estimer les latitudes à 10″ de degré, et les longitudes par chronomètres à 2″ de temps exact.) Son inconvénient est de ne pas donner avec la même facilité et précision des déterminations de distance en longueur pour l'usage des levées de détail, desavantage qui est en proportion de la grandeur de l'échelle dans laquelle elles sont desirées. Ce qui a été dit sur la vérification des différences de longitudes par signaux instantanés, sur les signaux, les divers journaux, et les personnes requises, est absolument le même pour cette méthode. Les levées de détail pourraient y être faites de la même manière que dans le système précédent, en disposant proprement pour ces usages, les triangles, et autres mesures mentionnées.

Les détails pourraient aussi être levés par une extension de cette dernière méthode jusqu' au détail, et alternativement même à une levée nautique. Mais alors, pour ne rien omettre, il faudrait faire tous les calculs de suite. Après les observations, on perdrait l'avantage de pouvoir les vérifier et tirer parti d'observations subséquentes. Les mêmes personnes employées aux déterminations les plus essentielles, seraient ainsi chargées des menus détails, ou en dépendraient dans leur marche, étant obligés de diriger ou préparer et fournir l'ouvrage des géomètres occupés du détail, la marche systématique n'existerait donc plus.

La dépense de l'une et de l'autre de ces deux méthodes peut être regardée comme la même. Ce que l'une coûte en instruments à mesurer les angles et transports de terre, l'autre le coûte en chronomètres et louage de bâtimens.

L'économie du tems est décidée: 1° Par la saison plus ou moins favorable aux observations astronomiques, dont la levée chronométrique a plus besoin que celle des triangles, qui peuvent être mesurés souvent, quand les observations astronomiques ne peuvent avoir lieu; 2° Du degré d'exactitude exigé de la mesure des triangles, qui demandent plus de tems à proportion que les observateurs doivent être scrupuleux; 3° Du plus ou moins d'entraves que les localités mettent à l'une ou l'autre méthode.

La différente nature des côtes et le différent nombre d'objets à lever (comme isles, bayes, &c.) sur une même étendue de côtes extérieures, pourrait, peut-être, faire préférer, pour une partie de l'ouvrage, la levée suivant une méthode semblable à la première, et pour une autre la levée chronométrique, et même la nautique. Pour bien juger de cela, il faut avoir des connoissances locales, qui me manquent jusqu' à present.

Excusez, Monsieur, ces détails et la longueur de cette lettre; mais neuf encore dans ce pays, je n'ai pu parler qu'en principe, et discuter, sans décider: la connaissance des vûes particulières qui pourraient entrer en considération, des moyens scientifiques et des personnes dont on peut disposer, ainsi que des obstacles qui peuvent se rencontrer, me manque; de là dépend la décision de la préférence pour l'une ou l'autre des deux méthodes. qui sont, à mon avis, les plus exactes, et les plus convenables aux vûes principales du gouvernement.

J'ai l'honneur d'être,

Avec le plus parfait respect,

Votre très dévoué serviteur.

F. R. HASSLER.

M. Gallatin.

Plan for putting into operation the Survey of the Coast of the United States.

In my general plan of operation for the survey, I mentioned, that the establishment of two observatories would be necessary; and I thought it proper to procure the instruments, destined for them, of such a quality and size, as to be suitable for a permanent national institution. For this purpose, it would now be necessary to add only a mural circle and a zenith sector, which, however desirable, I did not venture to order, as their absolute necessity, in connexion with the survey of the coast, was not so obvious as that of the instruments procured.

These observatories form the fixed points, to which the survey, and particularly the naval part of it, is referred. The selection of proper places, the erection of the buildings, and the setting up of the instruments, will require some time. It would therefore be desirable to begin with this part of the general observation as soon as possible.

As they will be permanent scientific establishments, it will be proper to decide whether the expense of their erection shall be comprehended under those of the survey, or be considered as separate.

It will also be necessary to decide, where they shall be erected. To procure the greatest advantage for the survey, their positions should be as far north-east and south-west as the very favourable position of the United States admits. The same location affords also the greatest scientific advantages. Supposing one in the District of Maine and the other in Lower Louisiana, nearly every celestial phenomenon observable from the tropic to the arctic circle, and within about two hundred degrees of difference of longitude, could be observed at one or other of them. The comparison of their distance and position, as determined astronomically and geodesically, would offer the most rigorous proof of the survey. The observations made in them could be compared with each other, so as to render them independent of foreign observatories. Still, various considerations might occasion and favour the desire of placing one of these observatories in the city of Washington, as observatories are placed in the principal capitals of Europe, as a national object, a scientific ornament, and a means of nourishing an interest for science in general.

This observatory would then be the most proper place of deposit for the standards of weights and measures, which make part of the collection of instruments.

The observatory will require a constant observer; the duties of whom are evident from the nature of the instruments and the object of the establishment, viz. to make observations of every phenomenon leading to the determination of time and longitude. When the position of such an observatory shall be determined, I will have the honour of submitting a plan of construction adapted to the object and the locality.

The wooden stands for the instruments, the boxes for the bars to measure the base lines, and the tin cases to make the pyrometrical experiments with, being objects of bulk and inconvenient transportation, I preferred having them made in this country. Their construction is necessary to fit the instruments for actual use. As soon as this is done, I should proceed to standard the bars for measuring the bases, and to make the pyrometric experiments upon them. It would be very desirable that I should be authorised to make an expenditure of about eight hundred dollars for these objects, as well as for signal spheres, and lamps for night signals, which I found it also better to have made in this country.

All these preliminary objects could be attended to this winter, so as to enable me to begin, next spring, the first part of the survey itself, viz. the reconnoitering of a part of the coast, in order to project a part of the triangles best suited for accuracy, as well as approaching nearest to the figure of the coast, and to find a proper place for a base line to ground them upon.

In this operation, I should wish to be accompanied by a man acquainted with the part of the country I shall have to go through, and to be allowed an expenditure, for the transportation of the small instruments, the erection of temporary signals, &c.

Thus prepared, it would be possible to make the actual measurement of one base line in the latter part of the summer or in the fall of the present year. During this time, the building of at least one of the observatories should be completed. The instruments destined for it could then be put up during the winter, and the adjustment of those intended for the survey itself could be made with the necessary attention and minuteness.

The work of the principal survey will be to form a chain of triangles, with sides of about thirty miles in length, along the whole extent of the coast, so as to join the distant parts by the shortest and most accurate lines possible, and to determine the azimuths of the sides of the triangles, and the latitudes and longitudes of their angular points.

Within these, a series of triangles, with sides of about ten miles, will be formed to join them, part of which it will sometimes be possible to carry on simultaneously with the large ones. The object of these will be to furnish an ample number of determined points, to which the survey may be referred, in all its details.

It will be necessary to furnish the chief operator with the following assistance:

1. Two officers of the corps of engineers, well informed in mathematics, and with so much knowledge of the practical operations, as will enable them to make the secondary observations, and to keep the journal of them correctly.

2. Twelve men of the corps of engineers, most of them artificers, with a sergeant and corporal.

3. One baggage wagon, with the necessary horses, and a driver.

4. Tents and other field utensils, sufficient to accommodate the persons employed, and to shelter the instruments. It will be necessary to construct the tents for the instruments particularly for the purpose

5. It would be convenient, and in many cases important, that a few cadets should be added, who, by following the work, would prepare themselves to take the station of the officers, when they would be employed in operating by themselves, as will be mentioned hereafter.

The duty of one of the officers will be,—to act as assistant observer, captain of the men employed, and purser for all expenditures relating to the transportation of instruments, the construction and erection of signals, and other similar objects. For this purpose, it will be necessary to make a yearly appropriation of about two thousand dollars, of which he will have to keep an account. I suppose that the support of men and horses will be comprehended under the military expenditures.

The duty of the second officer will be,—that of a lieutenant of the soldiers, and of secretary to the observers. This last office is necessary for the observations. Without it, it would be often impossible to execute them within the absolutely necessary limit of time.

The wagon will serve to transport the baggage, provisions, tents, signals, tools, and such of the instruments as will bear this mode of transportation.

The employment of the men will be,—to carry the principal instruments from station to station, to erect signals, to prepare the stations for observation, clearing the ways, and various similar works, which will occur constantly in the course of the survey.

This mode of proceeding will make the actual expenses of the survey the smallest possible, as the requisite aid may easily be obtained from the army, without interrupting its service. It will have the advantage of preparing officers in an essential part of their employment, and of giving them a knowledge of the localities of the country, by which they may become particularly useful in future.

The survey cannot be carried into its details, until such a portion of the above work shall be executed and actually calculated, as will serve to occupy two or three detail surveyors, in a certain district.

The same is to be observed with respect to the nautical survey, which is to extend from the coast as far as any object important to navigation may occur. It will be most proper to use, in these parts of the work, well informed officers brought up at the military academy, and naval officers.

It was the intention of Mr. Gallatin to divide the whole work into two parts. If that should be the wish now, two corps of surveyors, as described above, would be required.

As the general chain of great triangles must, however, form one single system, it may be found proper not to make this division, until a part of these are done, and when the secondary triangles, being more numerous, will require an increase of the number of observers.

Such distributions of the work may be advantageously made, as the principal work is proceeding; when it might be divided into such a number as the localities would indicate. Thus, for instance, the coast of Louisiana being, by its geographical position, separated from the other parts of the coast of the United States, would, of itself, form such a subdivision.

Robert Patterson, Esq. Director of the Mint in Philadelphia, has, from the beginning, been appointed general superintendant of this work. In him the correspondence, and general communications relative to it, have been made to centre.

This part of the arrangement is therefore considered as fixed, independently of the present plan; which is intended merely to comprehend the ways and means for putting the survey itself into operation.

According to the directions of Mr. Gallatin, the collection of instruments is made sufficient to furnish, temporarily, the necessary instruments for a determination of boundary lines. If, therefore, any such work is now in contemplation, the instruments for it may be supplied from the collection.

F. R. HASSLER.

Washington, 5th January, 1816.

On the 15th of May, 1816, a communication was made to the government, on the measures necessary to be then taken, in order to put into immediate operation such portions of the work as could be undertaken during that season. As this communication did not differ, in any essential particular, from the above, it has not been thought necessary to insert it here.

A Catalogue of the Instruments and Books collected for the Survey of the Coast.

It may be proper to insert this catalogue in these papers, both for the convenience of reference, and as an account of the means by which the work of the survey was to be executed.

The instruments were the following:

1. One theodolite, of two feet diameter, made by Mr. Troughton.

2. Two double repeating theodolites, of one foot diameter, with a complete vertical circle by the same.

3. Two double repeating circles, of eighteen inches diameter, with two telescopes, made by the same.

4. Four double repeating reflecting circles, of ten inches diameter, with stands and artificial mercury horizons, and spirit levels for measuring small angles of elevation, made by the same.

5. Two reflecting circles exactly like the former, without stands or levels, by the same.

6. Two artificial horizons of mercury, with a glass cover.

7. Two artificial horizons, of dark plane glasses, of eight inches diameter, with ground spirit levels.

8. Two common surveying theodolites, of nine inches diameter.

9. Two compasses, with needles one foot long, with centre work and spirit levels, made by Thomas Jones.

10. Two alhidades for plane tables, with transit telescopes, made by Thomas Jones.

11. Two plane tables, suited to these instruments.

12. Two sets of apparatus for measuring base lines by a peculiar arrangement: each set consisting of the following parts, viz. four bars of iron, intended to be made the length of two metres; various screw works and a number of rollers for the motion of these bars, and of the boxes intended to receive them; a sector with a spirit level; a directing telescope; four thermometers; and three stands, with motion works, and microscopes with two different foci. Made by Mr. Troughton.

13. One standard English brass scale, of eighty-two inches in length, divided on silver into tenths of inches, with a microscope, and an arrangement for the comparison and construction of other scales. Made by Mr. Troughton.

14. One iron toise, standarded by Lenoir in Paris, and compared with the toise of Peru at the observatory, by Messrs. Arrago and Bouvard.

15. One brass metre, standarded by Lenoir, and compared with the iron metre at the observatory of Paris, by the same gentlemen.

16. A certificate of these two comparisons, signed and sealed by these gentlemen.

17. One iron metre, standarded by Lenoir.

18. One iron tool for filing off bars, perpendicularly to their length, by a rotatory motion.

19. One iron plane.

20. One strong very fine balance, with English weights, from 10,000 grains to decimals of grains, standarded by Mr. Troughton.

21. Two subdivided kilograms, in the form of parallelepipedons, standarded by Fortin in Paris, who was employed by the Committee of Weights and Measures in making the originals.

22. Two standard litres, with covers of ground plate glass, standarded by Fortin.

23. Two transit instruments for observatories, with five feet telescopes, made by Mr. Troughton.

24. Two astronomical clocks for the observatories, with mercurial compensation pendulums, made by William Hardy in London, on the same plan as that of the Greenwich observatory.

25. Two box chronometers, going one day, with silver dials, and corrections for short and long vibrations, made by the same.

26. One box chronometer, going two days, by Mr. Brockbank.

27. Two box chronometers, going only one day, by the same.

28. Two silver pocket chronometers, by the same.

29. One box chronometer, by Grimaldi and Johnson.

30. Two time pieces, shewing the three hundredth part of a second by a hand attached to the balance, made by Mr. Hardy.

31. One six feet achromatic telescope of Dollond, with a four and a half inch aperture, one terrestial and six astronomical eyepieces, a finder, the tube in three parts screwed together, and a mahogany stand in two parts.

32. One five feet achromatic telescope, with a four inch aperture, one terrestrial and six astronomical eye tubes, brass

shifting equatorial motion, mahogany folding stand. steadying rods, and a lanthorn illumination, by means of a small reflector in the centre; also by Dollond.

33. One five feet achromatic telescope of Tully, with a four inch aperture, the tube in two parts, one terrestrial and four astronomical eyepieces, level, finder, steadying rods. folding mahogany stand, &c.

34. One achromatic telescope of Tully, four feet eight inches in length, with a three and a half inch aperture, tube in two parts, two terrestrial and four astronomical eyepieces. mahogany folding stand, &c.

35. One three and a half feet achromatic telescope, with a three inch aperture, one terrestrial and six astronomical eyepieces, simple brass tube without stand or finder, by Dollond.

36. One three and a half feet achromatic telescope, with one astronomical and two terrestrial eyepieces, three inch aperture, brass stand, and steadying rods, by Troughton.

37. Three double wire micrometers, by Dollond, with changes of eyeglasses and prisms for high altitudes, to be placed before the eyepieces, two of them fitting the telescopes, No. 31 and 32, and the third the four other telescopes.

38. One top joint and socket for a telescope, on three legs of wood, to fit any telescope, for easy transportation.

39. Six mountain barometers, with brass mountings, by Mr. Troughton. N. B. These were brought without mercury in them, for greater security against breaking on the voyage.

40. Two large thermometers. extending to the boiling point, with Fahrenheit's and Reaumur's scale, intended for the observatory, by Mr. Troughton.

41. Two thermometers, on boxwood scales, brass shelter to the balls, also for the observatory, by Mr. Troughton.

42. Four detached spirit levels, of two different sizes.

43. Two sets of magnetic bars, one containing two, the other four bars.

44. One dynameter, by Dollond.

45. Two beam compasses, with short and long rods, and a double set of points, and one set to work upon brass, by Fidler.

46. Three proportional compasses, with perpendicular legs, for reduction and for constructing maps, by Fidler.

47. Two steel rules, five feet long and four inches broad, and four steel triangles of two sizes, to use with them by Fidler.

48. Various duplicate parts, to replace accidental loss or breakage; as turnscrews, metal wire, spirit level tubes filled, dark glasses, magnifiers, barometer tubes, &c.

49. The books consist of the best and most recent works on astronomy and geodesy, particularly useful for the instruction of the young officers intended to be employed in the work,—the newest astronomical and logarithmic tables of different kinds,—catalogues of the fixed stars, and celestial atlasses,—some other works of interest for the observatory,—the French Connaissance des Tems for several years,—in the whole forty-five works, of many of which duplicates were provided.

Comparison of the French and English Standard Measures of Length, and Regulation of the Bars for the Base Line Apparatus.

The necessity of having a standard measure of length, as accurate and as authentic as possible, for the measurement of the base lines, is sufficiently evident to shew the propriety of all the care which was taken to attain this object.

The two measures of length which have been the most scientifically ascertained and compared, are the French and English.

They are essentially different in their principle, and of different metals, which circumstance has always presented difficulties in their comparison.

The English standard is a *brass scale*, divided into inches and tenths of inches. Upon this, the mean of all the possible measurements of any distance is considered as the proper standard value of that distance, the yard and the foot measured in this manner being equally legal standards, though probably the yard was originally intended as such. The different scales are of different ages and accuracy; having been successively improved by various artists, by making scales from the mean lengths of various distances, taken according to convenience, upon the scale from which the new standard was copied. Upon this subject, Sir George Shuckburgh Evelin's Account of the Comparison of Measures may be consulted.—Philosophical Transactions of London, 1798.

The French standard consists in a *certain determined unit of length in iron*, given by a bar cut off to the given length, either a toise, as formerly, or, as at present, a metre; the iron toises of Peru being the only authentic original to which all toises are referred, and the metres of the Committee of Weights and Measures the authentic originals of the metres. Of their ratio and the mutual comparison of their measures, the "Base du Système Métrique" gives a sufficient account.

The standard temperature of the English scale is 62° of Fahrenheit's thermometer; that of the French metre 32° of the same scale: and the metre having been compared with the toise at this temperature, it has also been adopted for the toise, which was formerly referred to 16° of Reaumur's scale.

He who has ever attempted to copy any absolute measured length, with the accuracy necessary to form a standard, must have soon discovered what great minuteness, and care in the choice of means, are required for this purpose. Beam compasses and similar means will soon be found inadmissible. The successive transfer of a measure from a scale is far less satisfactory than the successive mechanical addition of a number of copies made from a standard unit, and compared to the same, or any other, by proper means. This conviction, derived from experience and a careful comparison of the modes of proceeding used in the late works of this nature in Europe, decided me to adopt, for the unit measure of the bars intended for the base, the combination of four iron bars, each of two metres in length.

I had one more decisive reason for this choice, viz. that I had at my disposition one of the metres standarded by the Committee of Weights and Measures in Paris, in 1799, which being of the same authenticity, in all respects, with any of these measures in the possession of the respective governments, and with the platina metre of Paris, places the accuracy of my unit measure beyond all possible doubt. The comparison made between the different standards, this being among the number, reduces any multiple length of my determinations to any standard desired, by an easy numerical calculation.

This comparison of the different standards, and the standarding of the bars for the base line, I executed in the months of February and March, 1817; but I intended to repeat all the comparisons again, before the measurement of the first base line with the bars. I had likewise intended to compare the standard metrical and troy weights, of which I had a full and authentic collection, by the fine balances placed in the collection for that purpose, and by another founded on hydrostatic principles, invented by my friend and teacher, M. Tralles. All these it was not possible for me to effect: I will however here record what I have been able to do in this respect.

I will first give an account of the particular standards which I have compared, and of their origin, so that a judgment may be formed of their authenticity. I shall also state the means employed in their comparison, and for the standarding of my bars,—to shew the degree of reliance which may be placed in my results.

The standards were the following:—

1. An iron metre standarded at Paris, in 1799, by the Committee of Weights and Measures, composed of members of the National Institute, and of deputies from other countries. Its breadth is 1.13 inches, its thickness 0.36 inches, English measure. My friend, Mr. J. G. Tralles, now member of the Academy of Sciences of Berlin, was at that time the deputy of the Helvetic Republic for this purpose; and, as may be seen in the account of the operations of this Committee, he was the foreign member directing the construction and comparison of the measures of length. He had one metre constructed for himself and one for me, at the same time with all the others, and subjected in all respects to the same processes and comparisons. In the ultimate distribution, it is known, that they were taken indiscriminately, and considered equally authentic, this metre being one taken by M. Tralles. He was so kind as to give me, at the same time, a standard *kilogramme*, constructed in the same manner, under the direction of Mr. Van Swinden. These original standards, both of length, measure, and weight, bear the stamp of the Committee, viz. a section of the elliptic earth, of which one quadrant is clear, with the number 10.000.000 inside of the arc; the other three quadrants being shaded.

2. One iron toise, with its matrix, in which it fits exactly, forming together a bar of three inches broad and half an inch thick, French measure. It is of careful execution, and presents the form seen at Plate IX. fig. 11. It was made by *Canivet, à la sphere, à Paris*, which is also engraved upon it, as also the notice, *Toise de France, etalonée le* 16^{me} 8^{bre}, 1768, *à la temperature de* 16° *du Thermometre de M. de Réaumur.* A line is drawn along the back of the toise, and from a perpendicular, crossing this line near one of its extremities, to a point taken near the other extremity, is engraved, *La double longueur du Pendule sous l'Equateur.* A point is marked between the other two at the simple length of the pendulum. Having been in Paris, in 1796, shortly after the death of M. Dionis du Sejour, I bought this toise

from his heirs. M. Lenoir, the artist who made the metres of the Committee, considered this standard, and that of M. Lenoir, well known from the Base Metrique, to be the most authentic of the kind in private hands. About the time stated for the standarding of this toise, the Academy of Sciences of Paris discussed the propriety of establishing, as a natural standard, the double length of the pendulum under the equator. M. Du Séjour being then a member of that Academy, and interested in the subject from his situation, this toise probably had reference to their views, which were afterwards directed to the metric system.

3. Two copies of the toises of Lalande, which were compared in England with Bird's scale, in 1765. The originals were lent to me by M. Lalande, in 1793. M. Tralles and I made two exact copies of each. The present are two of those copies: they are marked A. and B. like their originals.

The standards hitherto mentioned I brought with me to this country, in 1805. They are now deposited with the American Philosophical Society in Philadelphia; together with various works connected with the subject of a General Standard of Weights and Measures.*

4. A brass metre, of the same breadth as the iron metre above and half as thick, standarded by Lenoir in Paris, and compared by Messrs. Arrago and Bouvard with the iron metre, at the observatory, the 16th of March, 1813, as stated, No. 16 of the catalogue of instruments procured for the survey of the coast. M. Lenoir, who was employed by the Committee of Weights and Measures for the construction of the standard, had made for himself, at that time, a brass metre, which underwent all the comparisons at the standard temperature at the same time with all the iron and the platina metres. The present is a copy of this metre, respecting which the certificate mentions,—En applicant à nos mesures une correction dependante de l'inegalité de dilatation des deux metaux, il nous a semblé, qu' à zero du ther-

* See p. xliii., Vol. VI. Old Series.

mometre, le mètre en cuivre serait plus court que l'etalon en fer de nos archives de $\frac{1}{100}$me de millimetre.

5. An iron toise standarded by Lenoir, No. 18 of the catalogue of instruments. It is an inch and three quarters broad, and one third of an inch thick. The comparison of it by Messrs. Arrago and Bouvard, made at the same time with that of the metre above, says that it was found exactly equal to the toise from Peru in the archives of the observatory.

6. One iron metre standarded by Lenoir in Paris, but not compared at the observatory of Paris; being No. 18 of the catalogue. It is exactly of the same breadth and thickness as the metres of the Committee.

7. An iron bar, similar to the metre just mentioned, and intended to be brought to the metre length, in the course of these operations.

8. The brass standard scale, No. 13 of the catalogue, by Mr. Troughton. It contains 82 inches, divided into tenths, upon a strip of silver extending over its whole length. It is three inches broad, and half an inch in thickness. It bears the arms of the United States, and the name, *Troughton, London*, 1813.

To it belongs an apparatus for comparing measures by two compound microscopes, sliding on a rule and placed parallel to the scale of the same breadth and thickness. One of the microscopes has two fixed wires crossing under 30°, the other a micrometer with similar wires, pointing out distinctly the ten thousandth part of an inch. This apparatus has been described in Nicholson's Journal, and other works. A proper apparatus, with a Hindley's tracing tool, was added, to which the micrometer microscope is adapted, for the purpose of constructing other scales from this.

The scale was divided with that extreme care and accuracy for whch Mr. Troughton is so justly praised. It contains the double length of the principal part of his scale, of which an account has been given in Sir George Shuckburgh Evelyn's paper referred to above. Mr. Troughton first compared the different portions with one another, for which comparison and the subsequent division, he had constructed a proper apparatus. He thus formed a table of errors for his scale, in the manner described in his method of dividing, (Phil. Trans. of 1809) and then laid off the new scale, correcting each point according to the indication of the table.

The French standards were all compared with this scale of Mr. Troughton, by means of the apparatus described, and by methods which will be mentioned hereafter.

My particular method of standarding the double metre bars required another apparatus, which I had constructed for the purpose.

It may be said to be impossible to cut a bar perpendicularly to its length, by hand, with the accuracy required. The tool in question is intended for this purpose. The following are its principal parts:—

A plate of cast iron, about eight inches broad and two feet and a half long, exactly even and smooth, is adjusted by screws from below, upon a strong iron frame, at one end of which two pieces direct, in a perpendicular slide, the socket piece, which receives the axis of a circular file, of about three inches in diameter, to which the above plate is adjusted, so as to make the bar laid upon this plate, and presented to the file, exactly perpendicular to it. A strong iron bar is made to slide over the whole length of the plate, by means of two horizontal screws. The bar to be filed being laid upon the plate, and against this bar, a trial of filing, in two inverted positions, will show any defect of adjustment double. The adjustment must be made accordingly, and the surface of the cut will be perfectly even. There is a change of files of different fineness, and for the last, a turkey stone, which will take off all the marks of the file, and grind the surface smooth.

When only one bar is to be standarded, this tool must be used throughout with its different files, and the turkey stone last. But as I had four equal bars to standard at once, and could make the planes of their ends more perfect in consequence of the great surface they presented when joined together, I proceeded somewhat differently for the last finishing.

The bars were guaged, as nearly as the workman in London could do it, to the breadth and thickness of the metres of the Committee, and made seven feet four inches long. The double metre being only about six feet seven inches, there were nine inches to be cut off, which allowed me to make choice of the best parts of the bars for the cuts, and to avoid the parts near the ends, which are never equally well guaged, because the tools, which they are worked with, lose there their steady support, and fall off. The pieces so cut off were besides wanted for making the butting pieces for these bars and the metres in the comparisons, and for the final adjustment of these bars, as will be shown hereafter. The bars were lettered A, B, C, D, for the convenience of registering them. After their first cutting, there was enough left in length for the perpendicular filing. To bring them as nearly as possible to an equal breadth and thickness throughout, so as to present for the final adjustment one entire connected mass, they were all four laid close to each other upon a strong work bench, and pressed together by wedges. In this position, they presented, by the sum of their breadths, a surface four inches and a half broad, and by that of their thicknesses, one inch and a half. They were then filed together, with one of the circular three inch files of the above tool, varying their situation successively on both sides and in all positions. By this process they were brought to present, in all the combinations, an equal breadth and thickness throughout, and to lie together like one mass.

Having thus fitted the bars for lying accurately against the filing tool, they were filed down nearly to their proper length. A proper arrangement was made to extend the horizontal plane of the iron plate, so as to support the whole of the bar. Two of the pieces cut from the ends, one five, the other seven inches long, were adjusted, by the filing tool.

like the bars themselves, and rubbed with emery and oil, to serve as butt ends. for the final adjustment of the bars.

To execute this, the iron plate of the filing tool was fitted tight in the end of a plank, so as to continue its plane over the whole of it, to a greater length than the bars, and the plank was then planed, so as to form an exact continuation of the plane of the iron plate. Upon this plane the four bars were laid along side of each other, pressed together between brass pins and wooden wedges, and held down by wooden clamps. The ends upon the plank were butted by a straight piece of wood. The ends on the iron plate were rubbed with the seven inch long butting piece, with emery and oil; changing their relative position occasionally, until their ends presented, in all positions, one even, plane, and smooth surface, upon which the rubbing piece touched equally in all places, so as to present with them all one even, sharp. and straight line at their upper surface.

They were then all turned end for end, and made to fit against the five inch iron butting piece, so as to present again one even and sharp line, to which they were of course perpendicular. In this position, they were again fastened as before, and rubbed again with the seven inch butting piece, changing their relative position, until they presented, at these ends also, one uniform regular surface and sharp top line. The two iron metres of the Committee and Lenoir were then laid upon them, and appeared to coincide with them in length. This was of course tried several times; wishing however to suffer them to be somewhat longer, because the cooling down of the metal. which is always more or less heated by the working, will always shorten them somewhat. Indeed I have observed that the copies of measures made in this way are generally shorter than their originals. from this circumstance; their comparison being probably made too soon after the work, and before the metal is actually cooled down to the temperature of the original with which they are compared.

For the actual comparison of the metres and these bars, it was necessary to place them on the work bench, on which the above described comparator and English brass scale were, at the exact height, which would bring their upper surface, without parallax, to the foci of the microscopes, which were of course adjusted for the divisions of the scale. The influence of unequally supporting the standard bars, by merely laying something under them at different places, being great, I caused pine rules to be made, of sufficient breadth and length, and of the exact thickness required for each standard. Upon these each standard was laid, together with its proper butting pieces, when under comparison.

As it is wholly inadmissible to take the edge of a bar as an object under the microscope for the purpose of comparison, because it never gives a good image, the shorter pieces cut from the bars, from two to four inches in length, were filed on the tool, in the manner of the butting pieces above described, brought to the exact thickness of the standard with which they were intended to be used, and then the butting faces of them rubbed against each other with emery and oil, upon the iron plate of the filing tool, constantly inverting their positions, until such a perfect contact was obtained, that the line formed by it was not so thick as one of the divisions of the scale.

These pieces were always laid against the ends of the standard under comparison, so that the junction appeared like a line drawn upon the standard, with which the cross wires of the micrometer were made to intersect. The microscopes were furnished with reflectors, formed of white paper placed in a position inclining forwards, between the microscopes and their supports. By these the light was reflected upon the scale, or the standards, in the direction of the division lines, as required for accurate reading.

To prevent the heat of my body from having any influence on the scale and apparatus, a large sheet of paper was nailed to the work bench near the microscopes, and I worked with gloves on.

From seven to twelve thermometers were laid constantly over the scale and the standards, and were read at proper intervals of time.

The work bench itself was about double the length of the scale. It was accurately adjusted before the work, and the scale was so placed with respect to the windows of the room, that the microscopes received their light from separate windows.

The bench was made of two planks three inches thick, placed at right angles to each other, so that a transverse section was in the form of the letter T. The top plank was about twelve inches broad, and the whole rested on six legs.

No fire was kept in the room while the comparisons were making; and for some time before, the windows were left open day and night, to keep the different parts of the room in an equal temperature, being that of the surrounding atmosphere.

For the comparisons intended to be made in one day, every thing was prepared the day before, and left in such a state as to require as little handling as possible. This was done, in order that the parts of the apparatus might acquire throughout an equal temperature.

All these precautions were necessary to obtain satisfactory results, as is well known to men in the practice of such operations.

The probable error in the microscopic readings may be considered as increasing with the number of these readings. Having four metres, and the scale being sufficient to take in two, I had the means of diminishing this error one half, by comparing two at a time, instead of one. An equation between the results then enabled me to obtain the value of each metre. This method had the advantage of removing every prejudice from the mind of the observer in regard to the readings, in as much as the combination of the different measures and the different influence of temperature occasioned a variation which completely precluded previous estimates.

To prepare for reading, the microscopes were placed over the decimals, which, on the scale, corresponded to the length of two metres, viz. 78″,7 or 78″,8; and this distance was taken from +1″ to 79″,8; which brought it equidistant from both ends of the scale. The microscopes were fixed to this distance upon the scale with the greatest care; were then left for some time and were again verified. The scale was removed, and the two metres, with their supports, properly laid in its place, so as to bring the middle of their breadth under the faces of the microscopes. The middle contact was exactly made, the butting pieces laid to both ends, the coincidence of the end under the microscope with fixed wires effected, the middle contact again verified with a magnifying glass, the moveable wires of the micrometer microscope moved by the micrometer screw upon the image of the contact under its focus, and the value of the corresponding subdivisions read on the micrometer by its revolutions and subdivisions.

The longitudinal motion required to effect the contact cannot be communicated by the hand alone: the best mode of communicating this motion is by a few light strokes of a suitable piece of wood, applied carefully, and in such a manner as not to separate the different pieces by the counter-stroke.

The value of the micrometer parts was ascertained by repeated measurements of a decimal in different parts of the scale. From a mean of many such measurements, with the adjustment of the microscopes used for the metres, I found one decimal on the scale to be measured by one decimal and four units of the micrometer, or 0″,1 of the scale equal to 0″,1004 of the micrometer.

Lastly was to be determined, the individual value of the distance on the scale used in the comparison, in relation to the mean value of the same distance, resulting from its measurement taken on as many parts of the scale as were admissible, in order to give to the standards compared their value in terms of the mean distance of the scale, according to the principle of the English standard. This was effected by about fifty measurements with an unaltered microscope, and gave the distance used, 79″,8—1″,0=78″,800172 of the mean value of the scale. To this distance all the values obtained in the metre comparisons were ultimately referred.

To shorten the mode of registering the results, the combination of the metres, and their position, the following notation was adopted :—

M^c	denotes	The iron metre of the Committee of Weights and Measures in Paris.
M^l		The iron metre of Lenoir.
M^b		The brass metre of Lenoir.
M^y		The iron bar which I intended to bring to the metre length.
M^{c+l}		The metre of the Committee and that of Lenoir added together,—all marks being upwards.
$M_{ɔ+_l}$		The same metres,—all marks being downwards.

In like manner, in the other combinations, the addition of the special marks at the top, always denotes the sum of the metres so indicated, and the inversion of these letters the inversion of those metres.

On the 15th of March, early in the morning, the eleven thermometers, which remained on the scale during the preceding night, were read; and after having assured myself that all was in good order, I observed the comparisons inserted in the following table :—

Standards compared.	Micrometric measurements.	Mean of the four results.	Correction of micrometer.	Final value of the mean.	Mean of thermometers. *Fahrenheit's Scale.*
$M^{c}+^{b}$	78″,760400				30°,85
$M_{ɔ}+_{q}$	78″,761150				
Ends changed to middle.		78″,760962	—0″,000244	78″,760718	
$M^{c}+^{b}$	78″,760990				
$M_{ɔ}+_{q}$	78″,761310				
$M^{b}+^{l}$	78″,759030				
$M_{q}+_{l}$	78″,760575				
Ends changed to middle.		78″,759777	—0″,000240	78″,759537	
$M^{b}+^{l}$	78″,759200				
$M_{q}+_{l}$	78″,760303				
$M^{c}+^{l}$	78″,760415				
$M_{ɔ}+_{l}$	78″,760450				
Ends changed to middle.		78″,760472	—0″,000242	78″,760230	
$M^{c}+^{l}$	78″,760475				
$M_{ɔ}+_{l}$	78″,760550				34°,1

About half past eleven, the four double metre bars were successively put under comparison for the first trial of their length, and found, by one single measurement only for each, as follows:—

Bar A	78″,761500	—0″,000246	78″,761254	
B	78″,762275	—0″,000290	78″,761985	
C	78″,761450	—0″,000245	78″,761205	
D	78″,760900	—0″,000240	78″,760660	
				36°,1
Sum	315″,046125	—0″,001021	315″,045104	

The sum of the four double metre bars appearing still too great, the bar B, which gave a result above the others, was rubbed somewhat more in the manner above stated, though single, some of the butting pieces being laid on the side to support the plane.

The micrometer microscope, in the foregoing comparison, was read by addition, or from 78″,7 onwards. On the 17th of March, it was turned one half revolution horizontally, so as to read by subtraction, or from 78″,8 backwards, to compensate any possible influence of the micrometer. The micrometer values were verified again in this position, and found as before; all other things being left as before, and prepared for the comparison of the next day.

On the 18th of March, early in the morning, all being verified again and found in good state, the comparisons were repeated, with the results exhibited in the following table:—

Standards compared.	Micrometric readings subtractive from 78″,8.	Mean of the four results.	Correction of micrometer.	Corrected results to be subtracted from 78″,8.	Actual value of the distance.	Mean of the thermometers.
$M^{c}+^{l}$	0″,044075					46°,6
$M_{ɔ}+_{l}$	0″,043030					
Ends chang. to mid.		0″,043900	0″,0001756	0″,043724	78″,756276	
$M^{ɔ}+^{l}$	0″,043250					
$M_{ɔ}+_{l}$	0″,043235					
$M^{c}+^{y}$	0″,039175					
$M_{ɔ}+_{ʎ}$	0″,039300					
Ends chang. to mid.		0″,039702	0″,0001588	0″,039643	78″,760357	
$M^{c}+^{y}$	0″,040200					
$M_{ɔ}+_{ʎ}$	0″,040135					48°,6
$M^{l}+^{y}$	0″,041525					
$M_{l}+^{ʎ}$	0″,040830					
Ends chang. to mid.		0″,041295	0″,0001651	0″,041130	78″,758870	
$M^{l}+^{y}$	0″,041600					
$M_{l}+_{ʎ}$	0″,041225					

The four double metre bars were now successively put under comparison, in their four possible positions, the inversion of the letters denoting the inversion of the bars:—

Standards compared.	Micrometric readings subtractive from 78″,8	Mean of the four results.	Correction of micrometer.	Corrected results to be subtracted from 78″,8.	Actual value of the distance.	Mean of the thermometers.
Bar A	0″,044475					
∀	0″,044250					
Chang. end for end.		0″,0443690	0″,00017750	0″,0441915	78″,7558085	
A	0″,044325					
∀	0″,044425					
B	0″,043375					
ꓭ	0″,043750					
Chang. end for end.		0″,0433620	0″,00017340	0″,0431886	78″,7568114	
B	0″,043150					
ꓭ	0″,043175					
C	0″,043575					
Ↄ	0″,043775					
Chang. end for end.		0″,0437940	0″,00017520	0″,0436190	78″,7563810	
C	0″,043850					
Ↄ	0″,043975					49°,8
D	0″,043300					
ᗡ	0″,043100					
Chang. end for end.		0″,0433625	0″,00017345	0″,0431890	78″,7568110	
D	0″,043550					
ᗡ	0″,043500					50°,5

In the afternoon of the same day the comparisons of the metres were repeated, with the results presented in the following table :—

Mc+l	0″,045390					50°,3
M +,	0″,044625					
Ends chang. to mid.		0″,0448290	0″,00017930	0″,0446497	78″,7553503	
M+l	0″,044750					
M,+l	0″,044550					
Mc+y	0″,040475					
M,+6	0″,040525					
Ends chang. to mid.		0″,0408500	0″,00016340	0″,0406866	78″,7593134	
M +y	0″,040850					
M,+6	0″,041550					
M'+y	0″,043175					
M +6	0″,042450					
Ends chang. to mid.		0″,0426125	0″,00017040	0″,0424421	78″,7575579	
M	0″,042300					
M,+6	0″,042525					51°,8

To make these results comparable, it is necessary to reduce them all to one temperature, by the difference of expansion between iron and brass. I shall for this purpose make use of the results of my pyrometric experiments, made immediately after this comparison, aud described in p. 224, Vol. I. N. S. of the Transactions of the American Philosophical Society, the mean results of which gave the expansion expressed in decimal parts of the whole length, for one degree of Fahrenheit's Scale, as follows:—

In iron,=0,000006963535
In brass,=0,000010509030
Difference,=0,000003545495

As all the details of the comparisons are here stated, it will be easy to apply any other expansion in the further calculation of the result, if desired.

The temperature having increased during the comparison with considerable regularity, and my work having been uninterrupted and uniform from the beginning of each series of comparisons to the end of it, the temperature corresponding to each of the results may be considered equal to the mean temperature between the two observed. The temperatures adopted in the table of results were therefore determined upon this principle.

I found it best to reduce all comparisons to the temperature of 32° Fahrenheit, or 0° Centesimal and Reaumur, for both the brass and iron, as we may easily obtain this temperature in nature, and it can therefore be presented by experiment; which would not be possible, if the value of the French measures at 32° were given in a length of the English brass scale at 62°, since this would always introduce a result of mere calculation. I shall reduce from iron to brass: so that the length of the metres will be given in English inches in brass, at the temperature of 32° Fahrenheit. The brass metre is therefore in this case considered as needing no reduction.

In the final reduction of the values obtained. I shall add, as a constant quantity, 0″,000172 to each result: this having been shown above, to be the surplus length of the individual division used over the mean length of the scale for 78″,8.

The following table will present the results of all the foregoing comparisons for the temperature of 32°, with all the necessary reductions:—

Dates of the comparisons.	Standards compared	Temp. at the comparison.	Immediate result of the comparison.	Fahrenheit, 32°.	Reduction for temperature.	Value at 32° Fahrenheit.
Mar.15 A.M.	M^c+b	31°,1	78″,7607180	—0°,6	—0″,0000837730	78″,760806229
	$M+b$	32°,5	78 ,7595370	+0°,5	+0″,0000698108	78 ,759778811
	M^c+l	33°,7	78 ,7602300	+1°,7	+0″,0004747134	78 ,760876715
				+	+	
Mar.18 A.M.	M^c+l	47°,1	78″,7562760	15°,1	0″,0042165000	78″,760664500
	M^c+y	48 ,1	78 ,7603570	16°,1	0″,0044957000	78 ,765024700
	$M+y$	48°,9	78″,7588700	16 ,9	0″,0047191000	78″,763761100
	Bar A	49°,2	78″,7558085	17°,2	0″,0048028600	78″,760783360
	B	49°,5	78″,7568114	17°,5	0 ,0048816200	78″,761865020
	C	49 ,8	78″,7563810	17°,8	0″,0049704000	78″,761523400
	D	50°,2	78″,7568110	18°,2	0″,0050820400	78 ,762065090
	A+B+C+D					315 ,046236870
Mar.18 P.M.	M^c+l	50°,5	78″,7555503	18°,5	0″,0051656700	78″,760687970
	M^c+y	51 ,0	78 ,7593134	19 ,0	0 ,0053055500	78 ,764790950
	$M+y$	51°,5	78 ,7575579	19°,5	0 ,0054451000	78 ,763175000

The principles of the arrangement of this comparison show that the result for each individual metre will be obtained by a simple equation of the following form, viz.:

$$c = \frac{(c+b)+(c+l)-(l+b)}{2}$$

and in like manner for all the others, by a proper mutation of letters.

The following table will present these results :—

Dates of comp.	M^c	M^l	M^b	M^y
Mar. 15, AM.	39″,380952064	39″,37992415	39″,379854162	
Mar. 18, AM.	39″,380964100	39″,37970040		39″,3840606
Mar. 18, PM.	39″,381151960	39″,37953601		39″,3836290
Means	39″,381022708	39″,37972015	39″,379854162	39″,3838448
Correction of Brass Metre, as per Certificate			+0″,000393810	
Brass Metre corrected according to Certificate			39″,380247972	

These results might now be compared with others: viz. with those obtained by M. Pictet of Geneva, in 1802, and those by Captain Kater, since mine were made ; but as I have not the details of their operations and the expansion they used, on which it is evident that much depends, I shall omit such comparison here.

I shall confine myself to inserting the final results found by Mr. Troughton and myself, in London, in 1813, from a comparison of the two metres of Lenoir, in iron and brass, with Mr. Troughton's own scale, each metre being compared singly by the help of the butting pieces, as above described. They are :—

	Temp. of Fahrenheit.	Correction	Value at 32°.
		(for temperature.)	
M^l=39″,3783658	45°,5	+0″,0018848	39″,3802506
		(for certificate.)	
M^b=39″,3799395	46°,0	+0″,0003938	39″,3803333

the brass metre requiring no reduction for temperature.

The mean of these two metres in this comparison may be considered as identical with the mean of the three in the comparison detailed above ; and its difference from the mean obtained above for the same metres is equal to 0.00030789.

The consideration of all these results proves that all copies of metres tend to be shorter than the original from which they are taken, from the circumstance that whenever they are worked, either by filing or rubbing, to bring them to the proper length, they acquire unavoidably a certain degree of heat occasioning an expansion which does not subside fully, before the comparisons which direct the standarding are finished. The metre being therefore rendered equal to the original under these circumstances, will be found too short, when it is completely cooled down. Thus the metres made by Lenoir are both shorter than the original metre of the Committee of Weights and Measures. It is from this consideration that I did not bring the bar fully to the measure, but it still remained considerably above the proper length. Being however engaged in the comparison, I disliked changing it, and thereby overthrew a part of my work, wishing to delay it for a future time.

On the 21st of March, I took the different standards of the toise under comparison.

The toise of Canivet being half an inch French in thickness, and the English brass scale half an inch English measure, the microscopes were adjusted to fit this toise without parallax, and then the difference was compensated by laying four thicknesses of white paper strips under the whole length of the scale. The other toises had strips of proper thicknesses laid under them to bring them to the same focus.

The distance of 76″.8, which is nearest to the length of the toise, was taken between the microscopes, from +2″ to 78″.8 on the scale, placing them nearly at equal distances from both ends.

The value of the micrometer was determined by repeated measurements of the decimal on the scale between 78″.7 and 78″.8, which decimal was found to measure 0″,10053 by the micrometer.

I intended, as before, to determine their value by other intervals also; but this being deferred until the end of the operation, as well as the determination of the value of the distance used in mean distance of the scale, neither of these measurements has yet been made, on account of the interruption necessary in order to make the pyrometric experiments before the breaking up of the winter. The micrometer values indicated in the results are however corrected for the above value, and represent therefore actual decimals of the individual subdivision mentioned. From this circumstance, the comparison remains confined to the distance used on the scale; but it may easily be extended, by measuring this distance, as indicated, on as many other parts of the scale as admissible; and the difference will probably not be much.

When the microscopes were screwed fast in their places, the 0° point of the micrometer did not exactly agree with the division of the scale from which it was intended to read. Instead of adjusting it by the screw which guides the slider of the micrometer and the divided head of the screw, I preferred ascertaining carefully the point of coincidence on the division and on the micrometer, and to adopt this last as the 0° point of the micrometer, from which the divisions were to be subtracted, since the micrometer was read from 78″,8 backwards, or by subtraction. The point so determined was 78″,8001375; or the actual distance from which the readings were subtracted was 76″,8001375.

The repetition of the comparisons with the microscopic readings direct, which I had also the intention of making, was prevented by the circumstances stated above; and I never afterwards could bestow any time upon this subject, before the collection left my hands.

The abridged notations for the registering of the comparisons are as follows:—

C	denotes the toise of Canivet.	
L		Lenoir.
l^A		the copy of the toise of Lalande marked A.
l^B		the same marked B.

the inversion of the letters denoting that the marks on the toises are downwards, the erect positions that they are upwards.

The length of the contact in the toise of Canivet is about two-thirds of an inch. In this three points were observed, as marked Plate IX. fig. 8, between *mm*, in the middle; between *ii*, at about one-fourth of the contact with the matrix from the inner corner; and between *ee*, about 0″,05 from the end of the contact. The toise was of course kept with the matrix, as this formed a proper butting piece to observe by, though the line was not altogether as sharp as that with the butting pieces made for the other standards. The breadth of the matrix prevented me however from turning it end for end, as there was not room enough between the microscopes and their supports.

The following table will present these comparisons:—

Toises compared.	Micrometer readings subtractive from 76″,8001375	Mean of the readings.	Correction of micrometer.	Corrected readings.	Value of the scale or measure.	Temperature.
C^m	0″,058250					33°,4
C^i	0″,059500					
C^e	0″,056400					
Chan. end for end		0″,0576958	0″,0003058	0″,0573900	76″,7427475	
ɯↃ	0″,057050					
ᴉↃ	0″,058675					
ǝↃ	0″,056300					
L	0″,061530					35°,1
⅂	0″,060550					
Chan. end for end		0″,0606200	0″,0003213	0″,0592987	76″,7408389	
L	0″,060700					
⅂	0″,059700					36°,9
l^s	0″,061020	0″,0618350	0″,0003277	0″,0615073	76″,7386302	
sl	0″,062650					
l^B	0″,053600	0″,0536750	0″,0002845	0″,0533905	76″,7467470	
Bl	0″,053750					
						39°,0

The results of this table are now to be reduced to the standard temperature of 32° Fahrenheit, as was done for the metres; for which I shall again use the results obtained by me, and stated before :—

Toises compared.	Temperature.	Immediate result of the comparison.	Temp. —32°.	Reduction for temperature.	Value at 32°
			+	+	
C	34°,25	76″,7427475	2°,2	0″,00059722	76″,74334472
L	36°,00	76″,7408389	4°,0	0″,00108820	76″,74192710
l^A	37°,40	76″,7386302	5°,4	0″,00146921	76″,74009941
l^B	38°,50	76″,7467470	6°,4	0″,00174145	76″,74848845
$\frac{l^A+l^B}{2}$					76″,74429393

At the time of comparison of the two toises of Lalande in 1765, when compared with Bird's scale, the mean of both was 76″,734 at the temperature of 62° Fahrenheit; and it was stated that it was 0″,024 longer than when determined by Mr. Graham, of which comparison I know no details. This comparison of 1765 reduced to 32°, by the results of my experiments on expansion, would give the mean of the two toises of M. Lalande, equal to 76″,742162. What expansion was used then, or whether any correction was applied for it, I do not know. I have no knowledge of other comparisons of the toise, except that which might be drawn from the determination of the distance over the British Channel, by both French and English measures, in the operations made by General Roy, and by Cassini de Thury, for the junction of the Observatories of Paris and Greenwich.

It is proper that I should observe here, that the toise of Canivet served to make the four toises for the base measuring apparatus, which was used in the measurement of the base line of about 42,000 feet on the Marsh of Morat in Switzerland, made by Mr. J. G. Tralles and myself, upon which the triangulation of Switzerland, begun by us, has been founded.

Though it is evident that the above comparisons of toises give only individual results, yet it may be proper to mention, approximately, the ratio they give between the length of the toise and of the metre, omitting the toises of Lalande. The combinations which they give occasion to make, all give the metre, in parts of the toise, between 0″,513162 and 0″,513137. The Committee of Weights and Measures adopted, in the construction of the metres, the ratio, 0″51317. M. Delambre gives, in the *Base Metrique*, 0″,513111185 at 16½° centigrade.

Description of the Apparatus for measuring Base Lines.

In all surveys of considerable extent, the exact determination of the line, which forms the base of the whole triangulation, is of the greatest importance.

This line forms the absolute unit on which all future units depend. It is expressed in terms of the unit of length employed in its admeasurement; and the extreme distances of the whole survey referred to it must correspond to the places which astronomical observations assign to them on the earth.

The measurement of a line may appear simple and easy in common life, where no minute degree of accuracy is required, and where commonly the line itself is of no considerable length.

In the application to large surveys this forms the most tedious part of the work; and presents, in its mechanical execution, difficulties, which have always called forth the inventive genius of the operators.

This is not the place to expect a history of the different means employed in determining this line, nor to comment on their comparative advantages or difficulties.

It may be easily conceived that the most minute care is required to determine the fundamental unit length of a bar or chain to be used in the measurement of a base, from the standard unit of length measure, and that the standard unit employed in it must be well authenticated. The means which I used, and the authenticity of my standards, are detailed in another place, to which I must refer for information on this subject. I shall only observe that I had peculiarly authentic and well adapted means to obtain a multiple of the metre lately determined from the measurements of twelve degrees of the meridian in Europe, and to determine the length so formed in English measure. I was therefore lead to give this multiple the preference, and accordingly I formed bars of eight metres in length, which I considered as the longest that would be well manageable in the actual measurement of a base line.

Considering the principles on which the measurement of a base line must depend, it is evident that the problem requires:

1. To determine absolutely in space the extreme points of the unit employed in the measurement.

2. To make this line begin at any given point.

3. To give it a certain determined direction.

4. To ascertain its position with respect to the horizon.

To satisfy the first condition, the theory of mathematics applies most generally three rectangular ordinates, and it is easily conceived that in this case something similar must be mechanically executed by some means or other.

In all the methods hitherto used, the mechanical contact of the bars or chain with the point from which either a previous bar or a line perpendicular to the direction of the base is measured, has been aimed at, and as the moving of the bars in their perpendicular direction presents much difficulty, on account of their weight and friction, this has been obviated by small sliders measuring the intervals between the bars laid near each other in the direction, occasioning of course a vernier reading which required much care and attention to small quantities.

I considered an optical contact of the ends of the bar with the determined point preferable to any other, both for accuracy and easy manipulation, and I obtained it in as perfect a manner as possible, by means of the following arrangement:—

This part of the apparatus is a microscopic arrangement, of which Plate III. fig. 1, presents a vertical section, of about the fourth part of their real size, showing all the screw motions in the direction of the three rectangular ordinates.

A compound microscope, *aa*, about seven inches long, is kept in a vertical position, by passing through two horizontal plates, *bb*, projecting from two columns, *ee*. It can be raised or lowered to bring it to the proper focal distance, and then held fast by the screws, *dd*, which press the spring of the circular part of the plates, *bb*, together.

The object glass of this microscope is formed of two halves of lenses of different foci. The one half will bring the image of a cobweb thread stretched over the end of the bar at *e*, about three inches from the lens, to the focus of the eye lenses: the other half lens will bring to the same focus the image of the rectangular crossing of two lines traced on a small plate of ivory, *h*, which is screwed to the middle of the thick brass plate, *ii*, at about six inches from the object lens, and adjusted in the collimation line of the microscope. The ends of the bar have, through the middle of their breadth, a semicircular opening, to admit the cobweb to be stretched across it, and to admit more light from the point *h*, to come to the microscope, as seen in its natural size in the horizontal section at *g*.

In using the apparatus, the images above mentioned are to be brought in contact as in a reflecting instrument, either by the screw of the microscope, or that of the bar, as the case may require. As the cobweb thread at the end of the bar is perpendicular to the direction of the base, it is best to place the rectangular crossing lines on the ivory plate, so as to make angles of 45° with the direction of the base. The contact will then be effected by making the image of the cobweb bisect the right angle thus formed. The microscopes themselves are to be placed so that the line dividing the two half lenses may be in the direction of the base or bars, in order that the light from both objects may be as equal as possible, which would not always be the case in any other position. The microscope must of course be placed at the proper distance from the point *h*, so as to present a distinct image of this point.

It is evident, that by this arrangement the optical contact obtained is similar to that of the microscope reading on a circular instrument, and can be made with great ease and accuracy. The determination of the point of contact in the vertical direction is equally accurate; for the limit of only tolerable vision in the compound microscope, which for the cobweb has about three inches focal distance, is already very narrow, and within less than one-twentieth of an inch. This would hardly affect the level of the bars, and still less the difference between hypothenuse and base. But when the vision is carried to distinctness, it will be totally destroyed.

The two horizontal motions required to place the point *h*, and the microscope, are made, in the direction perpendicular to the bars by the screw, *kk*, revolving in the end pieces of the plate, *ii*, and working in the socket which projects above the middle of the lower plate, *jj*. In the direction of the bars, the motion is made by the screw, *ll*, which turns in the lower plate, *jj*, and works in the socket projecting from the circular piece, *mm*, below. The positions of these screws, when in actual use, are seen in Plate III. fig. 7 & 8.

The circular plate, *mm*, is encompassed by a ring, *nn*, which presses it down to the plate, *oo*, to which this ring is fastened, but in such a manner as to admit its entire revolution within them, by hard friction, as it is usually called. By the circular revolution of this plate, *mm*, the whole upper part of this apparatus can be placed in the position best adapted to receive the bars freely, as is represented in the figure.

The plate, *oo*, is about four inches and a half in diameter, and is fastened to the steel triangular bar, *pp*, which is about seven inches long, and which slides closely up and down in the heavy brass truncated cone *qq* resting on three legs like *r*.

The steel triangle *pp* is moved vertically by the strong screw *s* of which the capstan head *t* is turned downwards, and rests against the smaller base of an inverted hollow cone *uu* screwed fast to the solid piece *q*. This screw *s* can be moved very gently, to bring the cobweb of the bar into the focus of the microscope, by a pin and handle fitted to the holes of the capstan head *t*.

The legs *rr*, which support this apparatus, are of wood, and a number of them of different lengths should be prepared to suit the inequalities of the ground within the limits of the motion of the triangular bar *pp*, by which the nearer adjustment to the focus is made. They screw in brass ferrules, which serve to connect them to the solid piece *qq*.

In the actual use of the apparatus, it is necessary to have at least three such microscopic arrangements, that while two of them are used before, the third may be left behind for reference in case of accident. This arrangement will be taken forward when the bar is laid off the second time.

The point *h*, so determined in space, becomes that from which, when the bar is moved forwards, the further measurement is to begin. By means of this apparatus, it remains steady in its place, and the bar, when laid down in the next position, is adjusted by making the cobweb at the other end coincide with the focus of the half lens corresponding to it, as at *g*; all motions are then made by the screw work on the bar apparatus, of which a description shall immediately be given.

The second and third requisites make it necessary that the bar which is to measure the distance should be adjustable in all directions. It will immediately be seen that the longitudinal motion is attended with the most friction, and must on that account be impeded as little as possible. This precaution however seems to have been overlooked in the

English base apparatus, where this motion was impeded by the weight of the whole box and its apparatus.

Plate IV. fig. 1 & 2, presents a horizontal and vertical section of the whole apparatus, placed as when in use.

The whole bar between the two foci of the microscopes consists of an assemblage of four iron bars each of two metres in length, and exactly of the same breadth and thickness as the metres constructed and standarded by the Committee of Weights and Measures in Paris in 1799. They are joined together end to end by means of two iron clamping pieces AA, a section of which, perpendicular to the bars, is seen, in one-fourth of its real size, in Plate I. fig. 2. Each of these pieces being clamped to its bar by the screw B, the two corresponding pieces of the adjoining bars are screwed, in order to make the contact of the bars, by the longitudinal screws CC, above and below the bars. The bars can be easily brought in contact, as any gap would be immediately observed; and there is no fear of compression, because the instant of contact is easily ascertained, and before any compression of the metal could take place, the friction of the screws B would give way, and restore equilibrium and contact.

This assemblage of bars stands edgeways upon rollers F of one-third of an inch in diameter, placed at short distances (so that each double metre bar may have four) in brass pieces DD, which bear also pillars of about one inch in length EE, rising on both sides of the bars and presenting a rounded surface to them like a section of a cylinder. This surface is near enough to the bars to prevent their vacillation, but not their motion. Different sides of them are seen at Plate III. fig. 2, 4, 5, and a plan of one of them is seen at fig. 3. In one of these pillars, which is directly above the screws for the motions of the bar, there is a clamping screw G. (Plate I. fig. 4) by which the longitudinal motion of the bars on these supporting pieces and rollers is arrested. From this point, therefore, the expansion of the bars is allowed to act with full freedom upon the rollers F.

The pieces DD, which are thus the immediate bearers of the bar, are fastened upon a wooden quadrangular bar H of two inches square and about twenty-six feet long, receding about seven inches from each end of the iron bar, Plate III. fig. 4. and Plate IV. To prevent, as much as possible, this wooden bar from warping in the air, it was formed of strips of wild cherry, glued together so as to break joints. To move this bar H in the direction of its length, and thereby also the iron bars, there is a brass frame K, Plate III. fig. 4 & 5, and Plate IV. with a screw arrangement adapted to one end of it, by three screws LL going through the wooden bar and the two brass plates which embrace it on both sides. Two strong perpendicular pieces MM, Plate III. fig. 4, of which one forms the butt end of the bar H, and the other is held parallel to it at the distance of eight inches, form the socket of the axis of the steel screw Q, which is about 0,6 inches in diameter, and which is hid in the brass framing K. It is turned by the milled head screw I, seen at the end of this frame, perpendicularly under the bar.

The piece P, which has the mother screw corresponding to Q, is fixed solid to the O, which lies flat in the bottom of the box to which it is fastened by four strong screws passing through the brass and the bottom board, and made fast by mother screws from the lower side of the board.

The piece P, having the mother screw corresponding to Q, has two friction rollers RR on its side, Plate III. fig. 5, which press against the upper plate N of the brass frame K, to prevent any rotatory vacillation by the friction of the screw.

By the screw Q, the measuring bars are evidently moved in the box in the direction of their length. This motion is fully eased by eleven rollers SS of about half an inch in diameter, passing under the whole breadth of the bar H. All lateral motion is prevented by steel springs T, pressing moderately against it from both sides, and which are fast to the uprights holding the rollers, so that the contact of the cobweb on the bar with the image of the cross on the ivory. is made by it, when this bar is to be placed for going off again from the point determined by the position of the microscope.

The piece O, bearing above the mother screw corresponding to Q, has also a part X, going downwards through the bottom of the box, which forms the socket of a steel axis of two inches long and two-thirds of an inch mean diameter, ascending vertically from the brass mother piece Y, which runs upon the steel screw ZZ, by which the box containing all the apparatus above described is moved horizontally in a direction perpendicular to its length.

The screw ZZ is held by a strong brass frame which is fastened to the end of a board of an inch and a half in thickness, by screws exactly similar to those which fasten the piece O to the box. At the other extremity of the box, a strong circular socket is fastened by screws, receiving below an axis Y, exactly equal to that described before, and moveable in the same manner by another screw Z, equally fastened to the thick lower board Z′.

This lateral motion is again eased by twenty-four brass rollers *aa*, an inch in diameter and one inch and a quarter long, fastened below the bottom of the box, and so fixed that two are opposite to each other near the side of the box.

This motion being across the grain of the wood, there are screwed to the lower board Z′, thin crossing pieces *bb*, of very hard wood, and in the direction of the grain, upon which rollers move with great ease, and without making any impression.

The box of this apparatus is always carried upon the thick board Z′, and placed upon the tripods in a direction so nearly true, as to be within the limits of the screws ZZ; it is then placed by these screws accurately in the true direction, being guided by a telescopic arrangement at the top of the box, to be described immediately.

The strong board Z′, which supports the box with the bar apparatus, rests upon five tripods with elevating screws in the centre, as seen in Plate IV. A number of these tripods, sufficient to support two lengths of bars, must be in readiness. They should have legs of different lengths, so that they may be raised or lowered, to suit the inequalities of the ground.

To place these tripods properly, so that the box may rest equally on them, it is necessary to have a large level, similar to those used by masons, and long enough to reach three tripods. It should have an alhidade hanging vertically by its own weight, with a horizontal spirit level, and an arc below consisting of as many degrees as the locality of the ground may require, as seen at Plate IV. fig. 3.

The box including the bars and the other apparatus described, of which XX is the bottom, is about nine inches in width and height at both ends and fifteen inches in the middle. It is strengthened at the upper part by seven crossing pieces *dd*, with notches holding the sides in their proper positions. There is no wooden cover to the box, as a piece of canvas is intended to be hung loosely over it, which prevents the inner part of the box from heating. At both ends there are projecting pieces, which widen so as to cover the microscope apparatus, and shut out the side light from the objects observed and the sun from the ends of the bar. They move on hinges, in order to turn them back on the sides of the box and to prevent them from injury. This arrangement is seen at Plate IV.

At the top of the side of the box, near the end where the screw motions are, a brass support *e* is adapted, having a telescope exactly equal to those on the ten inch sextants, and adjustable exactly in the same manner in its horizontal direction. It is of small magnifying power, so that a pin *f*, erected at the other extremity of the box, may be seen without parallax at the same time with a distant signal directing the measurement. It has a vertical wire in the focus to effect the adjustment of the box independent of the pin. It may not be amiss to place two such telescopic arrangements on the box, one directed forwards in the manner described, the other backwards on the other side of the box. These will serve for the purpose of verification, and may be taken from the collection of instruments, of which all the parts are double.

It is evident that half the breadth of the box, or distance of the directing telescope from its middle, must be considered in viewing the signals used in the alignments of the base. This condition will be satisfied by making the breadth of the signals equal to that of the box, and by directing the telescope to the proper side of each signal in the fore and back observations.

In relation to the fourth requisite of the apparatus for measuring base lines, viz. the ascertaining of the position of each part towards the horizon, the simplest and easiest mode might seem to be to measure the line actually horizontal, and in case a difference of level should occur, in which it would be too inconvenient to follow the same level, to fall or rise to a different level by means of a plumb line. But this mode should not be adopted when great accuracy is required, as experience would soon prove to an attentive operator. The deviations from the level to be obtained will increase so as to be unsatisfactory, and the placing of the apparatus will be found too tedious, and at the same time liable to inaccuracy.

The measurements were generally taken as near as possible to the soil. This supposes of course that the lines measured in the intervals were all straight lines, which probably was not the case.

I considered that the shortest as well as most accurate mode of proceeding was to ascertain the true position of each bar when it was actually employed in the operation. Horizontal measurements, however, should be taken whenever the ground is favourable to them; and when this is not the case, the tripods should be fixed to the proper inclination by means of the level above mentioned.

The focal point of the cobweb on the bar being determined with great accuracy in respect to its elevation, (as is evident from the absence of parallax between the two objects,) we may measure from it in any inclination that occurs, without fear of error in the distance.

The following is the arrangement added to the bar apparatus to measure this inclination. It is seen in both figures of Plate IV. but more particularly in Plate III. fig. 4, 5, & 6.

Upon the strong brass frame K. forming the leading part of the wooden bar H, a sector of ten inches radius is screwed by its strong edge bar *mm*, (fig. 4) and presents itself vertically, its centre being at *h*, and the divided arc *g*, at the side of the head l of the screw Q. It contains an arc of upwards of thirty degrees. Upon the alhidade of this sector there is a spirit level of about seven inches long, adjustable to the 0° of the sector by the screw *i*, which makes it revolve about the point *k*. The alhidade being moved by the tangent screw racking in the circumference of the arc *g*, until the level be obtained with the alhidade corresponding to any inclination of the apparatus, the reading of the vernier on the arc will indicate the inclination of the apparatus or the bars to which the sector has been adjusted.

For the reduction of the inclined distances to the horizontals, it is evident that a table of differences between the hypotenuse and base of a right angled triangle can be constructed to any degree of accuracy desired, the quantities of which referring always to the same unit, viz. the length of one full system of bars, will be taken out without any calculation, and their sum can be subtracted from the sum total at once.

Respecting the thermometers, it will not be necessary to say any thing here, as it is easily conceived that they must all be read at each laying of a box.

I might now describe the manipulation of this apparatus in the actual measurement of a base line, but I consider the use of each part of it so obvious to a person sufficiently acquainted with these subjects, as to render such description unnecessary. Plate IV. presents both a horizontal and vertical view of the whole apparatus, as when actually employed in the measurement.

The safe transportation of the boxes between their placing and removal, from under the microscopes, will require considerable care, and also an arrangement to prevent the box from being put out of shape, in carrying it upon uneven ground, and by which in an extreme case even the bars might lose their contact. It will therefore be proper to adjust these bars, in case of any suspicion of this kind.

There being two complete sets of instruments in the collection intended for the survey, and a case seldom occurring in which both sets shall be employed at the same time, it may be convenient to use more than one full set in an operation. For instance, take more than three microscope stands. For greater security, take the directing telescope of the set not in use to make the back verifications of the line, by placing it at the other side and end of the box. Take additional rollers, thermometers, changes of legs, tripods, &c. &c.

The manner in which the journal of the measurement of a base line should be kept requires minute care. on account of the great number of observations and remarks to be inserted. I would here give a sketch or extract of such a journal, had I completed the measurement of a line with this apparatus ; but the survey of the coast was interrupted before this could be effected. I shall however insert a few remarks, which occurred to me in Switzerland, when measuring with Mr. Tralles, now Member of the Academy of Berlin, in 1791 and 1797, a base line of about 42000 feet in length, and upon which the triangulation was founded. This base was measured twice : first, with a chain similar to that made by Ramsden for the English survey,—and secondly, with an apparatus of four toise bars, somewhat similar to that above described.

I shall place these remarks under the following heads :—

1. It is necessary to mark in the preliminary measurement and the alignment of the base a number of points, at equal and moderate distances from each other, so that at least one of these points may be found in each day's work of the accurate measurement, for the purpose of showing whether the length of a bar had been omitted, or written twice.

2. The journal must have regular columns for the observations made at the laying off of each box, and a column should be left for incidental remarks, the first column showing the number of each bar from the beginning to the end.

3. The time at which the adjustment of each bar is effected by the microscopic apparatus should be noted to the nearest minute. This may be entered in the second column. It is evident that this will serve to check the registering of the bars, by showing whether any mistake had been made that was not accounted for in the remarks inserted in the left column.

4. The stand of the sector, indicating the position of the bar towards the horizon, together with the stands of the several thermometers, marked and placed after each other in the order in which they have been read, should occupy the third or next column.

5. The points of coincidence of each of the marks stated in Art. 1 with the bar or any fraction of it must be carefully marked in the next column. Likewise the passage of any ditch, fence, or other permanent object that may be of use in finding any particular point in the line after having passed it.

6. At every fifty or hundred bars, a mark should be left behind, so accurately determined, that, in case of accident, the measurement might be again made from it, without the necessity of returning to the beginning. These marks should be numbered, and the time of placing them should be written in the journal.

7. In the evening, or at any other time when the work is suspended, the place of the last microscope apparatus taken off should be marked and registered in the journal.

8. At such suspension, the last microscope stand and the bar last layed off with its microscope stands adjusted, must remain in their places till the work is resumed. The whole must be covered with a tent, and well secured.

(A tent made for this purpose, with others made for the microscope stands, was delivered with the apparatus.)

9. Notwithstanding all these precautions, it will be proper to keep a constant watch over the apparatus when left out, and even perhaps to make a fence round it, if it be in a place where cattle pasture.

10. In the morning, or whenever the work is resumed, every thing must be carefully verified and noticed in the journal.

11. It is of course understood that the dates before and after noon, the state of the weather, the temperature of the exterior air at stated intervals, and any circumstances that may increase or diminish the confidence in the work at any time, must be inserted in the journal, and that it should contain a detailed account of the manipulation adopted, the persons employed, &c.

12. If the base should not finish with a full length of bar, as is generally the case, the last point determined by the bars should be carefully marked on the ground, and the complementary distance measured by means of a beam compass, or by any other means that shall lead to satisfactory results.

13. The measurement of a base line should be continued with as few interruptions as possible. Considerable trouble will then be saved in respect to covering, fencing, &c. the apparatus, and all sudden and unequal changes of temperature in the bars will be completely guarded against. I would therefore advise the operator to finish each day's measurement without interruption, and when this cannot be done, to suspend the work till a more favourable opportunity presents itself.

Description of the Two-feet Theodolite.

Plate V. presents a general perspective view of the instrument; and Plate III. fig. 7 & 8. the details of the centre-work in a horizontal and vertical section.

The horizontal circle *aa* is of two feet diameter, divided on a silver arch to every five minutes. It is fastened on six conical hollow radii *bb*, proceeding from a strong hollow hexagonal centre piece *c* of six inches in diameter, to which they are screwed fast each by four strong screws passing from the inside of the piece *c* into the strong base of the cone. The diameter of the cones is three inches at the base, and an inch and a half at the outer circumference of the circle.

Of these six radii, three reach only to the outer circumference of the circle, and the three others, intermediate between these, project about two inches farther, to receive the spheric nobs *dd*, through which vertical double screws pass, which level and support the instrument upon the truncated cones *ee*. These elevate the instrument sufficiently above the stand, to admit the verification telescope under the centre of the instrument.

The construction of these double screws for the adjustment of the instrument in levelling is best seen in the section of the Repeating Theodolite, Plate IX. fig. 2: as this construction has been applied to all the larger instruments, in order to render their adjustment more exact. *c′* is the outer screw, which is of brass, going into the mother screw perpendicularly through the nob, and having its milled head *c′* below it. This screw being hollow receives the steel screw *a′* through its whole length: the milled head *d* has below it a segment of a sphere, left rough so as to impress itself into the lead which is in the top of the cone *e*. The screws being placed so as to give play to the screw *c′* both in the nob and inner screw *a′*, the motion of the screw *c′* serves to raise or lower the arm or radius of the instrument which it directs; and the inner steel screw having smaller threads than the outer c', the effect of its motion is proportional only to the difference between the distances of the threads of the two screws, by which means a very delicate motion is obtained.

By the three cones *e*, *e*, *e*, the instrument is fixed upon a solid stand of pine wood, the circular top board of which is two inches thick. A hexagonal frame underneath joins this board to the three legs, and at the same time preserves the top from warping. Pine wood was preferred, because it warps the least; and though, strictly speaking, a triangular board would be sufficient, the circular one is much preferable, on account of the protection which it affords to the instrument against accidental touches in passing round it during the observation. The board is, for the same reason, three feet in diameter; and I even took the precaution of placing the cones *e* always above the legs of the stand, to give the instrument more firmness. In the centre of the board is a hole, so that the centre of the instrument may be centered to the station by a plumbline hung from a loop in the centre below the axis.

The hollow hexagonal centre piece *e* above mentioned receives through its middle the bell metal axis *f*, Plate V. fig. 2 & 3, eleven inches in length, two inches in diameter at the bottom of the inner hollow part of the piece *c*, and an inch and a half at the top, which shows above the drum in the perspective view of the instrument, Plate V. The bottom part of this axis has a shoulder *hh* by which it is fitted into the hexagonal centre piece, and below it the plate *gg* projects to the outer circumference of the same hexagon, which serves to fasten the axis to this piece, by means of six strong screws, seen in fig. 8. The circular hole in the bottom of the centre piece *c* is the centre upon which the circle was divided.

The brass socket of the axis, by which the whole upper part of the instrument revolves upon the above axis, reaches through the drum, and is fastened to it by the three circular plates forming the top, the bottom, and the middle plate of the drum *i*, Plate V. fig. 3.

This drum is nine inches in diameter and five inches and a half in height. From the side of it project three horizontal arms *l*, *l*, *l*, at 120 degrees from each other, which are hollow truncated cones similar to the radii of the horizontal circle, and of the same diameter near the drum, but much more tapering. Each of them bears at the end a strong piece *qq*, with a circular vertical hole to receive the compound micrometer microscopes by which the divisions are read off.

These microscopes are six inches long, and with a magnifying power of about fourteen times. They are marked A, B, C, in the direction of the numbers of the gradation. The degrees are only read by the microscope marked A, and are there indicated by the light index *m*, which projects from below the arm of the microscope, and folds back upon it when not in use. When in use, it is made visible by the microscope, when laid out so as to point close to the division, without however touching the arch, in order not to scratch it. The field of the microscopes embraces about 4,5 minutes of the division, so that there is never any difficulty in reading the smaller parts. The thirty minute marks being extended entirely across, like those of degrees, and the degrees distinguished by a strong dot in the protracted part of the line, always one or the other appearing in the field. The micrometer heads *nn* read in the inverted direction, on account of the inversion of the image by the microscopes, so that while the degrees go from right to left, the reading in the microscopes presents itself directly, or from left to right.

These microscopes being well known by various descriptions, it would not be proper to enter here into further details respecting them. They can be adjusted to 120 degrees by a small horizontal motion, which they admit in the pieces *q*, directed and fastened by three screws on the side of these pieces at about 120 degrees from each other. The vertical adjustment of the whole microscope to the proper focus is made by two milled rings embracing the microscope, one above, the other below, the piece *q*. The adjustment for the arrangement of the microscope, as it refers to the proper situation of the wires with respect to the focus of the object glass, is obtained by screwing the lower concealed part into or out of the upper cylindrical part. It is held in its proper place by a small ring *b′*. As it is well known that these two last mentioned motions must always be made together, and the clearness of vision, absence of parallax, and accurate measurement must be obtained by both at the same time by trial, it will be sufficient here merely to indicate the screw serving for it.

A small screw *pp*, at the end of the micrometer opposite the screw head moving the rake or indented plate of the same which indicates its 0° point, will make the final adjustment to the division point, or the distance between the microscopes desired.

After some experience, I have, however, found it best not to adjust the microscopes to 120° distance, as it appears to me that the influence of a little deviation in this respect may be wholly neglected in comparison with the advantages of having the microscopes fixed simply in the middle of their holding pieces *qq*, which makes them more firm, and places the 0° point of the micrometer in the middle of the field of vision. I used them therefore always in this position, in which they remained perfectly steady, and which gave besides a kind of moral advantage, from the circumstance, that as the readings became thus different in minutes and seconds for each microscope, the observer remains entirely unprejudiced as to what he should read at each microscope, and each reading becomes thereby equally independent and impartial.

Upon the drum *i* are two spirit levels, four inches long, at right angles to each other, to serve for the first approximate levelling of the instruments, which I found, under tolerably favourable circumstances of temperature, always exceedingly correct, and rivalling the large upper level, when that nicety of adjustment was observed which their smaller scale naturally required.

The transit telescope, which forms the upper part of this instrument and by which the angles are observed, is supported by two columns fifteen inches high screwed upon the drum at right angles to the microscope A. In travelling, these columns are unscrewed at *oo*, to prevent the box in which they are carried from being top heavy, and more effectually to secure them from injury; though I had the box also fitted to receive them with the instrument in some cases, in order not to disturb the upper adjustments of the instrument.

At the lower part of the drum, in the direction of the two columns, towards the right from the microscope A, is the arm *k*, made broad, but thin, so as to have sufficient strength in the horizontal direction and yet very little friction on the limb. This has the clamping and tangent screws, and presents itself always conveniently to the hand, in all positions of the instrument towards the observer.

The tops of the two vertical columns bear two pieces *yy*, projecting outwards to admit the axis, twelve inches in length, of the transit telescope, which is supported between them in rectangular Y's as usual. In one of these pieces, at *r*, is a screw, with a capstan head, showing through a cut in the side, which bears by the head upwards against the piece *y*, and by the screw part below against the uppermost part of the column, forcing the piece *y* upwards by the mere spring of the metal, and, between this bearing point and the screw *s*, fastening this piece to the column.

The telescope is a complete and very excellent transit instrument, describing a whole vertical, the eye end of the telescope having room to pass between the two columns without touching the top of the axis *ff*. It has thirty inches focal length, two inches and a half aperture, and four magnifying powers, the largest of which is about seventy-seven times, and one of the middle ones prismatic. There is a lengthening tube of about five inches in length to the object end, to keep off the side light and shelter the object glass. It balances at the same time the opposite end of the telescope. Then equilibrium is established in all positions of the telescope without clamping, which always more or less affects the accuracy of its position.

In the focus of the telescope there are three fixed vertical wires, and one horizontal one moveable by a micrometer arrangement similar to that of the reading microscopes. by which small differences of level can be measured, as a very fine large spirit level can be hung lengthways to the telescope by two adjustable steel pins, on the side of the tube not seen in the figure. The vertical wires are of course adjustable like those of any transit instrument, by two opposite screws on the sides, as d'.

The middle piece of the transit is a zone of a sphere of five inches in diameter, to which the two parts of the telescope are screwed in diametrically opposite directions, and at right angles to these the two truncated cones, forming the axis. Their base is a circle drawn on the cord of about 120° of the central sphere. It diminishes to three-fourths of an inch at the other end, to receive the bell metal axis piece of half an inch in diameter. This shape presents a great strength of support against the sinking of the telescope by its own weight, while the central sphere is much lighter than the square formerly used, without any loss of strength.

This axis is perforated on one side to admit the light of a lantern placed on a piece projecting from the top of the column. A plane white glass is placed at the end of the axis. and in the spheric centre piece a plate, at an angle of 45°, perforated for the passage of the rays to the telescope. It is covered with gold leaf left unpolished, to prevent the glare of the reflected light on the wires. It admits of a small adjustment by the fastening screw t in the middle of the central sphere.

The lantern bearer is very light, slides from outside on the piece *y*, so as to embrace it by two small pieces, and is screwed on from below by a finger screw.

The other end of the axis bears outside of its support a circle of six inches in diameter, divided on silver. Upon this revolves an allhidade of three arms, the two horizontal arms *u*, *u* serving to read on both sides by verniers which are attached to them and to hold the spirit level. The vertical arm *v*, which is formed of the same piece of metal as the vernier arms, clamp these and the level, by the finger screw. The level being adjusted by hand, when so clamped, the telescope will, in revolving, read vertical angles with sufficient approximation to serve for finding a star, or determining any other elevation, within a certain degree of accuracy.

The adjustment of the axis of the telescope and the final levelling of the instrument are effected by means of a large spirit level *w*, suspended by hooks from both ends of the axis, outside of the supports *y*, *y*. As the space immediately under the axis is not free, it hangs on each side close to the columns. It is purposely without adjusting screws, and is therefore brought to adjustment by the filing of its hooks; and as the level is ground to a regular curve inside, the nice adjustment is made by two small ivory scales sliding upon the level, by two sections of tube holding to it by their spring. This is the arrangement of all the larger levels of the instruments, excepting those of the repeating circles.

Below the horizontal circle is a verification telescope, suspended in hooks from two opposite conical radii *b*, *b*, exactly similar in size and construction to the upper telescope, but of course without a vertical circle.

The eye end has a micrometer arrangement similar to the upper telescope, with one fixed wire in the direction of the length of the micrometer and three wires perpendicular to it, moveable by the micrometer screw. The whole micrometer arrangement stands at an inclination of about 15° with the horizon, so as to increase the chances of intersection with any distinct object within the field of the telescope.

The object end has a lengthening tube giving to this part some preponderance, by which the eye end is pressed upwards against an arrangement of three small sliding tubes x, which reach downwards from the limb of the circle, and present the rounded end of the finger screw z' to the upper part of the telescope. By the sliding of these tubes, and the final adjustment by the screw z', and the micrometer arrangement, the accurate pointing upon an object for the sake of verification is obtained.

As it cannot be my object here to go into such details of description as must be considered generally known, the above is, I believe, sufficient to explain all the peculiarities of the instruments, and to detail their principles and use.

Methods of Observing with the Two-feet Theodolite.

The limits assigned to the present papers rendered it necessary, in the description of this instrument, to suppose that a general idea of it might be obtained from the figures there given. The same reason now compels me to consider the general principles and method of levelling it, together with the adjustment of its line of collimation and axis, as well known, and to confine myself to the explanation of its peculiar properties, and of some theoretical principles and practical advantages not hitherto treated of, at least to my knowledge.

An observer furnished with an instrument with which he has never observed should first ascertain its properties and defects from the mathematical principles on which it is constructed. This will be more indispensable, when the instrument has had to undergo transportation.

In this inquiry he will be much assisted,—if, besides his general scientific knowledge, he is acquainted with the manner in which the instrument has been constructed, and the peculiar abilities of the artist who constructed it. Judging from these circumstances the possible and proportional accuracy of the execution of the instrument, he will be able to direct his inquiry sooner to a satisfactory result.

In an instrument which is as perfect as possible, the adjustments are of course only accurate within certain limits, and he has to guard against the errors which he may be liable to in consequence of them, as well as against those of the instrument itself.

It becomes therefore the duty of an accurate observer in no case to rely merely upon the accuracy of his instrument and his own skill, but to adopt such a method of observing as will counteract, as far as possible, the errors of the instrument and those to which he himself is liable in making his observations.

Without such a method, and a regular system in his observations, his mean results will be under the influence of hazard, and may even be rendered useless by adding an observation, which would repeat an error already included in another observation.

It is possible to correct angles measured by an incorrect or ill adjusted instrument, by mathematical formulæ, when the data for the reduction are exactly known; but such data are always difficult to ascertain with sufficient accuracy. The reductions require longer calculations than the observations themselves, or at least are more tedious than a repetition of the observations. In a work of great extent, these reductions occur so frequently, and the calculations of the observations are at the same time so numerous, as to render any method, in which it would be necessary to retain them, extremely laborious. On the other hand, the observations may always be repeated in a way in which these corrections will compensate each other.

As to the instrument intended for the survey, which is the subject of the present papers, I had reason to entertain the highest expectations. It was executed under my own inspection by that distinguished artist Mr. Edward Troughton of London, agreeably to our united views, and with that interest for its success, which the great friendship with which he was pleased to favour me could alone inspire.

The actual operations made at a station of a survey on solid ground, in a proper place, with good signals, &c. are in every respect best adapted for the trial of the instruments, and for devising a proper method of observing with them.

From the remarks which will be found in their proper place, on the method of dividing used in England, it may be observed and has been observed already by Ramsden in describing his dividing engine, that the exact placing of the axis in the centre of the division is still effected by trials and indirect means, and that when obtained exact, it may even lose this position by transportation or accident. It will therefore be proper to inquire whether the instrument be well centred or not, and, at all events, to use the indiscriminate mean of the two or more equidistant readings, which are now made on every instrument, as one single reading would be affected by the whole error of the eccentricity.

The half sum of any two vertical arcs in a circle is equal to the arc at the centre. Therefore the indiscriminate mean of any even number of opposite readings on an instrument will be equal to the angle at the centre. Also the third of of three angles at the same point out of the centre of the circle is equal to the angle at the centre of the circle. And in general it will be seen, that the indiscriminate mean of any number of equidistant readings will be equal to the angle at the centre of the circle. This property is new as far as I know, and may be demonstrated as follows:

Plate V. fig. 1.—Let C be the centre of the division, C′ the centre of motion, *d* the point on the limb marking the reading of the alhidade; C*d*=the radius of the division. Then C′CM is the line joining these two centres (protracted), and $dC'M$=the angle of the first reading with the line joining the centres. In the triangle dCC', let

$dC'M=\varphi$
$Cd\ =R=$Radius of the circle,
$CC'\ =e=$Eccentricity of the instrument; also

let $2n+1$ denote any uneven number of equidistant readings, into which the circumference has been divided, (as for even numbers, the demonstration is evidently made by the correction of two opposite readings.) and put β=the constant angle between the readings: Then we have $dCM-dC'M=C'dC$, and $\sin. d=\frac{e}{R}\sin.\varphi$ for the first reading, or that nearest to the line $C'CM$.

The second reading will give,

$$\text{Sin. } d'=\frac{e}{R}\sin.(\varphi+\beta).$$

The third,

$$\text{Sin. } d''=\frac{e}{R}\sin.(\varphi+2\beta).$$

And the $2n^{th}$ or last reading will be,

$$\text{Sin.} d^{2n}=\frac{e}{R}\sin.(\varphi+2n\beta).$$

The sum of all the corrections will therefore give the following series,

$$\text{Sin. } d+\sin. d'+\sin. d''+\ \ldots\ +\sin. d^{2n}=$$
$$\frac{e}{R}\left[\sin.\varphi+\sin.(\varphi+\beta)+\sin.(\varphi+2\beta)+\ \ldots\ +\sin.(\varphi+2n\beta)\right]$$

The sum of the series in the parentheses is equal to

$$\frac{\text{Cos.}(\varphi-\tfrac{1}{2}\beta)-\cos.(\varphi+\frac{4n+1}{2}\beta)}{2\sin.\tfrac{1}{2}\beta}$$

the numerator of which is 0, for $(2n+1)_{\beta}=2_{\pi}=$the circumference of the circle; and which shows that the indiscriminate mean point indicated by all the readings will give the true angle at the centre of the division between any given point and the line of centres.

For any other series of readings making with the line of centres an angle$=\varphi'$, the series of corrections would be similar to the above:

$$\text{Sin.}\,\delta+\text{sin.}\,\delta'+\text{sin.}\,\delta''+\ \ldots\ +\text{sin.}\,\delta^{2n}=$$

$$\frac{e}{R}\Big[\text{sin.}\,\varphi'+\text{sin.}(\varphi'+\beta)+\text{sin.}(\varphi'+2\beta)+\ \ldots\ +\text{sin.}(\varphi'+2n\beta)\Big]$$

The correction of the angle measured by these two series of readings will be equal to the sum of the difference of the two corrections for each microscope. Or,

$$=(\text{sin.}\,d-\text{sin.}\,\delta)+(\text{sin.}\,d'-\text{sin.}\,\delta')+\ldots+(\text{sin.}\,d^{2n}-\text{sin.}\,\delta^{2n})$$

$$=\frac{e}{R}\Big[\text{sin.}\,\varphi-\text{sin.}\,\varphi'+\text{sin.}(\varphi+\beta)-\text{sin.}(\varphi'+\beta)+\text{sin.}(\varphi+2\beta)-$$
$$\text{sin.}(\varphi'+2\beta)+\ \ldots\ +\text{sin.}(\varphi+2n\beta)-\text{sin.}(\varphi'+2n\beta),\Big]$$

observing that $\text{sin.}\,\varphi-\text{sin.}\,\varphi'=2\text{sin.}\tfrac{1}{2}(\varphi-\varphi')\text{cos.}\tfrac{1}{2}(\varphi+\varphi)$, and so on for the other arcs, the second term, or the sum of the corrections will become,

$$S=\frac{2e}{R}\text{sin.}\tfrac{1}{2}(\varphi'-\varphi)\Big[\ \text{cos.}\ \frac{\varphi'+\varphi}{2}+\text{cos.}(\frac{\varphi'+\varphi}{2}+\beta)+\text{cos.}(\frac{\varphi'+\varphi}{2}+2\beta)+$$
$$\text{cos.}(\frac{\varphi'+\varphi}{2}+3\beta)+\ \ldots\ +\text{cos.}(\frac{\varphi'+\varphi}{2}+2n\beta)\ \Big]$$

The series in the parentheses being that of cosines of arcs in arithmetical progression, is

$$=\frac{\text{sin.}(\frac{\varphi+\varphi'}{2}+\frac{4n+1}{2}\beta)-\text{sin.}(\frac{\varphi+\varphi'}{2}-\frac{\beta}{2})}{2\text{sin.}\tfrac{1}{2}\beta}$$

whence,

$$S=\frac{e.\sin.\left(\frac{\varphi-\varphi'}{2}\right)}{R.\sin.\frac{1}{2}\beta}\left[\sin.\left(\frac{\varphi+\varphi'}{2}+\frac{4n+1}{2}\beta\right)-\sin.\left(\frac{\varphi+\varphi'}{2}-\frac{\beta}{2}\right)\right]$$

and since by the supposition, $(2n+1)\beta=2\pi$, $(2n+\frac{1}{2})\beta=2\pi-\frac{1}{2}\beta$ $=-\frac{1}{2}\beta$. the two sines in the parentheses become identical, and consequently $S=0$.

It follows therefore, that whatever be the number of equidistant readings into which the circumference is divided, the indiscriminate mean of all the readings will give the true angle at the centre of the division. It is evident that for three microscopes. $n=1$, so that $(2n+1)\beta=360°=3\beta$.

The same circumstance which occasions the eccentricity of an instrument. may also cause the axis of motion not to be perpendicular to the divided plane of the circle. The axis being placed vertical, by the adjustment of the instrument, the plane of motion, thus horizontal, will not coincide with that of the divided circle upon which the readings are made, and will require a reduction to the imaginary horizontal plane, which will be exactly analogous to the reduction of the ecliptic to the equator, and may be determined by the formula given for that purpose.

It is evident that in changing the position of the instrument, so as to make the legs successively change their places. the plane of the circle will be placed in the same symmetrical positions with respect to any angle measured upon it, as was the case in the readings of the angle; and the angles will require successive reductions corresponding to the same number of symmetrical arcs.

The indiscriminate mean of these angles. observed in all these positions, will again be the true horizontal angle corrected for the want of perpendicularity of the axis upon the divided limb.

Plate VI. fig. 3.—Let *ad* be the inclined limb of the divided circle, *ac* the horizontal plane, *a* the point of intersection of the two planes, d being any point observed on the limb. Drawing the arc dc perpendicular to ac, the corresponding point in the horizon will be c, and ac will be the reduced arc. Calling the inclination of the planes $dac=\alpha$; the constant equal angles between the legs$=\beta$, (commonly three;) and the distance of the point d from the intersection of the two planes$=\varphi$; the series for the reduction of the ecliptic to the equator will give the corrections for each successive position as follows:

For the first position,

$$ad-ac=\delta=\frac{tg^2\frac{1}{2}\alpha}{\sin.1''}\sin.2\varphi-\frac{tg^4\frac{1}{2}\alpha}{\sin.2''}\sin.4\varphi+\frac{tg^6\frac{1}{2}\alpha}{\sin.3''}\sin.6\varphi,\ \&c.$$

For the second position,

$$ad'-ac'=\delta'=\frac{tg^2\frac{1}{2}\alpha}{\sin.1''}\sin.2(\varphi+\beta)-\frac{tg^4\frac{1}{2}\alpha}{\sin.2''}\sin.4(\varphi+\beta)+\frac{tg^6\frac{1}{2}\alpha}{\sin.3''}\sin6(\varphi+\beta),\ \&c.$$

For the third position,

$$ad''-ac''=\delta''=\frac{tg^2\frac{1}{2}\alpha}{\sin.1''}\sin.2(\varphi+2\beta)-\frac{tg^4\frac{1}{2}\alpha}{\sin.2''}\sin.4(\varphi+2\beta),\ \&c.$$

and so on for any greater number of legs and positions of the instrument. The sum of any number of such corrections being taken to ascertain the total correction as heretofore, and ordered according to their common factors, the following expression will result:

$$\delta+\delta'+\delta''=\begin{cases}+\dfrac{tg^2\frac{1}{2}\alpha}{\sin.1''}\Big[\sin.2\varphi+\sin.2(\varphi+\beta)+\sin.2(\varphi+2\beta)+,\ \&c.\Big]\\[2ex]-\dfrac{tg^4\frac{1}{2}\alpha}{\sin.2'}\Big[\sin.4\varphi+\sin.4(\varphi+\beta)+\sin.4(\varphi+2\beta)+,\ \&c.\Big]\\[2ex]+\dfrac{tg^6\frac{1}{2}\alpha}{\sin.3'}\Big[\sin.6\varphi+\sin.6(\varphi+\beta)+\sin.6(\varphi+2\beta)+,\ \&c.\Big]\end{cases}$$

and so in case of more legs.

It is evident that the series in this sum are similar to that before considered, being the sums of sines of arcs in arithmetical progression, limited by the sum of the β's being equal to the circumference of the circle, which makes their sum $=0$, and proves the indiscriminate mean of the angles observed in the symmetric positions of the instrument to be the accurate horizontal angle.

In an eccentric instrument, it is of course impossible to make the microscopes measure exactly in all parts of the division, but the above shows that if they are adjusted in any one position, their measure will be corrected by the changes of position of the instrument, without having recourse to any other means.

Errors may also arise from a want of horizontality in the axis of the instrument. It is proper therefore to adapt the method of observing so as to correct these errors. But such errors are easily corrected in this instrument, by observing with the telescope in two positions diametrically opposite to each other.

In Plate VI. fig. 2, let *ab* be the horizontal line in which the axis should be, and *tp* the section of the true vertical plane which the telescope should describe. Instead of this let the axis be inclined in one position of the instrument, so that the telescope moves round the line $a'b'$, and describes a circle making with the vertical an angle tct', $= tca' = bcb'$. All the results of observations on objects taken in this plane will require a reduction corresponding to this angle. Turning the telescope so as to revolve through a semicircumference horizontally and vertically, and observing the same objects again without any change of the adjustments of the transit, the axis will come in the direction $a''b''$, and the plane of revolution of the telescope will make with the vertical the angle $t''ct = t'ct$; but on the side exactly opposite. All results of observations will require exactly the same correction as before in respect to quantity, but they will be negative in respect to the former, and the indiscriminate mean of the two will be as before the true angle between the verticals of the observed objects.

This operation will besides bring the horizontal angle exactly to the points of the circle diametrically opposite to the former, and will again act as a correction in the same sense as the two mentioned before.

An error in the line of collimation will of course combine with that of the verticality of the circle described by the telescope, and be corrected partially by the double operation; but this adjustment is easily verified in this instrument.

An irregularity in the axes of motion of the instrument would of course have an influence on the observations; but in the horizontal angles, it is evident that this influence would be destroyed by the exactly inverted positions of the instrument in which the observations are made. This error therefore falls in with all the others, which appear of course always combined, and are finally compensated by a certain determined number of observations systematically arranged.

The only cause of error still remaining is the accidental error of any particular division, which might have been used in the series of angles. This chance can occur only by some particular accident in the work, as the dividing engine of Mr. Troughton is so regular, and his attention and care so great, that the error of the division may be supposed a minimum.

The displacement of my microscopes from their exact distance of 120° was too small to produce any influence on the accuracy of the compensations.

Upon the principles here demonstrated I grounded the following method of observing all horizontal angles with the two-feet theodolite.

1. Having carefully adjusted the instrument in all respects, the telescope is placed in such a position as to bring its eye end perpendicularly over the microscope A. In this position, which I call *direct*, I observe all the objects between which I intend to determine the angles at the time.

2. Then I turn the telescope round vertically, so as to

bring the object end of it perpendicularly over the microscope A, which position I call *reversed*, and observe the same objects which I had observed before; without any alteration in the adjustments of the instrument, not even its general levelling, if there has been no accidental derangement, but in every case without any alteration whatever in the adjustments of the transit telescope.

3. Then the theodolite itself is turned round horizontally for one change of legs or about 120°. So that all angles will now be read by each microscope at 120° from the former situation. In this position the instrument is again carefully levelled and adjusted in all respects.

4. In this second position the two operations before described are repeated; that is the same objects are again observed in both the direct and the reversed position of the transit.

5. After this the theodolite is again moved horizontally for one change of legs in the same direction as before, so as to come into the third possible situation, and each microscope to read again on the limb at 120° from its former situation.

6. In this third position, the same objects are again observed, both in the direct and in the reversed position of the transit; after the instrument has been adjusted in all respects as in any one of the two former positions.

By this method each angle is observed six times in the systematic order required for the compensation of all errors arising from the causes heretofore treated, and with much less trouble than if an equal number of observations were made by the merely accidental positions of the instrument, and as many observations would most probably be taken at all events of such points as would be considered as requiring great accuracy. The final angles are thus determined by the influence of eighteen angles on parts of the division symmetrically situated.

Experience has completely sanctioned this method of observing, by an accuracy in the final results never obtained without it.

I must here observe, in relation to the actual application of this method of observing in my triangulation for the survey of the coast, that it will not be found to have been rigorously followed; because it was the result rather than the element of that part of the work which I could execute. The necessity of advancing in the work, at the same time that I was bringing my method of observing to perfection both by theoretical researches and by practice, caused me to make use of all the observations obtained for both purposes.

In the examples of the Day-Book and the Journal of Results inserted at the end of the paper will be seen some fully registered in proper order. These are taken from the work on the Boundary Line with Canada, as I had not the opportunity of referring to any of my journals from the survey, having delivered them to the War Department.

The observations of the azimuths of celestial bodies, particularly of the sun, are very accurate and easy with this instrument. They should unite in one final result a complete system of the above compensating method of observing, besides an equal number of observations made six hours before and after the transit of the heavenly body used. This combination is necessary in order to render the elements for the calculations of the azimuths compensating to each other, and the influence of their error the smallest possible, as well as to make the observations the most favourable and accurate.

A full result of azimuths must therefore consist of twelve observations, which is not more than the number which would of choice be given to this element of the triangulation. With respect to the instrument, it will be the mean of thirty-six angles symmetrically situated upon the circle; so that the accuracy thus obtained must prove very satisfactory. In case that this complete series of observations cannot be obtained on a station, the only correction which may be omitted is that of the change of the theodolite upon its legs. All the others are completely indispensable for obtaining a satisfactory result

In observing the celestial body, its transit is observed on all the three vertical wires of the telescope; and when the sun is observed, which is the most advantageous of all for azimuth determinations, the contacts of both limbs are taken. By this mode of observing, which is very easy, and even very pleasant, with this instrument, the most essential element of the azimuths, the time, is observed six times (with the sun) for each observation, which is of course a great advantage as to accuracy. I should even have wished that the telescope had five vertical wires instead of three.

The following is the order which I followed in such an observation:—

Having carefully verified all the adjustments of the instrument, and the telescope being in the position which I have called direct, I observed first the terrestrial object with which the azimuth was to be taken, choosing for it the signal which by its illumination at the time appeared the most distinct, and in case of equality in this respect, that nearest to the sun, and read off the three microscopes. Then I turned the telescope horizontally, so as to receive the transit of both limbs of the sun at all the three vertical wires, and having clamped the telescope in this position, I observed these transits, the time of each being carefully observed by a chronometer or clock to seconds and decimals, and written in the day-book by the secretary. After this I read the three microscopes on the circle.

Then I placed the telescope immediately in the reversed position, and observed the transit of the sun again as before, and after it the same terrestrial object again.

By this method the two azimuths are observed the nearest possible to each other, and the terrestrial objects observed, correspond to each position of the transit.

If the circumstances allow one more azimuth to be taken, without however admitting the change of the instrument upon its legs, and an assistant be at hand to determine the time by the chronometer or clock, without taking the observer away from the azimuth, then the above second observation of the terrestrial object in the reversed position of the transit can be followed immediately by one of the sun in the same position of the transit; and returning the telescope to the direct position, one can again be made in this position, and the terrestrial object observed again for verification's sake, the terrestrial observation in the reversed situation serving for both azimuths in that position. Thus four azimuths, each from six transits of the sun's limb at the vertical wires, can be observed in a very short space of time.

It is evident that these azimuth observations would, whenever found necessary, be very well suited for the reduction to the mean time, according to the method invented by Mr. Söldner.

It is proper to make the azimuths as independent of the rate of the timepiece as possible, and therefore to make observations of time as nearly as possible before and after those of the azimuths; and if several observers should be together, a proper combination, which would admit both observations to be made at the same time, would be very advantageous.

The calculation of the result can of course be varied; being made either for each limb's transit, or, as I did, for each transit of the centre; but it is not allowed to take direct and reversed observations together in the same calculation.

The form of such an observation, and the manner of registering the results, will be seen in the corresponding examples of the Day-Book and Journal of Results.

I will here describe another method of observing azimuths, which may be of use in circumstances which admit only a portable transit and the means of determining the time. I applied it in 1793 in Switzerland, and it may sometimes be preferable to a measurement on a less accurate instrument. I adjust the transit telescope exactly in the vertical of the object, before the time when the sun will pass this vertical, and observing the transit of both limbs on all the wires, the time of the transit of the centre is thus obtained; and it is evident that the result of the calculation of the azimuth of the sun will give at the same time the azimuth of the object, the time being determined by proper means as near to this observation as possible. In this manner the azimuths of all objects in the vertical of which the sun passes in the day (on both sides of the zenith) may be determined, and the terrestrial angles between them be tolerably well ascertained.

By the same method also an astronomical circle well adjusted in the vertical may serve for the determination of azimuths; and when it is required to lay off certain directions on the earth, signals may be placed purposely to observe azimuths upon them by this method; and if the sun should not at the time pass such a vertical, a star properly situated should be chosen for the purpose.

It is proper in this place to introduce some practical remarks relative to the illumination of the division, which has a considerable influence on the accuracy and facility of the reading. The light upon the divisions must be reflected from a white unpolished plane; it must fall upon the divisions in the direction of their length, and not from the side; and if the reflection from the limb enter the microscope, the greatest light will be obtained. All glaring light will be improper. I found white paper the most proper surface; and for this purpose I folded a quarto sheet into an octavo form, and to give it more solidity folded rims to the open sides: then giving to this again a fold in the middle, so as to make the two parts stand at right angles with each other, in the middle of one half I cut a circular hole exactly fitting the microscope tube below its holder, and adapted to it by its close fitting. The screw going over the whole length of the tube, it kept its position, and the other half hung down to within a short distance of the limb of the circle outside; the reflecting surface being thus a tangent to it, and nearly perpendicular to the limb. When the observer stands in the direction of the radius of the microscope, the light comes as from the centre of the instrument, reflected in the same direction, and presents the divisions without any false shade, and very distinct. In any other position of the light or of the reflection, the strokes, which always present cavities, though they appear filled, will be viewed on the side, as one side of this cavity will always be in the light and the other in the shade; and the influence of this upon the accuracy of the reading is much greater than might be imagined, exceeding the limits within which it is possible to read with these microscopes.

For this same reason, night observations have not the same degree of accuracy on the horizontal limb of a theodolite as those made during the day; because in this case it is impossible to make the light fall in the proper direction, as no light can be placed in the centre, and outside, in the direction of the radius, it would occupy the place belonging to the observer. Night azimuths lose much on that account, and seldom give the satisfaction expected.

On the Signals and the System of Wires in the Telescope.

An object closely connected with the accuracy of the observation of terrestrial angles, is the choice of proper and distinct signals, and the adaptation of the system of wires to them.

In the first place, I must observe that objects seen from a great distance are visible rather in proportion to their difference in light and colour from the surrounding objects or the back ground on which they are projected, than in proportion to their size, which actually contributes very little towards the effecting of the vision, and is always detrimental to its distinctness. A small object seen by the shaded side, if projected upon a clear sky, will be visible at a great distance, and will be much more distinct, if it reflect the rays of the sun to the observer. These remarks must certainly have been often made; and yet I have not seen that advantage has ever been taken of them for the purpose here in view.

A staff is always a bad signal, as it will always be seen differently according to the state of the illumination; and if it is furnished with a flag for the purpose of discovering and discerning it from other similar objects, this will easily mislead the observer as to its actual position, and certainly make it appear to stand out of the perpendicular, if at any considerable distance. Truncated pyramids are inconveniently large, and require peculiar reductions according to the side of them which is observable, and which may even change in the course of the short time of observation, by the change of the illumination.

For the vertical angles the staff cannot serve at all. The point at which it is fastened into the earth can never be ascertained with certainty, as it may be hidden by uneven ground before, or the ground from behind upon which it is projected may be mistaken for it. Truncated pyramids may be seen of different heights in different states of the atmosphere.

A signal showing itself detached from the ground on which it stands, will also be distinguished far better than a much larger one connected with the ground.

All these remarks I might support with daily experience, of which it will suffice to mention, that in a warm summer day, the gilt ball of a steeple may be seen at a great distance; when the steeple itself is only supposed, and not actually distinguished.

Making in 1798 a triangulation in Switzerland with a repeating circle with two telescopes, where the angles are measured in the plane of the objects, and the determination of the elevation of the triangle points being an object of interest, I was desirous of a distinct signal which should be seen equally in all directions: this lead me to the idea of forming spheres elevated on poles. They were formed of barrel hoops, making the ribs of the sphere, and covered with white linen. Their diameters were from sixteen to twenty inches. They were very distinctly visible with the telescope on my instrument, though only thirteen inches in length, at a distance of fifty miles, and as far as ten miles with the naked eye; but they did not answer equally well in the lower atmosphere of this country near the sea shore, as was to be expected. I was therefore induced to use a kind of signals presenting a luminous point by the reflection of the sun, and adapted to the situation of that body at such times of the day as from the general state of illumination appeared to be most favourable to observation. In the middle of the day, the illumination will not serve at all for distinct vision, and even the largest objects become indistinct, on account of the vapour, (as this is commonly called); or rather because the reflection of the light from all objects goes upwards, and does not meet the eye of the observer on the surface of the earth.

As the cheapest reflecting surface which I could choose was sheet tin, and the construction of spheres became more difficult and expensive; and the spheres themselves always presented a small point, I chose the form of a truncated cone, under such an angle as would be the most favourable for the morning and evening illumination.

The next point which appeared desirable with respect to the signals was to find their places in case they should be removed. The means which I considered as best adapted for the purpose were the following:—

Plate VI. fig. 4.—*aa.bb* is a truncated cone of tin, the height *ab* equal to nineteen inches, the lower diameter *aa* equal to seventeen inches, the upper diameter *bb* equal to fourteen inches; the top *e* is a horizontal tin plate of three inches diameter, elevated five inches above the diameter *bb* which serves to nail the signal to the top of the pole *ef*, and from which to the diameter *bb* it forms a truncated cone of a greater vertical angle. The pole *ef*, upon which the signal is fastened, is about three or four inches in diameter, and of such length as to bring the top *e* of the signal about eight or nine feet above the ground at *g*. The tin cone is held steady in its vertical position by two iron wires fastened at the lower rim *aa* of the cone, in diametrically opposite places, and wound round the pole, and making right angles with each other.

To place a signal, a hole was dug in the ground to the depth of about three or four feet, and of proportional width, and a permanent mark was then placed properly centred in the station. These marks consisted of truncated hollow cones of hard baked stoneware open at top and bottom, their height *cd* equal to sixteen inches, the inner diameter at the top *cc* equal to six inches, the lower diameter *dd* equal to twelve inches. They were at such a distance below the surface of the ground as to be perfectly secured from accidents arising from ploughing, &c.

The signals can be pulled out of these cones perpendicularly, and the holes filled with earth so as to leave no apparent mark; while at any future time the cones can be easily uncovered; and being emptied of earth, without being displaced, they will be prepared to receive other signals.

These signals answered in every respect perfectly well, and though constructed of apparently costlier materials than rough signals, the expense attending them, with the permanent mark in the ground, &c. amounted only to about three dollars and a half each,—a sum for which no pyramid, or any thing similar, could be constructed.

In favourable circumstances, these signals appeared like a strong luminous point, often requiring, when the signals were near, the use of a dark glass before the eye. Their form then became as distinctly visible as the limbs of a planet.

In distances of thirty to forty miles, they presented a distinct luminous point, when the sun was in such a situation as to reflect its rays directly to the observer, which time is of sufficient duration.

It is evident that the luminous point which was observed on the tin cone depended on the angle which the sun subtended with the line from the observer to the signal, and required of course a small reduction to the centre of the signal. To obtain this element of reduction easily, I observed always at intervals the sun to the nearest degree only, as no great accuracy is required, by placing the telescope of the instrument in the shade formed by itself, and reading the stand of the microscope A on the limb. Calculating the apparent angle subtended by the mean radius of the signal cone for each distance, I formed a small table, and placed it at the head of each station in the Journal of Results. The reduction was very easy, and was quickly made by a construction and a short multiplication of decimals, of which it is proper to give here the explanation, as well in principle as in practice.

In Plate VI. fig. 5, let *a* be the station point of the observer, *c* the centre of a signal observed from this station, *lbd* the mean circumference of the tin cone, and *as* the direction in which the sun is seen from the station, at the time of the observation.

For the purpose here intended, it is perfectly allowable to omit the correction of the azimuth of the sun, between the station point and that of the signal (which would be proportionate to the convergency of the meridians,) and also to suppose the lines drawn from the different parts of the signal to the observer as parallel, which would vary always less than the apparent radius of the signal.) This permits us to suppose, $das=cas=ccs'=fds''$.

By the principles of reflection, the point on the circumference of the cone which will be reflected to the point *a*, will lie at *d* the middle of the angle *s'ca*, supplement to the angle observed between the sun and the signal. The correction will therefore be proportional to *de* the sine of $acd=\frac{1}{2}.s'ca$, or to the cosine of the complement of it, that is to cosine $\frac{1}{2}cas$, or half the angle between the sun and the signal.

Expressing therefore the radius *cd* by the seconds and decimals which it subtends at the station *a*, the multiplication of this by the cosine of half the angle observed gave the appropriate correction or corr. $(cd)''\cos.\frac{1}{2}cas$.

To construct this correction with great ease, I divided a quadrant on pasteboard of one foot radius, numbered with the double angles as in a reflecting instrument, beginning to count as if from the point of the circle perpendicular to *ca*, which represents of course the position of the sun in the protraction of *ac* behind the signal. This radius was divided into ten parts, and lines drawn perpendicular to it, cutting the circumference in the corresponding points, indicating the angles to which they correspond. Upon a smaller piece, cut at right angles, one of these decimals was divided into ten parts again; this piece being slided along the line nearest to the angle observed between the sun and the signal, the subdivisions of it being perpendicular to the same, until these intersected the circumference at the actual observed angle, the tenths and hundredths of the radius corresponding to this angle, were indicated, these being multiplied in the seconds, tenths, and hundredths subtended by the radius of the signal, gave the correction corresponding to the observed angle.

This operation was of course of sufficient accuracy, and much shorter than the calculation either by natural cosines of the half angles or their logarithms.

Operating in the same manner for both signals, between which the angle is to be corrected, the total correction of the angle is obtained according to the following easy principles, which will be evident, without demonstration, from a mere inspection of the figure:

1. When the sun is seen between the two signals, the sum of the two corrections is added to the angle.

2. When the sun is behind the station *a* in the vertical angle of the signals, as in *hak*, the sum of the two corrections is to be subtracted from the angle.

3. In all other positions of the sun, with respect to the two signals, the difference of the two corrections must be subtracted from the angle.

The angle between the sun and the signal determining the angle at the centre of the signal between the station and the reflecting point, and being bisected, it is evident that the accuracy obtained by the method described is fully adequate.

When the sun does not shine, and the state of the atmosphere is such as to affect no reflecting point, which will happen in dull and cloudy weather, the whole signals will appear like a white surface and in full size; and accordingly if its centre be observed, no reduction will be requisite. The state in which the signals are seen is therefore one of the necessary remarks to be inserted in the journal.

The system of wires in the telescope is to be adapted to the form of the signals, in the same manner in which the wire arrangement in the microscope is adapted to the kind of division of the limb. In this instrument the division being by lines, the wire arrangement in the microscope is that of wires crossing each other under an angle of about thirty degrees, which in placing it by the micrometer upon the division, will present this angle bisected, and enable us to judge accurately of the coincidence.

With a similar view, I suppose, Mr. Ramsden applied this arrangement to the telescope of General Roy's theodolite in the English survey, where staffs were used as signals, while the division of the instrument being with points, the micrometer wires were simple perpendicular wires.

For my signals therefore, the perpendicular wires were best adapted; and as they were fine and exceedingly well defined cobwebs, they showed the light of the reflected point of the signal on both sides, by the irradiation, which of course afforded a very nice pointing, far preferable to the contact on the side of the wire, which has sometimes been substituted for the bisection by the middle.

I shall add one remark more:—

An attentive observer will find the object pointed at always disappearing when very near the wire, and as if it were broken off. In like manner, in pointing with the crossing wires upon a signal presenting a point, it will be impossible to place it actually in the vertex of the angle of intersection, and it will become visible only at a certain distance, standing free between the wires, without admitting actual contact with the wires themselves.

Additions made to the Repeating Circle with two Telescopes.

The general principles and construction of this instrument are well known from the descriptions given by French writers on the subject. The peculiar construction adopted by Mr. Troughton is described in the English Encyclopedias. I shall therefore suppose such construction known, and describe only the peculiarities of the two circles which Mr. Troughton made for me.

In the usual construction of this instrument, when an observation is to be renewed for the sake of repetition, the front telescope bearing the verniers is to be moved; no trace of the foregoing observations is left; their value in some measure is concealed by the position of the back telescope or level. In celestial observations clouds or intervening circumstances in general, which occur so frequently in observations, may at this moment render all previous attention and care useless; and the observer feels always somewhat anxious on that account.

It is however evident that the successive steps of the level or back telescope measure the angle in the same manner as those of the front telescope. Upon this consideration I founded a construction, by which the instrument gives two separate series of angles upon the same division, from the same observations, by adding only one observation more at the end, and if accident should occasion the loss of one series, the other may be preserved.

Plate VII. fig. 1, is a general view of the instrument from behind, where the additions made to it are all visible. Fig. 2 represents a section of the limb and two readings, in the direction of a radius.

The limb of the circle consists of two circular rings fixed to each other, as seen in the second figure. A section of this limb or of the wings which form it resembles letter T. To the lower ring the radii *r* of the frame of the circles are fastened, the upper one being the divided limb itself, which is sufficiently elevated above the radii to give passage to the clamping piece D of the front telescope. The verniers of the front telescope, which are four as usual, reach to the division of the limb from the inside. To the back telescope and level, a frame, exactly similar to that of the front telescope, is adapted, with four verniers W, X, Y, R, which are fastened to the part of this frame extending beyond the circle by two pillars, bringing them round the limb outside, to reach to the division of the limb; so that there remains a sufficient space of the division free between two verniers to read them accurately, when two such verniers stand opposite each other. This space is about half the length of the strokes. The verniers then pass by each other freely, and are read upon the same division. The two magnifiers, which revolve upon the centre on arms, in the front of the circle, as seen in *b*, fig. 1, serve equally for both series of readings. As to the divisions, the strokes denoting degrees and half degrees are drawn out on both sides equally, so that they show equally for both the inner and the outer verniers. The degrees have points in the middle of the strokes, which will show when two verniers are opposite, and will serve to count them from the number seen on the left beyond the alhidade. Every ten degrees being engraved outside, and every five inside of the division, there is always a clear and equal reading for both positions of the verniers.

The verniers are all of double length, having on each side of the usual vernier one half length of vernier over, by which means two readings are obtained. A mean of these readings can be taken, in case of any difference.

The whole framing of the instruments is in general stronger in every respect than they were made before, and particular attention is paid to the stability of all the adjustments, as may be observed from a mere comparison of this figure with those in the Encyclopedia.

The breadth of the ring to which the radii of the instrument are fastened being about one inch, the distance at which the verniers W, X, &c. of the back allidade must be supported by it would twist this allidade by their weight, which would occasion them to read differently in different positions of the circle, as they would in all cases sink. This is avoided by adding on the side opposite to the vernier the nobs *a, a*, forming a counterpoise to the verniers, and effecting thereby their verticality in all positions.

To give more stability to the vertical or any inclined position of the circle, there are two semicircles *k, k* fastened to the horizontal axis *q* round which the circle is moved, close to the uprights supporting this axis at both ends, to which they are clamped by two screws *l, l*, instead of only one as in the former construction. There is also a small ball *s* upon the socket of the axis of the circle, between the counterpoise and the clamping arrangement *u* of the circle, adjustable by a sliding piece in the small upright *t*, which receives one of the axes of this level. The level swings on an axis, to serve in both opposite positions in which the circle may be placed by revolving upon the semicircles.

It appears to me, that in all instruments the allidades should be clamped on a separate arm not bearing any reading, (when these are not upon a full circle,) because the clamp is very apt to affect the reading to which it is adapted. For this reason, the clamp and tangent screw of the back allidade is put to the separate arm *n*, perpendicular to the telescope and level, and the reading arms are all left to their natural spring. By this arrangement also, the assistant, who sets the level during the observation, acting in a more convenient position, is less liable to affect the position of the instrument by the weight of his hands; and there being milled heads at both ends of the tangent screw, as in all others of the same kind, he can act with great steadiness by applying both hands.

The good quality and power of the telescopes is a desirable requisite in the observations; for it will be found that a great magnifying power facilitates all the observations. Therefore, though the circles are eighteen inches, the telescopes are twenty-two inches, which the instrument bears very well; and I found that a power of about sixty-six times was the most advantageous for use. The object ends have light lengthening tubes of about three inches, adapted instead of the covers, and equilibrating the telescopes.

The front telescope has three horizontal and three vertical cobweb threads in the focus. The back telescope has only two crossing each other at right angles.

The four readings of the front telescope are marked in the order of the divisions by the letters D, E, F, G, which serve to register them properly in the journals of observations, in the same manner as those of the back telescope are represented by W, X, Y, Z.

As a very great convenience for night observations, Mr. Troughton usually adds to his circles a smaller divided circle, fixed to the part bearing the level, and to the telescope he adds an arm, reaching over the frame of the instrument to this circle. Sliding pieces are adapted to this circle, and being adjusted to the proper zenith distance of the star. on both sides of the zenith, will arrest the telescope in such a situation as to bring the star in the field of the telescope, by the horizontal revolution of the instrument. This arrangement underwent a slight modification, on account of the interruption which a long arm from the front telescope would have met with from the back alhidade.

An arm *f*, similar to that for the clamp, rises perpendicular to the level, from the centre piece of the back allhidade to the circumference. There it bends over to *d*; and has a circular ring fastened to it, going round the circumference and forming a complete semicircle *dddd*, which is again fastened near both ends to two knees *v*, extending from the level frame. This semicircle is divided upon the flat outer part, like the moveable quadrant of a globe. Upon this ring small pieces *e*, *e* slide by means of springs on their inner part, and present their projecting part to a small arm *g*, adapted to the front telescope, by which this is stopped upon the proper zenith distance to which the stops *e*, *e* have been placed. This piece *g* should be a very light piece of brass, made to spring or give way when it comes in contact with the stops; so that it could not affect the position of the telescope in coming accidentally in contact.

The motion of the horizontal axis of the circle is stopped by the screw *u*, which presses to this axis an arrangement similar to the stop of a windmill; and the small motions are made by the screw at *m*, at the end of two arms, one of which is fast to this arrangement and the other to the centre piece of the horizontal axis *q*. To make this motion easy, the screw at *m* consists of two parts of unequal threads or paths, each going in the nut of its respective arm, and thereby causing the motion of the circle itself to arise only from the difference of the two screws. This motion is therefore as small as that arising from any other tangent screw on the instrument; and the use of the screws in the legs of the instrument can be fully dispensed with in this respect.

The horizontal circle of the instrument is fixed to the conical radii, which form at the same time the legs of it. The clamping and three readings A, B, C are adapted to the column forming the socket of the vertical axis of the instrument. A magnifier revolving round the lowermost part of the column serves equally for all three readings.

To stop the horizontal motion of the upper circle in the proper situation in respect to the azimuth, when stars are observed at night, two small stops *n*, *n* are placed on the limb of the horizontal circle, and are fastened to it by a spring beneath it, and presenting their projecting parts on the limb to the sides of the alhidade A. in the two positions of the circle in which the star is met by a vertical plane passing through it.

Instead of the arrangement formerly used to produce a small vertical motion in the legs of the instrument, the screws are here again constructed on the same principles of two screws working in each other, exactly equal in all respects to those described in the two-feet theodolite.

On some Adjustments of the Repeating Circle.

It will not be expected that I should give here a full description of the adjustment of this instrument: it is too easy and too well known. But I have no where seen mentioned the most proper mode of placing the circle accurately in the plane of the vertical and of verifying the parallelism of the two motions of the circle and the telescope.

This consists in observing the pole star, (best in its greatest digression,) both directly and by reflection from a mercurial horizon. I do it in the following manner, whenever any more nicety is desired than can be expected from the mere placing of the two semicircles *kk* to the coincidence of certain strokes made upon them at *oo*, with the sides of the supports of the horizontal axis *q*.

Having carefully levelled the horizontal motion of the instrument by the large level on the circle, so that the verticality should take place by the above adjustment, the telescope is pointed to the pole star, and the horizontal motion clamped. Then reading the approximate altitude or zenith distance, the telescope is lowered so much below the horizon as to receive its reflection from the artificial horizon, which is now placed in the situation indicated by the telescope, and sheltered from vacillation, if necessary, from the wind, by a glass cap.

If the motion of the telescope is exactly vertical, the reflected star in the mercury will coincide with the same vertical wire which was pointed upon the star viewed directly; if not, it must be corrected, half by moving the plane of the circle round upon the axis *q*, after unclamping the screws *l*, *l*, and half by the tangent screw on the horizontal circle.

If the circle is moved in the vertical, with the telescope clamped and every thing arranged as in the above observation, the verticality of its motion will be ascertained. If therefore there is any doubt respecting the parallelism of the circle and the telescope, it will be best to begin first by making the observation with the circle, the telescope being clamped, and when this is adjusted, to adjust the wires accordingly.

When these adjustments are made, and before any change in the level of the instrument takes place, the level *s* on the axis must be adjusted, and it will then serve to verify the verticality of the circle, as long as this circle is kept in its place. I therefore had the packing boxes so constructed, that the instrument might be removed without taking it apart, as I observed that the separate packing of the circle with the great counterpoise subjected the instrument to injury.

I think that some mechanical arrangement might be easily and advantageously adopted, for the purpose of giving to this adjustment a still greater degree of accuracy.

The illumination of the readings must be carefully attended to, as at night they are very difficult, and thereby become uncertain. I applied here also, with the best success, paper reflectors; folding a quarto sheet exactly as described for the two-feet theodolite; but instead of giving it a fold to bend it at right angles, I cut from about three-quarters of an inch behind the circular hole, which is here made so as to fit the tube of the magnifier, a slit to admit the arm of this magnifier, about two inches and a half long, and about half an inch farther, another short slit, at right angles to the former. By these the paper was slided and held upon the arm of the magnifier, and screwed to it along with its tube. Holding a light on the opposite side of the circle properly, the light will be reflected very well on the divisions, and give a very good reading. During the day the free light will have the same effect.

It is useful to know exactly the angular distances of the wires in the telescope, and the values of the divisions of the level. The first are very easily determined by pointing upon a well defined object with the different wires and reading the verniers. The last are equally easy to determine in these instruments, having readings to the level motion, by placing the level on all divisions successively, and reading all four verniers. It is proper to repeat these observations when made, as the determination has regard to a very small quantity. Methods for this purpose will easily suggest themselves to a skilful observer, and a very good use may be made of the results, when accidents have disturbed the usual regularity of an observation. Still I do not approve of a method suggested sometimes, viz. reading the level, though not fully adjusted, and keeping account of its standing at each observation.

In one of these circles, the intervals of the wires were 8′ 05″,3 in the arc, and ten small divisions of the level sub- 27″,75.

Methods of observing a Series of Vertical Angles with the Repeating Circle.

The instrument being well adjusted and levelled by means of the large level of the circle, I place the front telescope before the observation upon any convenient point of the circle, and read its four verniers D. E. F. G. taking a mean between the readings within and without their nominal. when any difference appears; or I read them in their accidental position, which may be that of the last preceding observation.

These readings are written in the third, fourth. fifth, and sixth columns of the Day-Book. In the second column the first letter of the series of readings is written, and the first column is left for the times.

In a night observation. the stops *e. e*, are placed to their proper zenith distance. allowing some free space for the quarter zenith distance of the star out of the meridian, and to avoid touching in pointing the telescope. The alhidade with the levels is moved so as to bring them near the projecting *g* of the front telescope, taking care to avoid actual contact. The circle is now turned so as to bring the level into an horizontal position.

By the horizontal revolution of the circle, the star will now appear in the field of the telescope, and when found, the horizontal stop *r*, fitting to the side on which the circle is, is placed in contact with the alhidade A.

Then the observer will make the accurate pointing upon the star or object. by the motion of the screw *m*. which guides the whole circle. while the assistant observer will adjust the level by its proper screw at the arm *h*. When both these are right together, the time is marked in seconds and decimals from a time piece by a second assistant, acting as a secretary. The time is written in the first column of the Day-Book before the readings of the front telescope, and forms the first time for the series of angles of the front telescope.

By the placing of the level, the verniers W. X. Y. Z come into their first position for the series of the level or back telescope. These four verniers are therefore now read off. and their readings written below the others in the same order. being marked in the second column by the letter W.

The circle being now brought on the other side of the column by a half revolution on the vertical axis, the observer will move the front telescope near the other stop *e*, and make the second observation, pointing by the tangent screw of this telescope on the arm D, while the assistant will adjust the level, if it should be necessary, by the circle screw at *m*; though this adjustment will be very slight, if any, when the circle is well adjusted.

The time of the simultaneous coincidence of the pointing and adjustment of the levels is again noted by the secretary, and written in the first column before the readings W, &c. constituting the first time of the series of angles with the back alhidade.

Before turning the circle off, the observer will take care to place the other horizontal stop *n* to the contact with the alhidade A from this second position.

From this, the circle will be placed again in the first position, and the observations continued regularly and in the same order exactly to the last of the series, which must be like the first, an observation in which the level is placed by its own screw at *h*, so that the whole series consists of an odd number of observations.

The series being thus closed, all verniers of both sets are read off, those of the front telescope are written opposite to the time before the last, and those of the back alhidade to the last time, prefixing again in the second column the first letters of the set of readings.

All these will be observed in their regular order in the corresponding examples of the Day-Book.

By one observation more than is usual in the other circles, these give therefore two complete, equal, and (so far as refers to readings) independent series of observations. To that of the front telescope belong all the times, the last excepted, and to that of the back alhidade all the times except the first. They form a check upon each other against mistakes or errors, and may in some measure serve as a test of the proportional accuracy of different series of observations, besides that all results are evidently doubled.

The convenience obtained by the use of the screw *m*, for the circle is such as to make the use of the screws at the legs for this purpose actually objectionable, as it brings the instrument out of its vertical and occasions always a tedious adjustment of the level: besides. that when a number of observations are to be made consecutively, it would be necessary to level the whole instrument again after every one, while otherwise the circle, once well adjusted, will remain so for as many observations as may be made in a whole night. if proper care has been taken as to the solidity of the stand, which, in the field, must always be placed on three plugs reaching deep into the ground.

It is evident, that the measurement of a series of angles in the plane of two objects may be conducted, in respect to the successive motions of the front and back telescope, exactly as has been described above, and the results taken in the same manner.

As two opposite readings correct the eccentricity, if any, it is evident that the indiscriminate mean of any two opposite readings should always be equal; but the different sinkings of the readings, and the different influence of the weight of the telescope and other moveable parts of the instrument, may introduce differences, as is well known and sufficiently discussed; therefore the indiscriminate mean of all four readings is also here to be preferred, and will ultimately be found to give a better result than a discrimination would give. The Day-Book examples will show, in their places, how I proceeded, in this respect, to scrutinise the results of my observations.

It is well known that this instrument is calculated to correct all its own errors by the effect of its repeating property and construction, particularly in the vertical angles. Still it is well known that (for instance in determinations of latitude) it is proper to take the indiscriminate mean of an equal number of results of observations from the north and the south side of the zenith.

For the same reason, if ever any doubt should exist as to the want of stability in the parts of the instrument, which is very possible, the circle should be used in the two inverted positions which the semicircles admit.

Peculiar Method of Observing Time with the Repeating Circle.

In the observations for the determination of time, this element itself is the principal object of research, and may be considered as the most difficult to obtain accurate. The proper adjustment of the level in an observation of such a transitory nature, and during which the circle may move considerably in the vertical by pointing, requires great dexterity in the assistant; and since the level itself oscillates in passing to equilibrium, it is often very difficult to be sure of its position.

From one complete observation with the circle in its two positions and the indiscriminate mean of the four readings, all the main corrections of the observation are obtained. Succeeding observations serve only to augment the probability of accuracy, and to correct accidental errors of division, which, as already stated, may be considered a minimum in the instruments of Mr. Troughton.

A method satisfying the two first mentioned desiderata will therefore secure more accuracy in this kind of observation than the usual mode of repeating. My peculiar situation, with assistants entirely unacquainted with observations, joined to these considerations, led me to devise the following method of observing time, which I have ever since practised, and which Dr. Tiarks, the British astronomer for the boundary line at Canada, adopted also in our common works there.

The instrument being well levelled and the position of the front telescope read off as usual, the circle is placed so as to receive the transit of the star, or both limbs of the sun, at all the horizontal wires. In this situation the level is adjusted with ease, sufficient time being given, by the placing of the circle; and the transit of the star, or both limbs of the sun, at each of the three wires is observed. This can be done with the greatest nicety, the instrument being at rest and all the observer's attention being directed to the time of contact which is rapid; the observer calling out *Null*, at each transit, the secretary being attentive to the chronometer or clock, can note the time with the greatest accuracy; and the transit of the sun's centre is determined by six observations.

The circle being now brought into its second position, by a semi-revolution on its vertical axis, the level will remain adjusted, if the instrument is well levelled. If it require any correction, this must be made by the circle screw *m*, as the position of the level upon the circle must be preserved.

The telescope is then unclamped at D, and again placed so as to receive the transits as before. These are observed and the time noted, as has been done in the first position.

This observation being made, the verniers of the front telescope are again read, and give the double zenith distance, or rather the sum of the two zenith distances at the times of the observed transits. The half of this sum is to be considered as corresponding to the mean time between the two transits.

Such an observation, when taken near the prime vertical, will not exceed the time allowed for taking an arithmetical mean, and will be the result of six or twelve observations of time.

If the transit of the sun is supposed to take too much time to observe both limbs on each side, the antecedent may be taken in the first position, and the consequent in the second. There being then but half the number of times obtained, the observation may be repeated after the reading, and a mean of two such observations taken, as in any other case, calculating each separate.

In all cases, the application of Mr. Söldner's method of reducing all observations to the mean time, by correcting the result for their respective distances from the same, applies here with great ease and accuracy, since for each transit the distances of the wires are equal on each side, as nearly as the distances of the wires are, and therefore the calculation of this correction may be made for half their number only. It will therefore always be found advantageous to apply this method in the calculation of the results.

This method of observing will be found very satisfactory in practice, in regard to accuracy and a saving of time, together with the facility of choosing it so as to come nearest the prime vertical.

This method will admit an observation of time to be taken among flying clouds, when the method by repetition would be inapplicable; and when no complete observation can be obtained, the observation of any pair of corresponding wires in both positions of the circle will at least give an approximate result, which will often be useful.

It would be very advantageous, in using this method, to have five horizontal wires in the telescope within a space near that occupied by the three, as the transits could easily be observed, and the gain for each wire would be double in the result. I have therefore sometimes applied them.

The registering of such an observation and the manner of taking the result will be found in their proper places in the Day-Book and the Journal of Results.

Description of the Repeating Theodolite of One Foot Diameter.

Besides the great theodolite, it was very desirable, as well for the intended survey of the coast as for other uses in the country, to have some instruments of the theodolite kind of a smaller diameter, and yet capable of giving the same accuracy as the large instruments, though at the expense of more skill, labour, and time of the observer. It was also desirable that the same instrument should equally serve for vertical angles, in order to enable the observer to determine accurately latitudes, times, and the angles of elevation of the signals.

The multiplication of the terrestrial angles in the plane of the horizon was far preferable to that in the plane of the objects, on account of the great influence of refraction near the sea shore, particularly upon sandy beaches and islands, where it may be considered as varying constantly; and even a saving of time in the calculations was an object worth consideration.

It was necessary, on this account, that the instrument should be of the repeating kind, and a theodolite.

In planning an instrument to answer these views, the principles mentioned when treating of the two-feet theodolite and the repeating circle with two telescopes, lead me to unite the properties of both these instruments, omitting only the means of measuring angles in inclined planes.

In repeating instruments, the main points to ensure accuracy are,—the exact and steady levelling of the instrument, and the constant parallelism of the motions with respect to each other, in the course of the repeated measurement of an angle. These being secured, the plane of the divided circle itself, with its division, serves as a mere indicator of the operations, which has no influence until in the final reading of the stopping point, by the amount of the reduction of the distance of it from its intersection with the real horizon and by the accidental error of the division used, which have been shown to be the two smallest errors. The influence of eccentricity being corrected by the indiscriminate mean of the three readings, and the instrument admitting all the systematic combination of the series of angles which the two-feet theodolite admits for the single angles.

The same principles, as far as relates to the mode of multiplying and the motions of the axis, could evidently be executed in the vertical as well as in the horizontal circle. By making the latter revolve in the manner of a transit, not only all counterpoising weight might be avoided, (and therefore the weight of the instrument very much diminished,) but also its stability in the observation might be secured.

Upon these considerations I founded the construction of an instrument, of which I presented a plan in full size to Mr. Troughton, who, approving the principles, thought however, at first, that with eighteen inches diameter, as I wished it, it would present some difficulties, and therefore executed two of them of twelve inches in diameter, availing himself of the liberty left to him, as a skilful and experienced artist, to alter in various respects their external appearance.

Plate VIII. fig. 1 is a full perspective view of the instrument, and fig. 2 is a vertical section of the horizontal circle through the centre.

The centre piece *aaaa* of the stand part is two-thirds of a strong sphere, perforated to receive the axis of the horizontal circle. The three hollow conical arms forming the legs of the instrument are fastened to this piece by large strong screws, which are stopped below by the small screws *b*, *b*.

These arms terminate in spherical nobs which receive the vertical double screws *a'*, *c'*, in the same manner as in the two-feet theodolite and the repeating circle. They rest upon three truncated cones having lead in the top, and being sufficiently elevated to admit the verification telescope between the instrument and the stand.

The vertical axis *cc* of the instrument is fitted in the spheric centre piece by a collar, in the same manner as in the two-feet theodolite, and fastened by six screws from below. The lower part of this, represented by *ee*, is nearly two inches high, and forms the axis of the horizontal circle, which revolves upon it by means of the socket *dd*. The upper part, seven inches long, has its diameter diminished so as to leave a collar *ee* of about one-tenth of an inch to rest the upper part of the instrument upon. This socket is in the middle between the two columns *g*, *g* which support the axis of the upper telescope and circle, and is connected with them by means of the plate *ll* of about half an inch thick, and the cross piece *f* at the upper end of it.

Upon the spheric centre piece *aa* is fixed a circular ring *hh*, having three radii in the direction of the three legs of the instrument, which bear at their ends the three verniers D, E, F, with a clamp and tangent screw at D. This holds the circle *dd* by its lower plane, which is also that of the radii of the circle.

The divided limb of the circle *ii* is elevated above the other plane, so as to leave both on the inside and outside a recess sufficient for the clamping parts of the inner and the outer verniers. The inner clamp and tangent screw at A clamping and leading the upper part of the instrument, has the three verniers A, B, C reaching upon the same division of the limb *ii*, and affording readings for both the forward and the backward motion of the telescope. These motions are required in measuring an angle by multiplication. For, alternating between the two clamps at A and at D, the circle will, in one motion, move with the upper part of the instrument, and in the other remain clamped to the stand part.

The reading glass is on a detached part, consisting of a piece *m* about an inch and a half long, two-thirds of an inch broad, and one-third of an inch thick, bearing at one end a small pillar, upon which the projecting arm revolves. This brings the magnifying glass, with its reflector over any vernier required. At the other end a solid nob forms, at the same time, a handle and counterpoise to the magnifier. The reflector is a circular plate of brass lined below with plaister of Paris.

The two columns *gg* rise from the strong plate *ll* on both sides of the centre, so that their bases touch the base of the central cone which forms the socket of the axis. They are about two inches and a half in diameter at the base, and fifteen inches high. Each carries upon its top a solid piece *yy*.

which projects a little more than an inch beyond the column, to bear the supports of the transit axis of the telescope.

The axis of the transit is nine inches long. Its two parts, as well as the two parts of the telescope itself, are screwed in a spheric centre piece of about two inches and a half in diameter, and are in all respects similar in construction to the telescope of the two-feet theodolite. The telescope itself is nineteen inches long and of two inches and a half aperture. It has a lengthening or rather sheltering tube before the object glass, and in the focus three vertical and three horizontal threads of cobweb. The eye glasses are exactly the same as those of the two-feet theodolite and repeating circles; so that they will serve for any of these instruments in case of loss. The largest magnifying power is about forty-five times.

On the side of the telescope tube opposite to the circle, there are two small pins or axes, which are adjustable, and, by receiving a level constructed for the purpose, make this telescope serve as a very fine levelling instrument.

Through one side of the axis the wires in the focus are illuminated by the lantern which is placed upon a light projecting piece opposite to the axis, and fastened to the piece *y* by a screw.

The other part of the axis of the telescope forms the axis of the vertical circle, which revolves upon it in a manner exactly similar to that of the horizontal circle upon its axis.

An alhidade, bearing two diametrically opposite verniers W, X, is fastened to the axis of the telescope by its middle circular part, and forms the outer reading upon the divisions, exactly as in the horizontal circle, and clamps in like manner to the outer part of the limb.

A triangular piece, of which one side is horizontal, bears the two diametrically opposite readings Y, Z, reaching upon the division from the inside, and clamping to the limb of the circle by means of the inner recess between its plane and the plane of the radii.

To the angle of this piece, which is turned downwards, is attached a piece *q*, which bears a steel pin fitting in a vertical slit in the bar of the triangle, which prevents all angular motion of this piece around the column.

In the middle, between the two verniers of the bar of the horizontal triangle, is the centre socket *p*, within which the axis of the telescope revolves. This socket, and that of the telescope, are held to the axis by the ring *u*, which is screwed to the shoulder of the bell metal part of the axis of the telescope forming the axis to these two motions.

The two magnifiers, which serve for all readings, revolve with their arms, round the socket of the triangle. They are fixed to a ring that turns round this socket, and which is held in its place by the projection of the same piece *u*.

In observing vertical angles, the circle is clamped alternately to the alhidade of the telescope or to the triangular piece, by the alternate use of the clamps at X or at Z, and the two series of motions give two separate series of angles, each with two diametrically opposite readings.

All the verniers of both circles are double in this instrument, as in the repeating circle, having one half vernier on each side.

The adjustment of the axis of the telescope is made by two strong screws under the pieces *y*, *y*, showing a capstan head at *r* in the uppermost plate of the column, and pressing these pieces upwards by their spring around the screws *s*, by which they are held fast to the columns.

A detached level is placed upon the ends of the axis, passing between the radii of the circle, for the final accurate levelling of the instrument. When the instrument is adjusted, this level is removed and placed upon an arm *t*, at the top of the column opposite the circle, in a position parallel to the same, and there adjusted by a screw, below one end of the arm, to serve as a constant test of the stability of the level of the instrument during the observation.

By bending the lower angular part of the triangle above mentioned a little inwards, it may be disengaged from the pin in the piece *q*, which holds it in its position. Then the axis of the telescope can be lifted out of its supports, and the whole upper part, which serves to measure vertical angles, can be taken off, and placed in an inverted position for the verification of the line of collimation of the telescope, though it can not serve in this inverted position for the measurement of vertical angles.

The verification telescope below the instrument is exactly similar to the upper, and can, if desired, be used in its place. It hangs in hooks *x*, *x*, one of which hangs from one of the legs, and the other from an arm of the stand part of the instrument, purposely intended for it. It is pointed in the same manner as that of the two-feet theodolite, by an arrangement *w* of three sliding tubes, and a screw presenting its head to the upper part of the telescope tube at the eye end, which is pressed upwards to it by the overpoise of the object end.

To ease the first approximate levelling of the instrument, there are two small levels *k*, *k*, about two inches and a half long, and half an inch in diameter, placed at right angles to each other, at the side of the socket of the axis, between the two columns, on the side opposite to the vernier marked A, which in the figure show only a little between the axis and the columns.

The elevation of the upper telescope above the horizontal circle increases the facility of observing very high altitudes. The eye end passes through the nadir above the piece *f*, crossing the top of the vertical axis. The whole instrument is about thirty-two inches high, and the base of it through the truncated cones is a circle of about nineteen inches in diameter. It is therefore well proportioned for stability, particularly as the upper parts are not heavy.

In my original plan several of the arrangements were different. They were executed with great success in another instrument; and every artist or practical experienced observer will of course vary the disposition of many of the parts according to his own convenience and experience, and also according to the particular skill or means of the artist who constructs the instrument. The high opinion which I had reason to entertain of so distinguished an artist as Mr. Troughton induced me to leave much to his judgment and ideas.

I had the horizontal circle constructed so as to have the axes of both motions. The centre part had cones both downwards and upwards. The axis downwards revolved in the centre of the stand part. The legs of this were inclined from the centre to the circumference where the perpendicular screws come and upon which the instrument stands. The other axis receives the upper part of the instrument by means of a socket similar to that in the other instrument, but much shorter.

These two axes were of bell metal, with steel rings at their inner and outer ends. They were differently proportioned to each other. The lower was about twice as long as the upper, and of a more acute conical shape, in order to give it a greater wedging power; which, with the greater superincumbent weight on it, when the circle is moved with the upper part, increased its friction. The upper axis was about two inches long; its lower diameter was about the same length, its upper less than one inch. The socket of the axis lay close to it, and moved with ease, as the weight of the upper part was light. Accordingly, in moving this part, the great weight of the horizontal circle, and its great friction prevented all dragging of it after this motion. This, in the instruments made by Mr. Troughton, and in which the horizontal circle is light, is prevented by completely detaching the circle from the upper part, when the clamp A is loose.

Mr. Troughton's objection to this shape of the axes was, that they could not be rubbed so well with emery in a kind of screwing motion which takes off all the rings of turning and renders them smooth. But as these rings always form themselves in the instrument by use, I should think that in vertical axes there is no bad influence to be apprehended from them.

The vertical circle being supported in this kind of instruments between two columns, it is subject to less spring, and has much more stability than in the circle with two telescopes, where the double weight of the circle hangs upon a short axis, upon which equilibrium is maintained between the circle and its counterpoise. The verification of the verticality by the pole star can be made with the greatest nicety; and the large detached level itself can be adjusted upon it.

Method of Observing Horizontal Angles with the Repeating Theodolite.

The adjustments of this instrument are evidently the same as those of the two-feet theodolite, and grounded upon simple and well known principles, which are self evident from a view of the instrument, and need therefore not to be explained here.

The use of common theodolites with double axes for the repetition of angles is also so well known, that the mere description and view of the instrument would lead to the use of these double repeating theodolites, yet it may be proper to describe here the mode of taking a regular series, in order to render more intelligible the other peculiarities which are to be mentioned as means leading to the greatest accuracy.

When the instrument is carefully levelled, the riding level is placed upon the arm *t*, parallel to the vertical circle, and there adjusted.

Then the vernier A being placed upon 0° or any other division, which may also be the last reading of a foregoing series, the stands of the verniers A, B, C are inserted in the Journal. The clamp D being loose, the telescope part, together with the circle, will be turned so as to point the telescope upon the object to the left of the observer, and the pointing made by the tangent screw at D. After which, the three verniers D, E, F are read off, and inserted in the Journal. It is best to write them consecutively in the six first columns of the journal, heading each with its proper letter; the superscription of the angle to be measured being general, and above all the letters, with any requisite remark or designation of the signal, &c.

Then the clamp at A being opened, the upper part of the instrument without the circle is turned towards the object to the right of the observer, and being pointed by the tangent screw of the same, the first angle of the series of the three verniers A, B, C may be read.

After this the clamp at D being opened, and the telescope part, together with the circle, being turned back upon the object to the left and pointed by the tangent screw at D, the first angle of the series of D, E, F will be obtained.

In this manner will the observations be continued through as many repetitions as may be desired, paying attention to conclude with the same kind of movement with which the observation has commenced, in order to give to both series the same number of angles.

In order to keep some account of the progression of the angles, it is also proper to read one vernier, for instance A and D, at each observation, and insert the readings in their proper place in the Day-Book.

From the order of progressing here indicated, the angles will successively follow the order of the divisions. If more series are observed, it may be proper to take the second series in an inverse order, or backwards on the divisions; as the influence of pressures of screws or friction, &c. would act inversely, and the indiscriminate mean correct them as far as possible.

It is also evident, that if the greatest accuracy be aimed at, it is advisable to take two series, like the simple angles in the two-feet theodolite, with the telescope in a direct and in a reversed position, in order to compensate the influence of the verticality of the telescope; though near the horizon this influence is very small. In like manner also, the instrument may be placed in the three possible positions of the legs upon their cones, and such series may be taken at each position.

All these changes would undoubtedly contribute to accuracy, by the compensation which they would give to the indiscriminate mean of the proper number of series. It might be asserted that these changes with series of only a smaller number of angles would be preferable to long series in one position.

What has been said upon this subject relative to the two-feet theodolite, refers evidently to this instrument, as it is grounded upon the same principles, the multiplication of the angles excepted, which, in using it according to such a system, would be considered merely as a compensation for the greater diameter of the instrument. I shall not enter here into further details on this subject, as I never had time or opportunity to test these instruments completely. I measured only some angles by way of trial, the coincidence of which with those of the two-feet theodolite was very satisfactory.

Method of Observing Vertical Angles with the Repeating Theodolite.

When the instrument has been carefully adjusted and levelled in all respects, the observation of a series of zenith distances with it is taken nearly in the same manner as with the repeating circle; but in respect to its order in the use of the clamps, it admits two different successions, differing only in the ease with which the screws come to the hand in each motion.

The observation can evidently be made by one person alone, as the level requires no particular attendance. It may however be observed from time to time, to be sure that the instrument has not been disturbed.

The following order will bring the screws so as to be always convenient to the hand of the observer.

1. Place the vernier Z on 0° or any division, and read Z and Y. These readings are written in the third and fourth columns of the Day-Book.

2. The clamp at X being loose, make the first observation by the motion of the telescope alone, and point by means of the tangent screw of the same vernier Z. When the object observed is a celestial body, the time of this observation is observed, and written before the readings of Z and Y, in the first column of the Day-Book.

3. Then W and X are read off, and written in the fifth and sixth columns of the Day-Book, one line farther down than the Z and Y have been written.

4. Unclamp the circle at Z, turn the upper part of the instrument one half a circumference round horizontally, and the telescope together with the circle through the zenith again to the object to be observed, upon which, the clamp at Z being again fastened, the pointing is effected by the tangent screw of the same Z, and the time observed is written in the first column opposite to the foregoing readings. By this, the first angle of the series by Z will be obtained.

5. Turning the instrument a semicircumference horizontally, and after unclamping the vernier X, also the telescope alone without the circle through the zenith to the object to be observed, the pointing is again performed by the tangent screw of the same vernier X, whereby the first angle of the second series, or by W, X, is obtained, and the time observed is written again in the first column.

6. The observer may proceed in this order, and in the

same manner as with the repeating circle, by a succession of the above alternating motions, until the desired series is obtained, ending at last with the same motion with which the series was begun, as here by a pointing with the tangent screw at X.

7. All the times of such a series, except the last, will belong to the series of Z and Y, and all times, excepting the first, to the series of the reading, W, X.

If several series of the same zenith distance of a terrestrial object should be desired, for the sake of great accuracy, it would be advisable to take these series in the two different manners which the instrument admits, and to use the indiscriminate mean in preference to either.

The manner of taking out the results of such a series of observations, and of calculating them, is of course exactly the same as in the repeating circle with two telescopes ; and the mode of registering the observations and the results in the day-books and journals may therefore be omitted here, as sufficiently obvious.

It is evident that the method of observing time described in the repeating circle, applies also to this instrument with equal advantage and ease.

Besides this, the ease with which the light vertical circle, or the telescope alone, moves upon the transit axis, affords, in the present case, another method,—viz. to measure double altitudes by reflection on a mercury horizon, the level showing the stability of the instrument, which for this kind of observation needs no inversion or movement in azimuth, except for the small progress of the celestial body during the observation.

By alternating the motions of the transit, with and without the circle, between the direct object and its image in the mercury horizon, a series of observations of double altitudes may be obtained with great celerity ; and if the sun should be the object, the limbs may be alternated, as in another observation. The times of the two series will follow exactly as in the series for the zenith distances ; and all other directions given for these apply equally to the series of double altitudes. An observer, with a little experience, will be able to make such an observation without further direction. All that is desirable for it is a large mercury horizon, in order to have no need of moving it during the observation.

It is easy to adapt to this instrument a stopping arrangement for finding stars by night. These may be very light, and removeable, when not needed. On this occasion, I may remark that it is proper to make the touches of these stops light springs, and not solid parts, that in case they should come to touch, the telescope or other part of the instrument stopped, may not be affected by it.

Description of the Repeating Circle of Reflection.

The application of the principle of reflection from plane mirrors has produced the instrument which has most contributed to the advancement of nautical astronomy and geography.

When the mirrors are perfect, the accuracy which may be obtained in the measurement of vertical angles observed by means of the mercurial horizon, is certainly far superior to that from any other instrument of equal size, in which the level or plumb line is used, the circumstances in all other respects being the same.

The use of a circle, instead of a sextant or octant, introduced by Tobias Meyer, has in this, as in all other instruments, freed the results from the influence of eccentricity; and the improvements of it by Borda have furnished the means of correcting the errors of the glasses and adding the property of repetition.

In multiplying instruments, the constant parallelism of the motions is one of the principal properties required, as stated before.

This is evidently to be applied in this instrument to the plane of reflection, which is itself determined by the position of the large mirror.

In Borda's construction, the axis upon which the mirror revolves being short, the plane of reflection is too much guided by the plane of the limb, which artists well know can not be executed with the same accuracy and ease as the axis. From this cause, the English artists abandoned the principle of repetition ; and Mr. Troughton gave to the circle a construction, in which the motion of the mirror is determined by a longer axis, and the eccentricity corrected by three readings ; without repeating which, from the excellence of his work, and his great care in the choice of the mirrors, has given most excellent results.

Reflecting instruments being indispensable in the survey of the coast, for the observations, to determine soundings, and others to be made on board of vessels, &c., I considered it proper again to turn my thoughts to the improvement of this instrument, as I had done long before, so as to preserve both the multiplying principle and the stability of the plane of reflection. I considered the circle itself as of minor influence, and therefore allowed it to be moveable, and alternately clamped to the solid part of the instrument, which bears the small mirror and the telescope, or to the alhidade of the large mirror, and moving with it.

Having made a description of such an instrument with a drawing of full size, before I left the country, I presented it to Mr. Troughton, who said immediately that he would make me one upon the same principles, though different in shape, as he wished the instrument to be lighter. He showed me at the same time the ideas of Mr. Mendoza, which had completely failed in a similar attempt, and of which I then obtained the first information.

Mr. Troughton gave to the instrument a shape similar to that of his reflecting circle, from which my drawing differed in many respects; but here I had the reason, as in the other instruments, to leave him at full liberty in this respect.

I may therefore be allowed here again to suppose the construction of Mr. Troughton's reflecting circle fully known, and describe only the alterations made to it, to give it the repeating property.

Plate IX. fig. 1 is a perspective view, and fig. 10 a section of the centre part of the instrument. The parts *a*, *b*, *c*, *d*, *e*, form the frame of the instrument, which contains in the centre piece *e* the axis both of the mirror and the circle: in *a*, the support of the telescope, which may be lowered or elevated for the equalisation of the illumination of the two objects, in the same manner as in Mr. Troughton's circle; in *c*, the small mirror is fixed, exactly in the same manner as are also the handles *f*, *f*, and the rectangular piece *g*, reaching over the large mirror to receive the straight handle; but the frame reaches only so far as to unite all the above parts.

The circle itself revolves on the side of the frame opposite to the mirror, by a bell metal socket *t*, *t* of half an inch in length, upon an axis turned to the brass centre piece *e* of the frame, through the middle of which the axis of the great mirror *s*, *s* passes, as far as the upper part where the mirror is fastened to it.

The alhidade AB of the great mirror is at the end of the axis, opposite to it, and revolves upon the circle so as to read upon the divisions.

The alhidade DC is fixed to the frame of the instrument, between it and the circle, and forms two diametrically opposite readings upon the circle, for the motion of the mirror and the circle together.

The two axes have therefore entirely independent revolutions, the mirror within, and the circle without the piece *u*, *u*. The clamps of the two motions are here both outside of the circle, as it is not necessary that they cross each other in the observation. Both alhidades will give a separate series of angles, corrected for eccentricity by the two opposite readings.

When the mirrors are parallel, the alhidade AB stands under the telescope, and the alhidade DC is at right angles with it, so that in the observations, the vernier A comes alternately on the two sides of the telescope. The angle between the collimation line of the telescope, and that from the centre to the small mirror, form an angle of about 17° at the small mirror. The direction of the handles *f*, *f* is perpendicular to the collimation line of the telescope.

As all angles are measured at least double, namely on both sides of the parallelisms, the circle is divided like every other into 360°.

To give to the great mirror the full field of reflection, on the side of the telescope, when large angles are measured, the telescope is not screwed fast in the support at *n*, but the part commonly made to adjust the collimation line parallel to the plane of reflection is here extended into a tube *m* about four inches long, in which the telescope is slided in and out according to what the angle may admit, and to keep the circle not farther from the eye than necessary.

On account of the ease of holding it, the screw *l* in the telescope tube slides in the slit of this tube, to prevent it from turning and thereby altering the direction of the collimation line towards the plane of reflection.

The different eye pieces are fitted in a separate tube which unscrews at *p*, for the ease of packing.

To give to this instrument the same advantage in finding stars by night, as the circles of eighteen inches have, there is a light divided semicircle *o*, *o* adapted to the alhidade DC, supported in the middle by a small piece reaching to the telescope *a*. Upon this two sliding pieces *q*, *q* are placed on both sides of the middle, to the proper double altitude of the star, and the light pieces *r*, *r* fastened to the other alhidade at A will be arrested by them, whether this alhidade moves alone or with the circle.

The other parts of the instrument being exactly similar to Mr. Troughton's circle, need not here be mentioned. It is also evident that the construction and shape of this instrument may be varied in different manners, without altering its principal qualities. I made various plans; but it would be needless to state here their varieties.

Method of Observing with the Repeating Reflecting Circle.

The adjustments of this instrument being of course in every respect the same as the well known adjustments of any reflecting instrument, must not be repeated here. In all repeating instruments, attention is required, to avoid mistaking in the regular course of alternating observations, and use of clamps and screws. It is therefore necessary to proceed at first with measured and cautious steps, and to form a regular habit of an order easy in the manipulation, which, when it becomes habitual, will always proceed more surely and rapidly. The examples of observations given in the exemplar of the Day-Book and Journal will prove that two series of ten altitudes may be taken in the space of five or six minutes.

The correspondence of observations with this instrument and others with the eighteen inch repeating circle, which I had an opportunity of making at the northern boundary line, proved that the former was capable of giving an accuracy nearly as great as the latter.

The most convenient order of proceeding in a repeated double series of observations is the following:—

1. Place the vernier A upon 0° or any desired or round number; and read off B.

2. Write these readings in the third and fourth columns of the Day-Book. (Vide Exemplar.)

3. The alhidade DC being unclamped, make an observation, by the motion of the mirror and circle together, the con-

tact being made by the tangent screw at C, when this has been clamped. The time of this observation is written in the first column, before the readings of A and B.

4. Read the verniers C, D, and write the result in the fifth and sixth columns of the Day-Book, one line lower down than the foregoing.

5. If a night observation, place the stop *q* on the light circle near the outside of the projecting piece *r* of the alhidade A, leaving it some freedom of motion, and the other piece *q* upon the opposite side of the parallelism, upon the same number of degrees, &c.

6. Invert the instrument, either from right to left, when in a vertical observation, or upside down in other positions, and unclamping the alhidade of A & B, move it up to the opposite stop on the small circle, or in general near the place which will be indicated by the reading on the small circle, and after clamping there, make again an observation, bringing the objects in contact by the tangent screw at A.

7. The time corresponding to this observation being observed, it is written in the first column below the former time, and opposite to the second reading.

8. If the stand of the alhidade of A & B is now read off, a result is obtained of the first angle of this series, to which the two times observed would correspond; and in a vertical observation on the mercury horizon, the angle indicated would be the double altitude corresponding to the mean of the two times.

9. Invert the instrument again, to bring it in the same position as for the first observation, unclamp the alhidade C, D and move the circle with the large mirror, (the alhidade of which remains clamped to it) near to the first position or place of the stop, where C is again clamped.

10. In this position, make again an observation effecting the contact by the tangent screw at C, and writing the time under the second time.

11. In reading the verniers C & D, the first angle of the

series would be obtained, giving again directly the double altitude corresponding to the mean of two last times, if the observation is a vertical one on a mercury horizon.

12. To continue the series farther, the next operation will be the moving of the alhidade A, or the mirror alone, as in No. 6, and the alternation may be continued as far as desired; the last observation being always one of the same kind as that first made, in order to give to both series the same number of angles.

13. The times belonging to the first series A & B will be all the times observed, except the last; and the times of the series C & D, all the times except the first, as in the repeating circle with two telescopes, and the calculation of each series will be separate.

If the angle observed should increase during the observation, as in observing time for instance, it will be proper to attend occasionally to the stops, that they may not be too near, so as to occasion them to be touched by the alhidade, and disturb the readings. In observing the sun, these stops are best removed to the end of the circle.

In keeping fast the clamp of the alhidade C, which holds the circle, and moving only the mirror, the instrument will perform exactly the same functions as Mr. Troughton's circle, by the single cross observation; and in determining the point of parallelism of the mirrors, the same observations may be made as with a sextant; but in these the instrument loses not only its peculiar advantages, but even would not serve so well as a sextant, which is lighter, and its parts purposely calculated for solidity in this kind of observations.

If in terrestrial angles, the two objects observed should be equally well illuminated, so that the equalisation of light could be made constant, the alternation of the angles can be effected without inverting the instrument, by changing alternately the object to be viewed directly; by which the other will be brought to alternate equally with the position of the mirror, to receive the reflection; and the inconvenient position of the hand, or the change of handles, is avoided.

Description of the Plane Table, and the Alhidade to the same.

The best method of surveying the minute details which are to fill up a triangulation, is undoubtedly by the plane table and its alhidade, with a telescope revolving in the vertical. This method will give to the detail surveyor the full result of the triangulation with respect to the relative position and distances of the points to be determined, in a mechanical form, appropriated to the nature of his work; and which will not only be a guide and reference, but also a means of enabling him to determine his distances, and to verify his work constantly as he proceeds, and by reviewing the fundamental points, to discover an error immediately, before it may mislead him. The detail surveyor can therefore proceed with confidence and celerity, and his work will be greatly diminished by this method, as well as by saving all the work commonly called plotting, (necessary in all other methods,) which besides introduces new errors, while those made in the field remain concealed until it is too late to correct them properly.

The plan of the triangulation being properly adapted, will besides be made at once sufficiently by the mere projection of the triangulation, as will be observed in its proper place. The details being introduced in the field, immediately under the eye, will be much more numerous, more accurate, and natural; so that to a man acquainted with the subject, it will be easy to distinguish details and plans surveyed by this method from those taken by the theodolite or the needle. The last of these instruments is the worst that can be employed for the purpose, and has probably been transferred to land only from its use at sea. As a historical proof of these assertions, I shall only mention that the plane table has been used in the surveys made in East India by the East India Company, under the direction of a German, and on account of the advantages for which I gave it the preference in this work.

The principles of the alhidade are simple. It may be accurately constructed, and easily verified. Its properties should be :—

1. To level a plane.

2. To describe an exact vertical upon this plane.

3. To draw, or rather indicate, upon this horizontal plane a line parallel to the vertical plane of an object.

All further complications are not only useless, but always prejudicial to the accuracy of some of its main properties, particularly in applications similar to those intended in this work.

In Plate IX. fig. 2, 3, & 4, *a*, *b* is a rule of about sixteen inches long, three inches broad, and one-tenth of an inch thick. Four pillars *c*, *c*, near its middle, rise about three inches high. They support a frame *d*, *d* perpendicularly across the rule, about six inches long. Upon the two ends of this arise perpendicularly two uprights *e*, *e* of four and a half inches in height, forming the supports of the axis of the telescope.

The telescope *f*, *g* is a regular small transit, describing an exact vertical upon the horizontal axis *h*, *h* without clamping, stop circle, or any similar contrivance. It is about fifteen inches long, and of about an inch and a quarter aperture. It slides forwards and backwards in a tube *l*, *l* of four inches in length, fixed to the square centre piece, and may, by that means, be placed in equilibrium, so as to remain in all positions by the mere friction of the axis in its supports, and the level hooks.

In one of the supports is the adjustment for levelling the axis of the telescope, by a capstan head screw *i*, *i*. There is expressly no horizontal adjustment for this axis, to effect the parallelism of the vertical plane of the telescope with the sides of the rule, because this is intended to be fixed and adjusted by the proper filing of the Y's in the supports, or the placing of the frame *d*, *d* on the columns *c*, *c*.

Before the object end of the telescope there is a light lengthening tube of three inches in length, to keep the side light and glare from the object glass, which is very necessary in this instrument.

The eye part of the telescope is in a long tube sliding in the main tube. By sliding it in and out, the wires are placed in the focus of the object glass; and by turning it in the tube they are placed perpendicular.

There are three vertical and one horizontal wires. The multiplication of the vertical wires is for the observations of transits of celestial bodies in observing transits, by which a survey may be properly oriented, or a true meridian drawn in it. The eye pieces may be chosen at the pleasure of the observer, and, in respect to their magnifying power, they must be adapted to the middle distance of the objects which may come under observation. It is therefore proper to have several changes; and it will be very convenient to have one prismatic, which being placed so as to look upwards, will serve for objects at such an elevation as will not easily allow room for the head between the plane of the table and the eye piece; and it would not be proper to give to the instrument too great an elevation in its construction, because it would affect the stability of the vertical plane of the telescope.

The spirit level *k* hangs to the axis by hooks, and has proper adjustments. It serves for the levelling of the axis of the telescope, and the plane table itself. The method of using it is too evident and simple to be detailed here.

As this instrument will, in its use, be placed on different parts of the plane table, it becomes a desirable object that it should be as light as may be consistent with its necessary solidity, in order that it may not affect the level of the plane table. For this purpose, the large rule is cut out as seen in fig. 2, so as to form only a skeleton to the outer straight line, and the supports of the telescope. In like manner, the frame *d, d* and the supports *e, e* are cut out, so that the instrument is rendered very light, and at the same time very solid, by the nature of its framing.

It may be useful to give here the description of an addition which this instrument admits, and by which it answers the purpose of a very good goniometer.

In the middle, between the pillars *c*, *c*, is a socket which receives an axis of at least one inch in length and about one-third of an inch in diameter. At both ends of the rule, *a* & *b*, there are two very thin pieces, either added to the end edges, or worked out in it, in which two points are made, at equal distances from the centre, and diametrically opposite to each other.

Another rule similar to the above, and of equal breadth and length, is kept from bending below by an edge bar tapering from the centre towards the two ends. This has in its middle the steel axis to the socket of the other rule, which is put upon it, and held by a screw from above, when the instrument is to be used as a goniometer.

In the middle, below the rule, is a centre piece, either square or round, with a screw sufficiently solid to hold well, and adaptable to any stand, which will of course be conveniently contrived so as to suit the motion work of the plane table. This table will be described hereafter.

A decimal scale will then be constructed on the radius of the instrument considered as a unit, which therefore may be chosen so as to serve at the same time as a scale for the plane table operations. The cords must be measured by a beam compass of proper length, &c. The numbers on the scale may be marked at one half their value, so that when the cord measured by the beam compass is applied to it, they will immediately indicate the size of half the angle, which being taken from a table of natural sines, will give the angles with great ease, and, if proper care is taken, with considerable accuracy.

The levelling, and all adjustments of this instrument, are of course exactly the same as when used on the plane table.

The measuring of the angles can of course be varied, and the cords of the two vertical angles can always be measured, and in many cases the supplements. It will be more proper to let every angle be composed of two, given by the cords of two angles, going off from a fixed position of the lower rule, than to place the lower rule together with the upper upon a point, with their points placed upon each other.

Instruments such as I have now described at length, I had executed in 1792, by the exact artist Develey in Lausanne in Switzerland, for the Surveyors of the Comissariat General of Berne, as we were not satisfied with the usual alhidades with lights. These instruments have, in all respects, answered very well, and have not deteriorated by long use.

The plane table itself ought to be about thirty inches by twenty-four in size, as light as it can be made consistently with solidity. It may, on that account, be proper to have it pannelled. I have always found that old pine board, which had served long as doors or house furniture, &c. was the best material for it. The size above mentioned allows papers of such dimension as will be found advantageous, while a small table will introduce inaccuracy, by the necessity of changing often, and adjusting many papers. For the same reasons plane tables, with frames to stretch the paper upon, are to be rejected. The paper must be allowed to be of great length; and a breadth of three feet and a half may well be placed on the table, of thirty inches in one direction. It is good to have the edges rounded off, so that when the paper is wound round it, the part not used may be rolled up under the table, and kept from folds or bends.

The paper is stretched and held upon this table by brass, or (which is still better) steel springs of sufficient strength, and of the shape and about the size seen in Plate IX. fig. 6 & 7. These springs sliding over the edges of the table, and holding in front, admit freedom to the paper around the table, by the greater width of the round spring part behind.

The motion work of the plane table is exactly similar to that of the large needles, and may be seen in Plate IX. fig. 5.

Instead of the pillars *d*, *d*, which carry the needle, there are three screws, by which the uppermost circular piece *n*, *n* is screwed fast to the middle of the plane table, which has for that purpose a circular part, giving an additional thickness to the table in this place.

The piece *n*, *n* is a strong circular rim, eight inches in diameter, with six strong radii. The outer part has a bell metal ring, upon which it revolves upon the lower plate *l*, *l*, to give a smoother motion than brass on brass. In the centre *m* is a bell metal axis, about three inches and a half long, passing through the centre of the piece *l*, *l*. The piece *l*, *l* is similar to the above in shape, only stronger, and projecting somewhat over it, so as to admit the clamping part *p*, which goes in a small rim cut in it all round, and by which the plane table is placed in the proper direction by a tangent screw, after being approximately placed by hand.

In the centre piece *l*, *l* is a strong piece *o*, *o*, through which the axis of the upper plate passes, and in which its revolution may be fully stopped by the milled head mother screw *t*. This centre piece has a small neck at *o*, *o*, below which it is formed in a part of a sphere of about an inch and a half in diameter, which is held down to the lower piece *r*, *r* by the sections of a hollow spherical piece *q*, *q*, covering the above part of a sphere.

In the plate *r*, *r*, which is again formed like the others, but made the strongest of the three, (the rim being about an inch and a half broad and one-third of an inch thick,) there are three perpendicular screws *e*, at one hundred and twenty degrees distance from each other, supporting the piece *l*, *l* upon round nobs, and being turned by their milled heads below the plate, which fall exactly in the middle between the three sockets *s*. These sockets receive the joints of the brass ferrules *a*, which move round the pin passing through them, and have a strong wood screw inside, in which wooden legs five feet long are screwed fast, and extend far enough out in all situations of the ground, in order to give sufficient solidity to the table. These legs have iron ferrules and points below.

At about two-thirds of their length from below, they are near two inches thick, tapering gradually and equally out on both sides; so that the lowest end becomes the smallest, and is reduced to about one inch. This form of the legs adds considerably to their strength, and prevents them from bending.

Of these alhidades and the motion works for the plane tables, I had only two constructed in England, though in the farther progress of the work a greater number of them would be required. These, however, might be made in this country, using those constructed in England as models.

Description of the Magnetic Needles.

In the survey of a sea coast to which ships come under the guidance of the magnet, it was of course of interest to observe the variation of the needle, to obtain data for this interesting element.

For this purpose, and not with any view to its use in the actual survey, two needles were constructed; and I intended to join to the observations of the variation, those of the oscillation, and for which I had a needle of my own. They are constructed exactly on the same principle as the one I had constructed in 1801, by M. Esser, Mathematical Instrument Maker at Arau in Switzerland.

Plate IX. fig. 5, is a vertical section of this instrument, which may suffice to explain its construction. The needle z, z one foot in length, is in a circular box about an inch high, having an horizontal circle x, x silvered, and divided to every twenty minutes. A small silver vernier on the needle assists in reading the subdivisions (which might however have been carried farther on the circle itself.) The circle is divided as usual into 360°, beginning from a radius parallel to the telescope. The glass cover rests on three points, and is held to them by the spring of a brass ring above.

The needle *x. x* hangs edgeways, has a jewelled cap mounted in brass, which can be screwed in the centre from both sides, to verify and compensate the parallelism of the magnetic line of the needle with the middle line of its figure, which serves for the readings.

Four pieces are adapted outside of the needle box, projecting a little above it, to receive a large spirit level across the box, in two situations, at right angles to each other, one parallel to the telescope, the other parallel to the axis,—by which the instrument is levelled.

The needle box has below two strong pieces *b. b* diametrically opposite to each other. These form the sockets of the horizontal axis *y. c* of the telescope, bearing at its thicker side *c* the piece *h*, in which a tube of four inches long is fastened. Through this tube passes a telescope, in all respects exactly equal to that of the plane table alhidade, so that they might be interchanged in case of accident.

This telescope describes a complete vertical circle, to which it is of course adjustable by the motion of the wires, and it was not found proper to give it any other adjustment. Its verticality is best verified by the reflection in a mercury horizon of the pole star, or any other object seen under a large vertical angle, when the instrument is adjusted by the level. The correction is of course to be made, if necessary, half by the wires, and half by the supports of the level. The needle itself is then equilibrated for this adjustment by the brass counterpoise *f*. The adjustments are so simple, easy, and apparent, as to need no description.

The needle is prevented from moving by a stop, when not in use.

The needle case with all the above rests upon six pillars *d, d*, by which it is made fast to the plate *n. n* which is the first of the stand part of the instrument. All the lower parts being exactly equal to those of the plane table, I shall refer to the description of that instrument for further details.

In making an observation, the needle box revolves by the rims at n upon the plate l, l, and is clamped, and the telescope pointed, by the clamping and tangent screw at p. If the sun or a star is observed, the transits of the three wires are observed as in any other azimuth, and the time accurately noted, and determined by other observations.

When a magnetic azimuth has been observed, and read off at both ends of the needle, with the telescope on one side of the box, suppose to the right hand, then the needle must be turned a semicircle in the azimuth, and the telescope as much in the vertical, and the observation repeated again, exactly as in the observations with the two feet theodolite.

The indiscriminate mean of these two observations, with their four readings, must be taken for the result, as it will be corrected for the eccentricity of the needle, and the eccentric position of the telescope.

A more minute description of the operations will not be necessary. The inversion just mentioned ought never to be neglected in any use of the magnetic needle whatever, as no reliance can be placed in the results without it.

It may be proper to observe that it is necessary to pay great attention to obtain what is called free brass for the construction of all instruments in which the magnetic needle is used. All castings from brass filings or borings contain more or less iron, which will act upon the needle.

With a view to have the needle as little affected as possible, I requested that the body of the azimuth compasses under consideration should be made of pure copper. But such was not to be obtained; as in England the copper in commerce is made by a precipitation from a copper solution by means of iron. By this process, it is always mixed with iron, and therefore rendered unfit for the use intended. I was therefore lead to the use of free brass, as just stated.

Peculiarities of the Five Feet Transit Instruments destined for the Observatories.

The axes of the transits are generally made of considerable length: but there is probably more lost by this in solidity than can be gained by the nicety of the adjustments.

In each of the transit instruments made by Mr. Troughton for the two observatories which were intended to be built, the axis is thirty-three inches long between the supports. The two truncated cones which form it meet in the middle upon a spherical piece about nine inches in diameter, which receives also the two parts of the telescope: exactly in the same manner in all respects as the transit telescope of the two-feet theodolite.

The bell metal ends of the axis, which are about three quarters of an inch in diameter and one inch and a quarter in length, rest on supports which are screwed to the flat top of the stone pillars, the transit not being hung to the inner side of the pillars, as was formerly the custom. They are of the following form:—

In Plate IX. fig. 8 & 9, *a, a, a, a* is a plate of brass about half an inch thick and six inches and a half square. Four strong screws *b, b, b, b*, fastened in the top of the stone by gypsum, receive it, and it is secured by four mother screws pressing it close to the stone.

In the middle of this plate is elevated at right angles a strong piece *c, c*, about three inches high and one inch thick, in the shape of a bridge, which slides in a runner, cut in the plate parallel to the telescope. This piece being moved by means of the screw *e, e*, will adjust the telescope to the meridian. In the uppermost part of this piece is the rectangular incision, forming the Y's upon which the axis revolves. Below it, this piece is cut out in the form of a segment of a circle, which is subtended by a perpendicular screw in the middle d, which can be moved by its milled head, and presses with its lower part against the cord part of the same piece below; the upper screws in the bridge thus forcing its middle up or relaxing it by the mere spring of the metal. This is all the adjustment which is allowed to the supports, as it is supposed that the stone pillars, and therefore the plates, may be brought within these limits by previous levelling, and thereby greater stability be obtained.

About five inches from both ends of the axis, are two strong rings, of about four inches diameter, turned exactly on their edges. These turn upon perpendicular rollers of the same diameter, which are pressed against them from below, instead of counterpoises, by means of springs enclosed in circular boxes, about eight inches long, which press upwards the square slide bearing the rollers. The springs are moderated from below, by a screw at the lower end of the cylinder. These counterpoising arrangements are fastened to the inner sides of the pillars, in the same manner that the pans of the transits rising between the pillars usually are.

There is neither semicircle, nor alhidade, nor clamp of any kind, to keep the transit in a certain position; as all arrangements of that kind are very apt to disturb the verticality or accuracy of the circle described by the transit; which induced Dr. Maskeline to remove them from the transit of the Greenwich Observatory, and to substitute in their place an optical arrangement.

In these transits the pointing in altitude is performed by two semicircles, one on each side of the eye piece, on which levels move by friction, around their centre, with verniers and all proper adjustments. These circles are numbered, so as to show altitudes, as they could not be adjusted to declinations or polar distances, on account of the unknown latitudes of the future observatories. The verniers being therefore placed upon the proper altitude, the telescope is turned upon its axis until the level is horizontal, when the star intended to be pointed at will appear in the telescope,—one semicircle serving north of the zenith, and the other south of it.

The level for the axis of the transit is a free level hanging between the pillars, and has a tube of upwards of an inch in diameter.

The illumination is through the axis, by a lantern placed on one of the stone pillars.

To see the meridian mark distinctly and without parallax, in case of its being somewhat near, (as the nice adjustment will not permit us to alter the focus from the infinite distance) it has been usual to adapt before the object glass another glass of the focal distance equal to the distance of the mark. I considered this method liable to some objections, and besides could not know the distances of the future meridian marks.

I suggested therefore the following simple arrangement, the correctness of which I had long ago tried, and which obtained the approbation of Mr. Troughton. A brass plate is screwed to the end of the additional tube placed before the object glass, having in its centre a hole of not more than half an inch in diameter through which only the middle rays of light are admitted. Thus all parallax is avoided, the image is exceedingly well defined, and the great loss of light which naturally takes place is of no importance.

As these transits are not within my reach, it would be improper to enter into a more minute description of them. This task is left for the astronomer to whose care they shall be committed.

On the Astronomical Clocks intended for the Observatories.

About a year before I came to London, a new clock had been put up in the Royal Observatory of Greenwich, to serve with the mural circle which Mr. Troughton was then making. Dr. Pond gave me the most favourable account of this clock. He told me it never deviated from true time more than half a second; and accordingly I considered it proper to have the clocks for the intended observatories made by the same artist, and upon the same principles; as it is difficult to get a very good clock, and the prices asked are proportionally far above those of chronometers. A greater number of the latter are constructed on account of their constant use in the navy and naval commerce, which forms in England the principal support of this branch of the arts, as well as of the mathematical instrument making.

The clocks were therefore constructed by the same artist, Mr. William Hardy from Scotland, residing in London, and who is eminent for various valuable inventions in the line of clock and chronometer making, and for the very superior execution of all his works. The scapement, as well as the arrangement of the wheelwork, is of his invention, and exactly similar to the clock of the Greenwich Observatory, with only some small differences which I suggested, in order to augment the stability, and facilitate the reading upon the dial.

As I have not access to these clocks at present, I cannot give as full a description as might be desirable. I must therefore confine myself to observing, that each of them consists of four wheels, and has the hour wheel of about four inches in diameter in the backward motion of the drum, carrying a plate which shows the hour through the dial plate. It may however be useful to describe the scapement from the drawing which I made of it in London, as I know of no description either of it or of the other peculiarities of Mr. Hardy's clocks.

In Plate VI. fig. 8, 9, 10, 11, *a*, *a*, *a* is the scapement wheel, with thirty teeth. The pinions go on jewels. It stands beyond the hind plate of the clock *b*, *b*. Its outer pinion goes in the bridge *c*, *c* projecting from the back plate, the arbor going through the clock to bring its other pinion in the front plate of the clock.

A strong piece of brass *d* is adapted to the plate *b*, projecting a triangular piece *e* directly over the scapement wheel. It receives on each side two steel springs *m*, *m* & *n*, *n*. These are held fast to the piece *e* by the lower screws *g*, *g*; and by means of the upper screws *f*, *f* they can be adjusted to more or less pressure in their lower parts. These form the sloping and impelling part of the scapement, which is therefore regulated by them.

All the four springs have circular holes, at exactly equal height, immediately below the triangular piece *e*, and between the two strengthening rims *h*, *h*, where they are weakened so much, as to present only a very light spring in their action upon the scapement wheel.

At that place also, the springs are bent, so as to make them tangents to the scapement wheel.

Each of the springs *n*, *n* bears at *i* a ruby mounted in brass, and adjustable by the small screws *k*, *k*, projecting from the spring towards the clock, over the scapement wheel, which is stopped by their falling alternately within the circumference of the wheel upon a tooth, when they are not supported by the pendulum in its motion. These rubies stand ten teeth and a half distant from each other. The distance which they are allowed to fall is regulated by two screws *l*, *l*, going through strong arms reaching up from the bridge *c*. The screw *l* is screwed in or out, as the adjustment of the fall of this spring may require. At the end of the springs are light brass pins *o*, *o*, projecting outwards over the pendulum *s*, to meet the inclined planes *p*, *p* at the two ends of the cross bar of the pendulum. By this the springs are alternately lifted to disengage the scapement wheel.

The two springs *m*, *m* bear, at the distance of one tooth farther on each side, each an inclined plane or pallet *q*, *q*, which are jewelled, and by means of which the springs are alternately lifted by the teeth of the scapement wheel, when this slides under them, after being unstopped; so that on the side at which the wheel is stopped, the tooth is at the top of the inclined plane, and on the side where the top falls between two teeth, a tooth stands below the inclined plane. These two springs have also at their end, each a light brass pin *r*, *r* reaching to the same inclined planes *p*, *p*, which terminate the cross bar of the pendulum. This inclined plane or pallet meets these pins exactly when the stop *i* is disengaged and the oscillation of the pendulum is completed, and the pins press upon it by the strength of the returning spring, to give to the pendulum the necessary impulse after each oscillation. This impulse is moderated by the screws *f*, *f*, and the inclined plane returns, by the same power of the spring, into such a position between two teeth, as brings the screw which is more distant exactly at its lower end.

The succession of these motions, alternating between the two sides, forms the scapement. Their equality, and coincidence with the motion of the pendulum, is adjustable by a small horizontal movement of the bar *p*, *p* upon the pendulum, which is directed by a short arm or tooth *z*, turning upon the pendulum by means of a key, and fitting in an indenture of this bar. The motion is stopped by the pressing screw *y* in the middle of the cross bar, the hole being somewhat elongated, to admit a small horizontal motion.

The pendulum *s*, *s* is suspended from a strong brass bar *u*, *u* passing over the upper ends of both plates of the clock, and supported (agreeably to my suggestion) outside of the pendulum, by a strong square pillar *t*, which stands under it and is screwed below to the same strong brass plate upon which the clock itself is screwed fast.

The spring *v*, which forms the suspension of the pendulum, is mounted in a brass piece *w*, sliding in a slit of the bar *u*, and there kept in its proper place by a steel pin crossing over the piece *u*, *u*. The pendulum rod is adapted to the spring by a steel pin *x*, crossing both.

To determine the centre of oscillation in the suspending spring *v*, this is again perforated, the horizontal diameter of the round hole being exactly in the same horizontal plane with the horizontal diameter of the four holes of the springs, in order that the motion of the pendulum and the spring may go off as from one axis, to avoid all friction in the touching of the pins *r* and *o* upon the inclined plane *p*.

The pendulum rod itself is a parallelopipedon of steel, one-third of an inch broad and one-tenth of an inch thick. The compensation for temperature is made by a mercury column about seven inches high, and 1.9 inches in diameter, included in a glass cylinder, which serves as the lens of the pendulum. It is therefore adjustable by experiment, and completely at the disposal of the observer, and for any latitude. There is also a screw at the end of the bar, by which this arrangement is suspended to it, and by which the length of the pendulum itself is adjustable.

This pendulum is well known by the name of the Mercury Compensation Pendulum; and it is evident that it was the only one adapted to my purpose, as I was uncertain in what latitude the observatories would be built. On general principles, any compensation of a pendulum must compensate for the sum total of the effect of temperature upon the going of the clock, and not merely for the expansion of the rod itself. It must therefore be determined by experience and observation; as a rod compensating itself exactly in a pyrometer, would not for that compensate every clock; and these clocks would not be compensated by it, on account of the influence of the temperature upon the scapement springs.

The jewelling of the larger pinion holes of a clock does not appear to me to be of any advantage. The pressure upon them appears too great, and on that account occasions a grinding of the pinions. Therefore only the scapements are jewelled in these clocks. The other pinion holes are boxed with brass taken from a piece brought to England from Bengal as a sample, which was given by the Board of Longitude to Mr. Harrison, the first inventor of chronometers. At his death, Mr. Hardy bought it, and uses it with the greatest economy for such purposes. The ends *p*, *p* of the cross bar on the pendulum are also lined with this brass.

The dial plate is thickly plated with silver, in order to preserve well the whiteness, which facilitates the reading, while the mere silvering commonly used, soon becomes so dull as to render the reading by night or from a distance inconvenient.

With the same views—to facilitate the reading, the circle of the second hand is larger than usual, and all useless numbers are excluded, in order to give to the divisions a more striking appearance.

It was my intention to make the weight always move at some distance even, below the lens of the pendulum, to avoid the too great influence of it upon the pendulum, particularly in the proximity of the lens, as it is a well known fact, that the clock will always change its rate of going in consequence of the mutual attraction between the lens and the weight.

In clocks which go only twenty-four hours, as those described above, which are always wound up at regular times. this influence, occurring every day equally, will on the whole compensate itself, and the intermediate deviations occasioned by it will remain concealed, as the clock will always be regulated according to its mean daily rate. It appears therefore the most evident in those clocks which go a long time with one winding. On a Franklin clock, which I put up at West Point in 1808, and which shows only four hours, and went forty days with one winding, the pendulum was completely stopped when the centre of gravity of the weight was about ten inches below that of the lens, their horizontal distance being three inches and a quarter; the weight and lens both were considerably heavy.

To counteract this mutual influence, I hung a musket ball by a thin wire from the board on which the clock rested to the point where the centre of gravity of the weight was when the clock stopped, and in a few seconds it began to oscillate isochronous with the pendulum.

These two experimems I repeated several times, with exactly equal results; and though I attributed the stopping of the clock to a small defect in its position, I made the weight to go in future below this stopping point, and I never wound it up as far as that point. This reduced its time of going, till the weight rested on the floor to fourteen days, and also destroyed the effect of the attraction of the lens and weight.

The placement of the clocks here described requires great care, attention to solidity, and various peculiar arrangements which cannot be described here. Without such arrangements, they would be spoiled immediately, and disappoint the expectations which are with reason entertained of them.

Plan of an Observatory proposed to be built in Washington.

In my plan of operation for the survey, I proposed the erection of two observatories in such places as might be found most advantageous. It seemed evident to me that the use of these establishments might be extended to objects of general scientific improvement, independent of the survey, without any considerable increase of expense : and my views on this subject were supported by the approbation of many eminent men in public life.

When I rendered in the accounts of my mission for the instruments in June 1816, the President, Mr. Madison, as well as the Secretary of the Treasury, Mr. Dallas, were as desirous as I was, that this part of my plan might receive its immediate execution. I thought it important that one of these observatories should be located at the seat of government; and many considerations led me to select for this purpose a part of the hill north of the Capitol, and in the centre of the city. Circumstances which it would be useless to relate here prevented the execution of this project ; but still it may be proper to give the plan and description of the proposed observatory, as they are necessary to complete the subject of these papers, and may at some future time become useful.

The present state of astronomy is averse to those vast and splendid buildings formerly erected for observatories which now stand near the smaller buildings forming the actual observatories, and obstruct their view.

I therefore thought it my duty to propose a comparatively small building, adapted to the instruments intended to be used in it, but still so formed as readily to admit of enlargement, if this should become necessary.

The principal aim in an observatory building, besides proper shelter for the instruments and convenience for their use, is the stability of the instruments themselves, so that they may be independent of the influence of any motion in the observatory itself, or in its neighbourhood. This object is obtained by founding the parts intended to support any instrument at some depth in the earth, insulating the building from the surrounding ground by a ditch, and supporting the floor of the observatory itself upon pillars separate from all other parts of the building, and particularly from the pillars that support the instruments.

The instruments for which my plan was adapted were,—a transit instrument of five feet, an astronomical clock, the eighteen inch repeating circles, and the large telescopes, and a zenith sector of six feet, ordered and yet expected of Mr. Troughton. It was also intended to make this observatory the place of deposit of the standards of weights and measures, the chronometers or any other instruments of the collection when not in use, and of an appropriate library.

Plate VIII. fig. 1, is the plan of the observatory, at the level of the floor; fig. 2 the vertical section, in the direction of the meridian, through the transit; fig. 3 the northern front; and fig. 4 the vertical section in the direction of the parallel, through the transit.

The whole building is forty-two feet in the direction of the parallel, and twenty-eight feet in the direction of the meridian. The walls are at least two feet and a half thick below ground, and may be diminished to about one foot and a half at the top.

The south front has three windows, the east and west front each one, and the north front two. The door is in the place of the north eastern window. In the middle of each of the windows, the wall projects inward, in form of a semicircular pillar two feet in diameter, *a, a, a,* the top of which, together with the window shelf, is covered with one flat hewn stone, fastened in the wall, and three feet above the level of the floor. This admits any moveable instrument to be placed under the window for observation, even in the meridian of the transit, and the windows and shutters can be closed outside of it, without disturbing it.

The windows are all five feet broad and nine feet high in the clear, which will admit observations as near to the zenith as is otherwise practicable with moveable instruments, and give sufficient freedom in the azimuth, not only for all circum-meridian observations, but also for corresponding altitudes.

The windows and the shutters slide by counterpoises entirely below the window seat, in the recesses *b, b,* made for the purpose in the outside of the wall, and covered by a wooden frame projecting sufficiently to shelter them all. The covers *c, c* of this frame form the outer part of the window seat, and move on hinges; by which means they open or shut the recess with its frame, and support the windows and shutters, when these are closed.

The middle of the observatory is occupied by the transit, which rests upon two solid stone pillars *p, p* elevating it nearly seven feet above the floor. Their inner sides are perpendicular, and thirty inches from each other; the three outer sides are tapered towards the top. Their bases are about two feet square, and the tops about ten inches. Upon their flat tops the supports of the transit are fastened, and on the inner sides the counterpoising spring rollers, as has been described in the proper place, and may be seen in fig. 4.

These pillars go through the floor without touching it, and rest below upon a solid block of masonry, about six feet high, firmly founded below the excavation of the cellar on a base the breadth of which must be proportional to the solidity of the material employed, of which the best would be one solid block of stone.

Upon a similar pillar *q*, somewhat on the side, to the south east of the transit, the clock is to be placed in such a direction as to present the face about perpendicular to the desk. The centre of the second hand must be made to come about five feet eight inches above the floor, for the ease of reading and to show below the transit. It can be easily illuminated by a lantern placed on the side of the pillar near it, so as not to throw any light to the eye of the observer.

The top of the pillar is regulated by the size of the clock, and the base by the necessary solidity. It must be independent of the floor, and have a particular shape adapted to the clock. To admit the case to go round it, without enclosing the pendulum in the stone, it may rest upon the same basement as the transit, or upon a similar one equally solid; but there must be room made in it to admit the weight of the clock, intended always to go below the floor.

The complaint against the small cuts in the roofs of observatories is well known, and their influence, in a warm climate particularly, in producing a local refraction near the observer, would be too great. This was the reason for placing the transit in the direction of the windows, which will be opened entirely for observation.

The part above the window, up to the roof, presenting itself outside like a continuation of the wall, fig. 3, *e*, *e*, must also open completely, like an inside shutter.

The roof over the transit between the two windows must slide out to both sides upon the other roof for the whole breadth of the windows. It is composed of five double shutters of strong sheet tin, moving on round iron bars *g*, *g* lying on the roof, and reaching far enough in the cut to give a solid support to the shutters; and if small, they might go entirely across without taking so much light from the telescope as to produce any impediment.

The easy motion of these shutters, and their close shutting, against drifting snow particularly, is an object to be attended to carefully, which cannot be described here.

The second instrument, for which a separate stand was to be prepared in the observatory, was the zenith sector. This was intended to be placed upon the conic pillar *d*, and to have a large and suitable aperture in the roof, like that for the transit. But as the zenith sector is not yet obtained, all arrangements could be merely preparatory; and they could only be well adapted when the instrument should be at hand.

When at any future time a mural circle should be added to the observatory, this was intended to take the place of the sector, and the roof between the corresponding windows to be opened as for the transit. The sector would then be removed to the corresponding situation on the other side of the transit, where now the observer's and guard rooms were placed, the partition being taken away, and an addition of one or two windows breadth being made to the east of the building to provide these necessary rooms.

The entry would still remain the same, and it must be observed, that all direct communication between the actual observatory and any other room which may be heated in winter, must be avoided.

These rooms must be placed in the east side of the building, and the fire place as much as possible towards the south-east, because the north-east wind is in this country the rainy wind, and therefore the smoke of the chimney, which would obstruct the observations, can only be brought by the wind over the observatory, when the weather would otherwise not allow the observation to be made; and with all other winds which accompany fair weather, it will be driven from the observatory so as never to be incommoding.

The floor of the observatory is supported upon separate pillars of masonry *h. h.* built in the cellar, and touches neither the wall nor any of the pillars; the joints being covered with cloth nailed to the floor to prevent the draft of the air from the cellar. The under part of the floor is plaistered like a ceiling, in order to prevent more effectually the dampness, and make it a more compact body or mass.

The cellar must be about five feet deep, as well to prevent dampness under the floor and about the pillars, as to admit easy access to these, and beneath the floor, in any case of need. For the same reason also, the bull's eye windows are given to it in the southern and northern front. The access to it may be under the step which leads to the upper room, and under the main door and the bridge before it a door may be made to come into the ditch.

The ditch around the building must be at least four feet deep, and about three feet in breadth, to intercept all oscillations of the surface of the earth which may be occasioned by wagons, &c. particularly in cities or near inhabited places, roads, &c. This of course renders necessary a light bridge passing to the door.

The roof is arched, and elevated about twenty feet above the floor, to avoid all close air under any circumstances whatever.

Instruments which would reach into the upper heated air of a room would never make a good observation, particularly in such a variable climate as this.

My plan for the framing of a roof may be seen in the figure. In the arrangement of the rafters, it was necessary to pay attention to the opening in the roof that might be required for the additional instruments mentioned above.

Promiscuous Remarks upon the Principles of Construction, the Choice and Trial of Instruments.

After having described various instruments, it may not be improper to add some general observations upon the subject, which my experience has enabled me to make.

The navy, and ships employed in commerce, constitute in England the principal support of the mathematical instrument making, and have established this branch of the arts on a large scale, and contributed to its perfection in the last century, after the invention of the reflecting instruments.

The next encouragement arises from gentlemen who take a pleasure, and rationally amuse themselves in astronomical observations. These amateurs occupy the artists on instruments of larger dimensions, of greater accuracy, and more complicated and varied construction.

The use of instruments for scientific establishments come after these two in the line of influence. The instruments constructed for such purposes are, comparatively speaking, limited as to their number, and last too long to be of much consideration to those who construct them.

From this results the following state of things in relation to the instrument making in England.

The instruments suitable for naval purposes and for common surveying and levelling furnish the principal support of the artist. From the profits arising from these, he pays his workmen, and brings up his apprentices. The extent of these two branches is proved by the numbers which are put upon the instruments in regular succession.

Amateurs requiring from the artist a greater variety, and instruments of a larger size, he is enabled to extend his establishment, and to employ his workmen at a greater variety of work. This prevents their passing into the class of common mechanics, to which those are really reduced who are confined to the making of the usual naval or surveying instruments.

The scientific instruments which the best artists alone will or can make, are improved by the establishment of the works for amateurs; and the artist obtains by them his credit and fame. But the profit on them is of little consideration; as the time and care which the artist must bestow upon them himself, to the detriment of his profitable work, renders them very expensive to him. On this account, none but artists who are in easy circumstances can execute them.

On the continent of Europe, the case is somewhat different. The navy does not of course employ as many of these establishments as in England. They are more limited in their extent, divided into a greater number of branches, and directed more to such instruments and philosophical apparatus as are used on land.

The English establishments of this nature having towards the end of the last century surpassed those of the continent of Europe, they have frequently supplied the latter with instruments of various descriptions. But the improvements to which science has given rise on the continent, the delays occasioned by the distance, and the separation occasioned by the events of the last twenty-eight years, have established this branch of the arts again on the European continent, in the hands of various artists, and on a new and well principled foundation.

The frames of instruments made on the continent are generally cast in one single piece, and filed by manual labour. Their diameters are three feet, to avoid the spring of the metal. Mr. Reichenbach in Munich refuses to make any instruments of greater diameter, in consequence of the bend or spring to which they are subject.

The English prefer such constructions as admit of turning. They avoid the manual labour of filing, and therefore compose all the instruments of large diameters of pieces that can be turned. By this means, the instruments are constructed lighter and at less expense than by the former mode. Mr.

Troughton makes use of the spring of the metal itself for the adjustment of his instruments, as has been seen.

The comparison might be made to a greater extent, but such would not be consistent with the object of the present papers. It will be proper, however, in any given case to pay attention to the nature of the establishment, and the particular branches in which each artist is most distinguished, that a preference may be given to such as will be likely to give most satisfaction.

Similar considerations apply to the different kinds of time-pieces. Chronometers are of such importance to the navy, that every attention has been directed to their improvement, since their invention by Mr. Harrison. On the contrary, the improvements in clock making have been comparatively limited, and the artists employed in this branch are not so able as those employed in the construction of chronometers.

Astronomical clocks are not kept for sale as chronometers are. There are but a few constructed, and those agreeably to order only.

As to chronometers, it is hardly to be expected, that among the great numbers kept on hand by different artists, there should not be some of them preferable to others. If therefore several chronometers be required, as was my case, it will be proper to take them from different artists, in order to have a greater chance of success, which no artist can invariably attach to his work.

It must be observed, from the principles upon which chronometers are constructed, that they will go differently at sea from what they do on land. This I have proved by seven chronometers which I kept going on my passage from London to Philadelphia, and which I compared together daily. It is evident that the constant motion of the ship must affect the heavy balance, which is never affected when the chronometer is completely at rest. The quantity of this effect is of course both uncertain, and peculiar to each chronometer, both in respect to quantity and direction.

The delicacy of the scapement may be the cause why English chronometers are very liable to momentaneous gains or losses, which amount to a considerable number of seconds, though in other respects they may be very good, and may again return to their usual rate. It is probable that these may be owing to some very slight motion which occurs just at the moment when the scapement passes the stopping spring, which then may either let the wheelwork, and of course the hands, pass a number of seconds, or stop it for some time, before it recovers its free and regular play, and rate of going. This cannot be prevented in any voyage or journey.

On the continent of Europe, a much smaller number of chronometers is made, for the same reasons as stated in respect to mathematical instruments. Only the most eminent watchmakers engage in them, and they are, generally speaking, as successful as the English. The principles upon which they work are also different: but this is not the place to enter into details on this subject. It is only proper to mention that in case repairs, or even cleaning, should be necessary in a chronometer, it can seldom be expected, that any other chronometer maker will be able to do it so well as he who has made the instrument, on account of his peculiar mode of working. A like remark will apply with greater force to English and French chronometer makers.

I should advise the use of no chronometers but such as go only one day. All that go for a longer period have by no means the same degree of accuracy. It is probable that one of the causes of this arises from the too great influence of the inequalities of the springs, which must of course extend over a longer space of time.

As it is well known that the principal difficulty in the division of mathematical instruments consists now in the proper centring of the division with the axis of motion, it may be proper to mention the manner in which this is effected, and to give an idea of a dividing engine by which this error may be avoided, and which I communicated to Mr. Troughton. He approved of it so fully, that he advised Mr. Thomas Jones, who made several of the instruments here described, to make his dividing engine upon the principles which I indicated.

When the instrument comes from the hands of the first workman, it is technically said to be *tight*, or fitted so as to admit little or no motion of its axis. Then the circle intended to be divided, with its axis screwed to it, is put in a lathe to receive the last adjusting turning, both with respect to the axis and the plane of the circle. For this purpose, it must turn upon two points making part of the protracted axis. As it would not turn sufficiently concentric in any common lathe arrangement with chucks, a temporary pulley is fixed to some convenient part, for the cords of the wheel to run in.

The motion should be slow and steady, to avoid all vacillation and swinging. Therefore the wheel is small, commonly one of those used with the hand lathe, and it is turned regularly by a separate person by hand.

When the axis and the plane of the circle are thus finally turned true, and before any thing is changed in the arrangements, those circles, between which the divisions are to be drawn, are immediately turned upon the plane of the instrument, by the pressure of a fine point held in a position inclined to its motion, at about an angle of ten degrees, so that no actual cutting takes place. These circles are perfectly concentric with the axis, and are described better on a silver arch than one of brass, on account of its more uniform texture and the ease with which it receives such an impression.

The instrument being now taken from the lathe, the socket of the axis, finished in the same manner, is rubbed upon it with emery and oil, by a kind of screwing motion, until an easy and even motion is obtained. This turning following always the conical surfaces by close contact, has no sensible tendency to change the centre.

The present construction of the English dividing engines requires an operation which makes the centre of the division depend on the motion of the axis. It is necessary to take the axis out of the circle, to adapt this latter to the engine, and consequently it is not absolutely certain that the axis be screwed again exactly in its position, &c.

The dividing engines have all a centre pin, to which the instrument is centred. These pins are either fixed, or changeable, for different diameters of axes, suited to the usual and common instruments. To adapt any instrument having a central aperture for an axis different from these, a collar is turned, having its outer diameter to fit this aperture, and its central hole the centre pin of the engine. But it is evident, that the concentricity of these two circles is not always certain, and that in the last turning above mentioned, the centre may have been displaced from the centre of the aperture, which receives the axis, and which was of course not turned with it.

The division being completed, the axis is again screwed in its place, and the adjustment of it is to be made, both with respect to its concentricity and its perpendicularity to the circle. The reading of opposite verniers or microscopes must indicate the corrections which are necessary. To give the axis its proper position, it is necessary to raise three burrs with a punching tool at such places as appear to require it. By repeated trials of this kind, the axis is again centred, and this operation is to be discontinued when a sufficient approximation is obtained. When an instrument has to be removed to a considerable distance, these burrs may wear out by the greater pressure they sustain, and the instrument may become eccentric by it.

All this troublesome operation, and the disadvantages attending it, may easily be avoided, if instead of the pin or axis, the dividing machine had in the centre a circular hole of about five inches diameter, and of sufficient depth to admit the lower parts of the axis of any instrument, so that the instrument could be placed upon the engine, together with the axis, in the same situation as it came from the last turning and rubbing, without any dismounting whatever. To ease the approximate placing of the circle on the engine, a number of concentric circles of proper diameters could be drawn upon the plate.

The axis of the engines being generally very strong, would easily admit the necessary aperture in the centre; and it might for that purpose have an outer diameter of seven inches, without impeding its easy motion in the manner in which the engine is otherwise made and used. All other parts of the engine would be exactly similar to that of Mr. Troughton, as described in the Encyclopedia of Brewster; Art. *Graduation.*

The circle intended for dividing being laid upon the engine, with its axis fast to it, and centred approximately by any one of the circles, a compound micrometer microscope is placed between the two bars, at the place of the cutting tool, having its wires so placed as to form one or more tangents to the circle drawn on the instrument for the limits of the divisions. The instrument will evidently be centred, when the wire of the microscope touches this circle always in the revolution of the engine upon its axis. As long therefore as this does not take place, the position is to be corrected, half by moving the instrument properly upon the engine, and half by bringing the microscope, or its wires, nearer to, or farther from the centre; and the different circles upon the instrument may serve to verify each other.

When the instrument is thus adjusted upon the engine, it may be fastened by various means. If melted wax be cast about the parts by which the instrument is supported, it will be sufficient to keep it steady during the time required for dividing, and will not derange it by any unequal pressure.

In the present improved state of the dividing engine of Mr. Troughton, accidental errors of the divisions are scarcely possible, if due attention be paid to the proper stability of all the moveable parts, and the regularity of treading, so that no tooth of the racking wheel may be passed over, and that the tracer may not admit any vacillation in its adjustments.

The tracer of Mr. Troughton is better than the round point commonly used. It is ground below to an elliptic section, of which the longer diameter is in the direction of the lines, and the shorter perpendicular to the same. The intersection of these two lines forms below a short and sharp edge which cuts with such ease and keenness, that on silver the tool cannot even be left to press with its full weight, and on brass its weight alone is sufficient to make a deep and sharply defined line in one stroke.

The verniers may be easily divided, by placing them on the instrument itself at such a proportional distance within the circumference of the circle as the part shall be into which they are to divide a subdivision of the instrument, and then dividing as usual. This produces evidently, when they are removed to the circumference, the loss of one division upon their full length, in their comparison with the divisions of the circle. On the dividing engine, with a tangent screw, this division can be made by the mere adjustment of its revolutions.

On some of my instruments, the pin holes which served for this operation, and which are usually filled up again, are left open, that a vernier may be restored again from the division of the instrument itself, if need should be.

It may not be improper here to mention some of the details which are to be observed in the choice of instruments, or in the direction of their construction; as their influence on the practical use of the instruments is greater than might be supposed, and as they are not always attended to by every artist.

The quality of the metal of which the framing part of the instrument is made is not indifferent, as the stability of the instrument depends in some measure upon it. If brass is used, this is subject to very great variation, without being observed by a person not well acquainted with the subject. The mixtures of copper and tin, properly cannon metal, though usually called bell metal, are much more easily distinguished in quality, and therefore preferable in many instances. The use of this metal for the axes, when the sockets are brass, or for the sockets, when the axes are steel, must be considered as indispensable. Formerly the artists in England had for this purpose a still better metal,—the *tutenague*, imported from China, but now prohibited. The greater hardness of this metal was particularly favourable for the axes of transits, &c. which, by their frequent revolution upon the same parts, without going completely round, are very apt to become partially worn, and which cannot be made of steel, on account of its rusting. All the nobs and sockets in which the tangent screws move should be of good cannon metal; for these screws, being frequently used, will soon lose their easy motion, if they turn in brass, in consequence of their close contact and equality of texture; and after this, they acquire an inefficient or lost motion, to the great annoyance of the observer. To avoid this in all cases, I think it would be easy to adapt a spiral spring of steel wire around the screw between the two nobs in which the screw works, pressing it always to the same side of the path.

In the general construction of the instrument, attention must be paid to give to the lower parts such strength and weight with respect to the upper, as may not allow of any spring. This is the great difficulty which requires the observer's particular care in the repeating circle with two telescopes, where the main weight of the instrument is supported in equilibrio upon a small axis, so that the vertical observation must in some measure be made without touching the instrument.

The verniers which present inclined planes to the divisions must touch them in order to show accurately the coincidence and avoid parallax. This renders it necessary to give some spring to the arms which bear them, and care must therefore be taken, that they do not rub the divisions, and of course do not drag. Mr. Reichenbach in Munich avoids this by dividing the verniers upon a complete circle, which presents itself inside to the divisions in the same plane. But this requires very nice work, and as the circle is light, some care to prevent its warping, which may be occasioned by a return of some hammered parts of it to their former irregular shape.

These light parts are very liable to spring back, on being exposed to a considerable variation of temperature. By this construction, Mr. Reichenbach has applied verniers in his circle of the Paris Observatory, of which the diameter is one metre, and which is the largest size he finds advisable to give to any instrument.

The English artists, on the contrary, use compound microscopes for the readings, where the diameters are above eighteen inches, and find them to be very convenient. These microscopes, and probably the readings with them, are more accurate; but they require more labour and very accurate work.

I have already observed, that for a division by points, the micrometer must have one single wire in the direction of the radius; and for a division by lines, two wires, intersecting each other and inclined equally to the radius, making angles of about fifteen degrees on each side of the division stroke, the equality of which is very easily judged with great accuracy.

The divided circle, as well as the radii, arms, or plates bearing verniers or microscopes, ought never to be attached to other parts of the instrument, except the central piece, in order to be in all cases equally free, and left to their own spring and shape. In like manner the centre piece is to be connected with the stand part alone.

The clamping and tangent screw arrangement ought always to be strong, and never to be fixed to an arm bearing a vernier or a microscope. It is very apt to affect it differently from the other verniers, as it has to act on all parts as leader, and to overcome the resistance of the central friction. On this account, it is commonly made somewhat stronger than the others. If the verniers are not attached to a full plate, it will be best to give the instrument a separate strong arm, expressly for the purpose, and to make all arms of verniers or microscopes exactly equal.

The quality and power of the telescopes on an instrument must always exceed the degree of accuracy which is obtain-able by the other parts of the instrument, as it serves to verify these, and also gives certainty to the observer by the accuracy of the pointing. I have always found, in terrestrial as well as celestial observations, the largest power which the telescope could bear the most advantageous for use. Great light is not an essential requisite. The distinctness of the image and its size are far preferable, as in terrestrial objects they help in pointing minutely, and in celestial observation they increase the quantity of visible or apparent motion. The same considerations show, that there is no gain in a disproportionate aperture. Accuracy of the image is lost by it, as may be easily tried by diminishing the apertures of large telescopes by covers of different openings.

In the course of my geodesical operations, I was obliged only towards winter to lay aside the greatest magnifier of the two feet theodolite, of seventy-seven times, and take the next, of about fifty times. But soon after, observations at some distance became entirely impracticable, so as to give the desired degree of accuracy.

These circumstances render it proper to choose the diameters of instruments such as to allow with propriety and ease the application of some of the telescopes which are obtained in greater perfection; and in this respect it is proper to mention here some facts relating to this subject.

The telescope which is obtained the most perfect in its kind is that of three feet and a half focal length, and about three inches aperture. For instruments, the aperture of about two inches and a half is preferred. Below that size, the telescope of thirty to thirty-two inches, with the same apertures, is obtained in great perfection. These two regulate therefore the size of the largest moveable instruments. After this, the telescope of twenty-two inches, with about an inch and three-quarters aperture, which is well suited for the eighteen inch circles, is very good for its size. The smaller sizes are made in great numbers and of various qualities, where almost no distinction can be made in respect to size, except what chance introduces. Those, however, about thirteen inches long, for some of the better geodesical instruments, and six inches long for reflecting instruments, are the most carefully attended to. Above the three feet and a half telescope, those of five feet focal length, and three to four inches aperture, are frequently obtained very good; and Mr. Tully, Optician in Islington, has been very successful in them. Those of six feet focal length are difficult to obtain in great perfection. They have the same aperture as the five feet ones; and Mr. Dollond has made some very good telescopes of this size, though of course after many trials, and the rejection of many glasses.

A good telescope of seven feet focal length and greater, with four to five inches aperture, may be considered as the result of a happy chance, and proportionally to what is expected of such telescopes, I heard only of about three or four that had acquired a well deserved fame. Of these the largest and best is the ten feet telescope, with six inches aperture, made by old Mr. Dollond for the Greenwich Observatory, to prove the possibility of making an achromatic telescope equally as good as the ten feet reflecting telescope of Dr. Herschel. In this he actually succeeded, but only in one glass out of a number made with that view. This telescope has lately been adapted by Mr. Troughton to a transit instrument for the Observatory.

The sizes intermediate between five feet and twenty-two inches are considered as generally speaking not good. For instance, the four feet focal length is not suitable for scientific purposes. They are therefore generally mounted for pocket telescopes or spy-glasses.

In the larger telescopes, the optician is not quite certain of the focal length in the formation of his object glasses. This may vary within two inches, though the glasses come out of the same forms: but such a difference is of no importance.

A high polish to the object glasses is not desirable in instruments. The glaring light which it occasions is not agreeable in observing. A well defined image in a milkish white light will be found more agreeable. Though the artists say that they can polish an object glass as much as they choose, without detriment to the shape of the glass, and therefore accuracy of the image, I should prefer, from experience, the greater certainty of accuracy with less polish.

The object glasses frequently contain crystallisations, which injure the brightness and accuracy of the image. These crystallisations become very apparent in the following mode of trial, which I found to be the best for judging of the accuracy of the image :—When the telescope is adjusted and directed upon a fixed star, the eye part is drawn out, which will cause the microscope which the eye glasses form, to view in its focus successively other sections of the cone of light of the object glass, and in proportion as the light will be equally diffused upon the circle so seen, and as it will bear to be more drawn out, without becoming diffused, the telescope will be more perfect and more accurately adjusted. Few telescopes will stand a very scrupulous trial of this kind. Most generally the light will be much stronger towards the circumference of the circle than in the interior, and in this will almost always be found some dark spots of angular shape, presenting themselves exactly like crystals under a microscope, which show the effect of the crystals in the glass, throwing the light from its regular course. Any stray light, as the opticians call the rays which appear as if darting out of the circle, is very apparent in this trial. The best telescopes therefore are those which, directed upon a small and not twinkling star and put a little out of focus, will present a sharply defined image with a disk like a planet. The larger this image can be made, the better the telescope.

The opticians meet with great difficulty in finding good glasses: and in making large object glasses, much more glass is wasted than is used. Various other circumstances also increase the price of the larger glasses ; so that a good object glass of a long focus and large aperture has completely a fancy price :—But it would be too tedious for me to enter here into details on this subject.

It may be proper for me to mention a source of error which may affect the accuracy of the spirit levels. These may generally be supposed to be adjusted at a mean temperature, of course a mean length of the bubble. At the higher and lower temperatures in which it is often necessary to observe, the longer or shorter bubble may measure differently in the course of the level, if this is not very regular; besides that its oscillation will at all times become sluggish and more irregular.

The manner of packing the instruments is of considerable importance for the preservation of their accuracy. The boxes ought always to be of light and straight grained wood. No piece must ever be fixed in a direction diagonal to the grain, as it will be pressed out of shape by the drying of the wood. Any piece fastened separately must always be placed in the direction of the length of the fibres. In travelling, the instrument should always be placed as much as possible in the same position in which it is used, those parts only which are not fixed to it being taken off and packed separately. The centre being the part which bears the greatest weight, must be the most firmly supported. Any stay used to steady the instrument in the box must be placed against one of its solid parts. No circle nor telescope should ever be suffered to touch the box, nor have any bearing to support or steady the instrument. They must be suspended freely in the box, by the parts destined to hold them. It is even advisable, in all cases in which the weight of the instrument allows this precaution, to make the boxes as light as possible, that in case of accident, they may break, before an effectual reaction upon the instrument can take place.

The larger instruments of the collection for the survey of the coast all travel in their boxes in the position used in observation, and are supported according to the above principles; and Mr. Troughton agreed with me in preferring this mode of packing to the usual one, which requires the instruments to be dismounted.

On the Mechanical Organisation of a Large Survey, and the Particular Application to the Survey of the Coast.

Though the mathematical theory of such works is fully treated and well known, their practical application is left completely to the practical man; and the success and accuracy depend in a great measure on the organisation, and the different details of arrangement, which such a work requires. It may therefore be useful to give here some practical principles on this subject, in order to guide the operator in taking proper advantage of the time and circumstances, and to overcome the difficulties which are always to be met with in practical works.

The application of these to the survey of the coast may serve as an example, which at the same time will give such information with respect to that part of the work which I have executed, as may enable the operator to take advantage of it, or to continue it in future.

The leading features of the general organisation are exposed in the plans of operation which I presented to government; and now inserted in these papers; and of which the present will show the more detailed application.

The first operation is of course to find a proper place for a line of sufficient length to form the base of the triangulation, in such a situation as will enable the surveyor to arrive by simple operations and with accuracy to the determination of a distance between two elevated points, in a favourable position relative to the surrounding mountains and the country at large. If these points be at the same time the highest and freest in the neighbourhood, the multiplication of the chances of forming the subsequent triangles will not only accelerate the work by the greater number of points which may be determined from them, but also enable the operator to choose the most advantageous combination of triangles; and if the survey shall extend over a whole country, it is proper to begin in such part of it as will soon lead to the largest triangles possible.

This was the principle which induced me to begin in the neighbourhood of New York, after I had received a letter from Mr. Dallas, Secretary of the Treasury, authorising me to begin wherever I should think it most advantageous.

The configuration of the country, particularly the direction of some principal chains of mountains, may guide us in the research for a base line, because it is generally parallel with straight ranges of mountains, that the more level and extensive plains are found, and the first triangle point will fall upon some elevation in an opposite range of mountains, if these be not very elevated.

It is therefore necessary to make first a preliminary reconnoitring survey of such a tract of the country at least as may be likely to furnish the base, and a complete system of triangles, admitting of verification. The more minutely this can be done, the more advantageous on every account will it prove for the actual survey.

In an uniform simple triangulation, it is most proper to place the two base lines, which are necessary at least in all such works, near the two extremities of the triangulation, and therefore to make also at the beginning the necessary reconnoitring for that purpose. But in my case in this work, it was desirable to obtain in an early stage of the work a verification of the linear unit upon which the triangle was founded, to allow me to make use of it for the detail surveys as soon as possible. Besides, in all cases where the triangulation is to serve for geographical purposes, it may most generally be expected that several base lines will be measured in the course of the work.

This first reconnoitring requiring the most extensive and free view of the country, must be made early in the spring or late in the fall; for the naked woods will admit many views hidden in the summer by the branches and leaves, which may be afterwards cleared away for the work of the actual triangulation. Such was for instance my case with the base line itself and several important triangle points.

This geometrical view of a country is by no means without difficulties, and requires great attention and a kind of geometric eye, as the accuracy of the work depends much on the favourable system of triangles which is projected on these data.

The most favourable season for the actual triangulation is during spring and summer, when the length of the mornings and evenings will afford the longest time of favourable illumination for observing, which at the noon elevation of the sun is inadmissible. In this climate this time is often interrupted by the frequent rains in August.

In the fall, the atmosphere of low countries, particularly the sea shore, becomes very untransparent, and the time of the day favourable for accurate observations so limited, that it can hardly ever be expected to take a full series of angles consecutively. For instance, from my station at the east end of the verification base near Gravesend, in December, 1817, the large lighthouse off Sandy Hook, only about nine miles distant, was never visible a whole hour in the morning or evening; and as soon as the ground was warm in the morning the signal at the west end of the verification base, near five miles off, moved about irregularly in a circle of about one minute.

The winter will be fully employed in the final calculations, projecting the triangles upon paper, and other labours relative to the last summer's operations and preparatory to those for the next summer. This will occupy more persons than the actual observations have occupied in summer; as it is proper that all actual calculations be made at least double, and by different persons. The verification, comparison, and combination of the results will take up much time.

In choosing a station and in reconnoitring, due attention must be paid to select the most advantageous point of the mountain or place for the view of all the signals required, and the most conspicuous and easily discovered from other places. We must clear, in case of need, the neighbourhood so as to make the signal distinctly visible. Besides this, the ground upon which the instrument is to stand must be very solid. Unless upon rocks, or very dry hills, the solidity will hardly ever be found such as not to affect the level of the instrument by walking near it, or by the different position in which the observer stands with respect to it.

In a simple triangulation, where only few angles are observed upon the same point, it may be allowed without much inconvenience to place the instrument at any point near the actual signal which may be favourable for the observations, and to reduce the angles to the signal or station point by the angle of position and distance required. Thus we may use steeples, parts of buildings, or such fixed points, (but never trees) as station points. This however must be avoided, when a great number of angles rest upon a point, and it is to serve for detail surveys; because the consequent calculation of the reductions is actually more tedious than the calculations themselves, and because it would be very inconvenient to keep account of two such near points on the papers intended for the detail surveys.

It must however be observed, that in general steeples and buildings are always to be avoided if possible, on account of their not giving accurate signals. They should therefore only be used for the determination of their own position, and not to form points in a series of triangles.

In any case of such a reduction occurring, I used to calculate separately all the angles subtended by the eccentric distance, at each of the signals upon which angles were observed, and to combine them according to the case of each of the angles which I had to correct, as the following equation takes place in all cases :—

In Plate V. fig. 12. let

S=Station point observed.

C=Centre of the station or signal.

A & B=The two signals observed from S

Then is evidently,

$$C+A+B=180^{\circ}=S+(A\pm SAC)+(B\pm SBC)$$

where the signs are easily known from angles BSC and ASC compared with ASB.

I found this method the simplest, shortest, and least liable to mistakes.

When the ground at the station point is not perfectly solid, it is necessary to place in the ground strong plugs or short posts, sawed off horizontally, and nearly level with each other.

The sand hills on the low sea shores, and the looming which takes place upon them, would have rendered necessary for these places the construction of a stand of about twenty-four feet elevation, solid and firmly attached to the ground, upon which the instrument with its stand might be placed. I intended to have had one constructed in the form of a triangular pyramid; but it is evident that the use of such means is to be limited as much as possible, on account of the many inconveniences attending them.

The instruments must be well sheltered from all weather, and the sun must not shine even upon the stand or the ground near its legs. It is therefore necessary to have a separate and suitable tent constructed for each instrument, with curtains all around, but separate, so as open the side necessary for observing, without depriving the instrument of its shelter.

The instruments are to be taken out of their boxes, placed, levelled, and adjusted in all respects, as soon as possible after arriving at the station: in order that they may recover from any unequal pressure to which they may have been subject in the boxes and in travelling, so that the parts may come to rest in their proper position some time before the instrument is used.

The chief observer, as well as all the assistants and the labouring men, must be encamped at the station, the latter not so close, as to occasion any impediment or interruption to the observations by the noise of any other necessary occupation. The living in neighbouring houses is completely incompatible with the advancement of the work.

The safest, and at the same time most expeditious and least expensive, mode of transporting the instruments is in a spring carriage constructed purposely, the body of which will closely fit the whole of the boxes of the instruments, so that they stand in it packed, without being permitted to shake.

On the first station of such a work, the task of the observer is of considerable extent, besides the mere observation of the stations. He must begin by supposing his instruments completely out of adjustment, which will certainly be the case with all moveable instruments, particularly if they have undergone any long transportation of any kind. He must adjust them, and observe with them some time, not with the view of the actual use of the observations in the work, but in order to get acquainted with his instruments, to find an easy mode of using them, and to discover all their qualities and defects.

Absolute mathematical accuracy exists only in the mind of man. All practical applications are mere approximations, more or less successful. And when all has been done that science and art can unite in practice, the supposition of some defects in the instruments will always be prudent. It becomes therefore the duty of an observer to combine and invent, upon theoretical principles, methods of systematical observations, by which the influence of any error of his instruments may be neutralised, either by direct means, or more generally and much more easily by compensation. He must not leave his first station, before he is so far clear upon this subject, as to need nothing more than the proof, always anxiously looked for, of the sum of the three angles of his first triangles. It is not here the place to present a theory on this subject, nor to enter into practical details. I will merely refer to my operations with the two feet theodolite as an example.

The methods thus decided upon will determine the number, as well as the form and combination, of the observations which are required to give the greatest probability in the results, and these methods must be the constant rule for all the observations.

If observations, which are limited by their nature to a certain time, are made with repeating instruments, the number of observations must be determined by a proper combination of the theoretical formula or principle used in the case, the number of observations required to compensate the possible errors of the instrument, and the accuracy aimed at in the observation. This is the case, for instance, in circummeridian observations, &c.

The quantity of work which is made in one summer's campaign, the multiplicity and variety of cases occurring, obliterating naturally the accurate remembrance of the peculiar circumstances of an observation, which however determine the degree of relative confidence which it deserves, it is necessary to be very accurate and minute in the notation of every thing in the day books and journals kept of all observations and other operations. A certain systematic and constant form must be observed in them; they must be written with such regularity and perspicuity, that any man, with the proper theoretical knowledge, could execute the calculations, though he might have been unconnected with the work itself.

It is best to keep them in folio form, to bring as much as possible under view at once, in order to facilitate the taking out of the results for use in calculation, to admit room for all accessory notices, and bring every thing readily under the eye.

If assistance enough could be had, it would be proper always to make two fair copies from the first journal, kept under the direction of the observer. These first journals should rather be written in ink than in pencil, for greater distinctness and better preservation, as it is proper to preserve them at least till after all calculations are made, in order to be able to verify the fair copies by them, in case of any doubt.

The method which I adopted in this respect is evident by the exemplar given of it in these papers. I distinguished the day book and journal evidently only to facilitate the order of the work by separate denominations. Every page is divided into six columns, which suit very well for all kinds of observations and results, and the headings of which go uniformly through the whole book. Not having my journals of the actual work of the coast survey at my disposition, the exemplars are taken from the similar operations made for the determination of the boundary line between this country and Canada.

The day book is kept by minute order of time. The reverse page of each leaf is destined for all the details of the observations, and the direct page facing it for the immediate results of them in all their details. The further particulars may be seen in the exemplars themselves.

The journals of results are two fold. One series of them is destined for the vertical angles, with the heading, "Of the repeating circle," though it contained vertical angles in general. The other series contained the results of all horizontal angles, and was superscribed, "Of the great theodolite," this being the instrument used. In these journals, the order of the subject is the leading principle, and they subdivide naturally, as seen in the exemplars at A and B. The date in the first columns refers each result to its observation in the day book. The next columns contain the resulting lines and angles, &c. forming the element of the calculation, of which all the particulars are introduced in separate columns, for the case of the verifications. The final result with the minute details may be seen in the exemplars. I have not the opportunity of giving an exemplar for the elevation of the terrestrial objects, signals. &c. over the sea.

which was of course apart from the operation. But it may easily be imagined how such a journal should be kept.

The ultimate results of the work are to be collected with great order into a separate book. The mode of doing this I cannot exemplify further than will appear from No. 3 of the Journal Exemplars. The titles of the other columns depend in some measure on the formula of calculation used, the methods of projecting, and the like, besides the general results, which will always remain. Examples of it may be seen in the different accounts of measurements of degrees, &c.

For the assistants in the calculation, it was my intention, if the work had proceeded to a greater extent, to have had formulæ of blank calculations printed purposely, which is a great means of security against omissions in the calculations.

To proceed in such a work with the greatest advantage and celerity, it is proper that various assistants and an adequate number of labouring men be with the chief operator. The necessary discipline and regularity which the nature of the work requires, would, when possible, give for both the preference to military men. Good old soldiers will always be the best for the labours. The whole work must go on with the greatest regularity, to give proper confidence in the precision of it, and the desired accuracy in the results.

The better the assistants are informed in mathematics, and the more they take a proper care and active interest in the work, the more advantageous will it be. They must be furnished with written instructions upon their respective duties, and it will be proper that they change duty in regular rotation, either weekly or by station. The separate journals which they will have to keep are to be signed by them at the end of every day, to facilitate a reference to their recollection, in case of mistake.

I found the following distribution of their work advantageous:—

One to act as secretary to the observer. He is to write the names, readings on the instruments, &c. under his dictation.

and always to repeat them aloud when he has written them, to prevent mistakes; and if he is attentive, and acquainted by practice with the proper succession of the readings, he can, in case of mistaken or improbable readings, by warning the observer, cause the correction of any mistake, by a repetition of the reading before the instrument is moved. In observations requiring the notation of the time, he will count with the chronometer, and mark the moment when the word is given to him by the observer.

A second will act as an assistant observer in such observations as require it, observe regularly, at stated hours, and at the time of every observation requiring it, the barometer and thermometer, of which he will keep a regular journal, make the observations of the magnetic needle, in cases where it is of interest, as in the survey of a sea coast.

A third assistant will find sufficient employment in preliminary calculations, the making of a second copy of the day book, occasional attention to the signals, directing the men in clearing views, and various similar occupations.

One of the assistants should be a draughtsman for views, who should draw on each station the view of the whole horizon, marking the positions of all the signals, so as to indicate their place if they should be needed at any future time. The foreground of his drawing will also aid in finding the station point itself. He will also make detailed drawings of the signals, as they present themselves in the magnified scale through the largest telescope, with all the other objects accompanying it in the field of the telescope. This will direct the observer in distinguishing the signals in the smaller telescopes of the instruments from other objects which it might be easy to mistake for them.

These drawings, which will form a pretty large collection, may assist in the proper shading of the elevations in the drawing of the maps; and they may serve, if circumstances should make it desirable, to made a model in relief of a part of the country, for which many of the mathematical data are given in the survey, as the elevation of all the signals over the sea will be determined by the vertical angles observed at the stations.

These additions to the mere horizontal survey will add more interest and usefulness to the work than might be expected, not only in a scientific point of view, but also for public utility. Joined to an accurate and minute detail survey, executed upon the principles which will be exposed hereafter, all the data should be collected, to enable the government to judge with propriety of the plan of any public undertaking or service, such as roads, canals, means of defence of the country, &c. That the survey of the coast was to contain all these data, besides the mere outlines of the coast, and that they were as necessary as the soundings outside of the line of the coast, appeared to me too evident to admit of any doubt, and I would have considered the full aim of the work missed without them.

Another addition, particularly useful to navigation, was to obtain a complete series of observations of the variation of the magnetic needle over the whole extent of the coast.

I intended that the magnetic bearings should be observed at all the stations every day by an assistant, the needle being stationary in one point for that purpose; but during the short time that I worked, the multiplicity of my other occupations and other circumstances hindered me from doing more than just to observe it once myself at the close of each station.

An oscillation needle, which I have, and which has been observed in Paris, in London, and in Washington, was intended to be observed also regularly at each station. The union of these two kinds of observation would have given an interesting result relative to this subject.

It will not be necessary to enter into the reasons which dictated the establishment of one or more observatories connected with the chain of triangles, thereby to bind the work to one or more permanent points astronomically determined. The advantage of such an arrangement is perfectly evident.

The following is the most proper order of the operations on a favourable day, at any station. Every day's work must be brought to approach as near to it as possible. It will show that no idleness is admitted, as the omission or loss of the points here mentioned would occasion an encroachment upon the next day, or perhaps its recovering be long impeded by circumstances. I suppose the observer to be furnished with at least one instrument for vertical angles, and one for horizontal angles, time pieces, a barometer, thermometer, sextant, and artificial horizon.

The observer must be at his instruments one hour before sunrise, to test their solid standing, clean them with a feather from sandy dust, which is so often introduced by the wind into the open axes, and upon the limbs, &c. If they need any oil in the open axes, merely passing over the finger is sufficient. He must level the instruments and verify all adjustments; adjust the collimation line and the focus of the telescopes and the reading microscopes, to clear vision, and complete freedom from parallaxes, and verify the value of their reading. For all this, the quiet state of the atmosphere, and the coolness of the morning, with the full light which precedes the rising of the sun, furnish the most favourable circumstances. His instrument must necessarily be in good order, and need very little of all these adjustments, &c. if he shall be ready about sunrise, as he should; and this will be the case, if he has devoted the proper attentions at the beginning of the station.

Then he will level his instrument finally, and the rising of the sun will the proper moment to observe the angles upon the signals, within about 40° on each side of the southern meridian, until such time as the sun is about its double diameter above the horizon in case of a southern declination, or on the six o'clock meridian when in a northern declination; at which time it is proper to take one or two azimuths of the sun, in the manner indicated at the proper place.

These azimuths must be followed immediately by observations of zenith distances or altitudes of the sun, for the determination of the time, which it is necessary to have as free from the rate of the chronometer as possible, and which should therefore be made during the azimuth observation itself, if assistants for that purpose are at hand.

After these observations, the instrument having been verified again, the observations of terrestrial angles will be continued, upon the signals from the fore mentioned situation to about due north until near ten o'clock, if the illumination of the day is favourable. About ten o'clock, corresponding altitudes may be taken with the sun, for which the easiest, and probably most accurate method will be, to take with a reflecting instrument the contact of both limbs of the sun, noting the time, and laying the instrument undisturbed and carefully aside, to observe the same again after noon. This will avoid every influence of any error of the instrument.

During the middle of the day, the state of the atmosphere and the illumination are so unfavourable to the observation of terrestrial angles, that none must be observed, the objects being all seen in the shade, and the reflection from the signals and any object in general passing high over the observer. In a hot summer day, the illumination will even cease to be favourable after 9 o'clock. But when the sun has a low southern declination, it may sometimes be possible to observe somewhat longer upon signals nearly north.

This is therefore the time to transcribe the observations into the day book, to take out the results of the terrestrial angles, to examine them, make such preliminary calculations as may be required to determine the time and rate of the chronometer, and arrange the work of the afternoon, &c.

About thirty minutes before noon, it will be necessary to adjust the vertical circle, and prepare for the circummeridian observations of the sun. For though it is not absolutely necessary in a triangulation, to determine the latitude of every station by actual observation, still it is not proper to let the sun pass the meridian without observing it, as every observation is an addition to the mass of this kind of observations, which it is necessary to have as large as possible, and they are all reduced to one point by the geodesical calculations, within such limits as will not admit too great an influence of the figure of the earth upon the reduction.

After this observation, time may be allowed for dining, attention being paid however not to miss the corresponding altitudes of the afternoon, the time of which must be calculated approximately before hand

Between three and four o'clock the favourable time for the observation of terrestrial angles may begin again, sometimes a little later, seldom earlier. There will be little time to lose, after the corresponding altitudes and the calculation of their result, before it will be necessary to commence the levelling of the theodolite, and the revision of all its adjustments.

The illumination will now become favourable for the signals in succession from due north past the east to about south or somewhat farther, according to the declination of the sun, as this forms the element of the angle of reflection from the signals to the observer. By this it is also evident that the time for accurate observations upon terrestrial objects becomes always more limited on both sides of noon, as the declination of the sun becomes lower, and an attention to this subject will have a great influence on the accuracy of the results.

The order of the observations in terrestrial angles, azimuths, &c. in the afternoon will be exactly the reverse of that of the morning, except that though it was possible to observe with and read on the instrument in the morning before sunrise, this will not be possible after the sun is set.

The task of the day is still not over. For it is necessary to introduce all the observations of the day book, to take out all the results and introduce them into their proper place in the journal of results, or at least into a register of the results of the station, to examine and compare them, in order to see what degree of accuracy has been obtained hitherto, and what is yet needed to complete the work of the station, and to plan accordingly for future observations. It is necessary to do all this before any derangement of the instrument has taken place, that any discrepancy in the results may be tested and corrected immediately.

This will most likely not allow an early rest to the observer. Therefore it will hardly ever be possible to do what would now be advantageous, viz. to observe circummeridian zenith distances of stars in the night, particularly to the north, to compensate the influence of the instrument upon the observations taken to the south with the sun, and correct the result by their means. The observer will be obliged to reserve his strength for the work of the next day, as his observations would lose much of their accuracy, if he should be overfatigued. Such night observations are therefore only possible, when he has assistants able to take a part of the task of the day from him.

Night observations require besides a temporary observatory, built for the purpose, and appropriated to the instrument used, like one which I had constructed for the work of the boundary line with Canada.

It is proper therefore that a peculiar and suitable station be selected, to make a regular and well combined series of observations on the latitudes, with all the necessary means and arrangements for accuracy. As it will then be possible to obtain many more observations of stars than of the sun, their number and kind may be so combined, as to serve as a full compensation for all the observations of the sun made at the other stations, and which are to be reduced to this by calculation.

It will naturally occur, that at such a station a complete series of azimuths may also be observed by a variety of methods, and with every means of accuracy; and that after such a station has been made, it will not be necessary to observe them on the neighbouring stations.

The indispensable observations of longitude are of course to be referred to the permanent observatory of the country, if such a one exists; if not, they also become necessary at such stations more particularly as are made for the series of the observations of latitude ; without however excluding the observations of occultations or eclipses, which may occur on any station, and which it would never be proper to omit.

Those observations only deserve complete reliance, in any kind and case whatever, which are made under proper arrangements, and with ease to the observer. A strong glare of light which dazzles the eye, and an inconvenient position of the body must always prevent the accurate pointing of the instrument and reading of the arcs. The ease and convenience of the observer are therefore not luxuries, but are necessary to the accuracy of the observations.

Though a detailed account of the work of the survey of the coast executed during the year 1817, in which I worked at it, would not be of any general interest, and could not in fact be given, as my papers have been delivered to the government, yet I will present here, by way of record, a sketch of the principal triangles executed either fully or partially. and add a few notices, which may give an idea of the arrangement and plan of the work, and of the accuracy obtained.

It is evident, that of the accuracy which I aimed at nothing could be abated, if the work were to be such as ought to be expected in the present improved state of science. The chance of an accumulation of errors upon such a long extent of sea-coast as that of the United States, particularly in the direction in which it lies, would have been too great, the consequences of a want of system and care would have become too glaring, not to bring discredit and shame upon a less accurate operation.

The different parts of the work would have given occasion to make a number of determinations of the length of degrees of longitude and latitude. From its extent and position, it would have had particular interest, and might have served as the foundation of a system of weights and measures for this country.

The principal base line was of somewhat more than nine thousand metres, and between *Ch* and *Vr*, Plate IX. The first triangles lie upon the points W and *Cr*. In the first, all three angles were measured, and W formed of course the main point. In the second, the angle at *Ch* could not be measured, on account of a near wood which hid the whole mountain upon which *Cr* was; while a high signal in *Ch* was distinctly observable from *Cr*. From the next point, BN, all the foregoing were observable, and vice versa. This gave occasion to bring, upon the line F and BN, the results of both into comparison, where from three triangles, of which all three angles were measured, and three in which two had only two angles measured, the two results were,—through W=15508,88 metres, and through *Cr*=15508,86 metres.

In the triangles, the sum of three angles, which I am unable to state from recollection, was satisfactory. I had not yet all the angles measured in the complete systematical order which I explained in treating of the two feet theodolite; because the great delays of all kinds which I experienced on the first station, on which I combined the method first, had occasioned me to leave it and be satisfied for the time with the number of angles I had in general.

The triangulation being now continued through *Sp*, TN, LS, WE, and EE, of which the stations TN and LS could not be observed for want of time, the verification base between WE and EE was measured, and compared with the result brought from the first base by nine triangles, and the coincidence proved as follows, from all the points named:—

The distance from WE to EE was=	7752,81 met.
Without using the triangle EE, LS, WE=	83
EE, TN, WE=	96
By actual measurement,=	7753,

This last number in the measurement was made a round number, on account of a chain measurement made preliminarily only, though twice, and within less than half a metre in the results, being all the accuracy that can be expected by this method.

The base between *Ch* and *Vr* had also been measured twice with the chain carefully, and if I recollect right, there was hardly three-tenths of a metre difference in the results. As this base was intended for a standing one for the work in general, the neighbourhood of it was surveyed in detail previously, in order to lay it out in the most advantageous position for the future accurate measurement, with the apparatus described in its place.

The base between WE and EE being intended, as has been stated above, only for an early verification of the linear unit of the work, in order to be enabled to begin the detail surveys as soon as possible, would most likely not have been remeasured, but another one, at a greater distance from the first, substituted for it, in the continuation of the triangulation.

The chain with which they were measured was made purposely, of links of a metre in length, which, as they do not bend into all the small inequalities of the ground, are far preferable to small links.

The coincidence of the two bases was, under these circumstances, of course above expectation, and as it gave such a proof of the accuracy of what had been done, has brought it far within the limits of what it would in any suitable scale be possible to show upon paper, it was of course considered sufficient to serve to ground the detail surveys of the neighbourhood on the triangles executed from these, which are seen in the sketch.

The point H was intended for the continuance of the survey to the east connected with W: the points S*p* and B were intended for the same purpose towards the south.

The distance HF having been determined both through W and through C*r*, had given a coincidence sufficiently satisfactory for the few angles which it had been possible to measure upon H from C*r* and W, which would of course have been repeated in the further operations, and corrected by the observations on H itself.

Through W the result was=42392,03 metres.

Through *Cr* the result was=42391,64

The other coincidences being equal to these, in general it appeared to me evident, that in applying the method described when treating of the two feet theodolite, in the angles of the main triangles, I could reach the accuracy of less than one second in the sum of the three angles, with full certainty always, and that only one pair of direct and reversed observations was fully sufficient to determine any near detail point; that it was therefore most advantageous to observe them in this manner from any station where they would be visible, as this gave a verification from different bases.

The azimuths observed gave results equally satisfactory, so far as they were calculated, but as their calculation was not completed, when the work was interrupted, what had been done was again cast away, as it did not present a final result, and might, by being considered as such, rather mislead than serve for any useful purpose. This was so much the more proper, as they were all to be considered as merely preliminary.

I had built in Newark, in my garden, a small observatory which could be determined from BN, and in which I intended to make a regular series of latitude, longitude, and azimuth observations, as stated above.

It will easily be observed, in the sketch of the triangles, which are the stations on which I observed any angle, the lines of the triangles being there drawn full, while to the points on which I had not observed, they are merely dotted.

The angles of elevation of the principal points were taken on all stations, so that their relative height can be calculated. To reduce it to the level of the sea, I levelled actually from the point N down to the water, this point being close to the shore, in the narrows, upon the high eastern bank.

The results of all that relates to this have not been calculated, as this could only take place after the calculation of the distances. The geodesical parts were of more importance to obtain first, as they lay nearer to immediate use.

Latitudes were observed on various stations, for temporary use in the determination of time, &c. The longitude was taken from the general acceptation of the longitude of New York; but all this to determine accurately, was of course referred to regular observations in the temporary observatory built for the purpose.

The organisation of the detail surveys always depends upon the administrative views according to which the work is to be executed. Its details must therefore be omitted in the present papers. Regular and full instructions must be given to the detail surveyors in writing, both on the principles which they shall make use of in their works, and on the objects to be attended to. The nature of the first is indicated to them by the instruments which they are to employ, and by the papers containing the triangulations which are given them to fill up, with the detail notices which shall accompany them. The mere elementary mathematical part is sufficiently treated of in a number of works. The latter must be reduced into regular tables forming the questions, which they shall answer by filling them up; and in an extensive work they should be in printed formulæ. Their nature, in the survey of the coast, is evident, from what has been said before upon this subject. I intended to plan such instructions, after my summer's work was finished.

The plane table is the most appropriated practical means that can be used for actual surveying in this case. It is also the most accurate and expeditious. Every other means will be found to require more labour, and to multiply the chances of disadvantage and error.

This part of the work is much more expensive and tedious than the triangulation. The surveys must be laid down on a large scale, $\frac{1}{20000}$ at least. The ports and harbours ought to be at $\frac{1}{10000}$. And all may be brought to an assemblage with convenience and propriety in the scale of $\frac{1}{50000}$ at least.

If the governments of those States through which the survey of the coast was to go, could be induced to take an interest in this part of the work, I considered the utility of the work would be much extended, both for the general government and those States, the proportional expenditure much diminished by their distribution, and the final execution more accelerated than could be possible by any other means. In the execution of the triangulation, it was easy to suit some peculiar want or interest of any State. This would have added double value to the work for this State, without increasing the expenditures and the work by any amount worth consideration.

Some remarks upon the best methods of transferring the result of the triangulation to paper may be inserted here; as frequently much of the accuracy of the work is lost by insufficient methods, and these are left to the knowledge and practical skill and experience of the operator, though the analytical formulæ of calculation and the principles of projection have been treated repeatedly and extensively.

In former works I have always found the calculation of the points in degrees, minutes, seconds, and decimals more convenient for this use than those in linear measures; and as the approximation can be carried, by the decimals of seconds, farther than it is possible to subdivide actually upon paper, there is no accuracy lost, particularly as all the decimals are always preserved in summing up any number of results that concur in the determination of a point, just as the logarithms obtained in the calculation are always used in any place where the results are required, and not again a logarithm of the number found anew; any loss in the fractions in transferring to paper having thereby no farther influence than upon the point itself.

I made a table of the values of the minutes, seconds, and decimals of latitude and longitude for all those parts of the projection which had been calculated, for the subdivisions of the different trapezii, which were traced by the projection, and which I commonly made only of five minutes at most, both in latitude and longitude, in order to bring the distances to be laid off from them within the limits of usual dividers; and in this manner every point was laid off by rectangular ordinates, from the nearest sides of the trapezium of the projection.

The accuracy of the projection is therefore the basis upon which the accuracy of the whole work depends, and to this great attention is to be paid. It will, on every sheet, begin by a right angle in the middle, extending over the whole paper both in latitude and longitude; and to obtain this with accuracy, as well as in all other parts of the construction, it is necessary to assist the eye with a magnifying glass, to augment the sharp vision of the small points, which it is only allowed to make, if the sinking of the beam compass shall not introduce errors in the work.

It is not allowed to use any compasses but those with rectangular points. For the smaller parts, the proportional beam compasses, No. 46 of the Catalogue of Instruments, were intended. They are very convenient in the hand, and easy to support against making too deep points. To prevent the beam compasses from making deep impressions, and to ease their guidance, I used to suspend them over the table by a roller with a counterpoise.

It is evident that in no case whatever a method of laying off a point, by means of an angle any how constructed, can be applied in these works. The only place where these are admissible is in the plane table operations, and in laying off points of soundings with the station pointer, observed by the problem of three points.

The projection which I intended to use was the development of a part of the earth's surface upon a cone, either a tangent to a certain latitude, or cutting two given parallels and two meridians, equidistant from the middle meridian, and extended on both sides of the meridian, and in latitude, only so far, as to admit no deviation from the real magnitudes, sensible in the detail surveys. I had just commenced some calculations relative to the question,—which radius of the earth was most advantageous to admit the greatest extent to the projection under the above condition, whether the geocentric radius of the latitude, the radius of curvature of the meridian at the tangent point, or the radius of the sphere tangent to the spheroid at the point. Further than this I had not proceeded, when I abandoned the subject, by the interruption of my work.

It is at all events necessary that these projections go off from different points of latitude, and be all of equal extent from the central meridian and parallel, in order that the deviations from the real magnitude may never become so great as to require the application of correction for the plane table operations, which determine of course the details in the neighbourhood of any point of a triangle from the position of these points, as laid down by the projection,—and that in bringing the different parts together, their points on the edges may meet again completely, being equally affected by the projection.

In each of these sheets, it was intended to bring the results of several parallels, so that the central meridian alone should become a straight line, and all the other meridians and parallels broken lines, nearest the curve, to which they belong; the angular points of the trapezium being transferred to paper by their rectangular ordinates, from the middle right angle, calculated from the angle at the centre of the projection, in the protracted axis of the earth.

The papers to be given to the detail surveyors should be divided differently: viz. they must always contain those points, and extend over such parts as may, by the nature and configuration of the country, be best adapted to be surveyed together. But the points must be laid down upon them according to the place which they would occupy in the above regular distribution of the projections.

This distribution of the projection, in an assemblage of sections of surfaces of successive cones, tangents to or cutting a regular succession of parallels, and upon regularly changing central meridians, appeared to me the only one applicable to the coast of the United States. Its direction, nearly diagonal through meridian and parallel, would not admit any other mode founded upon a single meridian and parallel, without great deviations from the actual magnitudes and shape, which would have considerable disadvantages in use.

Their union in one general map on a small scale would be exceedingly easy, and in making a minute projection, could almost be done without the aid of instruments.

EXEMPLARS

OF THE

DAY BOOK AND JOURNAL OF RESULTS.

NOTE.—In the Manuscript, the twelve columns used in each of the following pages are extended over two pages,—six being placed on each; and a reference to this arrangement is made in the body of the Paper. It was found impracticable, however, to print them in this form: but it is believed that the change will not give rise to any embarrassment.

EXEMPLARS FOR THE DAY BOOK.

1818. *Station near Chateaugay River.*

♂ [illegible]th September, PM. Time by Chronometer, No 50. Hardy.

Double altitude of the Sun with the Reflecting Repeating Circle for determination of time. (By N. N.)

Obs. times h. ′ ″	Mean of times h. ′ ″	Readings of the Mirror. A. ° ′ ″	B. ° ′ ″	Readings of the Circle. C. ° ′ ″	D. ′ ″	Results.	° ′ ″		Mean Altitudes. ° ′ ″
3 52 40,0		300 00 00	0 00 00						
3 53 52,0				47 32 25	.. 32 18	By A.	177 59 25	177 59 24 / 10 =	17 47 56,4
3 54 17,5									
3 54 50,0	3 55 12					B.	177 59 23		
3 55 12,0									
3 55 31,0									
3 55 57,5									
3 56 15,0						C.	177 13 07	177 13 26,5 / 10 =	17 43 20,6
3 56 33,0	3 55 40	117 59 25	0 59 23						
3 56 52,0				224 45 32	.. 46 04	D.	177 13 46		
3 57 20,5									

Barometer, 29,93. Thermometer, 66°, Fahr.

Immediately after. Azimuth Angles with the Two Feet Theodolite.

Names of places. Time by Chronometer, as above.		Objects.	Readings of the Microscopes. A.	B.	C.	Results of each Microscope. A. ° ′ ″	B.	C.	Mean.	Denomination of Angles.
Upon the Hill West.		Signal.	22 32 08,0	.. 15 38,0	.. 57 26,0	Telescope Direct.				
4 07 54,0 / 4 08 28,8 / 4 09 04,0 → (4 08 28,9	4 09 55,25					20 45 29,0	20 45 17,0	20 45 33,0	20 45 26,3	⊙ and West Signal.
Clouds / 4 11 1,6 / 4 11 56,7 →) 4 11 21,6		⊙	1 46 39,0	.. 30 21,0	.. 11 53,0					
4 13 05,5 / 4 13 39,5 / 4 14 14,4 → (4 13 39,725	4 15 36,96	⊙	182 48 06,0	.. 30 45,0	.. 12 34,0	Telescope Reversed.				
4 16 58,7 / 4 17 51,2 / 4 18 09,7 →) 4 17 34,2						19 46 23,0	20 45 07	20 44 43,5	19 45 21,2	⊙ and West Signal.
Upon the Hill West.		Signal.	202 31 06,0	.. 15 52,0	.. 57 17,5					

Immediately after. Double Zenith Distance ⊙ with the Repeating Circle for determination of time.

Chronometer as above. ″		D.	E.	F.	G.	Results of each Allidade.				Mean of opposites.		Mean.
4 23 37,7 / 4 24 23,3 / 4 25 18,6 → 23,225	25′ 58″,05	90 00 00	+12″	+17″	—02″	D.	155 47 08	E	155 46 34	155 46 40,5	155 46 44,7 / 2 =	° ′ ″ 77 53 22,3
4 26 17,0 / 4 27 32,0 / 4 28 19,5 → 32,875						F.	155 46 13	G	155 47 04	155 46 49,0		
Mean of times, 4h. 29′ 24″,431												
4 30 57,8 / 4 31 19,7 / 4 31 59,6 → 19,2	32′ 50″,812	245 47 08	.. 46 46	.. 46 30	.. 47 02							
4 33 56,8 / 4 34 22,7 / 4 35 07,5 → 22,425												

Barometer, 29″,91. Thermometer, 62°, Fahr.

1818.

♃ 15th October. Time by Chronometer, No. 30, Hardy.		Double Zenith Distance of ☉ at noon with the Repeating Circle. Readings of each Alhidade.				Results of each alhidade.			Mean of opposites.		Mean.
11 36 52,0 ◡	D=	42 35 00 E	.. 35 18 F	.. 36 17 G	.. 35 38	D=	281 41 47	E .. 47 50	281 48 09 ⎫	641 48 07,5	° ′ ″
11 40 01,5 ◠	W=	06 20 07 X	.. 21 17 Y	.. 20 12 Z	.. 23 12	F=	.. 47 31	G .. 48 50	.. .. 06 ⎭	12 =	53 29 00,6
11 42 54,0 ◡											
11 44 23,5 ◠											
11 45 13,5 ◡											
11 47 51,0 ◠		Barometer, 29,901				W=	281 47 15	X .. 48 55	281 48 30,5 ⎫	641 48 55,5	
11 48 52,0 ◡		Thermom. 64°				Y=	.. 49 16	Z .. 49 46	.. 49 20,5 ⎭	12 =	53 29 06,5
11 49 39,0 ◠											
11 50 37,5 ◡											
11 51 47,0 ◠											
11 52 46,0 ◡											
11 53 48,5 ◠	D=	324 23 47	.. 23 08	.. 23 48	.. 24 00						
11 54 47,0 ◡	W=	18 08 02	.. 10 12	.. 09 28	.. 12 58						

♀ 16th October, PM. Chronometer, as above.		Double Zenith Distance of the Pole Star with the Repeating Circle.									
10 47 04	D=	11 17 03	.. 17 07	.. 17 33	.. 17 58						
10 52 16	W=	54 34 36	.. 36 00	.. 35 17	.. 38 42						
10 53 49											
10 56 19											
10 58 00											
10 59 00						D=	119 25 14	.. 25 08	119 24 56,5 ⎫	1559 24 45,5	
11 00 42						F=	.. 24 39	.. 24 01	.. .. 34,5 ⎭	36	= 43 19 01,27
11 01 56											
11 03 00		Barometer, 30,9									
11 05 35		Thermom. 31°									
11 06 51											
11 07 51											
11 09 06											
11 10 00						W=	119 26 26	.. 25 40	119 25 39,5 ⎫	1559 25 41,75	
11 11 18						Y=	.. 24 55	 48	.. .. 41,0 ⎭	36	= 43 19 02,5
11 12 18											
11 13 31											
11 15 45											
11 17 09											
11 18 42											
11 19 40											
11 21 11											
11 22 19											
11 23 45											
11 24 58											
11 26 49											
11 28 02											
11 29 29											
11 31 06											
11 32 41											
11 33 55											
11 35 57											
11 36 48											
11 38 28											
11 39 52											
11 40 42	D	150 42 17	.. 42 15	.. 42 12	.. 41 39						
11 42 11	W	174 01 02	.. 01 40	.. 00 15	.. 04 30						

Station of St. R.

1818.

☿ 1st July, AM. Chronom. No. 50, Hardy.		Readings of—A	B	C	Azimuth Angles with the Two Feet Theodolite. A	B	C	Mean.	Denomination of the Angles
h. ′ ″					Telescope	Direct.			
5 22 26,5; 5 23 06,0; 5 23 57,0 (23 06,5); 5 25 41,0; 5 26 21,0; 5 27 01,7 (26 21,17); 5h 24′ 43″,76	☉	129 33 {46,4 / 45,0}	.. 18 {32,0 / 32,1}	.. 00 {24,0 / 23,0}	24 41 08,9	 05,25	 10,5	24 41 08,22	Sun and Signal in Cut
Cut to Fr. M.	Signal top.	154 14 {54,8 / 54,4}	.. 59 {38,4 / 38,2}	.. 41 {34,0 / 34,0}					
					Telescope	Reversed.			
5 37 40,7; 5 38 21,0; 5 39 32,0 (38 21,17); 5 40 58,2; 5 41 57,4; 5 42 20,0 (41 39,25); 5h. 40′ 00″,21	☉	312 04 {01,0 / 00,4}	.. 48 {31,0 / 31,8}	.. 29 {34,9 / 34,9}	22 11 04,1	.. 10 43,35	.. 13 59,8	22 10 55,75	
Cut to Fr. M.	Signal top.	334 15 {04,6 / 05,0}	.. 59 {14,4 / 15,1}	.. 40 {34,8 / 34,6}					

N. B —An Observation of time was made immediately after, and then the Terrestrial Angles continued, as follows :—(Telescope Direct.)

		A	B	C	A	B	C	Mean.	Denomination of the Angles
On the Island.	Signal top.	112 08 {40,0 / 40,0}	.. 53 {15,0 / 14,0}	.. 35 {05,5 / 06,6}	28 19 47,0	 59,5	 63,25	28 19 56,6	Island and St. R. S.
East End of St. R.	Signal pole.	140 28 {28,0 / 26,0}	.. 13 {13,0 / 15,0}	.. 55 {09,6 / 09,6}	42 06 20	 25,5	 33,25	42 06 26,25	Island and Cut to Fr. M.
Cut to Fr. M.	Signal top.	154 15 00	.. 59 40	.. 41 39					
Near the Black Cross.	Signal foot	181 10 20	.. 54 58	.. 36 43	40 41 53	 44,0	 43,0	41 41 46,6	St. R. and Black Cross.
					Telescope	Reversed.			
On the Island.	Signal top.	292 09 01	.. 53 43	.. 34 36	28 20 10,0	.. 19 52 0	.. 20 12,0	28 20 04,7	Island and St. R. S.
East End of St. R.	Signal pole.	320 29 11	.. 13 35	.. 54 48	42 06 33,0	 00,0	 31,0	42 06 20,3	Island and Cut to Fr. M.
Cut to Fr. M.	Signal top.	334 15 34	.. 59 43	.. 41 07	40 41 56,5	 19,0	 46,0	40 41 40,5	St. R. and Black Cross.
Near the Black Cross.	Signal foot.	1 11 07	.. 54 54	.. 36 34					
SAME DAY, PM.					Telescope	Reversed.			
On the Island.	Signal top.	292 08 49,0	.. 53 33,5	.. 34 23,3	28 20 03,5	.. 19 44,0	.. 20 03,7	28 19 57,4	Island and St. R. S.
East End of St. R.	Signal pole.	320 28 52,5	.. 13 17,5	.. 54 27,0	40 41 31,5	 13,5	 41,7	40 41 35,6	St. R. and Black Cross, S.
Cut to Fr. M.	Signal top.	334 15 20,0	.. 59 31,0	.. 40 53,0	42 06 31,0	.. 05 57,5	.. 06 29,7	42 06 19,4	St. R. and Fr. M. S.
Near the Black Cross.	Signal foot.	1 10 44,0	.. 54 31,0	.. 36 08,7					
					Telescope	Direct.			
On the Island.	Signal top.	112 08 24,0	.. 52 53,5	.. 31 47,0	28 19 50,0	.. 20 04,5	.. 20 08,0	28 20 00,8	Island and St. R. S.
East End of St. R.	Signal pole.	140 23 14,0	.. 12 58,0	.. 54 55,0	40 41 51,0	 44,5	 42,0	40 41 46,0	St. R. and Black Cross.
Cut to Fr. M.	Signal top.	154 14 10,0	.. 59 19,5	.. 41 19,5	42 06 16,0	 26,0	 32,5	42 06 24,8	St. R. and F. M. Cut.
Near the Black Cross.	Signal foot.	181 10 05,0	.. 54 42,5	.. 36 37,0					

N. B —These signals being so near, that every part of them was distinguishable, the reduction for illumination was not needed. If they had been more distant, the sun would have been observed at intervals, or at the beginning and end of each series, by the reading of the microscope A only, to determine the angle of reduction. For the same reason also, the microscopes were not continued to be read double, or from both nearest divisions on each side, as would otherwise have been done

☿ 8th July, PM. Chronom. No. 30, Hardy		Azimuth Angles with the Two Feet Theodolite.—N. B. Immediately after an Observation of [illegible] A	B	C	Telescope Direct. A.	B	C	Mean.	Denomination
[illegible] } 4[illegible],[illegible] ; [illegible] } 49 [illegible]4,0	☉	106 0[illegible] {16,0 / 18,8}	.. [illegible] {11,7 / 11,7}	.. 32 {09,8 / 09,0}	168 00 29,6	.. .. [illegible]3,8	167 59 59,[illegible]	168 00 21,1	☉ and F. M. Signal
Cut to F. M	Signal top	27[illegible] 05 15,[illegible]	.. 51 0[illegible]	.. [illegible] 19,3					
					Telescope Reversed.				
[illegible] } [illegible] ; [illegible] } 04 0[illegible]	☉	288 [illegible] {07,7 / 08,6}	.. 17 {[illegible] / [illegible]}	.. 58 {12,2 / 12,2}	165 [illegible] 16,8	.. [illegible] 47,8	.. [illegible] 48,8	165 [illegible] 14,4[illegible]	
Cut to F. M	Signal top	94 06 2[illegible],0	[illegible] 40,0	.. [illegible] [illegible],0					

Station on the Island.

♃ 11th July, AM.		Horizontal Angles with the Two Feet Theodolite.—(Telescope Direct.) A	B	C	A	B	C	Mean	Station	Denomination
Cut to F. M	Signal top.	9 48 11,0	.. 31 5[illegible],0	.. 1[illegible] 37,2	38 58 11,8	 56,0	.. .. [illegible],0	38 58 33,6	Main Station	& E. St. R
East End St. R	..	70 4[illegible] 10,0	27 15,0	.. 08 [illegible],0	99 53 10,8	 39,0	.. 54 08,8	99 [illegible] [illegible],2	..	Cut to F. M
Main Station Point	..	109 41 21,8	.. 2[illegible] [illegible],0	.. 07 16,0						
					Telescope Reversed.					
Cut to F. M		189 47 23,5	.. [illegible] 55,0	.. 1[illegible] 57,5	38 58 41,9	.. .. 3[illegible],0	 41,7	[illegible] 58 38,9	..	East St. R
East End St. R	..	250 42 15,3	27 39,7	.. 08 22,5	99 54 03,7	 17,7	.. 5[illegible] 28,[illegible]	99 [illegible] [illegible]6,6	..	Cut to F. M
Main Station Point.		[illegible]89 41 27,[illegible]	.. 26 12,7	.. 07 04,2						
	The Theodolite turned one change of legs forwards.									
Main Station Point	Signal top.	170 00 42,4	45 20,[illegible]	.. 27 10,0	99 53 26,2	.. [illegible] 00,5	.. 54 12,0	99 [illegible] [illegible]2,9		Cut to F. M
East End St. R	..	1[illegible]1 01 [illegible],[illegible]	.. 46 42,0	28 56,8	38 58 46,1	.. .. [illegible]8,3	.. .. [illegible],2	38 58 [illegible]9,2		East St. R
Cut to F. M		70 07 16,2	.. 51 19,8	.. 52 58,0						
					Telescope Direct.					
Main Station Point		350 01 0[illegible],8	4[illegible] [illegible],5	.. 26 [illegible],0	99 54 15,[illegible]	.. 53 17,[illegible]	.. [illegible] 1[illegible],8	99 5[illegible] [illegible]	..	Cut to F. M
East End St. R.	..	311 02 14,[illegible]	.. 46 4[illegible],0	.. 27 [illegible]8,0	38 58 50,5	.. .. 10,[illegible]	 57,0	38 58 [illegible]2,6	..	East St. R
Cut to F. M		2[illegible] 06 49,4	.. [illegible]1 58,0	.. 52 21,2						
	The Theodolite turned one change of legs forwards.									
Main Station Point	Signal top.	[illegible]	.. [illegible]7 [illegible],[illegible]	.. 08 [illegible]8,7	99 54 12,5	.. 18,[illegible]	.. 5[illegible] 16,7	99 [illegible] [illegible],8	..	Cut to F. M
East End St. R.		191 4[illegible] 51,0	.. 29 06,0	.. 10 41,2	38 58 36,5	.. .. 47,[illegible]	.. [illegible] 07,5	[illegible]8 58 50,4		East St. R
Cut to F. M	..	1[illegible] 48 5[illegible],0	.. 33 5[illegible],0	.. 1[illegible] [illegible]2,0						
					Telescope Reversed.					
Main Station Point	..	[illegible]	.. 27 [illegible],0	.. 09 1[illegible]	99 [illegible] 15,[illegible]	.. 5[illegible] 31,[illegible]	.. 53 58,0	99 5[illegible] [illegible],9	..	Cut to F. M
East End St. R		11 [illegible] 0[illegible],[illegible]	.. 28 51,0	.. 10 39,[illegible]	38 [illegible] [illegible]9,5	.. 49,0	[illegible]0,0	38 58 42,8		East St. R
Cut to F. M		310 [illegible] [illegible]8,0	.. [illegible] 58,5	.. 1[illegible] 12,0						

Station in Cut to F. M.

♂ 11th July, A.M.	Horizontal Angles with the Two Feet Theodolite.									
					Telescope	Direct.				
On the Island.	Signal top.	103 53 31,0	.. 37 45,3	.. 19 40,0	37 59 24,0	 38,0	 56,3	37 59 39,43	On the Island	and Main Station.
East End St. R.	..	75 42 45,6	. 26 49,4	.. 08 27,3	28 10 45,4	 55,9	 72,7	28 10 58,0	..	East St. R.
Main Station Point.	..	65 54 07,0	.. 38 07,3	.. 19 43,7						
					Telescope	Reversed.				
On the Island.	..	285 53 41,0	.. 38 28,0	.. 19 20,8	37 59 46,5	 48,0	 45,4	37 59 46,63	..	Main Station.
East End St. R.	..	255 42 40,2	.. 27 28,0	.. 08 19,0	28 11 00,8	 00,0	 01,8	28 11 00,9	..	East St. R.
Main Station Point.	..	245 53 54,5	.. 38 40,0	.. 19 35,4						
The Theodolite turned one change of legs forwards.										
On the Island.	Signal top.	163 06 33,7	. 51 01,7	33 01,0	37 59 48,0	 42,9	 48,0	37 59 46,3	..	Maio Station.
East End St. R.	..	134 55 28,3	.. 39 58,0	.. 21 54,0	28 11 05,4	 03,7	 07,0	28 11 05,4	..	East St. R.
Main Station Point.	..	125 06 45,7	.. 41 18,8	. 33 13,0						
					Telescope	Direct.				
On the Island.	..	343 06 49,0	.. 50 59,3	.. 32 19,0	37 59 53,4	 25,3	 36,6	37 59 38,4	..	Main Station.
East End St. R.	..	314 55 42,9	.. 40 13,0	.. 21 23,3	28 11 06,1	.. 10 46,3	.. 10 55,7	28 10 56,03	..	East St. R.
Main Station Point.	..	305 06 55,6	.. 51 34,0	.. 32 42,4						
The Theodolite turned one change of legs forwards										
On the Island.	Signal top.	222 59 30,0	.. 44 15,0	.. 25 32,8	37 59 37,0	 54,8	 27,8	37 59 39,9	..	Main Station.
East End St. R.	..	194 48 41,0	.. 33 11,0	.. 14 51,8	28 10 49,0	 64,0	 41,0	28 10 51,3	..	East St. R.
Main Station Point.	..	184 59 53,0	.. 44 20,2	.. 26 05,0						
					Telescope	Reversed.				
On the Island.	..	43 00 17,0	.. 44 05,8	.. 25 39,3	37 59 51,5	 51,8	.. . 48,3	37 59 50,3	..	Main Station.
East End St. R.	..	14 49 15,0	.. 33 01,5	. 14 38,0	28 11 02,0	 04,3	 01,3	28 11 02,53	..	East St. R.
Main Station Point.	..	5 00 25,5	.. 44 14,0	.. 25 51,0						

REMARKS.

Latitude Observations with the Repeating Reflecting Circle are registered, in respect to time, like those of the Repeating Circle with Two Telescopes; and in respect to the angles, like an Observation of Time with the Reflecting Circle.

Observations of zenith distances of terrestrial objects or signals being made exactly like those of celestial objects, are registered in like manner, the time excepted, which is omitted. But it is proper to read one vernier at each observation, and write it in the proper column of the Journal, in order to have a sure check upon the number of angles and the regularity of the observatioo.

The registeriog of the observations with the Repeating Theodolite is, in all respects, similar to that with the Repeating Circle for vertical angles,—and this as well for horizontal as for vertical angles; for the horizontal angles are taken in the same order as the observations of the vertical angles upon terrestrial objects. The denomination of the angle is placed at the top of the observation.

EXEMPLARS FOR THE JOURNALS OF RESULTS.

1. *Of the Repeating Circle.*

A. DETERMINATION OF TIME.

Station near Chateaugay River.

1818.	Time of Chron No. 50, Hardy	Zenith Distance ⊙ observed.	Declination South.	True Time.	Mean Time.	Difference of Chronom. with True Time	Difference of Chronom. with Mean Time.	Mean	Rate.		Denomination of instruments
	h ′ ″	h ′ ″	° ′ ″	h. ′ ″	h. ′ ″	h. ′ ″	′ ″	h. ′ ″			
29th Sept. PM	3 55 12,0	72 12 03,6	2 25 03,6	4 06 51,46	3 57 10,01	0 11 39,46	.. 01 58,01	0 01 58,44			Reflect. Circle
	.. 40,0	.. 16 39,55	 14,95	.. 07 22,33	 38,88	 42,33	.. 01 58,88				Repeat. Circle
	4 29 24,43	77 53 22,5	 47,64	.. 41 03,33	4 31 22,42	 38,9	.. 01 57,99				

B. DETERMINATIONS OF LATITUDES.

Station in the Manor.

1818.	Time of Chron No. 50, Hardy	Distance from the Transit.	Factors of Reduction. a	Factors of Reduction. b	Observ. Zen Dist. of ⊙	Reductions.	Merid. True Zen. Distance	Declination.	Latitude.	Mean of Front & Back
15th October.	h ′ ″	′ ″								
	11 36 52,0 ⌣	8 43,1	149,23	0,058						
	11 40 01,5 ⌢	5 33,6	60,69	9	Front.	Red. = −46,62				
Noon.	11 42 54,0 ⌣	2 41,1	14,15		° ′ ″	Refr. −Pa. } +69,39	° ′ ″		° ′ ″	
11h. 45′ 35″,1	11 44 23,0 ⌢	1 12,1	2,88		53 29 00,6		53 29 23,33		45 00 47,83	
	11 46 13,5 ⌣	0 38,4	0,80							
	11 47 31,0 ⌢	1 55,9	7,33			S = +22,75		° ′ ″		° ′ ″
	11 48 32,0 ⌣	2 56,9	17,06							
	11 49 39,0 ⌢	4 05,9	32,44	2				8 28 35,5		45 00 45,41
	11 50 37,5 ⌣	5 02,4	49,87	5						
	11 51 47,0 ⌢	6 11,9	75,45	13	Back	−47,2				
	11 52 46,0 ⌣	7 10,9	101,26	21	53 29 06,3	+69,39	 28,49		 42,99	
	11 53 48,5 ⌢	8 13,4	132,76	0,044						
	11 54 47,0 ⌣	9 11,9	166,11	0,067		S = +22,19				
Barometer, 29,8″		Front,	645,90	0,152						
Thermometer, 64°		Back,	650,78	0,164						

16th October.	10 47 04,0	29 17 8	1683,00	6,866	Polaris.					
	10 52 16	24 05,8	1139,20	3,144						
	10 53 49	22 33,8	998,80	2,418						
	10 56 19	20 02,8	788,54	1,507						
	10 58 00	18 21,8	661,76	1,062						
	10 59 11	17 10,8	579,26	0,814	Front.					
	11 00 42	15 39,8	481,54	0,563	° ′ ″					
	11 1 36	14 45,8	427,82	0,444	43 19 01,27					
	11 3 00	13 21,8	349,61	0,296		″				
	11 5 35	10 46,8	228,13	0,126		Red. —12,91				
	11 6 51	9 30,8	177,68	76		Ref. +59,02	43 19 47,38		45 00 45,74	
	11 7 51	8 30,8	142,29	51						
	11 9 06	7 15,8	103,58	25		S=+46,11				
	11 10 00	6 21,8	79,50	5						
	11 11 18	5 03,8	50,33	2						
	11 12 18	4 03,8	32,42							
	11 13 31	2 50,8	15,91							
Transit. 11 16 21,8	11 15 43	0 38,8	0,82							
	11 17 09	0 47,2	1,21							° ′ ″
	11 18 12	1 50,2	6,67					+		
	11 19 40	3 18,2	21,42	1				88 20 33,12		45 00 44,82
	11 21 11	4 49,2	45,61	4						
	11 22 19	5 57,2	69,58	12						
	11 23 43	7 21,2	106,16	26						
	11 24 58	8 36,2	145,31	51						
	11 26 49	10 27,2	214,52	0,111						
	11 28 02	11 40,2	267,35	0,173						
	11 29 29	13 07,2	337,89	0,276	Back.					
	11 31 06	14 44,2	426,26	0,440	43 19 02,8					
	11 32 41	16 19,2	522,74	0,662			 49,22		 43,90	
	11 34 33	18 11,2	649,20	1,020		—12,60				
	11 35 57	19 35,2	752,81	1,372		+59,02				
	11 36 48	20 26,2	819,56	1,626						
	11 38 28	22 06,2	958,50	2,225		+46,42				
	11 39 32	23 10,2	1053,20	2,689						
	11 40 42	24 20,2	1161,90	3,271						
	11 42 11	25 49,2	1307,64	4,145						
Barometer.	30,90	Front.	15500,09	31,373						
Thermomet.	31°	Back.	15124,73	28,652						

2. *Journals of the Results of the Great Theodolite.*

A. AZIMUTH.

Station of St. R.

1818.	Time of Chron. No. 30, Hardy	True Time.	Declination	Denominat. of terres. objects	Stand of the Telescope.	Terrestrial Angle observ.	Azimuth calculated.	Azimuth of the Object.	Mean of Direct and Reversed	Mean of Fore & After Noon	General Mean.
	h. ′ ″	h. ′ ″	° ′ ″			° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
1st July, AM.	5 24 43,76	5 22 16,2	23 09 58,0	Signal in Cut	Direct.	21 41 08,22	67 00 51,1	91 41 59,32	91 42 00,65	91 41 57,9	
	.. 40 00,21	.. 37 32,6	 56,0	..	Reversed.	22 10 55,75	69 51 06,2	.. 42 01,97			
8th July, PM	5 47 21,75	5 45 31,5	22 29 47,0	..	Direct.	168 00 21,1	75 18 20,2	.. 42 00,8	.. 41 55,17		
	6 02 24,71	.. 58 51,11	 44,0	..	Reversed.	165 35 14,45	73 53 23,9	.. 41 49,55			

B. TERRESTRIAL ANGLES.

Station of St. R.

1818.	Teles. Stand	Observed Angle.	Mean of Direct and Reversed.
		Signals in Cut	and on Island.
1st July, AM.	D	12 06 26,25	 23,27
	R	 20,3	
PM	R	 19,4	 22,1
	D	 24,8	
		Mean	12 06 22,7

Station on the Island.

1818.	Teles. Stand	Observed Angle.	Mean of Direct and Reversed.
		Mean Station &	Signal in Cut.
11th July, AM	D	22 54 46,2	 51,4
	R	 56,6	
	R	 52,9	 54,2
	D	 55,5	
	D	 55,8	 55,55
	R	 54,2	
		Mean	22 54 53,65

Station in the Cut to F. M.

1818.	Teles. Stand	Observed Angle.	Mean of Direct and Reversed.
		Mean Station & Island Signal.	
11th July, AM	D	[illegible]	 46,05
	R	[illegible]	
	R	[illegible]	 42,5
	D	[illegible]	
	D	[illegible]	 45,2
	R	[illegible]	
		Mean	7 21 [illegible]

Collection of the Triangles and Geographical Positions.

Number of the Triangle.	Num. of Angles obs. ev.	Denominations of Point.	Angles.	Spheric Excess & Corr.	Distances.
			° ′ ″		m.
	2	Main Station.	42 06 22,7		1824,62
1.	3	Cut to F. M.	37 59 43,53		1211,90
	3	On the Island.	99 53 53,65		
			179 59 59,88	+ 0,12	

NOTE.

This Paper was followed by a Journal of the "Principal Dates connected with the Survey of the Coast;" but as this Journal was not considered of general interest, and as the paper was already of great length, it has been thought proper to omit it.

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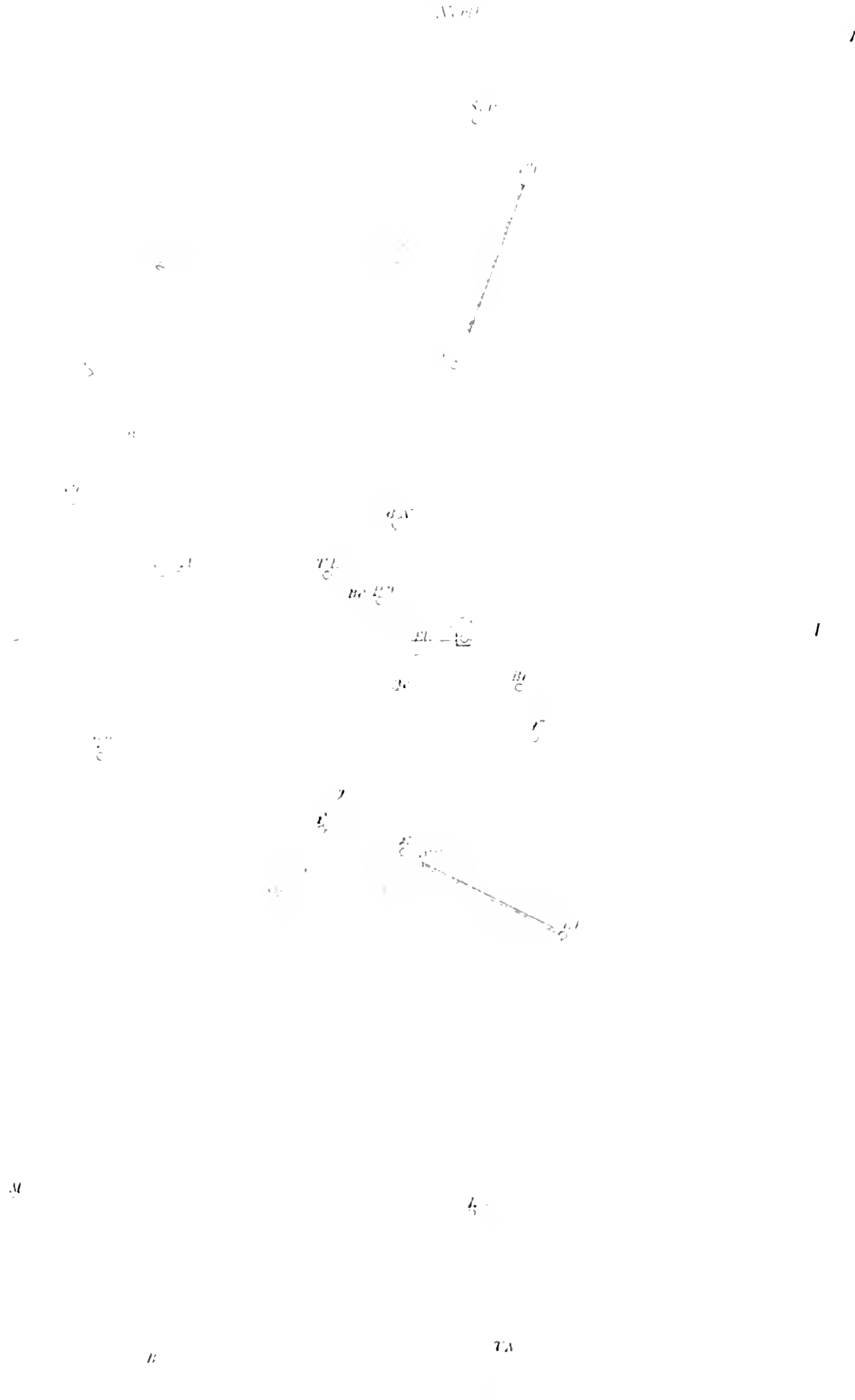


Horizontal

Fig 2

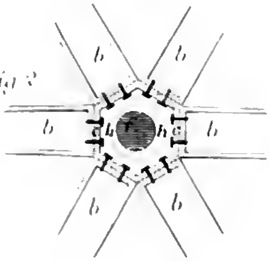
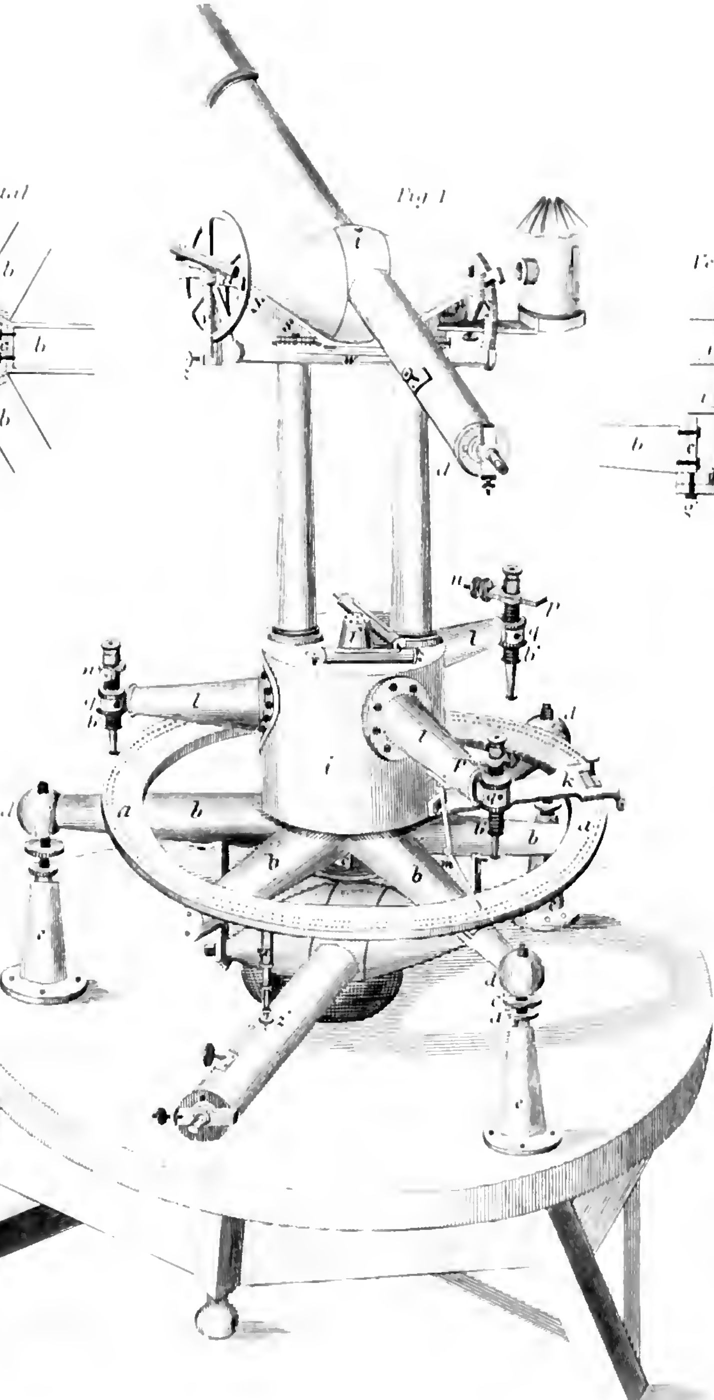


Fig 1



Vertical

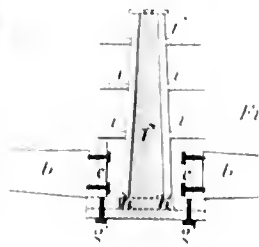


PLATE VI.

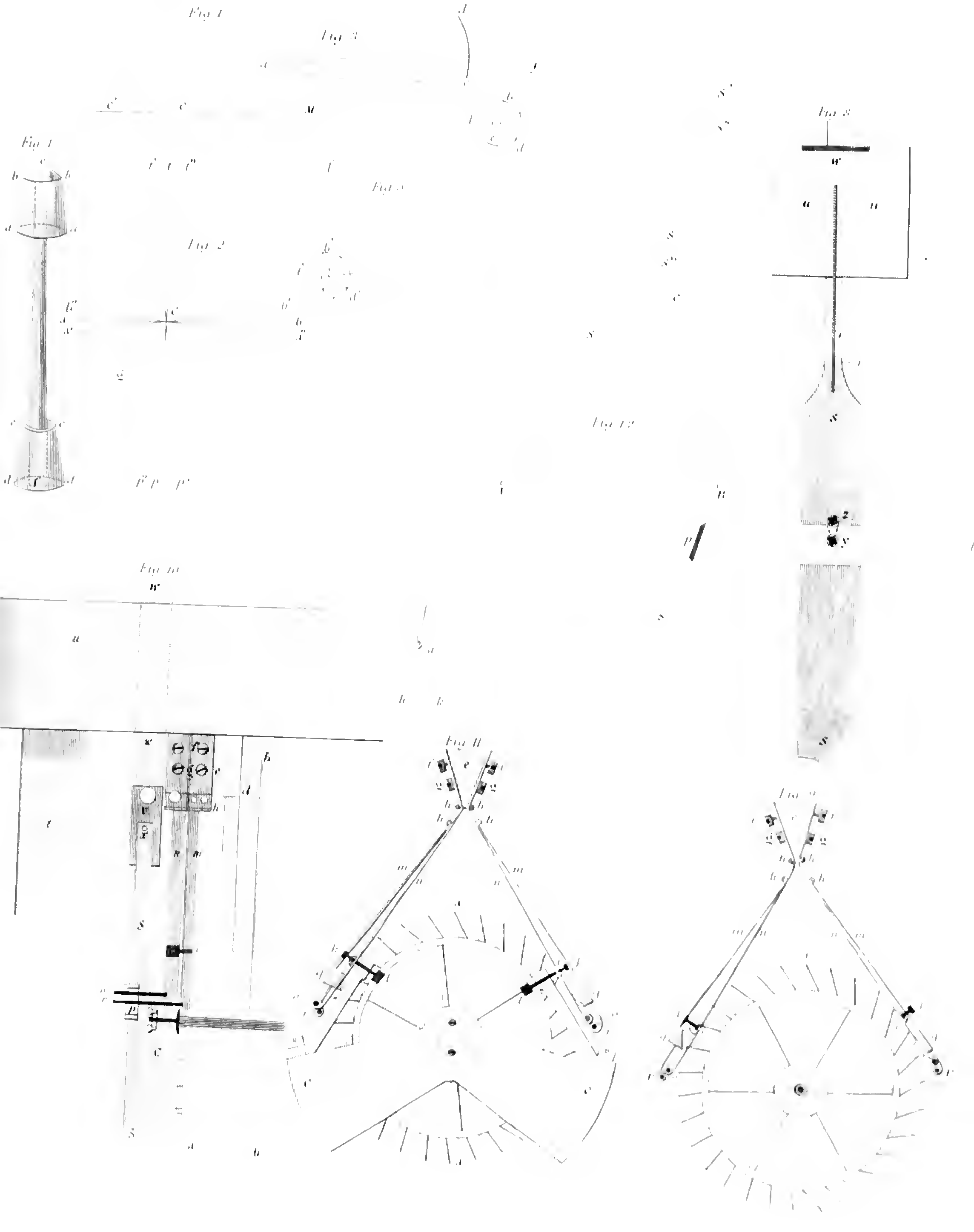


Fig 1

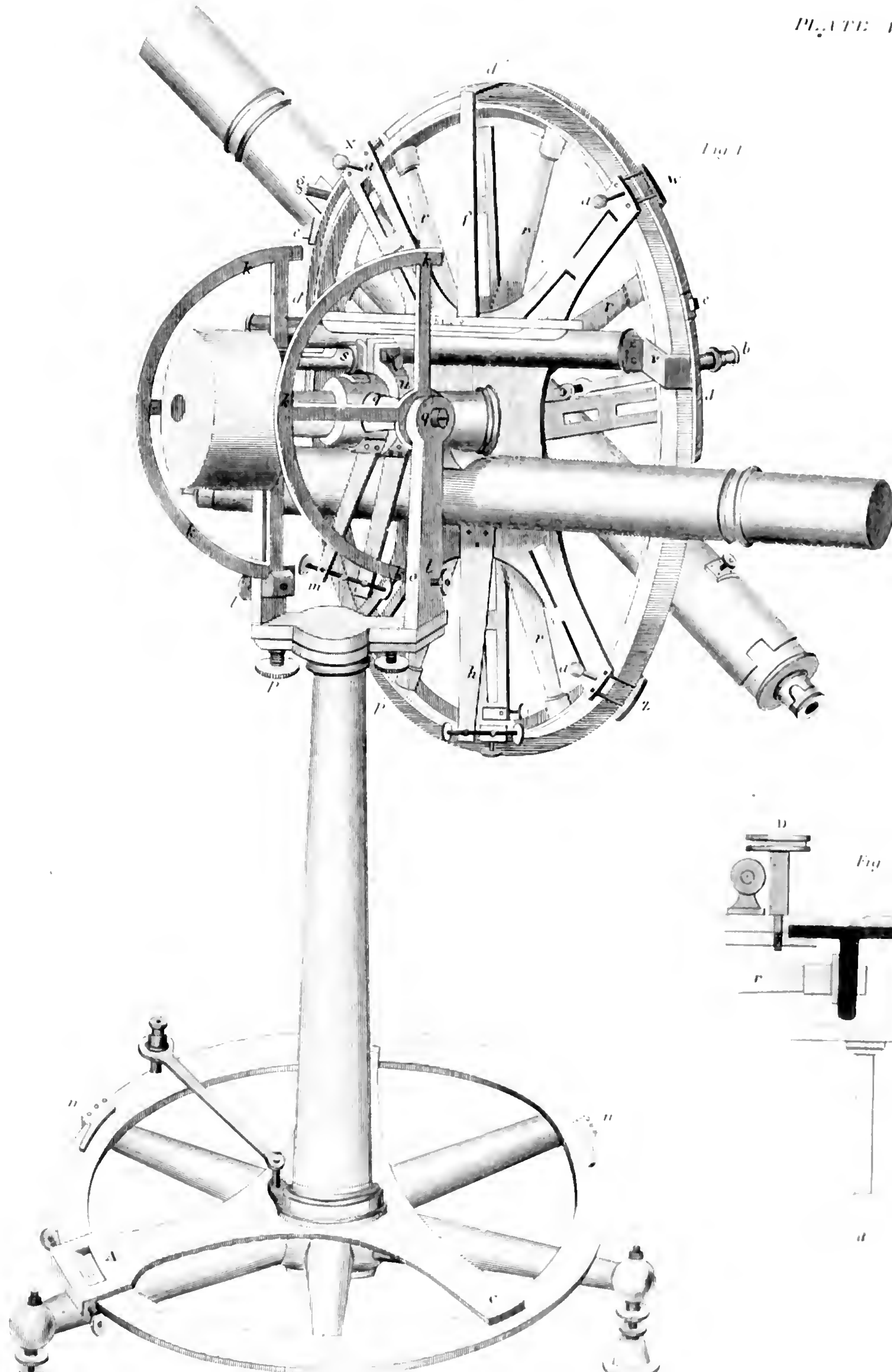
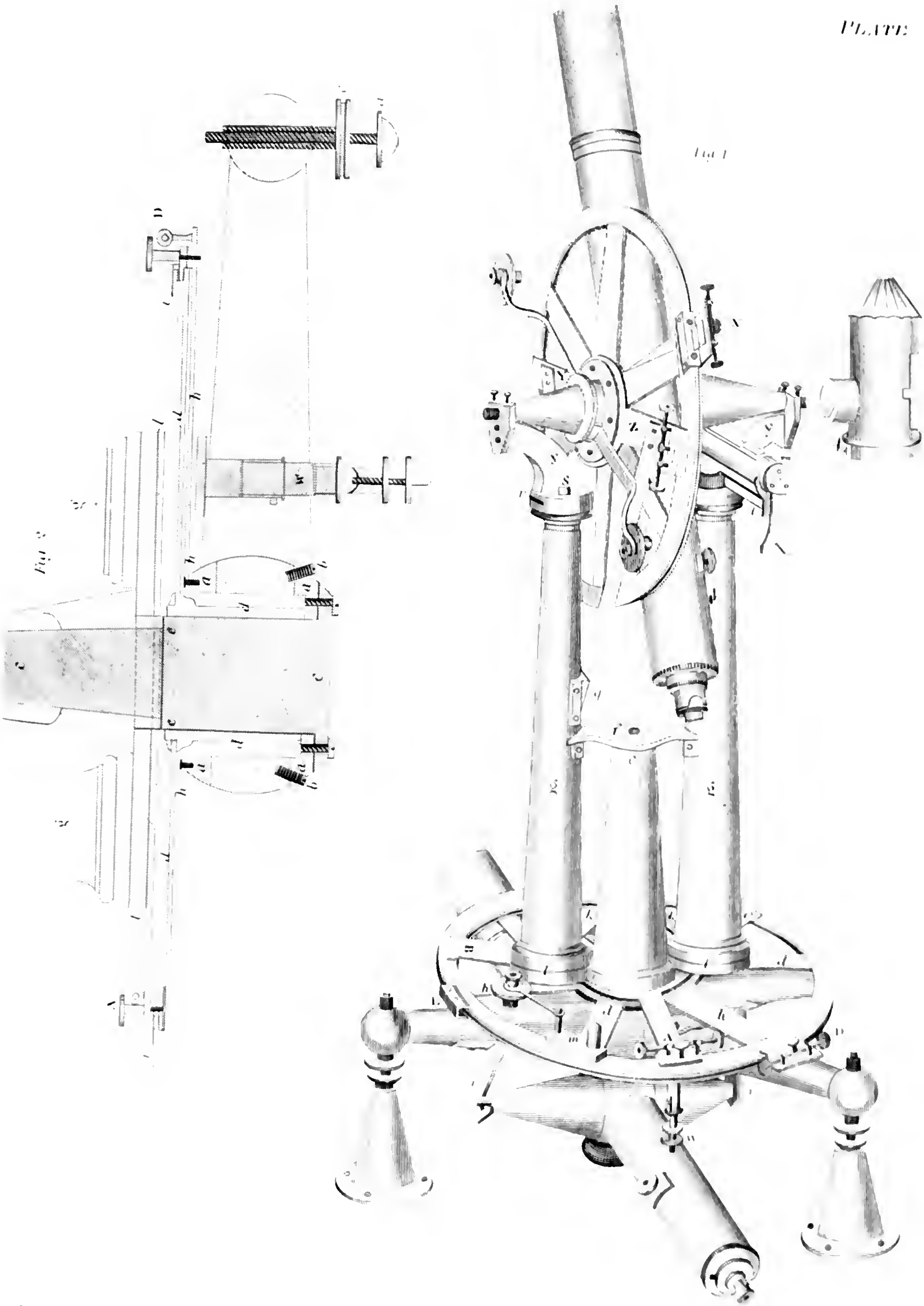


Fig 2

PLATE VIII.



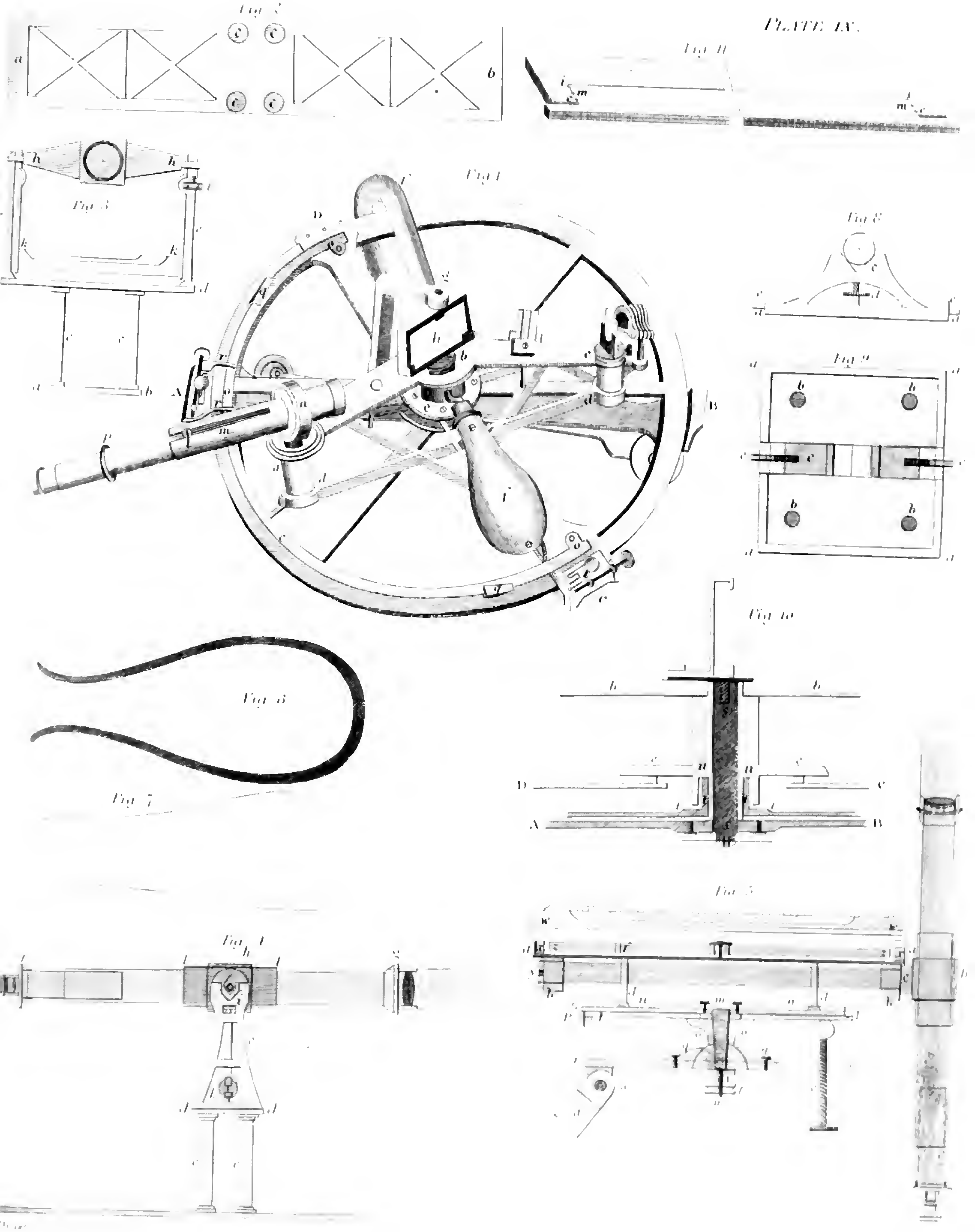
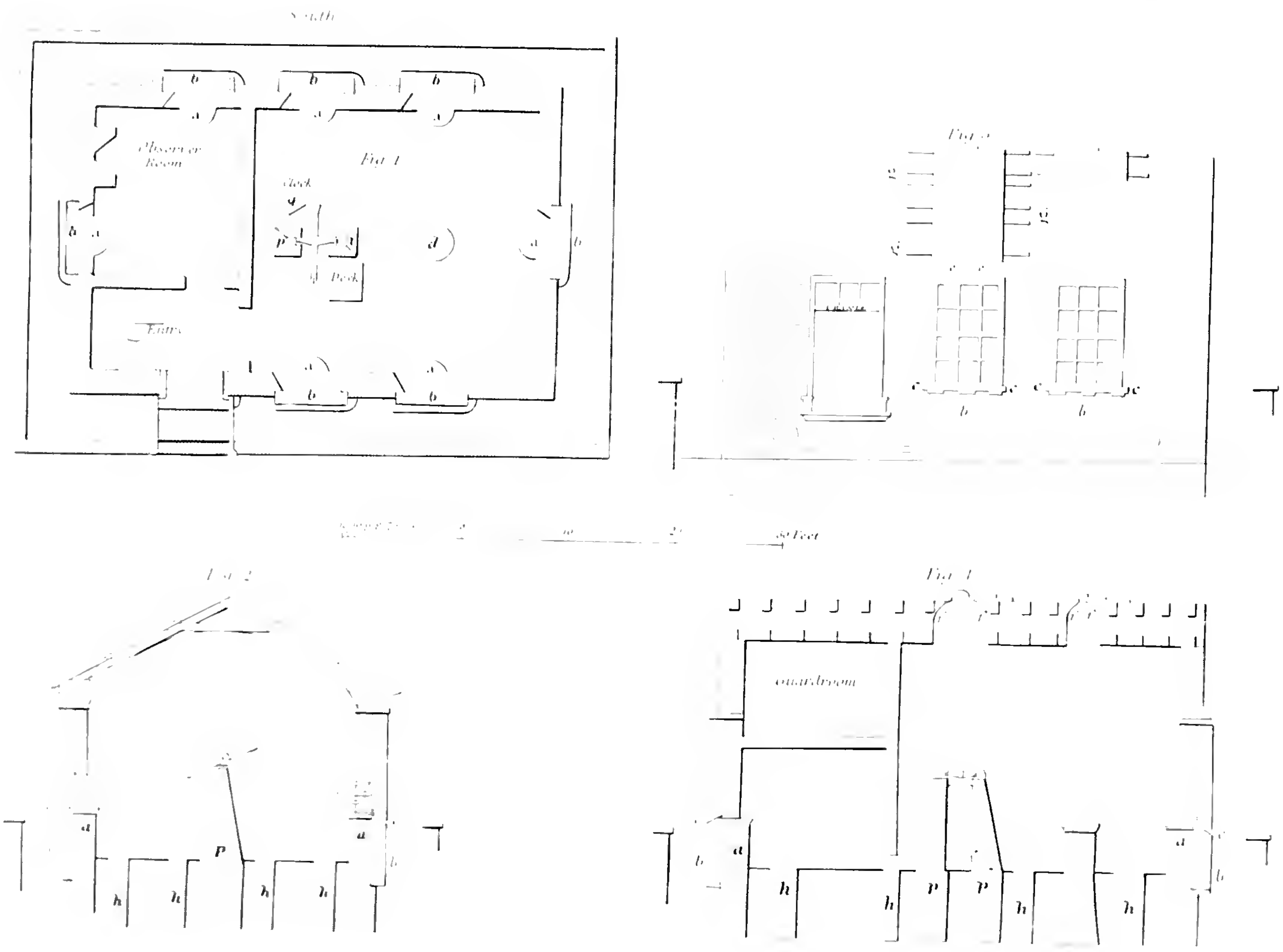


PLATE IX.

PLATE X


South
Observer Room
Fig. 1
Clock
Desk
Entry
Fig. 2
Guardroom
Fig. 1
Fig. 2
30 Feet

No. XIII.

Mémoire pour accompagner le Tableau des Observations Météorologiques faites à Washington, depuis le 17 Avril 1823 jusqu'au 18 Avril 1824. Par

JULES DE WALLENSTEIN,

Membre Correspondant de l'Academie d'Histoire de Madrid.

Read, 7th May, 1824.

LE Tableau des Observations Météorologiques que j'ai l'honneur d'offrir à la Société Philosophique de Philadelphie, embrasse l'intervalle du 18 Avril 1823 jusqu'au 18 Avril 1824.

Le baromètre dont je me sers a été construit par M. Fortin, l'habile artiste qui vient d'enrichir l'Observatoire Royal de Paris d'un beau cercle, et qui était connu antérieurement par l'extrême exactitude de ses balances et d'autres instruments qui demandent une égale habileté. La cuvette de ce baromètre a un fond mobile: un point d'ivoire indique le moment où la surface du mercure, dans la cuvette, est à son vrai niveau. Un curseur, muni d'un vernier, donne le moyen de connaitre jusqu'au 10^{me} d'un millimètre ou un quatre millième d'un pouce anglais, la hauteur de la colonne barométrique.

L'instrument est vissé, dans sa partie supérieure, de manière à conserver constamment sa verticalité. On en trouvera une description plus détaillée dans le Traité de *Physique Expérimentale et Mathématique* de M. Biot, (Vol. 1er, page 85.) C'est avec cette espèce de baromètre que les observations sur la pression atmosphérique se font à l'Observatoire Royal de Paris. Un thermomètre centigrade est enchassé dans la monture du baromètre. On ne saurait trop recommander cet instrument aux physiciens voyageurs. Il est le moins sujet à se casser ; les branches de bois, en forme d'échasses, qui lui servent d'étui, le couvrent de manière qu'il suffit de très peu de soins pour le préserver d'accidents.

L'hygromètre de Saussure a 2,5 décimètres de longueur : l'arc est divisé en 100°. Le point extrême de la sécheresse est réduit par le calcul à zero de l'échelle. Je tiens un thermomètre centigrade de Fortin suspendu à côté de cet instrument, et ils sont, l'un et l'autre, renfermés dans une petite case, qui les préserve de la poussière, et dont les deux côtés opposés sont couverts d'une gaze assez fine, pour les laisser en parfait contact avec l'atmosphère. L'exposition de ces instruments est à l'ouest : ils sont suspendus à 2,4 mètres du sol.

J'emploie aux observations purement thermomètriques, deux thermomètres gradués sur les tubes mêmes, dont l'un est de M. Lerebours, artiste attaché au Bureau des Longitudes de Paris, et l'autre de M. Fortin ; et d'un thermomètre de Mr. Troughton, avec des échelles centigrade et de Fahrenheit.

La plûpart de mes instruments étant divisés d'àpres l'échelle métrique, j'ai dû réduire chaque observation en mesure d'Angleterre, pour rendre plus aisée la comparaison de mon travail avec ceux qui se font dans d'autres points de ce pays.

J'ai suivi les conseils de M. Biot, relativement à la correction de la capillarité et de l'influence de la température sur les observations barométriques. Le diamètre intérieur du tube de mon baromètre est de $9{,}5^{mm.}$. J'applique une correction de $4{,}893^{mm}$ à chacune de mes observations, en tirant cette quantité par interpollation de la Table de Dépression calculée par M. de la Place. Cette correction est additive, et par elle les observations, indiquées dans le Tableau, sont comme si elles avaient été faites avec un tube assez large, pour que le mercure ne s'y abaissat pas au dessous de son niveau, ainsi que cela arrive dans les tubes capillaires.

Pour rectifier les observations, suivant la température du mercure, qui remplit le tube barometrique, j'emploie la formule donnée par M. Biot, $(P) = P - \frac{PT}{5412}$, dans laquelle P exprime la longueur de la colonne observée ou la longueur apparente, T, la température indiquee par le thermomètre du baromètre : la constante $\frac{1}{5412}$ représente la dilatation vraie du mercure pour chaque dégré, entre les deux termes de la glace fondante et de l'eau bouillante. Au moyen de cette correction, la valeur indiquée dans le Tableau, est la pression atmosphérique, rapportée à la température de 32° Fahrenheit. La comparaison de quelques *hauteurs apparentes* fera connaitre l'importance de cette réduction :

	Baromètre.	Thermomètre du Baromètre.	Pouces françai s.		Pouces angla
	m.	°	p.	l.	
Le 26 Juin à 4h.	0,7640	21,0	28	1.57	29,981
Le 29 Juin à 4h.	0'7640	26,0	28	0,46	29,822
Differences,	„	5,0		1,11	0,159

On remarquera que, dans les premiers mois, les observations n'ont pas été faites aux mêmes heures : en voici la raison. Parmi les changemens qu'éprouve l'atmosphère, celui qui est indiqué par les *variations horaires* du baromètre, n'est pas le moins curieux, ni le mieux éclairci, jusqu'à present, soit par la théorie, soit par les observations. M. de Humboldt s'est peut-être le plus occupé de ce sujet dans sa *Géographie des Plantes.* (p. 91.) Il rappelle les remarques de Godin et de La Condamine sur les oscillations horaires du baromètre sous l'équateur. Godin a, selon lui, indique le premier ce phénomène: c'est à 9 heures du matin et à 3 heures de l'après-midi que ces variations ont lieu, suivant M. de la Condamine, sous l'équateur:—mais il ne dit point, à laquelle de ces deux époques le *maximum* ou le *minimum* a lieu. M. de Humboldt conclut de ses propres observations, que "sur les côtes de la mer du Sud, dans les plaines de la rivierc des Amazones, et dans les endroits élevés de 4000 mêtres, les époques de ces variations sont les mêmes; qu'elles sont indépendantes des changemens de température et des saisons, et que le baromètre est à son *maximum* à 9 heures du matin, qu'il ne descend que très-peu jusqu'à 12h., mais beaucoup depuis midi jusqu'à 4 heures ou 4 heures et demie, et qu'il remonte de nouveau jusqu'à 11 heures de la nuit, où il est un peu plus bas qu'à 9 heures du matin: il baisse de nouveau toute la nuit jusqu'à 4 heures et demie du matin, où il est un peu plus haut qu'à 4 heures de l'après-midi: enfin, il remonte depuis 4 heures jusqu'à 9 heures du matin." Je renvoie le lecteur à l'ouvrage de M. de Humboldt pour les résultats remarquables, auxquels de pareilles observations peuvent conduire, et qui ont fixé l'attention de plusieurs savans.

Dans un autre ouvrage,* qui n'est qu'en partie traduit en français, et dont la publication est antérieure de plusieurs années à celui que nous venons de citer, M. de Humboldt avait considéré les variations atmosphériques, sous le rapport de la physiologie et de la pathologie. "S'il existait constamment *une même différence* entre la pression barométrique de deux lieux; si, par exemple, dans l'un de ces endroits, elle était de 28 pouces, et dans l'autre de 24 pouces, les corps organisés seraient probablement affectés de l'inégale densité de l'air, d'une même manière, d'après les loix de l'irritation habituelle. L'élévation et l'abaissement du baromêtre, *dans un même endroit*, ont un effet différent. Je ne doute point que les pays où les variations barométriques sont les moins

* Expériences sur l'Irritation des Fibres Musculaires et Nerveuses, (en allemand,) Vol. II. [Le Premier Tome est le No. 1130 du *Catalogue of the American Philosophical Society*. 1824.]

considérables, ne soient aussi les plus sains," (Vol. 2, p. 248, 249.) M. de Humboldt cite, à l'appui de cette opinion, la salubrité du Pérou, du Chili, et des pays montagneux. "Je suis porté à croire," dit le même auteur, dans un autre endroit du même ouvrage, (p. 292.) "que la nature ou la composition de l'atmosphère est moins variable sous les tropiques que dans les régions tempérées du globe. Tous les phénomènes météorologiques paraissent y suivre une certaine loi, dont ils ne s'écartent que très-peu: le flux et le reflux diurnes de la chaleur, de la lumière, de l'électricité, et du fluide magnétique, y sont plus égaux dans leur marche, du moins autant qu'il est permis d'en juger par le peu d'observations recueillies jusqu'ici: même le baromètre, dont les variations, si compliquées dans nos climats, embarrassent tant les naturalistes, s'abaisse et monte régulièrement, sous les tropiques, 4 fois dans l'espace de 24 heures. Doit-on attribuer à cette régularité dans la constitution de l'atmosphère, le caractère obstiné des maladies épidémiques, sous le climat des palmiers? Dès que sous ce climat un désordre arrive dans les fonctions vitales, il fait des progrès, sans être arrêté par nulle cause extérieure. Les changements du fluide environnant ne sont pas assez grands, pour arrêter les décompositions. Ce n'est qu'à l'arrivée d'une nouvelle saison, que la force des *causes excitantes extérieures* (pathogéniques) triomphe sur le développement morbide, qui a lieu dans la fibre. Dans les climats tempérés, au contraire, les variations dans les principes constituants de l'atmosphère sont si fréquentes et si considérables, qu'elles agissent puissamment sur les fonctions vitales. Un changement dans l'élasticité de l'air, dans la charge électrique, dans la quantité d'oxigène et dans l'humidité, modifie les fonctions vitales, et le progrès des maladies épidémiques est, en partie, paralysé par cette modification continuelle des éléments extérieurs, ou le mal prend bientôt partiellement une autre forme. Des médecins, bons observateurs, ont remarqué que, dans la zone tempérée, les endroits, ou la température est la plus variable, sont les moins exposés aux maladies épidémiques."

Dans cet ouvrage, publié en 1797, M. de Humboldt se rapportait aux observations de M. Moseley (*Treatise on Tropical Diseases*) relativement aux oscillations horaires du baromètre sous les tropiques, et à celles que M. Francis Balfour (*Asiatic Researches, Vol. IV.*) avait faites au Bengale. D'apres le *Tableau Physique des Régions Equinoxiales*, imprimé en 1805, ces observations ne s'accordent pas avec celles que M. de Humboldt avait faites, lui-même, sous les tropiques. (Voyez p. 90 et 91.)

En Allemagne, malgré de nombreuses perturbations dans la marche du baromètre, on trouve une certaine régularité dans l'abaissement de la colonne du mercure, qui a lieu à 2 heurs apres-midi, et son élévation, qui a lieu à 8 heures du soir."*

"M. Cotte a déduit d'un grand nombre d'observations faites en Europe, que le *minimum* de la hauteur barométrique y a lieu 2 heures après la culmination du soleil, et par conséquent, 2 heures plutôt que sous l'équateur. Dans nos climats tempérés, les variations horaires du poids de l'air sont, peut-être, cachées sous une multitude de causes locales, qui font monter et baisser irrégulièrement les baromètres. Mais je ne doute pas, avec M. Van Swinden, que des termes moyens, déduits de plusieurs milliers d'observations, faites d'heure en heure, n'indiquent que, même dans nos latitudes, le baromètre monte et descend à des époques déterminées."

M. Biot (*Traité de Physique Expérimentale, Vol. I. p.* 98) rappelle les résultats auxquels une longue suite d'observations a conduit le célèbre naturaliste des Pyrénées, par rapport au sujet qui nous occupe. "M. Ramond a reconnu qu'en France, le baromètre a son *maximum* de hauteur vers 9 heures de matin ; apres quoi il descend jusques vers les 4 heures du soir, où il atteint son *minimum:* de là il monte de nouveau jusqu'à 11 heures du soir, où il atteint de nouveau son *maximum:* après quoi il redescend jusques vers

* Expériences sur l'Irritation, &c. Vol. II. p. 293.

les 4 heures du matin, pour revenir à son *maximum* vers 9 heures. Cette marche est souvent dérangée dans nos climats d'Europe, où l'etat de l'atmosphère est si variable."

L'astronome embarqué sur les vaisseaux russes qui, en 1820, ont parcouru les hautes latitudes australes, a observé, pendant la navigation entre les tropiques, que "le baromètre éprouve régulièrement une baisse et une hausse périodiques et journalières, de manière qu'il atteint son plus haut point à 9 heures du matin et à 9 heures du soir, de même qu'il descend au plus bas à 3 heures du matin et à 3 heures de l'après-midi."*

Je me suis longtems arrêté aux oscillations horaires du baromètre. Mais je pense que cette partie de la physique merite d'autant plus d'attention, qu'elle parait avoir peu fixé jusqu'à present celle des naturalistes voyageurs. Il en est de même de la variation diurne de l'aiguille aimantée, dont peu de physiciens se sont occupés depuis Van Swinden,† avec autant d'attention et de persévérance qu'il a mises à ses recherches. Peut-être de bonnes observations sur les variations périodiques de l'aiguille aimantée, de l'électricité et du baromètre, recueillies par des savants tels que La Condamine, Mutis, Humboldt, et Buch, feraient-elles découvrir quelque liaison entre ces phénomènes, ou le moyen d'expliquer l'un par l'autre.

Il suffit, enfin, de savoir que les savants que nous venons de nommer, se sont occupés de ce sujet; qu'une liaison a été remarquée, par l'un d'eux (M. Mutis) entre les variations horaires de la colonne barométrique, et les conjonctions et oppositions de la lune, et que M. de La Place a soumis au calcul l'influence que peuvent avoir le soleil et la lune sur l'atmosphère, pour ne pas juger inutile de s'attacher avec quelque soin à ces observations; et l'on avait besoin de consulter des autorités aussi imposantes, pour ne pas se laisser, en général, décourager de tout travail météo-

* Nouvelles Annales de Voyage de M. Malte-Brun, Vol. XX.

† Recueil de Mémoires sur l'Analogie de l'Electricite et du Magnetisme, T. III.

rologique, par la défaveur, et presque le ridicule, qu'a jeté sur cette partie de la physique, un astronome rénommé par ses longs et utiles travaux. (Bode. *Gedanken uber den Witterungs lauf.* Berlin, 1819.)

Mais pour obtenir des résultats satisfaisants sur les changements périodiques du baromètre, je devais, dans le commencement, être incertain sur les heures convenables aux observations, à défaut d'y consacrer plus de tems qu'il ne m'était possible d'y vouer. Suivant M. Ramond, l'heure de midi est, en général, l'instant le plus favorable aux observations barométriques, " parceque l'équilibre de l'atmosphère, altéré par les vents du matin, se trouve ordinairement rétabli vers le milieu du jour." *(Mémoires de l'Institut de Françe, Tome VI.)* Aussi ai-je, dès le Avril, observé à cette époque la pression atmosphérique. Mais j'ai été longtems incertain pour les autres heures. C'est le 27 Juin que j'ai commencé à faire toutes mes observations météorologiques 4 fois par jour, c'est à dire, à 7 heures, à 9 heures, à midi, et à 4 heures. On verra par le Recueil de mes Observations, qu'à Washington, le baromètre est à son *maximum* de hauteur vers 9 heures du matin, et qu'il descend jusqu'à 4 heures. Je ne me crois pas encore en droit de tirer de mon travail d'autres conclusions. C'est aux physiciens, qui voudraient examiner mes recherches avec impartialité, à determiner jusqu'à quel point les éléments que j'ai fournis, peuvent être comparés à ceux, dont on a tiré les seuls indices d'une loi dans la marche du baromètre et de l'aiguille aimantée. Pour ma part, je me crois obligé de continuer mes observations, avant d'en déduire positivement un résultat. Ce n'est qu'après de nouvelles recherches, que je me croirai également autorisé à offrir des remarques sur les vents et leur influence, sur la charge électrique et l'humidité de l'air du lieu de mon séjour. Les observations que j'ai faites jusqu'ici, s'accordent si peu avec les conclusions de M. de Volney sur le climat de Washington, et je suis si peu disposé à hazarder des assertions contre un auteur rénommé, dût il en avoir donné lui-même l'exemple, que je préfère prendre l'engagement de continuer mon travail et de redoubler d'attention dans mes recherches, que de risquer soit de l'imiter, s'il a ete trop hardi dans ses conjectures, ou de ne pas lui ressembler, s'il a bien observé, ce qu'il dit avoir examiné.

Je viens aprésent aux resultats que fournit le calcul de mes observations :

Le Tableau, No. 1, contient :

1. Les températures moyennes de chaque mois.
2. Les températures moyennes *à midi*, pendant chaque mois.
3. Le *maximum* de la température, le jour et à l'heure où il fut observe, chaque mois.
4. Le *minimum* de la température, le jour et à l'heure où il fut observe, chaque mois.
5. (Dans une colonne suivante, on trouve la différence des deux quantités précédentes.)
6. La hauteur moyenne du baromètre pendant chaque mois.
7. Le *maximum* de la hauteur de la colonne barométrique, (jour et heure.)
8. Le *minimum* de la hauteur de la colonne barométrique, (jour et heure.)
9. (Dans la colonne suivante, on trouvera la différence du *maximum* et du *minimum*.)
10. Moyenne des observations hygromètriques faites avec l'hygrometre de Saussure, pendant chaque mois.

11 & 12. *Maximum* et *minimum* des observations hygromètriques et difference de ces quantités.

Ces résultats offrent un fait remarquable : pendant les mois de Mai, Juin, et Juillet, *la moyenne température du mois* était à fort peu près égale à la *temperature moyenne du mois précédent, à midi.*

	Température moyenne du *mois*. Centigrade.		Température moyenne à *midi*. Centigrade.
Mai	21,9	Avril	21,2
Juin	24,0	Mai	25,0
Juillet	27,1	Juin	26,6

Voici les différences des moyennes des mois :

1823.	Mai	2,1
	Juin	3,1
	Juillet	0,6
	Août	4,5
	Septembre	8,7
	Octobre	7,1
	Novembre	2,3
	Décembre	1,3
1824.	Janvier	
	Février	2,7
	Mars	5,1

La plus grande différence est entre Octobre et Septembre, et la plus petite entre Août et Juillet. J'exclus la différence des mois d'Avril et Mai, et celle d'Avril et de Mars, parceque j'ai commencé et fini mes observations le 17 Avril.

La moyenne des températures à midi de deux mois successifs, ne diffèrent souvent que d'un petite quantité.

	Difference.
Mai / Juin	1,6
Juillet / Août	0,1
Décembre / Janvier	0,7

La plus grande différence est entre Novembre et Octobre.

Le *maximum* de la hauteur du mercure dans le baromètre était généralement au matin. En Janvier, ce *maximum* a été observé à 4 heures du soir.

Le *minimum* a été observé, le soir, pendant 9 mois.

Ce tableau prouve, qu'à Washington la marche du baromètre est loin d'être aussi régulière que sous les tropiques.

Les observations faites avec l'hygromètre de Daniell sont en trop petit nombre pour être réduites à une moyenne. Je me propose de faire une suite régulière d'expériences avec cet instrument, dont M. le Professeur Schumacher continue, si je ne me trompe, à faire usage, et qui se prête, mieux, que celui de Saussure, à la decouverte de plusieurs faits météorologiques. Sa construction est décrite dans les Nos. 16 et 25 du "*Journal of the Royal Institution.*" Les observations, ou plutôt les expériences, que j'ai faites avec cet instrument, ont été calculées, au moyen des Tables de Mr. Daniell. Cet hygromètre soumet le physicien, qui s'en sert, non seulement à un travail plus long qu'aucun autre instrument météorologique, mais à une dependance de bons laboratoires de chimie, quelquefois fâcheuse pour ses recherches. J'ai eu la plus grande peine de me procurer, à Washington, de l'éther d'une qualité convenable à ces experiences. Dans un long voyage, à travers un pays encore peu habité, cet instrument ne serait, par cette raison, d'aucun usage. Mais, excepté cette difficulté, il mérite la préférence sur celui de Saussure, qui est plus sujet à se déranger, et dont les irregularités ne sont le plus souvent reconnues, que lorsque l'on est forcé à remplacer le cheveu, et à recommencer les expériences qui servent à determiner les deux termes extrêmes de l'échelle hygrométrique. L'instrument dont je me suis servi, et qui m'a ete fourni par M. Fortin, ayant éprouvé ce dérangement, l'artiste qui s'est chargé de le réparer, n'a pu, malgré les plus grands soins, faire parvenir quelques cheveux lescivés par M. Fortin, qu'à 10°, lorsque l'instrument devait être au *maximum* de la sécheresse.

Les observations hygrométriques faites avec l'instrument de M. Saussure, montrent la grande humidite dont l'atmosphère de Washington est chargée, pendant une grande partée de l'année. Mais le *minimum* a été presque observe dans le même mois (Juin,) que le *maximum*, (96°,5 et 46,°5). Le *minimum absolu* a été trouvé le 28 Octobre, à 4 heures (42°,0). En Novembre (le 7.) à 4 heures, l'hygromètre était exactement au milieu de l'échelle (50°). Le 25 Août, à 4 heures, l'instrument était à 50°.5. L'accident dont j'ai parlé plus haut, m'a empêché de continuer les observations hygrométriques pendant les mois de Janvier, Février, et Mars, et la première moitié d'Avril.

	Fahrenheit.	Difference
Moyenne de la température pendant l'année	58°.5	
Moyenne pendant l'été	67°,5	19°,6
Moyenne pendant l'hiver	47°,9	

	Pouces anglais.	Difference
Hauteur moyenne du baromètre pendant l'année	29,922	
Hauteur moyenne pendant l'été	29.910	0,016
Hauteur moyenne pendant l'hiver	29,926	

D'après un tableau météorologique de M. Josiah Meigs, ancien employé du "*General Land Office*," la température de Washington, pendant l'année 1820, était 55°,02, Fahr.

Voici un tableau comparatif de la température de Washington, pendant les 7 derniers mois de 1820 et 1823 :

	Observations de Mr. Meigs en 1820. Fahrenheit.	Observations faites en 1823. Fahrenheit.
Mai	63°,35	71°,4
Juin	72°,34	75°,2
Juillet	78°,81	80°,8
Août	75°,71	79°,7
Septembre	67°,44	71°,6
Octobre	51°,61	55°,9
Novembre	42°,43	43°,2
Décembre	34°,95	39°,0

Il resulterait de cette comparaison, que la température a été généralment plus élevée, pendant les mêmes mois en 1823, qu'en 1824. Mais avant d'en venir à cette conclusion, il faudrait être sur que les observations ont été faites avec la même précision, et avec de bons instruments, qui seuls sont comparables. D'ailleurs, les observations thermomètriques dépendent tellement de l'endroit ou les instruments sont fixés, de leur emplacement par rapport aux vents les plus dominants et des heures où l'on observe, que leurs résultats ne peuvent être admis comme des données comparatives, que lorsque le physicien, qui entreprend de les rapprocher, peut être sûr qu'elles ont été faites d'après une méthode à peu près uniforme.

Ces conditions sont toujours remplies suffisamment, lorsque l'on a le bonheur de comparer des observations que l'on sait avoir été faites avec une scrupuleuse exactitude, avec celles qui viennent d'un astronome pratique. J'ai l'intime conviction que le travail météorologique, publié chaque ann(e, dans l'Almanac de l'Académie des Sciences de St. Pétersbourg, ne laisse rien à desirer.

Les observations sont faites par M. de Wisniewsky, astronome-adjoint de l'Observatoire Imperial et un des savants, à qui la gèographie a le plus d'obligations, pour ce qui concerne la Russie. Il m'est doux de rapprocher mes recherches du travail de ce savant, qui a dirigé mes etudes dans l'astronomie pratique, et à qui j'aimerai à rapporter le fruit de tous mes efforts dans les sciences.

En 1820. *Maximum* de la témperature observe à St. Pétersbourg, le 26 Juillet (7 Août,) à midi, 20,5 de Reaumur=78.1 de Fahrenheit.

En 1822. *Maximum* de la température observe à St. Pétersbourg, le $\frac{3}{15}$ Juillet, à midi, 23,6, R.=85,1, F.

En 1823. *Maximum* de la température observe à Washington, le 16 Juin, a midi, 95,9, F.

En 1820. Le plus grand froid à St. Pétersbourg, le
6
— 18 Janvier, au soir, —25,4, R.=—
18

En 1823. Le plus grand froid à St. Pétersbourg, le 30 Décembre 1822, (11 Janvier 1823,) —14,2=—0,2.

En 1824. Le plus grand froid à Washington, le 2 Février à 7 heures, +11,3, F.

En 1820. *Maximum* de la hauteur du baromètre observé à St. Pétersbourg, le $\frac{7}{19}$ Décembre, $29^{p.}$,16 de Paris.

En 1823. *Maximum* observé à St. Pétersbourg, le 22 Décembre 1822, (3 Janvier, 1823,) $29^{p.}$,15 de Paris.

En 1823. *Maximum* de la hauteur du baromètre, observé à Washington, le 29 Novembre, à 9 heures du matin, 30,603 pouces anglais,=$28^{p.}$ $8^{l.}$,55 de Paris.

En 1820. *Minimum* de la hauteur du baromètre observé à St. Pétersbourg, le 18 Novembre, à midi, 26^{p},97 de Paris.

En 1822. *Minimum* de la hauteur du baromètre observé à St. Pétersbourg, le 27 Février, au matin, $27^{p.}$,06 de Paris.

En 1824. *Minimum* de la hauteur du baromètre observé à Washington, le 25 Janvier 1824, à 4 heures, 29,217 pouces anglais,=$27^{p.}$ $4^{l.}$,78 de Paris.

Les observations ont été faites à l'Observatoire de St. Pétersbourg, 3 fois par jour :

	Pouces de Paris
Moyenne tirée des 1098 observations faites pendant 1820	28,509
Moyenne des 1095 observations faites pendant 1822	28,180
Moyenne des observations faites à Washington, depuis le 17 Avril 1823 jusqu'au 17 Avril 1824	28 $0^{l.}$,66

J'aurai l'honneur de fournir a la Société Philosophique une traduction des autres résultats météorologiques, contenus dans les Almanacs de l'Académie des Sciences de St. Petersbourg des années 1820 et 1822.

Le tableau *de l'état de l'atmosphere* n'est pas fait avec une exactitude comparable à celle des autres parties de ce travail. Le langage adopte en Angleterre pour depeindre l'aspect du ciel et la forme des nuages ("*prevailing clouds,*") n'est pas encore assez universel, pour que je puisse beaucoup regrèter de ne pas m'y être conformé. Je ne prétends pas, non plus, que le Tableau No. 2, montre exactement le nombre de jours où certains vents ont règné à midi. Quelques mois d'observations m'ont trop appris combien les marées atmosphériques sont variables sur les bords du Potomac; j'ai vu trop souvent les vents parcourir, en peu d'heures, tous les points du compas, pour que je puisse me promettre des résultats très instructif de la direction des vents à une certaine heure de jour. Avant de suivre, avec plus d'attention, cette partie de la météorologie, je désirerais savoir, si *midi* qui, si je ne me trompe, est l'instant auquel sont rapportées les observations sur les vents, faites en Europe, par des astronomes, est le plus convenable dans un lieu où les vents sont si extrêmement variables.

Ayant été absent de Washington, depuis le milieu de Septembre jusqu'aux premiers jours de Novembre, je suis moins à même de garantir les observations pour cet intervalle du tems, que si je les avais faites ou si je les avais, du moins, surveillées. Mais je crois avoir été, à cet égard, aussi bien servi que l'on peut l'être : et mes regrêts de n'avoir pas pu suivre sans interruption ce travail, sont effacés par le souvenir des liaisons que j'ai formées, pendant mon séjour à Philadelphie et les impressions profondes que m'ont laissées mes entretiens avec les savants, de qui je pouvais plus aisément obtenir des lumières, qu'il ne n'est possible de leur en fournir, malgré tous mes efforts.

Philadelphie, 4 Mai, 1824.

TABLEAU.—No. 1.

Thermomètre.

1823 & 1824. Mois.	Température moyenne. Centigrade.	Température moyenne. Fahrenheit.	Température midi. Centigrade.	Température midi. Fahrenheit.	Maximum de la température. Jour.	Maximum de la température. Heure.	Maximum de la température. Centigrade.	Maximum de la température. Fahrenheit.	Minimum de la température. Jour.	Minimum de la température. Heure.	Minimum de la température. Centigrade.	Minimum de la température. Fahrenheit.	Différence. Centigrade.	Différence. Fahrenheit.
	+													
Avril.	18,2	64.	[illegible]	70,[illegible]	le 21	à 10 h.	25,5	77,9	le 28	à 10 h	10,0	50,0	15,5	27,9
Mai.	21,9	71	25,0	77,0	le 20	à 4 h.	33,8	92,8	le 5	à 8 h.	8,0	46,4	25,8	46,4
Juin.	24,0	75	26,6	79,9	le 16	à 12 h.	35,5	95,9	le 1	à 6 h.	10,0	50,0	25,5	45,9
Juillet.	27,1	8[illegible]	[illegible],4	8[illegible]	le 12	à 4 h.	34,7	94,5	le 23	à 6 h.	17,7	63,9	17,0	30,6
Août.	26,5	7[illegible]	[illegible]8,3	82,[illegible]	le 8	à 4 h.	35,0	95,0	le 24	à 6 h.	14,7	58,5	20,3	36,5
Septembre.	22,0	71	[illegible]	73,[illegible]	le 7	à 12 h.	31,7	89,1	le 27	à 6 h.	10,5	50,9	21,2	38,2
Octobre.	13,3	55	[illegible]5,9	60,6	le 5	à 12 h.	25,3	77,5	le 19	à 6 h.	—0,7	30,7	26,0	46,8
Novembre.	6,2	4[illegible]	7,4	45,[illegible]	le 22	à 4 h.	15,7	60,3	le 30	à 7 h.	—4,0	24,8	19,7	35,5
Décembre.	3,9	39	[illegible],2	45,[illegible]	le 31	à 4 h.	16,7	62,1	le 10	à 7 h.	—4,1	23,9	20,8	38,2
Janvier.	5,2	41	[illegible],9	44,4	le 11	à 4 h.	20,0	68,0	le 25	à 7 h.	—5,2	22,6	25,2	45,4
Février.	2,5	36	4,9	40,8	le 11	à 5 h. 30′	18,0	64,4	le 2	à 7 h	—11,5	11,3	29,3	53,1
Mars.	7,6	45,	10,2	50,4	le 5	à 4 h.	19,0	66,2	le 1	à 7 h.	—3,7	25,3	22,7	43,5
Avril.	15,1	55,[illegible]	[illegible]	[illegible]9,0	le 11	à 4 h.	23,7	74,7	le 2	à 9 h.	+4,5	40,1	19,2	34,6
De l'année.	14,7	58	[illegible],8	62,2										
De l'été.	19,7	67	[illegible],1	71,8										
De l'hiver.	8,85	47	10,7	51,[illegible]										

Baromètre.

1823 & 1824. Mois.	Hauteur moyenne. Millimètre.	Hauteur moyenne. Pouces anglais.	Maximum de la hauteur. Jour.	Maximum de la hauteur. Heure.	Maximum de la hauteur. Millimètre.	Maximum de la hauteur. Pouces anglais.	Minimum de la hauteur. Jour.	Minimum de la hauteur. Heure.	Minimum de la hauteur. Millimètre.	Minimum de la hauteur. Pouces anglais.	Différence. Millimètre.	Différence. Pouces anglais.
Avril.	0,7637	30,068	le 29	à 7 h	0,7713	30,367	le 21	à 3 h.	0,7526	29,631	0,0187	0,736
Mai.	0,7612	29,969	le 26	à 8 h.	0,7687	30,265	le 4	à 8 h.	0,7503	29,540	0,0184	0,725
Juin.	0,7607	29,950	le 12	à 8 h.	0,7691	30,280	le 8	à 4 h.	0,7534	29,662	0,0157	0,618
Juillet.	0,7600	29,922	le 6	à 9 h.	0,7691	30,280	le 18	à 12 h.	0,7462	29,379	0,0229	0,901
Août.	0,7609	29,957	le 25	à 6 h	0,7698	30,307	le 8	à 4 h.	0,7502	29,536	0,0196	0,776
Septembre.	0,7619	29,996	le 3	à 12 h	0,7760	30,552	le 7	à 4 h.	0,7521	29,611	0,0239	0,941
Octobre.	0,7609	29,957	le 1	à 6 h.	0,770[illegible]	30,33[illegible]	le 9	à 12 h.	0,7541	29,690	0,016[illegible]	0,642
Novembre.	0,7646	30,103	le 29	à 9 h.	0,7773	30,603	le 26	à 4 h.	0,7552	29,733	0,0221	0,870
Décembre.	0,7651	30,123	le 26	à 9 h	0,7762	30,560	le 19	à 7 h.	0,7505	29,548	0,0257	1,012
Janvier.	0,7513	22,580	le 8	à 4 h.	0,7729	30,430	le 25	à 4 h.	0,7421	29,217	0,0308	1,213
Février.	0,7610	29,961	le 13	à 12 h.	0,7764	30,568	le 11	à 5 h 30′	0,7447	29,320	0,0317	1,248
Mars.	0,7542	29,694	le 21	à 9 h.	0,7726	30,418	le 28	à 4 h.	0,7523	29,619	0,0213	1,099
Avril.	0,7575	29,824	le 3	à 7 h.	0,7647	30,107	le 12	à 4 h.	0,7435	29,273	0,0212	0,834
De l'année.	0,7600	29,922										
De l'été.	0,7597	29,910										
De l'hiver.	0,7601	29,926										

Hygromètre de Saussure.

1823 & 1824. Mois.	Moyenne.	Jour.	Heure.	Maximum.	Jour.	Heure.	Minimum.	Différence.
Avril.	73,1	le 30	à 3 h.	94,0	le 30	à 7 h	55,0	39,0
Mai.	71,0	le 13	à 8 h.	95,0	le 4	à 8 h	48,0	47,0
Juin.	77,7	le 8	à 7 h.	96,5	le 11	à 12 h	46,5	50,0
Juillet.	76,5	le 2	à 6 h	95,0	le 12	à 4 h	55,5	40,5
Août.	74,5	le 11	à 12 h	88,0	le 25	à 4 h	50,5	37,5
Septembre.	77,6	le 11	à 9 h.	89,5	le 30	à 4 h	46,0	43,5
Octobre.	69,7	le 5	à 9 h	88,0	le 28	à 4 h.	42,0	46,0
Novembre.	64,2	le 7	à 12 h.	92,5	le 13	à 4 h.	50,0	42,5
Décembre.	79,5	le 19	à 12 h.	91,0	le 1	à 12 h.	67,0	24,0

TABLEAU.—No. 11.

TABLEAU

De l'etat de l'atmosphère à Washington, du 18 Avril 1823 au 17 Avril, 1824.

Mois.	Nombre des Jours des divers changements.									Vents.								
	Beau temp.	Temps couvert	Temps pluvieux.	Temps orageux	Eclairs et Tonnère.	Brume.	Neige.	Gelée blanc	Forte gelée	du Nord au N. E.	du N. E. à l'E.	de l'E. au S. E.	du S. E. au Sud.	du Sud au S. O.	du S. O. à l'O.	de l'O. au N. O.	du N. O. au Nord	Calme.
Avril, 13 jrs.	6	4	2	1	"	"	"	"	"	1	2	1	"	8	"	1	"	
Mai, . .	14	17	7	5	1	"	"	"	"	5	"	3	5	5	1	6	6	
Juin, . .	14	16	5	6	1	"	"	"	"	4	1	2	9	"	3	"	4	
Juillet, .	17	10	4	4	2	"	"	"	"	3	"	8	7	1	"	2	7	
Août, . .	20	7	4	3	2	"	"	"	"	6	3	4	10	2	1	1	4	
Septembre,	15	11	4	2	"	"	"	"	"	3	3	6	3	"	"	2	11	
Octobre, .	22	5	3	"	"	1	"	"	"	7	3	4	6	"	"	1	8	
Novembre,	16	8	7	"	"	2	2	4	1	7	1	7	3	"	1	1	10	
Decembre, .	22	5	3	"	"	1	1	2	3	7	1	9	1	"	"	1	9	
Janvier, 1824	17	4	5	2	"	2	1	"	1	4	5	"	1	6	"	1	10	
Fevrier, .	15	11	4	1	"	"	4	1	1	1	5	"	7	1	3	4	4	
Mars, .	11	13	5	1	1	1	1	"	"	5	4	5	3	1	1	3	6	
Avril, 17 jrs.	10	6	3	"	"	"	"	"	"	"	1	"	3	3	2	"	8	
Recapitulation,	199	118	56	24	7	7	9	7	6	53	29	44	58	27	[illegible]	25	87	32

No. XIV.

On the Language, Manners, and Customs of the Berbers, or Brebers, of Africa. Communicated by William Shaler, Consul of the United States at Algiers, in a Series of Letters to Peter S. Du Ponceau, and by the latter to the Society.—Read at different times.

I.

Letter from Peter S. Du Ponceau to the President of the Society.

Philadelphia, 15th September, 1823.

Dear Sir,

I have the pleasure of enclosing to you a communication which I have received from William Shaler, Esq. Consul of the United States at Algiers, on the subject of the Berbers of Africa, and particularly of their language. I beg you will be so good as to lay it before the Society at their next meeting.

The Berbers, as is well known, are a white race of men, who inhabit the chain of Mount Atlas, and extend to the borders of the Desert of Sahara. To the north of them are the Bedouin Arabs, and still farther north are the Moors, whose dominions line the south western coast of the Mediterranean. The country of the Berbers is considered as included within those dominions, but the Moorish governments have not yet succeeded, nor probably ever will succeed, in reducing these tribes to a state of complete subjection. Although the greatest part of them follow the practices of the Mahometan religion, yet like our ultra-Mississippian Indians, they live in a state of savage independence, occasionally submitting to, but never acknowledging, the supremacy of their nominal masters.

These people are divided into four principal nations or large tribes: 1. The Amazirg, who inhabit the dominions of the Emperor of Morocco; their language is called *Shilha*. 2. The Kabyles, to the eastward in the territories of Algiers and Tunis, and whose language is called *Showiah*. 3. The Tuarycks, in middle Africa, south westward of the kingdom of Fezzan. 4. The Siwahs, to the East, extending to the frontier of Egypt. These inhabit the Oasis of the same name where is supposed to have been the oracular temple of Jupiter Ammon.

Some authors have considered the Tibbo as a part of the Berber nation; they live to the south east of Fezzan, and are believed to be the remains of the ancient Troglodytes mentioned by Herodotus. They, in fact, live in caves like their ancestors. But they are a coloured race, approaching in the shape of their features to the Negroes, although they do not exactly resemble them. Nor have we yet any specimen of their language, at least that I know of. It seems premature, therefore, to include them within the general denomination of Berbers.

The Amazirg and the Kabyles were the only people of this extended nation known to the world,—the former by means of the travels of George Hoest, a Dane, and the latter by those of Dr. Shaw, until Mr. Hornemann, who, in the years 1797 and 1798, travelled from Cairo to Mourtzouk, the capital of Fezzan, in the employment of the English Society for exploring the interior of Africa, became and made us acquainted with the Siwahs and the Tuarycks, and disco vered that the Shilha and the Showiah, the idioms of the Amazirg and Kabyles, were with little difference the same.

Mr. Hornemann having sent a scanty vocabulary of the Siwah dialect to Sir Joseph Banks, the late President of the Royal Society of London, it was by him communicated to the learned William Marsden, who, after comparing it without success with various oriental and other languages, at last bethought himself of comparing it with the language of the Amazirg, which is called Shillah by the Arabs, and by themselves Amazirg, and to his great surprise and delight, he found a very great affinity between those two idioms, so much so, that he did not hesitate to express his opinion, "that the languages of those countries of Siwah and Shillah, distant from each other by the whole breadth of Africa, were one and the same; whence he presumed that the Shillah or Berber extends across the whole African continent, in a direction between the Negro dialects on the southern side, and the Moorish or Arabic of the Mediterranean coasts, and that it was the language of the whole of northern Africa before the period of the Mahometan conquests."

This hypothesis being once afloat, other philologists set themselves to work, and made profound researches to destroy or confirm it: the latter conclusion appears to have been the result of their investigations. The celebrated Vater, whose profound learning is only equalled by his astonishing sagacity, discovered this ancient African language in that of the Guanchos, who still inhabit the Canary Islands, of which they are considered as the aborigines. He traced also in it some affinity with the Amharic and Coptic, but not sufficient to lead to a satisfactory result.

Yet this interesting phenomenon of one nation and one language, extending across Africa from the Canary Islands and the coast of the Atlantic Ocean to the Red Sea, is only evidenced by about twelve words of the Shillah and Siwah dialects compared together by Mr. Marsden, by a lesser number compared by Vater with that of the Guanchos, and by the assertion of Hornemann that the Tuaryeks speak the same language with the Siwahs. It is clear, that however plausible these proofs may appear, the subject still requires further investigation.

With this view, understanding last year that Mr. Shaler was about to return to his consulate at Algiers, and knowing him to be a zealous friend of the sciences, and at the same time possessed of such mental qualifications as fit him for their pursuit, I prevailed upon him, (not without difficulty, however, on account of his great diffidence,) to devote part of his time to the investigation of the history, manners, and customs of the Berbers, and particularly of their language, in order that the hypothesis of Mr. Marsden and Professor Vater might be brought to a surer test than has been done heretofore. The enclosed communication contains the first fruits of his labours, and we may expect hereafter something more important, which I shall not fail successively to communicate. I have thought that the Society would not consider as devoid of interest, a subject that has attracted the attention of the most learned philologists of Europe.

The Society will easily perceive that the study of this language has not only in view the gratification of philological curiosity, but that it is an interesting object to trace, if possible, through it, the history and origin of this extraordinary people. On this subject there are various opinions among the learned. Mr. Marsden, and with him Mr. Langles, is of opinion that the Berber is a corrupted remnant of the Punic, while Professor Vater, with more probability, is inclined to consider it as the ancient Numidian, altered in a degree by intermixture with other idioms and particularly the Arabic. The reasons that he gives for not thinking it to be the Phenician are very strong, and in my opinion conclusive. He observes that the language of the Carthaginians was not far spread into the interior of Africa, and that they were obliged to learn the Libyan language (as it was called) as well as their own, whence they were called by the poets *bilingues*,* *migdibiles* or *migdolibes*, and *bisulcilingues*. The first

* "Domum timet ambiguam, Tyriosque bilingues."—Virgil

and the last expression might have been metaphorical, and intended to express their alleged moral duplicity, but *migdolibes*, an epithet applied to them by Plautus, could hardly have been so, as it implies a mixture of nations or languages. Indeed, it is not probable, that the comparatively small number of Phenicians who settled themselves on the northern coast of Africa could have introduced the use of their language far into the interior of the country: on the contrary, it is astonishing that they themselves preserved it so long as they did; for it was still in use at the time of the Vandalic War, as we are informed by Procopius. And when we see a language extending itself from the Atlantic coast almost to the Red Sea, we cannot presume it to be that of a foreign colony, whose dominions never extended to that distance.

It is therefore more natural to suppose that the language of the Berbers is that of the ancient inhabitants of the country between the sea and the desert, who have been driven back by successive conquerors into the mountains. Mountainous countries are known to be the repositories of ancient languages, of which a stronger example cannot be given than that of the Basque, which has existed for so many centuries in the Pyrenees and their vicinity. When we consider the peculiar structure of that language, we cannot entertain a doubt of its antiquity, and it may be reasonably presumed that it was once spoken in various dialects throughout the western part of Europe. The late investigations of the Baron William von Humboldt* have gone far towards proving this supposition; but more and still stronger proofs of it are yet to be and no doubt will be obtained. The examination of the numerous traces of it which Larramendi† has found in the ancient and modern languages of western Europe requires to be farther pursued.

But to return to the Berber. Mr. Marsden thinks that he

* Prüfung der Untersuchungen über die Urbewohner Hispaniens, vermittelst der Vaskischen Sprache.

† See the Introduction to his *Diccionario trilingue*. St. Sebastian, 1745.

has perceived in it, independent of the Arabic words that it contains, some strong affinity to the oriental languages which the German philologists call *Shemitic*, and hence he concludes it to be the ancient Carthaginian. But Mr. Marsden does not tell us in what that affinity consists, and has exhibited no specimens to satisfy us on this point. Of the grammatical forms of this idiom we know too little, to be able to form a satisfactory comparison. We must wait until Mr. Shaler shall have pursued his inquiries farther on this interesting subject. His present communication offers but few specimens of grammatical forms. There is one, however, which appears to deserve particular attention, as it bears a strong affinity to those curious discriminating forms which prevail in the languages of our American Indians. It seems that *Tamtolz* in the Showiah is the word commonly used to signify "a woman," but if the speaker is addressing several women being in the same place, he makes use of the word *Khaleth*. A form analogous to this exists in the language of the Cherokees, in which the dual number of the verbs varies its inflections, according as those to or of whom one is speaking are present or absent. My learned friend Mr. Pickering has now in the press a grammar of this language; I shall not therefore anticipate upon the interesting information we may expect to derive from it.

If Mr. Shaler's communication contained but this simple fact, he might be said to have made a valuable addition to the Philological Science. But his vocabularies are important, inasmuch as they confirm the opinion before entertained, that three at least of the Berber idioms, the Shilha, Showiah, and Siwah, are dialects of the same general language. The Shilha and Siwah had been compared by Mr. Marsden, and the vocabularies that we possessed of the Showiah, though not very extensive, showed a strong similarity between it and the two others. Mr. Shaler has carried the proof farther as will appear from the following words, found only in his vocabularies, and which bear an incontestable affinity to the same words in the Siwah, as given us from Hornemann by Mr. Marsden:

	Showiah of Shaler.	Siwah of Hornemann & Marsden
Beard,	Tamert,	Itmert.
Bread,	Agrom, Agarom,	Tagora.
Dates,	Theganee,	Tena.
House,	Ackham,	Achben.
Sheep,	Ouly,	Jelibb.

Thus we have accumulated proofs that three nations residing at opposite ends of the peninsula of Africa speak dialects of the same language, radically different from those which surround them, and peculiarities have begun to be observed in its grammatical forms, which lead to the conclusion that this must be an original idiom, which once extended over a much larger surface of country. That the Tuarycks, who reside between these nations, speak a similar dialect, we are informed by Mr. Hornemann, who no doubt had it from good authority, but we have not yet the means of instituting an actual comparison. Of the Tibbo we know nothing, but that this people exists, and that it differs in colour and features from the other Berbers, and therefore probably in language. It is to be hoped that intelligent travellers will add to the stock of our information respecting them. I expect much from Mr. Shaler's inquiries and exertions, particularly if this Society should feel an interest in his researches.

In order to make Mr. Shaler's vocabularies more useful, I have arranged them in alphabetical order in a tabular form, and have added in a separate column the vocabulary of the same language (the Showiah) by Dr. Shaw. What farther information I have received from Mr. Shaler, not contained in his letters, I have subjoined in the form of notes, and from a wish to make this communication as complete as possible on the subject of which it treats, I have translated from the Mithridates Professor Vater's account of the grammatical forms of the Berber, with the Lord's Prayer, in the Shilha dialect, from Jezrael Jones' Dissertation* upon that language, which is also found in the Mithridates, and have inserted them at the end of the communication.

I am, with great respect and esteem,

Dear Sir,

Your most obedient servant,

Peter S. Du Ponceau.

II.

Extract of Letters from William Shaler, Esq. Consul of the United States at Algiers, to Peter S. Du Ponceau.

21st January, 1823.

On making inquiry concerning the *Bisearies*, of whom you wished to obtain some precise information, I find that they do not possess an original language, but use a dialect of the Arabic. I have made some progress in obtaining a vocabulary of the language of the *Kabyles*, (so named from an Arabic word which signifies a "tribe," and is therefore applicable in that sense to every separate horde in Africa,) and it is my intention to extend it as far as I can. By an occasion for Marseilles, I will transmit to you the result of my inquiries on this subject. In the words which I have collected, I discover several which are evidently Arabic, such as *father*,

* Jezr. Jones—*Dissertatio de Lingua Shilhensi*, in the work entitled, *Dissertationes ex occasione Sylloges Orationum Dominicarum Scripta ad Johan. Chamberlaynium.* Amstel. 1745. This book, it is believed, is not in this country.

mother, *son*, *daughter;* and *Adrar*, mountain, that corresponds exactly with the *Siwah* and *Shilha* of Hornemann and Marsden. I have two other words of the short list of the latter, viz. sun, *Jetig*, and cow, *Tesley*, which are entirely different. In *Jetig* the *J* has the sound of the Spanish *Jota*. Respecting the *Biscaries*, as they have no language to investigate, I can only repeat what I have heretofore said, that their appearance and manners are purely African, while the *Kabyles* resemble in both the peasantry of the north of Europe.

15th February. I herewith have the pleasure of transmitting to you a beginning of a vocabulary of the language of the Kabyles of this kingdom. I have had the good fortune to interest in this pursuit a Swedish gentleman attached to the consulate of his nation here, who is a man of considerable regular instruction and possesses some knowledge of the Arabic. His translations are given by him in English, and in addition to the lists of words, he has given me many valuable explanations. My other co-adjutor is an intelligent Hebrew, well acquainted with the Arabic, but with whom I communicate in French. I trust that in future I shall be able to explain the discrepancies which are found between the two lists. I have already an impression that they arise in a measure from the abundance of the language. At present I send them as I received them, not daring to trust myself with making any correction in either; for the sounds are probably recorded as they struck the ear respectively: it is also probable that our alphabet is unequal to rendering the exact pronunciation of this language. You will remark, however, that they are both sufficiently distinct to prove its identity with the vocabularies of Hornemann and Marsden. Then it appears to me established beyond a doubt, that this language is spoken by the inhabitants of the mountains of Morocco, (*Shillah* of Marsden,) at the Oasis of Jupiter Ammon, (*Siwah* of Hornemann,) and by the *Tuaryeks*, who are represented by Hornemann as a great and powerful people, extending to the neighbourhood of Tombuctoo. Captain Lyon speaks of them in the same manner, and adds that they are proud of the antiquity of their language, which, they say, was spoken in preference to any other by *Noah.* Thus this language is spoken in several vast regions of Africa, by nations who exhibit traits of original character and resemblance with each other both physical and moral, as I shall presently notice. Shaw remarks that the language of the mountaineers of Morocco is termed *Shillah*, and that of this country *Showiah*, of the derivation of which terms, he says, they are ignorant; but as these languages are essentially the same, they may be denominated tribes of a common origin. I cannot refrain here from lamenting that so accomplished a scholar as Dr. Shaw, who resided twelve years in this country, should have devoted so little of his time to philological research. For ought I can discover, the Teutonic origin of the Kabyles must be abandoned as indefensible; but being on the spot, I will venture to hazard a few observations, which, if they should prove to be founded, would tend to remove the antiquity of their origin into the night of time, and perhaps discover this language to be that which you are in search of. The Kabyles of north Africa are a white people, they invariably inhabit the mountains where they maintain their independence, and probably have never been completely subjected by any of the conquerors who have at different periods overrun this country. Each mountain usually forms an independent state, and they are often engaged in petty wars with each other, which are fomented by the Turks, who thereby sometimes succeed in extorting from them a precarious tribute; but since the days of Barbarossa, although some may have been exterminated, none have been entirely subjected to Turkish domination. Although the Kabyles are a very ingenious people, with the most tractable and social dispositions, they have not the commercial propensities of the Moors and Arabs. Independence appears to be the greatest object of their existence, as with it they cheerfully endure poverty in the most rigorous climates. Such, at least, is their actual political condition, and with such unequivocal marks of primitive originality of character, I think they may be regarded as a safe depositary of a language. From various causes, they may have thrown off their surplus population amongst their neighbours, and even sent out colonies in a country that does not appear to have ever been properly settled, yet under such circumstances, having no distinct religion of their own, they might easily enough accept that of their neighbours, where nothing was hazarded by it: at this day the Kabyles are regarded as very barbarians, both in the theory and practice of Islamism; there is a foundation in Algiers expressly for their instruction, which they receive *gratis*. From what is related of the Tuarycks by Hornemann and Lyon, they are also a white people, very numerous, brave, warlike, and of an independence of manners and deportment that displays a remarkable contrast with the servility in practice at the court of Fezzan. They inhabit vast regions intersected by desert, have little knowledge of Islamism beyond its forms, and in several districts they are pagans. It is not therefore a great stretch of credulity to believe that the Tuarycks are also an original unconquered people, and the depositaries of an ancient language, which being identified with that of the Kabyles, leads to the conclusion that it is one of the ancient languages of the world, which has withstood the conquests of the Phenicians, of the Romans, of the Vandals, and of the Arabs. As I have the authority of the learned Shaw for believing that this language is radically different from the Hebrew and the Arabic, I think the premises justify this conclusion, though it would certainly be more interesting to discover the language of Sanchoniaton than the Numidian. This question, however, must be left to the decision of the learned, when its vocabulary is made more complete, and a greater insight is obtained into its grammatical forms.

N. B.—Accident, to which we owe almost every thing in this barbarous land, has lately discovered that there is a periodical caravan from Oran to Tombuctoo, under the auspices of a Sheik in the neighbourhood of Sahara, who is independent of this government. This personage is expected to visit Oran this ensuing spring, and through my Jewish friend, I have taken measures to obtain all the information that can be procured relative to this interesting fact, which may lead to the most important discoveries. I really wish that our government would determine to educate a youth here, through whom, when well instructed, and under able direction, we might take our share in the honourable task of unrolling the records of time. He might, through such recommendations as the government might command, learn the rudiments of the Hebrew and Arabic in the Oriental School of Paris, and then come here and acquire a perfect familiarity with the dialects of this country. With such an instrument, if he should happen to be of the right stuff, there can be no conjecture as to what could be obtained.

20*th April.* I herewith transmit a continuation of the lists of words of the Kabyle language by the same persons. On examining in the works of *Chemin* and of *Ali Bey*, their vocabularies of the languages spoken by the inhabitants of Mount Atlas, to which they give the denomination of *Brebe*, I find that there can be no doubt of their identity with this. I shall, therefore, in future, consider this fact as established. If the same identity with the *Siwahan* and the *Tuaryck* were as well proved, the conclusion would be irresistible that this is one of the dialects of ancient Libya. You will of course remark the discrepancies between the two lists, and of both, in many instances, with the vocabulary of Shaw. Whether this arises from the ignorance of the persons questioned, who are common peasants, from there being several dialects of the same language, or from its own abundance, I cannot yet determine: for instance, the different words expressing *No*, which may possibly express different degrees of negation. I will endeavour to obtain all the information that is possible upon this subject.

There is a people inhabiting the Sahara, south of the country of the Biscaries, known by the name of the *Mozabis*, who have a commercial compact with this government, and maintain an *Amin* or resident here to take care of their interests. I am assured that these people speak a language totally different from any other in use here. Their trade with Algiers consists in dates, slaves, gold, ostrich feathers, &c. I am not so credulous as to believe without good authority for it, that they speak an original language; for I am informed they inhabit an Oasis in the desert, only three days journey from its northern border; a position where it appears to me they never could have maintained the independence necessary for the preservation of a language. I have taken measures, however, to obtain the best possible information on this subject.

5th May. I have just received some notions respecting the *Mozabis*, which I avail myself of an opportunity for Gibraltar viâ Oran, to communicate. My information is derived from a Jew who has commercial relations with these people. I gave him a list of words, and he brought me their interpretation, which I wrote down, as he spoke the words, as nearly as I could express the sounds with our English alphabet. This language, as you will remark, has an evident affinity with the Shillah, the Showiah, and the Siwahan, and is probably the Tuaryck. I wish I might be permitted to denominate the main stock the "Libyan." They are all certainly kindred dialects, but at present I dare not hazard any further speculation upon the subject. My Jew informs me that "*Mozabees*" is the Arabic translation of the Hebrew term "Beni Moab," or Children of Moab. They inhabit the desert, forty days journey from Algiers, the precise direction he could not inform me of. They dwell in five large towns, districts, I presume. as the same word in these languages is used to signify a town or a district of country. They say that they profess the Mohammedan faith, only from policy when here. Their own religion, which they say is not Islamism, they term the fifth of the world. They do not frequent the mosques in Algiers; they have a place of worship of their own in a mill. They say their forms of prayer are different from those of the Moslems. When they address the Divinity, they strip as naked as decency permits, and stand erect with one hand behind the back. They are a white people, very intelligent and keen in trade; they are very industrious, and are undertakers of all the baths and mills in Algiers. They are very clannish, they mutually assist each other, and inviolably keep each other's secrets. They never appeal to the Algerine tribunals for justice: all disagreements among themselves are amicably settled, or by their *Amin.*

Opportunities are so rare from here, Sir, that I determined to send you these notes just as I received them. I have taken measures to obtain further and more exact information respecting this interesting people, which I will not fail to communicate as occasions occur. My Jew assures me that not one of the enclosed list of words has any affinity with the Arabic. By the first convenient occasion I shall send you corrected duplicates of all I have before written upon this subject.

P. S.—On applying to major Rennell's map, I find that they have been measurably correct in stating the distance of the country of the Mozabees from Algiers, and that they must be the identical Tuaryeks. A wealthy merchant of this nation is to visit me in a few days, when I hope I shall be able to ascertain this fact, and possibly, in consequence, to solve a philological problem of the utmost importance.

10*th October.* From a *Thaleb* of the nation of the *Buri Mozaab* or *Mozabis*, I have learned that these people inhabit a district of the desert, surrounded by high, rugged, barren mountains, twenty days journey of a caravan south of Algiers; that the nation is formed of five towns or districts, viz. Gardica, Birigan, Wargala, Engensa, and Nadrama, each of which is governed by a council of notables, elected by the people. Theirs is a barren country, producing little else of value than dates. They have no intercourse with the interior of Africa, but through Gadamis and Tafilet. In their mountains there are mines of gold. They profess Islamism.

but the Arabic language is unknown amongst them, except by those who travel abroad. He appeared to be well acquainted with the Tuarycks, who, he said, were a formidable nation of robbers, inhabiting the desart, and speaking the same language as his nation. I showed him the coloured prints of the Tuarycks in Lyon's travels, which he named immediately, examined them attentively, and said they were a most perfect resemblance of that terrible people. I find the names of the districts composing this nation laid down in major Rennell's map between the thirty-first and thirty-third degrees of north latitude, which makes the distance shorter from here than that given me by my Thaleb, unless a day's journey of a caravan be only fifteen miles, and both are liable to error. I found this man reserved, and disposed to equivocate in his answers to my questions, as they all are, except the Kabyles, from some vague fear of committing themselves, and particularly with a consul. My dragoman came in during this interview, which completely disconcerted the Thaleb. I tried to verify with him the list of words which I had collected; he contradicted several of them, and gave me the Arabic terms in their stead! I have never been able to see again the Jew who first assisted me in forming a list of the words of this language, and who may probably entertain the same foolish apprehensions.

I am, &c.

WILLIAM SHALER.

III.

Vocabularies of the Language of the Kabyles.

A

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Apples	tefah		
Arm	afllus, *plur.* effassen	irril, *plur.* i-g'rallnik	
The Fore-arm		irilik	
The Upper-arm		tigeltzint	
Arms (weapons)	slahy		
Army	mhella	gassin, gasia	
Arrow	amezrig		
To Ascend	anally		
Ass	aghiul, agioul, *fem.* tagioult	agajæul	

B

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Bad	efah		defoual
Balloon		asenik	
Barley	tiemzin		themzee
Battle		æming'ry	
Bath	anessan		
To Be	akly		
Bean		ibbaun	*plur.* yibowne
Beard	tamert		
Bird	agtit	ægetit	
Blood		idæmen	
Body	trissa		jitta
Boy		akschisch	acksheesh
Little Boy		tivourt æmsien	
Bread	agrom	agaroni	agroume
Breast	chaboze		
Brother	eguia (my)		
Bull	azguir, *plur.* ezgarem		
Butter	aoi alkak		dahan
Butter-milk			swaagy

C

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Camel	elgom, *plur.* elogman	ælægamd	

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Cat		emshis, *fem.* temshist	
Cattle, flock of,	egenmy	*plur.* acktar	
Cheese	abagsy		ageese
City, town	elmelki	mourt	arsh
Cloak		abidy	
Coal		tirgith, *plur.* tirgin	
Cock		ejaset, *fem.* tejaset	
Corn	ynden	timesin	earden (wheat)
Country		mourt	
Cow	tesley	teffunest	

D

Dates	etmet		theganee
Daughter	elli	illi	
Day	ess, essa	ouess, wess	
Death	elmaut		
To Descend	ansoub		
To Dismount			erse
To Do	anih'dem		
Dog		ackashium	
Door		tivourt	
A little Door		tivourt æmsien	
To Drink	anesson		atsoue

E

Earth	elkaa	ækel	elkaa, tamout (The)
The Earth (world)		dunit	
To Eat	anousch	iætsch	aitch
Enemy	*plur.* ehaæan'ou	adou	
Eye	emizoquin, *plur.* atten	tet *plur.* etten	
Ewe (*brebis*)	tigsy	tiksy	

F

Face	akaæoum		woodmiss
Father	baba	baba	
Feet (The)			thareet
Fever	toulà		thaulah
Field	caha	zahal	
Figs	tazart, *plur.* etezart	tib zinzin, tib khazizin	
Fine, handsome		adjemi	

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Flesh	aksaum (meat)		aksoume
A Fool	emabout (a mad-man)		abeloule
Foreign country		mourtibadin	
Forest	emada tamazerit		
Fountain	elenser		thaw-went
Friend	*plur.* amiæaklıou	aou	

G

Garden		gennan	
Girl		tackschist	taksheesh
A little Girl		tackshist tæm-sient	
To Give	adakfka		ouse
Goat	*fem.* tagat	tagat	
Good	ellaly		illaaleh
Grapes	tezarin	tisurin	thezaureen
Grass	tuga	tuga	
Great	amekran		amoukran (a great man, a master)

H

Hand	elcouffa, *plur.* el-couffation	*plur,* effus	
To Hate	kraaht		
To Have	gory		
Head	akirouy	akaroy	louse
Heart			oule
Heaven			tigenoute
Hell	ouzal		
Here			akyth
Hill		timmery	
Hillock	tissaunt		
Honey	tament		thament
Horn		isch	
Horse	hadin, *plur.* ea-dioum	audin	aowde, yeese
House	akam	ackham, ækahan	akham

I

Jackall		oushin	
Ice	egris	ægris	
Iron			ouzail
It (something)			ikra

L	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Lamb		isimur	
Land		ærmel	thamurt
Lance		ægerget	
Leg	adar, *plur.* adárin	atar (legs, feet)	
Lentils		laæds	
Life	eder		
Light		temesebat	
A little	amezcan, chouilak		thamzeen
To Love	bqueet		
M			
Man	ergas, argaz, *plur.* argazen	ergas	ergez, arghaz, *plur.* ergassen
Young Man		ærges æmfien	
Mare	tamguut		tegmert, alowdah
Market		zuk	
Market town		mourzuk, mourtzuk	
Meat	aksoum	el mækela	
Milk	aifky		aukfee, iktee
Money	edremen		
Month	agour		
Moon	ayur	eijur	tizeer, youle
Mother	imma	imma	
To Mount			einah
Mountain	adrar, *plur.* idurar	æderer	athraiz, *plur.* ithourair
Mouth	akimousch	ækemousch	emee
Much	bouan		
Mud	acal	æberet	
Mule		eserdun, *fem.* tiserdunt	
N			
Neck		ezkeba, aqaleb	
Night	eta		thigata
No		ella, elda, æsea, æla, assun	
Nose		tinfert, *plur.* enfern	
O			
Oil	ezit	zut, zeit	
Old	amgar	amegat	

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw.
Olives	tazunry	esemor	
Olive tree	tazemourt		
Oranges	china		
Ox	eyng	æjous, æjug	

P

Partridge		te-kourt	
Peace	nifra	afia	
Pen, quill		efferu jaseæ	
People	ga-hi (un peuple)	medden (nation)	ewdan
Plain (subst.)	lauta	lota	
Prince, chief	eghelid	ænressuat	

R

Rain	leona	læhuva	
River		igasar	yegazar, *plur.* yegazran

S

Sand	ermel		
Sea	bhar	bahar	
To See			akel
Sheep		ikeri *plur.* ikerein	ouly
Sickness	yoden		
Sister	oullma (my)		
To Sit down	kim, khim		
Sky		asiggena	
Slave	akly		
To Sleep		igen	
Shake	azum		azrimme
Snow	adfil	edfell	alfill
Snuff		shimma	
Something	ksa		
Son	emmi	jemmi	
To Stand			bidfillah
Star	jetri, *plur.* jetran	*plur.* ithri	yethra
Stomach		abbot	
Stone	equnhy	æblat, oblat	azgrew
Street		asenik	
Sun	jetig	teffoekt	taphoute, kylah
Sword, sabre, knife	agenouy	eschenuy	

T

Table		ælubra	
To Take away	elef		owee
Tent	elkba	khabba	
Thigh		emsat	

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw
Tobacco (smoking)		dockhan	
To-day	essa	uessa, wessa	assa
To-morrow	azequa		arica
Tooth			*plur.* ouglan
Tree	sigrà		tasta

V

Valley		æsenick	

W

Water	aman		
War	amengui	dæmong'ry	
Week	gemba		
Wind		ato	
Woman	tamitut	tamtolz, khaleth	thamatouth
Wood	sgarin	æsg'raum (fire-wood)	
World	denia		

Y

Year	assugas		aseegass
Young	amzian	æmissien	

NUMERALS

One	yeoun	iüon	ewan
Two	sin	sin	seen

The remainder as in Arabic.

PRONOUNS

I or me	neky	nickhy	neek
Thou	goug		ketche
He	neta		netta
It			ikra
We	nekny		nekenee
You	kanouy		hownouwee
They	nutny		nutnee
Mine	enou	ince	enou
Thine	inek		eaniss
My hand	afus		
Thy hand	afusis		
His hand	afusorien		
Your hands	ifasen		

	By a Jewish Interpreter.	By a Swedish Gentleman.	By Dr. Shaw.
Their hands	ifasen ensen		
My horse		audin ince	

VERBS

I love	neky thebit		
Thou lovest	keche ny thebit		
He loves	kechy thebit		
We love	nekny thebit		
You love	kanouy thebit		
They love	nutny thebit		
I speak			neck sewel
Thou speakest			ketche sewel
I spoke			neck seulgas
Thou spokest			ketche seulgas
Eat! (imper.)			itch
Drink! (imper.)			iswa
Rise! (imper.)			iker.

PHRASES.

By a Swedish Gentleman.

Good morning,	Esbahala haireh.
Good evening,	Umsele haireh.
Have you heard?	Eselit?
Sit down, (imperat.)	Kim kit shini.
Come hither,	Jae garda.
Give paper to write on,	Aunia el caret ektylen.
Which is the way to the English garden?	Ensi ebbrid hat el gennan Inglis?
Go, bring my horse,	Rouba ouiae audin inu.
Go to your country,	Rouh hat mourtik.

By Dr. Shaw.

Where is it?	Manee illa?
Give me that,	Oushee ende.
I give it,	Oushedowra.

Ifkee, or Ifgee, is another word for Give me: as,

Give me to eat, for I am hungry,	Ifkee ikra adetshag neck alouzagh.
Give me water to drink, for I am thirsty,	Ifkee ikra wamani adeswaag nec foudagah.

I am not thirsty,	Neck urfedaag ikra.
How many years have you been here?	Kadesh assegassen themeurtaye a kyth?
A good man fears nothing,	Ergez illalee oury tagadt ikra.
A bad man is afraid,	Ergez defoual tagedt.

IV.

Notes on the foregoing Vocabularies.—From Mr. Shaler's Communications.

The modes of spelling adopted by the Swedish Gentleman and Jewish Interpreter who compiled these Vocabularies are to be attended to. The latter seems to have had in view the French pronunciation of letters, the former that of his own language or the German. Therefore the letter *j*, when it occurs in his vocabulary, is to be pronounced as our *y* before a vowel, and the ü like the *u* of the French language. The sound which he expresses by the diphthong *æ*, he states to be a middle sound between the French *a* and *e*, resembling the ê apertum, in the French words *bête*, *tête*, and our diphthong *ai* in *hair*, *fair*. The *th* in his vocabulary is to be pronounced as the English *th* in *the*. This combination of letters does not appear in that of the Jewish Interpreter. The guttural sound of the Spanish *jota* or German *ch* is expressed by *kh*.

In the vocabulary of the Jewish Interpreter, the Kabyle words are explained in French: in that of the Swedish Gentleman, partly in French and partly in English, but principally in the latter language. We have here used the English throughout.

There are in the Berber, as in the Arabic, several sounds of the letter *s*, one of them approaching to that of the English *sh*. It is expressed in these vocabularies by *sh* or *sch*.

There is a sound in this language peculiar to it, which Mr.

Shaler calls "a monster in pronunciation;" it is that of the *g durum* of our language, as we pronounce it before the letter *o* in *God*, *gotten*, followed by that of the *r fortement grasseyee*, as the French would express it. This *grasseyement* is not known in this country, though in England it is occasionally met with. It cannot be represented except to the ear. In this Berber sound, the *g* is softly and the *r* strongly articulated. It is represented in these vocabularies by *g'r*.

Mr. Shaler has hitherto been able to communicate but little information respecting the grammatical peculiarities and the forms and construction of this language. The following is all that his latest communications contain.

The word *aseniek*, which means *balloon*, signifies also a *street*. *Young* and *little* are expressed in the same manner by *æmsien*,—a little door, *tivourt æmsien;* a little (or a young) girl, *tackshist tæmsien*. The letter *t* prefixed or affixed indicates the feminine gender.

The word *mourt* signifies both *town* and *country; mourtibaden*, a foreign country; *rouh hat mourtik*, go to your country. The word *zuk* signifies *market*, which seems to give the etymology of the name of the city of *Mourtzuk*, capital of the kingdom of Fezzan, *mourt* town, *zuk* market, a *market town*. But it is said that *zuk* or *zouk* signifies also a *market* in Arabic; so that this name may not be entirely and originally of Berber derivation.

There is a remarkable peculiarity in this language. The word *woman*, as we see in the vocabulary of Mr. Shaler's Swedish friend, is expressed in the Kabyle dialect by *tamtolz* and *khaleth;* but he observes that the latter word is only employed when speaking to several women in the same place. This is analogous to the various dual forms which exist in the verbs of our American Cherokees, which vary in their inflections according to the persons to or of whom one speaks. This will be explained at large in a grammar of the Cherokee language, which our learned countryman Mr. Pickering of Salem is now preparing for the press, and which may be expected shortly to appear. We will not anticipate upon the interesting facts which that work will communicate.

V.

Vocabulary of the Mozabee or Mozabi Dialect.

An Ass	Aziun
Barley	Temzeyenee
A Bird	Ageet
Black	Aberkan
Bread	Argoum
Butter	Tiluzee
A Camel	Aziun
Country	(See Town)
Dates	Tineenee
Day	Duges
An Ewe	Tesfrin
A Field	Amezin
Figs	Temshem
Grapes	Adillee
A (she) Goat	Alleem
The Heavens (Sky)	Ageenee
A Horse	Izee
A Man	Erges
A Mare*	Afoonest
Meat	Assium
Milk	Amelelee
The Moon	Tezjeree
A Mountain	Amzies
Night	Dgueed
No	Eyuee
A Slave	Aberkan
A Star	Eteyan
The Sun	Teforeit
Town (or Country	Atfran
Tree	Zejereet
Wheat	Arden
White	Ameleleen (colour of milk)
A Woman	Tajinmeet
Yes!	E, e!

NUMERALS.

1	Egat
2	Senet
3	Sharot
4	Engest
5	Semset
6	Zet
7	Sat
8	Temmet
9	Tzat
10	Mireott or mireon
20	Senet mireon
30	Sharot mireon
100	Tuin seet.

* *Note by Mr. Shaler.*—I think my friend must have made a mistake, and that a *bull* or *ox* is meant by *afoonest*, which seems to be according to the genius of the language in distinguishing male from female.

VI.

Grammatical Structure of the Berber Language.—Translated from the Mithridates, Vol. III. Part 1, p. 51.

1. Besides the letters of the Arabic alphabet, the Berber language has the sounds of the three Persian letters. *Gamma* (Ghain) and *Theta* are predominant sounds; words with *kha, dhâd*, and *dha* are not of Berberic origin.

2. The substantives borrowed from the Arabic, after throwing out the Arabic article, prefix the letter *t* or *nit*: ex. *el mukhal* is changed into *temukhalt* or *temukhalnit*; *thimdint* is derived from *medinat*, for which the Berbers had no word; the letter *t*, moreover, is expressive of the feminine gender: ex. *emchich* (in Morocco, *mouch*) a cat, in the feminine is *temchicht*, and in Morocco *tamoucht*; *mezzi* small, fem. *tamzint*. To the Arabic adjectives the syllable *da* is prefixed, as for *qadym* old, *daqadym*.

3. The formation of the plural of nouns is very difficult in consequence of the many changes of the vowels in the syllables of the words, of transpositions of the consonants, and many additional terminations, which perhaps may be considered as the result of the intermixture of other languages. The inflections or terminations are *in, awen, an, en, i, nen, uin, er*; ex. *eïazid* a cock, plur. *iouzad*; *aidi* dog, plur. *idan* (according to *Venture*; according to *Hoest*, the singular of this word is *aid*, and *idee* according to *Jones*;) *erghaz* man, plur. *irghazen* (*Jones*) or *erges*, plur. *ergessen* (*Shaw*;) *ikhf* or *aqaroui* head, plur. *ikhfawen* or *iqaharouin* (*Jones*;) or *eaghph*, plur. *eaghfan*, the singular according to *Hoest* is *agayo*; *edrar* mountain, plur. *idourer*; or *athrair*, (*Shaw*) plur. *ithourar*, (the singular according to *Hoest* is *adarar*.)

4. The cases are expressed by prepositions: the genitive by *en, ou, b, ghi, n, eb, nou, eghy*; the dative by *i, gher, se, es, ghi*; the ablative by *zigh, ghaf*, and *so*: ex. *amuuqran*

ghi Felissen, the Scheick of Felissen, (*amouqran*, fem.; *mouqrit* signifies properly *great*;) *i onerghaz*, to the man; *s'akham*, at home (à la maison;) *zigh thesirt*, from the mill.

5. Shaw is the only one who has given us the personal pronouns in this language. He has given the pronominal adjectives or possessive pronouns as separable or independent words, which all begin with *ea* or *en*, to which the pronominal is suffixed. But these pronominal adjectives are also suffixed to the substantive, as *nou* mine, *nek* or *nak* thine, and *sen* your (plural.) These, when suffixed to the verbs, express the accusative or dative of the persons, *i* me, *th* (in the Arabic with three points) him. These accusative or dative pronouns are moreover prefixed to the verb, preceded by the syllable *adh*, as *adhi* to me, *adhasen* to them. If the verb is negative, the pronominal sound is annexed to it, and so placed before the verb; ex. *ouagh yrwet*, not us man strikes (we are not struck.) In the second and third persons of the pronouns there are different modes of connecting them with substantives feminine, as in the Semitic languages.

6. The root of the verb is the imperative. In order to form preterites, *gh* is added at the end of the first person of the singular, *t* at the beginning of the second, and *i* at the beginning of the third in the masculine and *t* in the feminine—plural, *n* at the beginning of the first person, *t* at the beginning of the second, and *m* at the end in the masculine and *mt* in the feminine, and *n* at the end of the third person in the masculine, and *nt* in the feminine. The present is expressed by putting *ed* or *é* before the preterite. The imperative plural ends in the masculine in *et*, in the feminine in *imt*. According to Shaw, in the countries where he was, the present is not at all inflected, and in the preterite the termination *gas* is suffixed: in both cases, however, the personal pronoun is prefixed.

Berber Numerals.—From the Mithridates, p. 57.

	Shilha according to Jones.	Shilha according to Hoest.	Showiah according to Venture.	Tibbo according to Hornemann
1	Yean	Jen	Ouan	Trono
2	Seen	Sin	Thenat	
3	Crat	Karod	Kerat	Aguesso
4	Koost	Kuz	Gouz	Fousso
5	Summost	Semus	Summus	Fo
10	Murrow	Merau	Meraoua	Markhoun.

NOTE.—As far as these Numerals go, no marked affinity appears between the Berber dialects and the Tibbo. This would seem to support our hypothesis, that the Tibbo are not a part of the Berber nation.

The Lord's Prayer in Berber.—From Jones, in the Mithridates, p. 54.

Amazeagh, Lord, noble
na baba, our father
Erby, God
ghi, who
y ginna, in heaven
berkat, hallowed be
ysma*nick*, name *thine*
yi hackem, thy kingdom
geegn tusked, be coming
ougusseeda, kingdom
beherra, great
isker, happen, be done
omor*nick*, will *thine*
ophodn doonit, as on earth
wi y ginna, so in heaven
fkee, give
na *nogh*, to *us*
oghorom*na*, bread *our*
oghagossa, daily, for every day
amazeagh*na* erby, Lord God, Lord *our* God
t'opphur, release, forgive
duwb*nogh*, sins *our*, offences *our*
zoond, as
smah*nogh*, release *we*
yeadnm, others
elmochottyeén, offenders
uphala*noch*, against *us*
addan, and
woortphilt, not let
en yxshem, go
y allowwr, into temptation
ado*nogh*, but *us*
tiphkeet, preserve
oghodn, from
dnoob, evil
dwyu*nick*, for, because *thine*
ega, is
boutkemt, kingdom
ogo, ———
downit, earth
omor, power
ega, is
omor*nick*, power *thine*
tphul*keet*, glory *thine*
ghoury, is
n'taphookt, above sun and light
abadan, ever
wo abadan, and ever
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No. XV.

Solution of a General Case of the Simple Pendulum. By Eugenius Nulty.—Read 21st August, 1818.

In a letter which I wrote to Dr. Patterson, and which the Society thought worthy of publication, I found a new converging series for determining the times of oscillation of the simple pendulum in a plane. This has since led me to consider a more general case of the simple pendulum, in which the motion is supposed to arise from the action of gravity and an impulse not directed in a vertical plane, and to take place in the surface of the sphere of which the radius is the length of the string connecting the oscillating point and centre of suspension. As the series which I have found in solving this problem have not been noticed by the latest writers on mechanics, I have thought that the following investigation might not be unworthy the attention of the Society.

Let x, y, z be the vertical and horizontal distances of the oscillating point from three rectangular planes X. Y. Z. given in position with respect to the centre of suspension, dt the element of time during which the motion is considered as uniform, and g the accelerating force of gravity.

The velocities at the beginning of dt in the directions of x, y, z are $\frac{dx}{dt}$, $\frac{dy}{dt}$, $\frac{dz}{dt}$; the forces lost during this element are therefore $\frac{d^2x}{dt^2}$, $\frac{d^2y}{dt^2}$, $\frac{d^2z}{dt^2}$; and by the principle of virtual velocities, the sum of these forces, multiplied by the variations of their directions, is equal to the action of gravity multiplied by the variation of its direction. We have therefore

$$\frac{d^2x}{dt^2}\delta x + \frac{d^2y}{dt^2}\delta y + \frac{d^2z}{dt^2}\delta z = g\delta x. \qquad (1)$$

Let the invariable length of the pendulum be denoted by a, and let the common intersections of the three planes **X**, **Y**, and **Z** be in the vertical passing through the centre of suspension at a distance equal to a below this point. We shall then have

$$\sqrt{\{(a-x)^2+y^2+z^2\}}=a,$$

and of which the variation is

$$\frac{x-a}{a}\delta x + \frac{y}{a}\delta y + \frac{z}{a}\delta z = 0, \qquad (2)$$

an expression which the variations in the equation (1) must satisfy.

Let us therefore multiply this expression by an arbitrary quantity T, and add the result to the equation (1). We shall then find

$$\left(\frac{d^2x}{dt^2}+T\frac{x-a}{a}-g\right)\delta x + \left(\frac{d^2y}{dt^2}+T\frac{y}{a}\right)\delta y + \left(\frac{d^2z}{dt^2}+T\frac{z}{a}\right)\delta z = 0.$$

The variations δx, δy, δz are independent in this equation by virtue of the arbitrary quantity T, and accordingly we have

$$\frac{d^2x}{dt^2}+T\frac{x-a}{a}-g=0,$$

$$\frac{d^2y}{dt^2}+T\frac{y}{a}=0,$$

$$\frac{d^2z}{dt^2}+T\frac{z}{a}=0,$$

which are easily verified by observing that the first terms are the components of the inertia of the oscillating point in the directions of x, y, z; the second terms, the components of the tension of the string in the same directions; and g the effect of gravity in the vertical direction x.

Multiplying these equations respectively by dx, dy, dz, adding the results, and observing that by virtue of the equation (2) we have

$$\frac{x-a}{a}dx+\frac{y}{a}dy+\frac{z}{a}dz=0,$$

we shall get

$$\frac{d^2x}{dt^2}dx+\frac{d^2y}{dt^2}dy+\frac{d^2z}{dt^2}dz=gdx,$$

of which the integral is

$$\frac{dx^2+dy^2+dz^2}{dt^2}=2g(b-x). \qquad (3)$$

Again, multiplying the second and third of the preceding equations by z and y, and taking the difference of the results, we shall find

$$z\frac{d^2y}{dt^2}-y\frac{d^2z}{dt^2}=0,$$

of which the integral is

$$\frac{z\mathrm{d}y-y\mathrm{d}z}{\mathrm{d}t}=b'. \qquad (4)$$

The equation (3) expresses the known principle of living forces, and the equation (4) that of the equable description of areas.

Let v be the horizontal angle formed by the projection of a on the plane X, and by the vertical plane Z. Then it is evident that $y=\surd(2ax-x^2).\sin.\ v$ and $z=\surd(2ax-x^2).\cos.\ v$; and their differentials are

$$\mathrm{d}y=\frac{a-x}{\surd(2ax-x^2)}.\sin.v\mathrm{d}x+\surd(2ax-x^2)\cos.v\mathrm{d}v,$$

$$\mathrm{d}z=\frac{a-x}{\surd(2ax-x^2)}.\cos.v\mathrm{d}x-\surd(2ax-x^2)\sin.v\mathrm{d}v.$$

Substituting these expressions in the equations (3) and (4), we shall find after obvious reduction,

$$\frac{a^2\mathrm{d}x^2+(2ax-x^2)\mathrm{d}v^2}{\mathrm{d}t^2}=2g(2ax-x^2).(b-x),$$

$$\frac{(2ax-x^2)\mathrm{d}v}{\mathrm{d}t}=b',$$

from the first of which eliminating dv, and from the second dt, we get

$$\frac{\mathrm{d}x}{\mathrm{d}t}=\pm\frac{(2g)^{\frac{1}{2}}}{a}\surd F, \qquad (5)$$

$$\frac{\mathrm{d}x}{\mathrm{d}v}=\pm\frac{1}{a.c^{\frac{1}{2}}}.(2ax-x^2)\surd F, \qquad (6)$$

in which $F=x^3-(2a+b)x^2+2abx-c$, and $c=\frac{b'}{2g}$.

These are the equations from which the motion of the pen dulum is to be determined. The first will give the time in a vertical direction, and the second the horizontal angle described about the vertical which passes through the centre of of suspension.

In order to integrate these equations, let us observe that the oscillating point can neither ascend so high on the spherical surface as to attain a point of which the vertical ordinate is equal to $2a$, nor descend so low as the horizontal, tangential plane X. The curve described will therefore be contained between two horizontal circles drawn on the spherical surface, and it will evidently touch these circles in two points P and Q, corresponding to the greatest and least values of the vertical ordinate x. Let these values, or the ordinates of P and Q be denoted by p and q, and let us observe that the vertical velocity $\frac{dx}{dt}$ decreases as the oscillating point approaches P and Q, and vanishes at the instant of their coincidence. We shall therefore have $F = 0$, both when $x = p$ and $x = q$, and accordingly this equation must be divisible by each of the factors $x-p$, $x-q$, and consequently by their product $x^2-(p+q)x+pq$. Let the third factor of F be $x-r$. Then we shall have

$$F \text{ or } x^3-(2a+b)x^2+2abx-c = \{x^2-(p+q)x+pq\}.(x-r),$$

from which, by comparing like powers of x, we get

$$2a+b = p+q+r,\ \ 2ab = pq+(p+q)r,\ \ c = pqr,$$

and thence

$$r = 2a + \frac{pq}{2a-p-q},\quad c = (2a + \frac{pq}{2a-p-q})pq.$$

The equation F may now be transformed into the product

$$\{x^2-(p+q)x+pq\} \,.\, \{x-(2a+\frac{pq}{2a-p-q})\},$$

which may be written in the form,

$$\left\{(x-\frac{p+q}{2})^2-(\frac{p-q}{2})^2\right\}.\left\{(x-\frac{p-q}{2})-(2a+\frac{pq}{2a-p-q}-\frac{p-q}{2})\right\}$$

$$=(\frac{p-q}{2})^2.(1-u^2).\frac{p-q}{2k}.(1+ku), \text{ by putting}$$

$$\frac{p+q}{2}-x=\frac{p-q}{2}u, \text{ and } 2a+\frac{pq}{2a-p-q}-\frac{p-q}{2}=\frac{p-q}{2k}.$$

By virtue of this assumption, we have

$$\sqrt{F}=\frac{p-q}{2}.(\frac{p-q}{2k})^{\frac{1}{2}}.\sqrt{\left\{(1-u^2).(1+ku)\right\}},$$

in which $u=-1$ corresponds to $x=p$, and $u=1$ to $x=q$.

Substituting this expression in the equation (5), and observing that $dx=-\frac{p-q}{2}du$, we shall find

$$\frac{du}{dt}=\frac{[g(p-q)]^{\frac{1}{2}}}{ak^{\frac{1}{2}}}\sqrt{\left\{(1-u^2).(1+ku)\right\}}, \text{ and thence}$$

$$dt=\frac{ak^{\frac{1}{2}}}{[g(p-q)]^{\frac{1}{2}}}.\frac{du}{\sqrt{\left\{(1-u^2).(1+ku)\right\}}}. \qquad (7)$$

With respect to the equation (6), we have

$$2ax-x^2=(2a-x)x=(2a-\frac{p+q}{2}+\frac{p-q}{2}u).(\frac{p+q}{2}-\frac{p-q}{2}u)$$

$$=\frac{(p-q)^2}{4k'k''}.(1+k'u).(1-k''u), \text{ by assuming}$$

$$\frac{p-q}{2}=k'(2a-\frac{p+q}{2})=k''\frac{p+q}{2}, \text{ and accordingly}$$

$$\frac{du}{dv}=\frac{1}{a.c^{\frac{1}{2}}}\cdot\frac{(p-q)^2}{4k'k''}.(1+k'u).(1-k''u).\sqrt{\{(1-u^2).(1+ku)\}},$$

and thence

$$dv=\left(\frac{2ck}{p-q}\right)^{\frac{1}{2}}\cdot\frac{4ak'k''}{(p-q)^2}\cdot\frac{du}{(1+k'u).(1-k''u).\sqrt{\{(1-u^2).(1+ku)\}}}. \quad (8)$$

These are the simplest forms in which dt and dv can be presented. It is impossible, however, to express their integrals in finite terms by means of circular arcs and logarithms; but series exhibiting their approximate values may be found in the following manner:

Putting, for the sake of brevity, the constant coefficient $\frac{ak}{g(p-q)}=K$, and expanding the factor $(1+ku)^{-\frac{1}{2}}$ by the binomial theorem, we have

$$t=K^{\frac{1}{2}}\int\frac{du}{\sqrt{(1-u^2)}}\left\{1-\frac{1}{2}ku+\frac{1.3}{2.4}k^2u^2-\frac{1.3.5}{2.4.6}k^3u^3+\frac{1.3.5.7}{2.4.6.8}k^4u^4-\text{\&c.}\right\},$$

in which, if we put the integral of $\frac{du}{\sqrt{(1-u^2)}}=\text{arc}(\sin.=x)=A$,

and the integral of $\frac{udu}{\sqrt{(1-u^2)}}=-\sqrt{(1-x)}=A'$, we shall have

$$\int\frac{u^2du}{\sqrt{1-u^2}}=\frac{A-u\sqrt{1-x^2}}{2}=\frac{B}{2},$$

$$\int\frac{u^4du}{\sqrt{1-u^2}}=\frac{3B-2u^3\sqrt{1-u^2}}{2.4}=\frac{C}{2.4},$$

$$\int\frac{u^6du}{\sqrt{1-u^2}}=\frac{5C-2.4u^5\sqrt{1-u^2}}{2.4.6}=\frac{D}{2.4.6},$$

&c. &c.

$$\int \frac{u^3 du}{\sqrt{1-u^2}} = \frac{A'-u^2\sqrt{1-u^2}}{3} = \frac{B'}{3},$$

$$\int \frac{u^5 du}{\sqrt{1-u^2}} = \frac{B'-3u^4\sqrt{1-u^2}}{3.5} = \frac{C'}{3.5},$$

$$\int \frac{u^7 du}{\sqrt{1-u^2}} = \frac{C'-3.5u^6\sqrt{1-u^2}}{3.5.7} = \frac{D'}{3.5.7}.$$

&c. &c.

by virtue of which, the integral of the preceding expression is

$$t = K^{\frac{1}{2}} \left\{ A + \frac{3B}{4^2}k^2 + \frac{5.7C}{4^2.8^2}k^4 + \frac{7.9.11D}{4^2.8^2.12^2}k^6 + \frac{9.11.13.15E}{4^2.8^2.12^2.16^2}k^8 + \&c. \right.$$

$$\left. + \tfrac{1}{2}A'k + \frac{5B'}{2.4.6}k^3 + \frac{7.9C'}{2.4.6.8.10}k^5 + \frac{9.11.13D'}{2.4.6.8.10.12.14}k^7 + \&c. \right\},$$

the difference between two values of which corresponding to given values h, h' of x will give the time taken by the oscillating point to describe a portion of the curve, corresponding to the vertical height $h-h'$.

If we extend the integral from $x=p$ to $x=q$, and consequently from $u=-1$ to $u=1$, we shall have the time (t) which the oscillating point requires to descend from the highest point P on the spherical surface to the lowest point Q, and vice versa. In this case, the integral A becomes simply $\frac{\pi}{2}$, (π being put for the semicircumference of a circle to radius $=1$,) the integrals B, C, D, &c. become respectively A, $3A$, $D=3.5A$, &c. and the integrals A', B', C', D', &c. all vanish We shall therefore have

$$(t)=K^{\frac{1}{2}}\pi\left\{1+\frac{1.3}{4^2}k^2+\frac{1.3.5.7}{4^2.8^2}k^4+\frac{1.3.5.7.9.11}{4^2.8^2.12^2}k^6+,\ \&c.\right\},$$

$$=K^{\frac{1}{2}}\pi\left\{1+\frac{1.3}{4^2}k^2+A_2\frac{5.7}{8^2}k^2+A_3\frac{9.11}{12^2}k^2+,\ \&c.\right\},\qquad(9)$$

A_2, A_3, representing the second, third. &c. terms.

Let us resume the differential equation (7) and put $s=\frac{1-u^2}{1+ku}$. From this we get

$$u=-\frac{ks}{2}\pm\frac{1}{2}\sqrt{(4-4s+k^2s^2)}=-\frac{ks}{2}\pm\frac{1}{2}S^{\frac{1}{2}},$$

putting for the moment $S=4-4s+ks^2$, and thence $\sqrt{\{(1-u^2).(1+ku)\}}=s^{\frac{1}{2}}(1+ku)=\sqrt{\left\{s\left(1-\frac{k^2s}{2}\pm\frac{k}{2}S^{\frac{1}{2}}\right)\right\}}$, and $du=-\frac{ds}{S^{\frac{1}{2}}}\left\{1-\frac{ks}{2}\pm\frac{k}{2}S^{\frac{1}{2}}\right\}$. Substituting these expressions, we shall have

$$dt=K^{\frac{1}{2}}.\frac{-ds}{\sqrt{\{s(4-4s+k^2s^2)\}}}.$$

Let $2-ms$ and $2-ns$ be the factors of the quadratic $4-4s+k^2s^2$ in this expression. We shall then have $m+n=2$, $mn=k^2$, and thence $m=1+\sqrt{(1-k^2)}$, $n=1-\sqrt{(1-k^2)}$. The preceding expression may now be written

$$dt=K^{\frac{1}{2}}.\frac{-ds}{\sqrt{\{s(2-ms).(2-ns)\}}},$$

which will take the form of the original equation (7) by assuming $s=\frac{1-u'}{m}$; since then $-ds=\frac{du'}{m}$, $\sqrt{\{s(2-ms).(2-ns)\}}=$

$\surd\{\frac{(1-u'^2)}{m}.\frac{2m-n}{m}(1+\frac{n}{2m-n}u')\}=\frac{K_1^{\frac{1}{2}}}{m}.\surd\{(1-u'^2).(1+k_1u')\}$,

by putting $\frac{n}{2m-n}=\frac{1-\surd(1-k^2)}{1+3\surd(1-k^2)}=k_1$, and $2m-n=1+3(\surd 1-k^2)$ $=K_1$. We have therefore

$$dt=(\frac{K}{K_1})^{\frac{1}{2}}.\frac{du'}{\surd\{(1-u'^2).(1+k_1u')\}},$$

an expression which integrated between the limits $u'=1$ and $u'=-1$ as before, gives

$$(t)=2\pi.(\frac{K}{K_1})^{\frac{1}{2}}.\{1+\frac{1.3}{4^2}k_1^2+A_2\frac{5.7}{8^2}k_1^4+A_3\frac{9.11}{12^2}k_1^6+\text{\&c.}\}$$

a series exactly similar to that above found, and derivable from it by introducing the factor K_1, and changing k to k_1.

It is evident that a third series may be derived from this by introducing a new factor $K_2=\surd\{1+3\surd(1-k_1)\}$, and changing k_1 into $k_2=\frac{1+\surd(1-k_1^2)}{1+3\surd(1-k_1^2)}$; and that a similar process may be continued ad infinitum. We shall therefore have

$$(t)=2^n\pi\,(\frac{K}{K_1.K_2.K_3.\ .\ .\ .\ K_n})^{\frac{1}{2}}.\{1+\frac{1.3}{4^2}k_n^2+A_2.\frac{5.7}{8^2}k_n^4+\text{\&c.}\},$$

or rejecting the second, third, &c. terms of the series in the brackets as indefinitely small,

$$(t)=2^n\pi(\frac{K}{K_1.K_2.K_3.\ .\ .\ .\ K_n}). \qquad (10)$$

This is an elegant expression for the determination of (t).

It has not been hitherto noticed, at least to my knowledge, and is the object I had in view in the present paper.

It may be proper to observe that the equation (10) may be easily modified so as to apply to the case in which the vibrating point moves in a vertical plane. We have merely to put $q=0$ in the expressions represented by K and k, since then the constant arbitrary quantity b' expressing the effect of the impulse from which the conical motion arises will vanish, and the vibrating point will descend to the horizontal plane X. The values of K and k will become, in this case, $\frac{a}{\surd\{g(4a-p)\}}$ and $\frac{p}{4a-p}$, and the corresponding value of (t) will be exactly of the same form as that just considered. If we limit the expression to the factor K, we shall have a particular case of the first expression found for (t), the same as that already given for the common pendulum.

With respect to the equation (10), I shall only observe that its integral may be found in a series by means of the integrals A, B, C, &c. A', B', C', &c. after the factors $(1+ku)$, $(1+k'u$, $(1-k''u)$, are expanded by the binomial theorem. By using peculiar artifices, other series may also be found; but their coefficients are so complicated, as to deter me from inserting their investigation.

I shall conclude this paper by a computation of the value of (t) for a particular value of k. This will give an idea of the rapidity with which the quantities k_1, k_2, &c. decrease, and at the same time show the great superiority of the formula (10) over the series (9).

The extreme value of which k is susceptible being unity, let us suppose this quantity greater than its mean value $\frac{1}{2}$, or $=\frac{3}{5}$. Then we have $k_1=\frac{1}{17}$, $k_2=\frac{1}{2263+}$, a fraction of which the square and higher powers may be safely neglected. We shall therefore have $k'_1 = \frac{17}{5}$, $k'_2 = \frac{67.911688}{17}$, $\surd(k'_1.k'_2) = 3.685422$, and accordingly

$$(t) = k'^{\frac{1}{2}} \frac{4}{3.685422} = k'^{\frac{1}{2}}(1.08535737),$$

a result which is true to the last figure.

Again, substituting $\frac{3}{5}$ instead of k in the series (9), we shall get

$$\begin{aligned}(t) = k'^{\frac{1}{2}} \{ \; & 1.00000000 \} \\ & 6750000 \\ & 1328906 \\ & 328904 \\ & 90192 \\ & 26218 \\ & 7914 \\ & 2453 \\ & 775 \\ & 248 \\ & 81 \\ & 26 \\ & 8 \\ \hline = k'^{\frac{1}{2}} \{ \; & 1.08535725 \},\end{aligned}$$

in which the last two figures are incorrect, although the divisions have been extended to the ninth decimal place.

No. XVI.

Notice of a New Crystalline Form of the Yenite of Rhode Island. By Dr. G. Troost.—Read, 15th October, 1824.

I PUBLISHED in the Journal of the Academy of Natural Sciences of this city the discovery of the Yenite, found for the first time on this side of the Atlantic. The specimens of that mineral which fell under my examination presented only the *quadriduodecimal* and some crystals approaching to the *trioctonal* and *monostique* of Hauy. Dr. Mease, one of our members, lately presented through me a specimen of the same mineral to the cabinet of our Society, which contained some crystals deviating considerably from the forms mentioned; but they were so small as to prevent me from ascertaining the value of the angles, and I was therefore not able to determine their true form. Having since received some specimens through the politeness of Dr. Samuel Robinson of Providence, R. I., I found them of the same form, and of a size sufficiently large to enable me to measure the inclination and to determine the form. The crystal in question is a straight rhomboidal prism, the angles being 83° 58′ and 96° 2′, and the sides forming with the base an angle of 90°. I call it

PRISMATIC YENITE. (*Fer calcaréo-siliceux prismatique.*)

If we adopt the primitive form obtained by mechanical division by Hauy, which is a rectangular octaedron, we shall have for representative signs $\underset{s}{4}F\overset{\textstyle 4}{\underset{r}{}}B$; and adopting the hypothetical nucleus of Cordier, which is a straight rhomboidal prism, its representative signs would be $\underset{s}{4}G\overset{4}{\underset{P}{}}P$.

The specimen now in the collection of the Society is composed of a few of the above described crystals placed in an horizontal position, with crystals of greasy quartz, on granular quartz, containing some minute octaedrons of magnetic iron ore which make it act upon the magnetic needle.

I found some modifications of the same form on the specimens which I received from Dr. Robinson. Some of the prisms are joined side by side, so as to form an even plane which might be taken for an extensive tabular crystal; but when examined by a magnifying glass, we perceive the joints by which these different prisms are united. Some of these tables are terminated by a plane under an angle of 90°, and must therefore be composed of the prisms above described. Others are terminated by an angle of between 145° and 150 which I have not been able to ascertain owing to the position; so that it is probable that at this locality some other forms may be discovered.

The Yenite is generally of a black colour; as is the case with the European mineral. But that of Rhode Island offers also a greyish white, intermixed with yellow and passing from that through the various shades of rubiginous yellow and brown to perfect black. However these colours are rare. I have but one specimen in my collection, and it is the only one that I have seen.

It occurs likewise in the quartz already mentioned; and in limestone of a peach blossom red colour, probably coloured by manganese and some green fibrous substance which seems to be the acicular actinolite and limestone, which has assumed a fibrous appearance,—and it is only by a magnifying glass that we discover that the fibres of the Yenite are formed by a combination of minute crystals of that mineral.

As to the geognostic situation of this mineral, nothing can with certainty be said. It is found on the farm of a Mr. Brown in Cumberland township, fifteen miles north of Providence, Rhode Island, where it occurs, according to Dr. Robinson, among heaps of stone which were blasted no one knows why,—possibly for the purpose of obtaining metal.

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ERRATA.

In Vol. I. New Series, p. 401, the Paper of Thomas Say was printed during his absence and contains the following errors :—

Plate XIII. fig. 19 represents a variety of C. *pusilla*, fig. 12, and not the C. *formosa*, as was intended.

Fig. 11 represents a variety of C. *punctulata*, (Oliv.) fig. 9, instead of C. *decemnotata* as was intended.

In the present volume, correct the following errors:

Page 26,	line 7 from the bottom,		for	is	*read*	be
52,	line 30	do.	for	Marshal	*read*	Marsham
65,	line 2	do.	for	depressed	*read*	impressed
93,	line 32, 33,	do.			*dele*	labium and
271,	line 33	do.	for	fig. 8	*read*	fig 11
275,	line 28	do.	for	ee	*read*	cc
278—284, passim,			for	Plate IV.	*read*	Pl. III. fig. 7. 8
278,	line 26, and 4	do.	for	Plate 1.	*read*	Plate III.
281,	line 9	do.	for	c	*read*	e
287,	line 31	do.	for	Plate III. 7, 8	*read*	Plate V. 2, 3
"	line 11	do.	for	Plate IX.	*read*	Plate VIII.
"	line 5	do.	for	d	*read*	a'
288,	line 15	do.	for	e	*read*	e
"	line 5	do.	for	8	*read*	6
296,	line 4	do.	for	Plate V.	*read*	Plate VI.
316,	line 20	do.	for	R	*read*	Z
317,	line 13	do.	for	ball	*read*	level
"	last line		for	n	*read*	h
355,	line 35	do.	for	*xx*	*read*	zz
366,	line 8	do.	for	VIII.	*read*	X.
401,	first line		for	Plate IX.	*read*	Plate IV.
451,	line 11	do.	for	*Buri*	*read*	*Bem.*
463,	line 29	do.	for	the three	*read*	three